WORLD BANK TECHNICAL PAPER NUMBER 14

Water Supply and Sanitation Project Preparation Handbook

Volume 3: Case Study

Feasibility Report for Port City

Brian Grover, Nicholas Burnett and Michael McGarry

WTP14

November 1983

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UNDP Project Management (INT/82/002) Report Number 1

This is one of three companion volumes which, together, comprise the Water Supply and Sanitation Project Preparation Handbook.

Volume 1: Guidelines

Volume 2: Case Studies
- Identification Report for Port City
- Immediate Improvement Project for Port City
- Pre-Feasibility Report for Farmville
- Pre-Feasibility Report for Port City

Volume 3: Case Study
- Feasibility Report for Port City

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FOREWORD

Close to three billion people in the developing countries will need improved water supply and sanitation services by 1990. This is the ambitious goal of the International Drinking Water Supply and Sanitation Decade (IDWSSD).

Among the major impediments to meeting this goal are a scarcity of expertise for planning good projects and the lack of globally accepted project preparation standards. The limited human and financial resources in developing countries can be used more efficiently if water and sanitation projects are initially prepared to standards meeting requirements of approving authorities and financing agencies.

The Steering Committee of United Nations Agencies involved in promoting the Decade was urged by developing country representatives to set out, and make uniform to the extent practicable, the information requirements of the agencies which provide financial assistance for water supply and sanitation projects. At the request of this Steering Committee, the World Bank commissioned the development of this Project Preparation Handbook by three consultants, as part of the Bank-executed United Nations Development Programme (UNDP) Project "Information and Training for Low Cost Water Supply and Sanitation".

The Handbook consists of a set of Guidelines, setting out the information requirements, and accompanying Case Studies which illustrate how the Guidelines might be followed for specific projects. The Guidelines and Case Studies are mainly addressed to proponents of water supply and sanitation projects in the developing countries. They explain the process of project development from the perspective of the agencies which might be asked to provide financial assistance. Guidelines are suggested and illustrated for the reports expected on completion of three successive stages of pre-investment planning for specific projects: identification, pre-feasibility and feasibility. In addition a Guideline is provided for preparing a program of rural water supply and sanitation.

Guidelines cannot be a substitute for professional judgement. They provide guidance, suggest approaches and methods of evaluation, and must be sufficiently comprehensive to be useful in many situations, covering projects of various complexities. They must be used flexibly. The extent to which specific suggestions are followed, and in what detail, must be left to the professional judgement of the planner. As a consequence, the selection of staff responsible for project preparation, and local and foreign consultants to assist them, if necessary, is the most important step an agency takes in project development.

Flexibility in the application of the Guidelines has been a major consideration in their preparation. The three project Guidelines of Volume 1 do not distinguish between urban, semi-urban or rural projects because the principles and methods elaborated, properly applied, will result in the most cost effective project, regardless of location or size. The final Guideline, however, is specially designed for a rural program, involving a number of sub-projects for water supply and sanitation.

Because urban and semi-urban projects provide better opportunities for demonstrating the full scope of the Guidelines, urban projects have been selected for the Case Studies of Volumes 2 and 3. Even within that framework, the Case Studies demonstrate different levels of preparation, reflecting projects of different complexities: a simple project for a small town; an immediate improvement program and a large and complex project for a major city.

Many individuals in the bilateral and multilateral agencies and other organizations named in the following list have reviewed the Guidelines and, in most cases, the Case Studies. Their thoughtful comments, all of which are gratefully acknowledged, led to substantial revisions and improvements to the Handbook. Listing these reviewers does not imply in any sense that these documents reflect all their comments or represent the official policies of their institutions. Given the variety of institutional objectives, it would be impossible, indeed, undesirable, to have one single, rigid standard. What the authors have attempted to do is to present a methodology and approach which will result in a plan for a quality project whatever its complexity. Project proponents and development agencies should together decide on the degree of detail that any specific project requires. In this sense, hopefully, the documents do represent a standard acceptable to many institutions. The IDWSSD Donor Catalogue is a first source of information about the particular requirements of various international development agencies.

This Handbook will remain valuable only as long as it remains up to date. We therefore anticipate future revisions to reflect new developments and experience gained in the use of the documents. Similarly, the addition of other Case Studies might be helpful. We would appreciate receiving comments and suggestions for incorporation in future volumes. Users of the Handbook are encouraged to send comments derived from its practical application to the address below.

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Chief, Applied Research
and Technology Division,
Water Supply and Urban
Development Department,
The World Bank

John M. Kalbermatten
Senior Adviser,
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November 1983

ACKNOWLEDGEMENTS

This Handbook is a product of the World Bank-executed UNDP Project INT/82/002 "INFORMATION AND TRAINING FOR LOW COST WATER SUPPLY AND SANITATION" . Other project outputs which will become available during 1984 are films, audio-visual training modules, manuals, guidelines and visual learning kits. A Project Brochure describing objectives and target audiences as well as the format and content of the material to be produced is available from the Applied Research and Technology Division, Water Supply and Urban Development Department (WUD), World Bank, 1818 H Street, N. W., Washington, D. C. 20433, U.S.A.

Project INT/82/002 was initiated with financial support from the Canadian International Development Agency (CIDA), the National Film Board of Canada (NFB), the United Nations Center for Human Settlements (UNCHS), the United Nations Development Programme (UNDP), and the World Bank. Subsequently, the United Nations Children's Fund (UNICEF), the Finnish International Development Agency (FINNIDA), the Gesellschaft fur Technische Zusammenarbeit (GTZ) of the Federal Republic of Germany and the Directorate of Development Cooperation of Switzerland provided financial assistance.

In addition to INT/82/002, the following UNDP projects executed by the World Bank contributed to this Handbook: the Regional Offices for the Preparation of Water and Sanitation Projects in Asia (RAS/81/001) and in Africa (RAF/82/004), the Field Testing and Technological Development of Rural Water Supply Handpumps Project (INT/81/026) and the Research and Development in Integrated Resource Recovery Project (GLO/80/004).

Finally, we wish to express our gratitude to the authors of the Handbook, Brian Grover, Nicholas Burnett and Michael McGarry, who deserve credit for a difficult job well done, and to the collaborators whose contributions have greatly improved these documents: Mr. Leo Lawson, Director of Engineering of the National Water Commission of Jamaica; Mr. John Sipper, Economic Editor, Asian Development Bank; and Mr. Joseph Freedman, Rural Water and Sanitation Adviser of the World Bank's Water Supply and Urban Development Department.

The support of all these agencies, projects and individuals is gratefully acknowledged.

LIST OF REVIEWERS

The following organizations have reviewed one or more volumes of the Project Preparation Handbook. Their comments have greatly contributed to the value of these documents and are hereby gratefully acknowledged by the International Drinking Water Supply and Sanitation Decade Steering Committee, the World Bank, and the authors. The list of reviewers includes those who commented on the initial version of the guidelines (Volume 1) beginning early in 1981. It is possible, therefore, that some of the individuals named no longer hold the positions described.

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Asian Development Bank	David A. Howarth Manager Water Supply Division
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Danish International Development Agency	Birte Poulsen Head of Section
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PREFACE TO THE CASE STUDIES

The Case Studies in Volumes 2 and 3 of this Handbook are typical reports which illustrate the Guidelines in Volume 1. All refer to a fictional area including Port City and the town of Farmville, in a fictional developing country, Optima. While fictional, however, the Case Studies are loosely based on a real example and contain credible physical, engineering, financial, and economic information. And while the reports refer principally to a large urban area, they do include a component for a smaller town and for some rural villages.

There are five Case Study reports. The Identification Report would typically be prepared by a sector ministry or agency in the country, here the Port City Water and Sewerage Commission (PCWSC). The other four reports could have been prepared by the agency itself but in this example were prepared by consultants working with the agency.

The Immediate Improvement Project for Port City, the Pre-feasibility Report for Farmville, and the Pre-feasibility Report for Port City are examples of pre-feasibility reports, the first two in a form suitable for presentation to an international development agency for funding and the third as an interim report toward the preparation of the Feasibility Report for Port City. The Immediate Improvement Project and the Farmville Report both illustrate that a comprehensive feasibility report is often not necessary for some financing agencies to decide on a relatively small loan, either for the rehabilitation of existing systems in a large town like Port City or for a comprehensive project in a small town like Farmville. A full Feasibility Report is normally essential, however, before a lending agency can agree to help finance a major project like that proposed for Port City.

The variety of reports included in these Case Studies is intended to demonstrate that the Guidelines should be followed in a flexible manner. Indeed, none of the Case Studies conforms entirely to the Guidelines. The format of any report must be adapted to meet the needs of the particular project it covers and the audience for whom the report is intended.

An important lesson that the Case Studies illustrate is the need to build into the report-producing process some decision points to ensure that those preparing the project are complying with the instructions of their client. In these Case Studies, this is achieved through the inclusion of a rigid schedule for production of and comment upon the reports, as well as through the use of Technical Memoranda requesting decisions from the Steering Committee overseeing the consultants' work.

A second important lesson is the need to integrate data and skills from several disciplines, including engineering, financial, economic, sociocultural, health, and management, in the process of preparing projects. As authors of these fictional Case Studies, using ideas and data from various sources, we found this very difficult to do, even among our small team. Yet, we urge all those concerned with preparing real projects to work together, right from the start - it may be difficult but it is essential.

These Case Studies have been prepared for educational purposes. While they demonstrate the reports that normally make up the project preparation process, they do differ from those that would be found in a real case in a number of ways and thus should not be imitated exactly:

a) There is less technical substantiation here than would normally be provided. For reasons of space various items of background information, such as maps, geological records, and copies of legislation and regulations have been excluded. Many technical details concerning field conditions, choice of materials, technical specifications, alternative designs and other engineering matters are also omitted because such conventional topics are well understood by experienced project planners. In the feasibility study (Volume 3), many such details are assumed to be available in Technical Appendices which would normally be produced to substantiate the report but are not actually included herein.

b) Design criteria, unit costs, and other technical data discussed in the Case Studies are specific to the Optima and Port City situation. Operation and maintenance assumptions are likewise specific to these hypothetical cases. Similar parameters for real projects should always be specific to those projects; they should also be analyzed carefully.

c) The figures in the Case Studies have been specially prepared for reduction to single page size in black and white. In reality, they would usually be both larger and more comprehensive and might well include color.

d) Some of the terminology used in these reports may not be standard in some countries. A figure illustrating some of the engineering terms used follows this preface. A list of units and acronyms is included in each Case Study. It is suggested that terms, units and acronyms acceptable to the local authorities be used for specific projects.

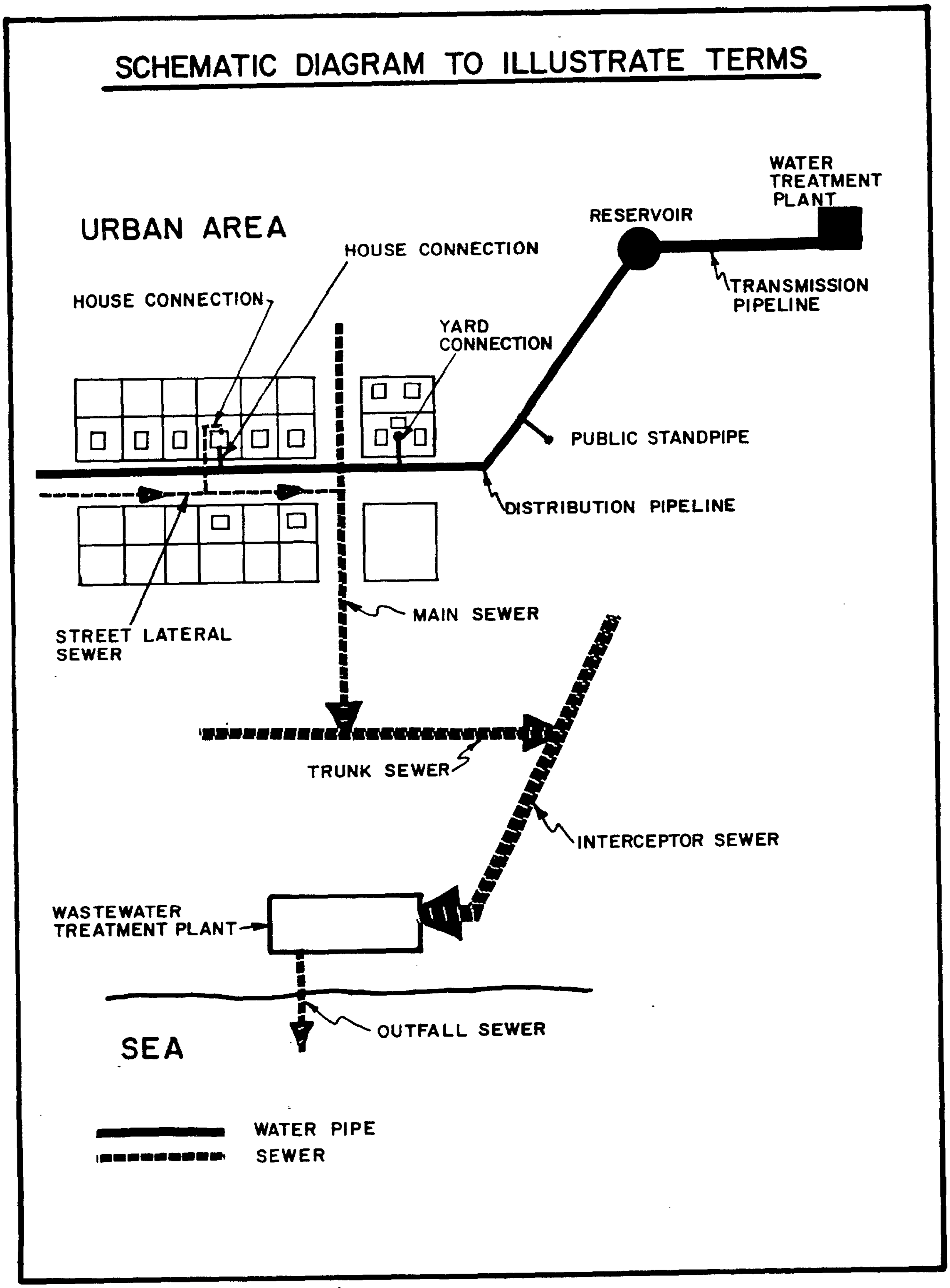
In writing these Case Studies, the authors have benefited tremendously from the assistance of many. The reports incorporate material that originated from Doug Manion, Elizabeth Harwood, and Harry McPherson of their firms and from Al Heron and Surong Bulakul of the World Bank. Production of the reports has been a major challenge involving Erika

Sheehan, Dilshad Karim, Robert McWilliams and Maria Fenyvesi of their firms and Kathy Kerekes and Sylvie Brebion of the World Bank. The Review Committee of the World Bank, including Mr. Leo Lawson, provided invaluable guidance, as did the many external reviewers listed previously.

The entire exercise could not have been completed without the constant support of John Kalbermatten. To all of these we offer our thanks. We nevertheless accept full responsibility for the final product, a Handbook which we hope will benefit those faced with the task of preparing real projects to provide people with improved services for water supply and sanitation.

Ottawa
June, 1983

Brian Grover
Nicholas Burnett
Michael McGarry


SCHEMATIC DIAGRAM TO ILLUSTRATE TERMS
URBAN AREA
WATER TREATMENT PLANT
RESERVOIR
TRANSMISSION PIPELINE
HOUSE CONNECTION
HOUSE CONNECTION
YARD CONNECTION
PUBLIC STANDPIPE
DISTRIBUTION PIPELINE
MAIN SEWER
STREET LATERAL SEWER
TRUNK SEWER
INTERCEPTOR SEWER
WASTEWATER TREATMENT PLANT
OUTFALL SEWER
SEA
WATER PIPE
SEWER

PORT CITY

WATER SUPPLY AND SANITATION PROJECT

FEASIBILITY REPORT

February, 1983

XYZ Consultants
Port City

XYZ Consultants
Sheehan Centre, Suite 103
350 Dilshad Road
Port City

February 18, 1983

Mr. K. Undugu
Project Director
Port City Water and Sewerage Commission
Port City

Dear Mr. Undugu:

In accordance with our contract of August 20, 1981 and its accompanying Terms of Reference, we are pleased to submit the final version of our Feasibility Report for the Port City project. The Executive Summary is presented first, followed by the full report, including the Table of Contents.

This report takes account of the many valuable comments on the draft report which was issued two months earlier. We wish to acknowledge the generous cooperation of staff members of PCWSC and of the Project's Steering Committee.

We appreciate having had the opportunity to work on this challenging assignment and are pleased to note that many of our recommendations, particularly those dealing with immediate improvements, have already been implemented.

Please do not hesitate to call on us if we can be of further assistance.

Yours very truly

X. Pert
Study Manager

EXECUTIVE SUMMARY

A. Introduction

This Feasibility Report summarizes the results of a comprehensive feasibility study for water supply and sanitation systems in Port City. The report concludes an 18-month consulting assignment. Interim results, which were reported in the Pre-Feasibility Report ten months ago (April 1982), are reviewed, generally endorsed and elaborated on the basis of further information and analyses.

Existing and prospective urban developments in Port City to the year 2000 have been examined; alternative water supply and sanitation projects have been evaluated; priority components to be built in the implementation period for a project (1984-86) have been identified and planned. Throughout this analysis, water and sanitation requirements have been treated together.

Port City's population is projected to increase from 1.5 million in 1981 to 2.8 million by 2000. Its water supply and sanitation services are already inadequate for its present population. Water shortages have been increasing since 1975, inconveniencing domestic consumers and impeding industrial growth. Sanitation conditions (including defecation in the open, and the use of unimproved pit latrines, overflowing cesspits and septic tanks) cause increasing hazards to public health. Major programs are necessary to provide safe drinking water and improved sanitation to all the population and to cope with future growth of both population and density.

A report recommending an Immediate Improvement Project, submitted in February 1982, proposed measures to rehabilitate the existing systems of water supply and sewerage. That work has now begun. It is expected to be completed by mid-1984 at an estimated cost of Z9.7 million, assisted by a loan from the Productivia Agency for International Development.

The necessary first stage expansion of the water supply and sanitation systems can be implemented in 1984-86, the project period. The recommended project forms the first stage of the least cost long term strategic plan.

B. Strategic Plan to the Year 2000

The water supply network of the Port City Water and Sewerage Commission (PCWSC), covering 77% of the urban area, served 71% of the population by means of house connections in 1981 and a further 18% from standpipes. (Private wells were used by the others.) Per capita water use was 120 litres daily at house connections, compared to 127 litres daily in 1977. People dependent on standpipes used between 13 and 20 litres per capita daily.

By the year 2000, an estimated 2.6 million people, or 92% of Port City's population, will be willing and able to pay for water supplied through house connections and for facilities to dispose of wastewater hygienically. Most of the remainder will be too poor to afford such standards and will obtain their water from standpipes. The water supply distribution network will have to expand by some 3,030 ha, or 48% of its present area, and an estimated 50,000 additional water connections will be required.

Source constraints have limited water sales since 1975. The capacity of existing sources totals 335,000 m^3/day, compared to the projected future water requirements in Table 1. A major augmentation of the supply is needed as soon as possible. Total requirements by 1995 will be about twice the present source capacity.

Table 1 PORT CITY: PROJECTED WATER DEMANDS FOR PCWSC SYSTEM

	1981	1987	2000
Total Population (000)	1,455	1,796	2,844
Population Served by Water Connections (000)	1,037	1,552	2,628
Water Sales: (000 m^3/day)			
Domestic Connections	126.8	182.1	359.6
Standpipes	4.0	3.3	3.3
Industry/Institutions	44.7	80.5	151.8
Farmville[1]	-	1.5	11.3
Total	175.5	267.4	526.0
Water Production (000 m^3/day)	317.5	435.0	809.0
Unaccounted-for as % of Production	45	39	35

[1] Farmville to be provided with bulk water supply by PCWSC in future.

Two major water sources to expand the PCWSC system have been evaluated: the North River Wellfield, estimated to yield 200,000 m^3/day, and the Large River surface scheme, with an estimated total capacity of 300,000 m^3/day. Both will be required by the year 2000, but the wellfield scheme should be built first. A program to reduce unaccounted-for water is already underway and will be intensified. Pipelines, reservoirs, and distribution system extensions have all been planned for the year 2000.

The only sanitation system in Port City for which PCWSC is responsible at present is a conventional system of sanitary sewers, which covers about 35% of the city but serves only about 20% of the population. Existing and alternative future service levels for sanitation have been evaluated in conjunction with water supply standards. Conclusions are summarized in Table 2. Very unhygienic sanitation practices are followed by a quarter of the population who use open defecation and unimproved pit latrines to dispose of excreta. Another quarter use cesspits or septic tanks, a large proportion of which do not work satisfactorily (they overflow and/or pollute the aquifer).

Table 2 PORT CITY: PROJECTED DOMESTIC SANITATION SERVICE STANDARDS

Population Served (thousands)	1981	1987	2000
A. On-Site Systems			
Open defecation	158	-	-
Unimproved pit latrines	196	-	-
Ventilated improved pit latrines and pour-flush toilets	-	154	156
Cesspits	647	587	-
Septic tanks	172	291	5
Pour-flush toilets with sullage soakaway	-	56	20
Sub-total	1,173	1,088	181
B. Off-Site Systems			
Small bore sewers	-	239	2,025
Conventional sewers	267	429	618
Public toilets	15	40	20
Sub-total	282	708	2,663
Total Population	1,455	1,796	2,844
Total Wastewater Flow in Sewer Systems (000 m^3/average day)	62.0	124.3	433.3

It is recommended that the existing conventional sewer systems not be expanded but be more fully utilized by residents in the sewered area. Outside the area presently served by conventional sewers, a new system of small bore sewers has been confirmed as the least cost solution for sanitation for all residents with house connections for water supply. Wastewater from the conventional and small bore sewer systems should be treated at new stabilization ponds to be constructed at Hog's Bay; the existing and ineffective Meanthyme Wastewater Treatment Plant should be closed and its site converted to a maintenance base. By the year 2000, some 94% of the population would be served by sewer systems.

Open defecation should be eliminated as soon as possible, supported by a hygiene education program and the construction of new facilities. Low cost on-site systems (ventilated improved pit latrines and pour-flush toilets) are to be provided, as well as public toilets for people who do not have water connections. Most of these on-site systems are expected to be upgraded eventually and incorporated into small bore sewer systems, except where people do not have domestic water connections.

On-site systems capable of disposing of sullage as well as excreta will have to be used by people with water connections for an interim period until the small bore sewer system can be expanded to serve all areas that are outside the existing sewer network. Suitable on-site systems include cesspits, septic tanks, and pour-flush toilets with sullage soakaways.

Several of the recommended sanitation technologies are novel in Port City, so major efforts will be needed to encourage their acceptance by the users through intensive promotion activities, particularly during the first year of the project.

The estimated costs of implementing the strategic plan to the year 2000 are summarized in Table 3.

Table 3 TOTAL COSTS OF WATER SUPPLY AND SANITATION PROGRAM

	Project Period 1984-86	Longer Term 1987-2000	Total 1984-2000
	Z million of 1982		
Water Supply	69.0	256.2	325.2
Sanitation	32.8	93.6	126.4
Total	101.8	349.8	451.6

C. Proposed Water Supply and Sanitation Project, 1984-86

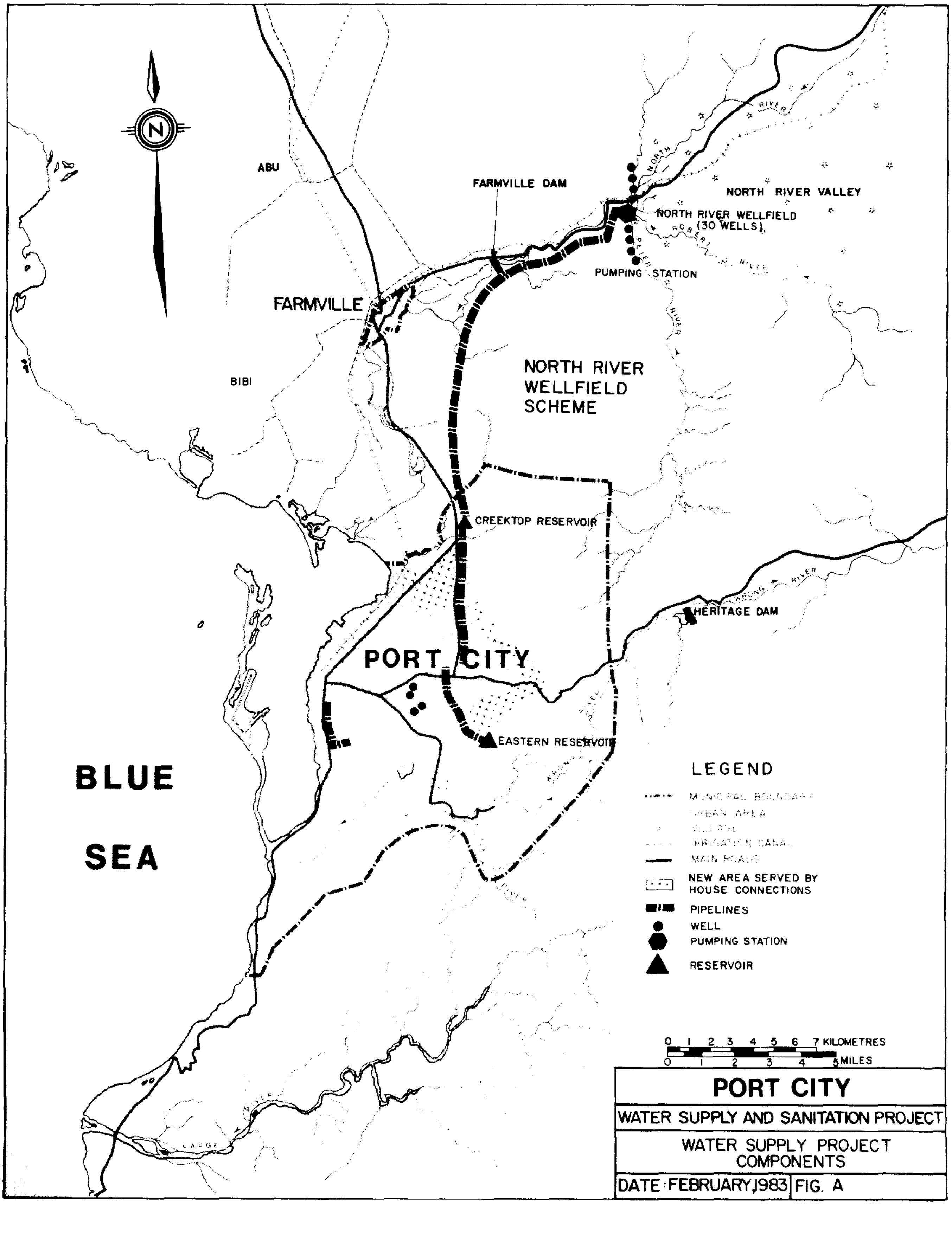
The water supply component in the proposed project, shown on Figure A, includes new city wells; the North River Wellfield and pumping station; a 19.5 km pipeline to Port City; treated water reservoirs with an aggregate 80,000 m^3 of storage; 14.3 km of transmission pipelines and 1,700 ha of network extensions within Port City; some 37,000 domestic water connections and 230 standpipes; and rationalization of the existing networks. By 1987, when project facilities are operational, some 86% of the population would be served by house connections and 11% by standpipes. Total water sales are projected to be 37% greater than in 1981.

The sanitation component of the project includes sewerage elements shown on Figure B: the initial stage of the small bore sewer system, serving a priority area totalling 600 ha; the first stage of waste stabilization ponds at the new treatment plant site at Hog's Bay; and interceptor sewers to convey all wastewater to this plant. By 1987, some 13% of the people would be served by the new system of small bore sewers and 24% by the existing conventional sewers. Also included are some 13,800 ventilated improved pit latrines and pour-flush toilets, plus 25 public toilets for people without water connections (about 11% of the population). Some 17,000 existing septic tanks and cesspits outside the sewered areas will be upgraded as part of the project. A similar number of new on-site facilities will be built outside the sewered areas by the owners of buildings which receive water connections during the project period.

The proposed project and its costs are summarized in Table 4. The estimated cost of the project, totalling Z134 million in current prices (allowing for price increases through the implementation period), is realistic, based on preliminary designs plus an allowance of 15% for physical contingencies.

Two-thirds of the total project costs are for water supply and one third for sanitation. The estimated foreign exchange component is 52% for the water supply component, but only 17% for the sanitation component (since it requires less imported equipment), giving an overall foreign exchange cost of some Z55 million, or 41% of total costs.

The tentative financing plan, summarized in Table 5, assumes loans from two international development agencies totalling Z81 million, or 46% of project costs (including capitalized interest during construction). A government loan of Z41 million is the other major source of finance. Funds generated from PCWSC revenues and consumer contributions for connections together account for 26% of the proposed project financing.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FARMVILLE DAM
NORTH RIVER VALLEY
NORTH RIVER WELLFIELD
(30 WELLS)
PUMPING STATION
FARMVILLE
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NORTH RIVER
WELLFIELD
SCHEME
CREEKTOP RESERVOIR
HERITAGE DAM
PORT CITY
EASTERN RESERVOIR
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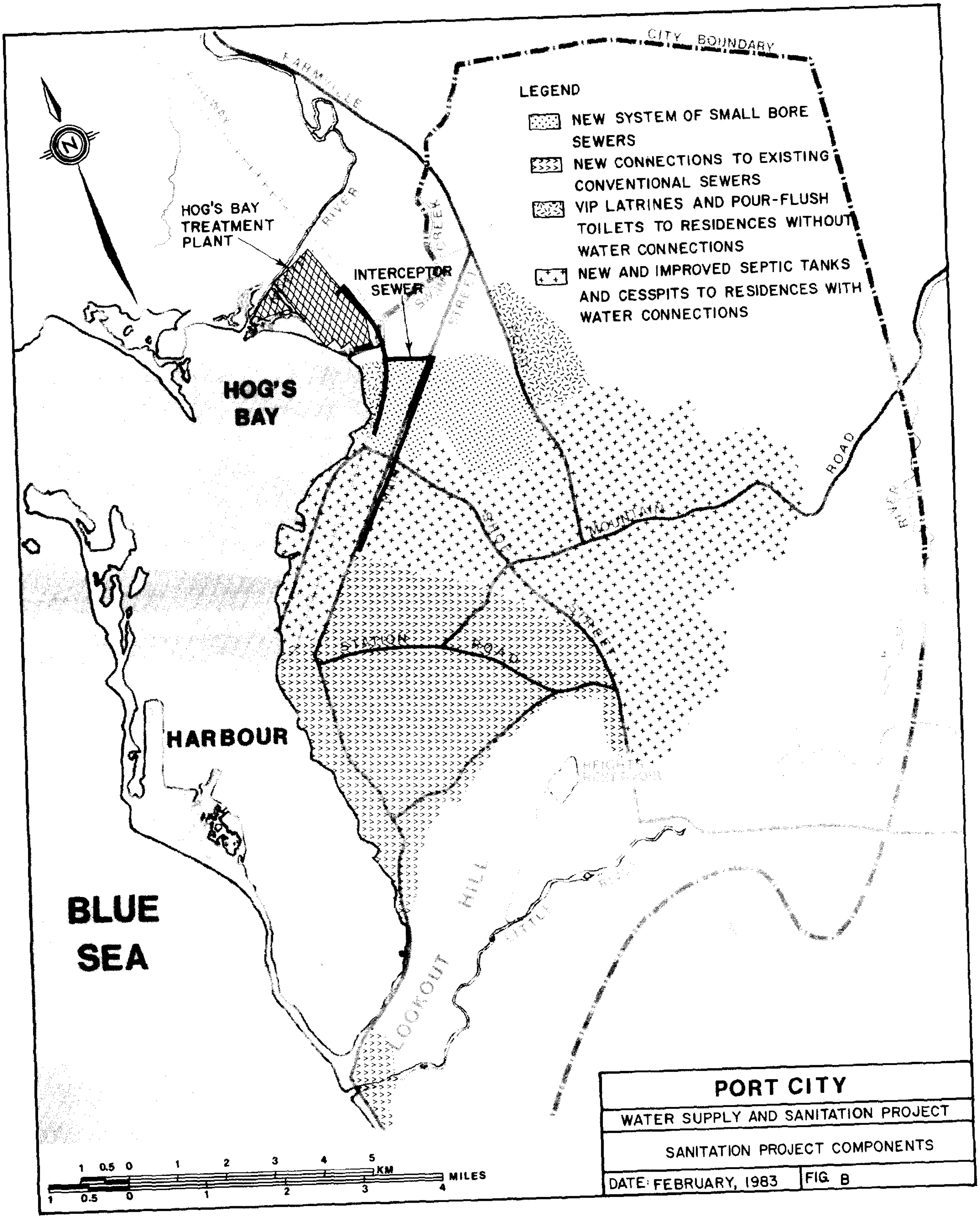
PORT CITY
WATER SUPPLY AND SANITATION PROJECT
WATER SUPPLY PROJECT
COMPONENTS
DATE: FEBRUARY 1983
FIG. A



PORT CITY

WATER SUPPLY AND SANITATION PROJECT

SANITATION PROJECT COMPONENTS

DATE: FEBRUARY, 1983 | FIG. B

Table 4 SUMMARY OF ESTIMATED PROJECT COSTS THROUGH 1986

Item	Total Z million
Water Supply Component	
City Wells	0.90
North River Wellfield Scheme including Pipeline to Port City	26.90
Storage Reservoirs	8.00
Transmission and Distribution of Pipelines within Port City	12.30
New Connections and Consumer Meters	4.20
Rationalization of Existing Networks	1.30
Water Supply Sub-total	53.60
Sanitation Component	
On-Site Systems	4.70
Small Bore Sewer System	3.95
Extensions and Connections to Conventional Sewers	4.60
Interceptor Sewers	6.40
Hog's Bay Treatment Plant	5.55
Public Toilets	0.60
Support Activities	0.85
Sanitation Sub-total	26.65
O&M Facilities and Equipment	3.15
Sub-total	83.40
Consulting Services	5.70
Physical Contingencies	12.70
Sub-total (1982 prices)	101.80
Price Increases	32.20
Total	134.00

Table 5 TENTATIVE FINANCING PLAN FOR PCWSC, PROJECT PERIOD 1983-86

	Z million	% of Total
Sources of Funds		
PCWSC Internal Cash Generation	39.9	23
Consumer Contributions	5.4	3
Working Capital	1.4	1
Government Loans and Credits	43.4	25
International Sources:		
PAID	4.1	2
International Bank	59.3	34
Oceania Development Fund	21.6	12
Total	175.1	100
Application of Funds		
Capital Expenditures	161.6	92
Debt Service	4.6	3
Consumer Loans	8.9	5
Total	175.1	100

Without the project, existing water shortages in Port City will worsen, further impeding its industrial development and reducing residential services. Public health conditions will continue to deteriorate in the absence of adequate sanitation services in the increasingly dense urban area. Pollution of local groundwater and of the harbour, already serious, could rise to dangerous levels. The project is therefore essential.

The project will satisfy water demands to the year 1991, at which time another major expansion is expected to be ready for service. By that time the wastewater treatment plant at Hog's Bay will also need expansion.

Several key actions are necessary if the project is to succeed:

1. PCWSC should be made responsible for on-site sanitation as well as for off-site (sewerage) systems so that a comprehensive program of sanitation improvements can be implemented. This basic expansion of the Commission's role will have to be formally agreed with the Ministry of Health (currently responsible for on-site sanitation), but no insurmountable problems are anticipated. In future PCWSC will maintain on-site sanitation systems as well as sewer systems under the proposed arrangements. Appropriate legislation will be necessary to

allow PCWSC to operate on private property. PCWSC should also be empowered to withhold a water connection to a property until a satisfactory sanitation system is installed.

2. The organizational structure of PCWSC should be modified to reflect the increase in responsibilities and the need to serve its customers more effectively. New qualified staff must be employed to serve the more comprehensive responsibilities of PCWSC, but the overall size of the organization need not be increased, since much of the extra workload will be undertaken by consultants and contractors. A major training program is necessary for staff at all levels.

3. Financing for project implementation must be confirmed. The government should endorse the project officially and actively seek financial support from prospective international lenders, several of which are already familiar with the project.

4. Changes in structure of the PCWSC's tariffs are needed as well as increases in the charges for services. At present all water is sold at a uniform rate of Z $0.25/m^3$. Consumers on the sewer system pay a surcharge of Z $0.08/m^3$ of water. Increases in water charges, averaging 25% in 1984, are proposed, as well as a step tariff for residential consumers (to keep rates for basic needs at affordable prices). From 1985 onwards, when PCWSC is providing sanitation services to all consumers with water connections, a surcharge of 55% of the water bill should be applied for sanitation.

5. PCWSC should initiate several actions necessary for project implementation including:

   - arranging for final design work (beyond that required for the first year of implementation, which is already underway) to avoid any hiatus between the approval of this report and the start of construction;
   - obtaining necessary water resource and environmental approvals for project components, especially for the extraction of groundwater from the North River Valley; and
   - obtaining land for the project facilities.

The project is technically feasible and provides the least cost solution for providing water supply and sanitation services throughout Port City at standards which are affordable to the project users. The proposed modifications in sector responsibilities and strengthening of local institutions are essential for the project to succeed. With the proposed financing plan and changes in tariffs the project is financially sound. Implementation of the project will significantly improve the local environment and health of the people in Port City. Its implementation should now proceed.

FEASIBILITY REPORT

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ANNEXES

Technical Appendices (Not included with Report)

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Units and Acronyms

BOD	Biochemical Oxygen Demand
cm	centimetre
ha	hectare
IIP	Immediate Improvement Project
ISD	Institute for Social Development
l	litre
lcd	litre per capita per day
m	metre
m^2	square metre
m^3	cubic metre
m^3/day	cubic metres per day
masl	metres above sea level
mg/l	milligrams per litre
mm	millimetre
MOE	Ministry of the Environment
MOH	Ministry of Health
MWD	Ministry of Water Development
NRIA	North River Irrigation Authority
PAID	Productivia Agency for International Development
PCWSC	Port City Water and Sewerage Commission
TAP	Technical Advisory Panel
VIP	Ventilated Improved Pit latrine
Z	Zinar, the currency of Optima (Z 1.00 = US$ 1.00)

Note: The financial years of PCWSC and MWD are the same as the calendar year.

Chapter One
INTRODUCTION

This is the final report on the comprehensive feasibility study covering water supply and sanitation services in Port City. Terms of reference for this study were provided as an attachment to the Identification Report of January 1981 by the Port City Water and Sewerage Commission (PCWSC). The contract for carrying out the study was signed with the client, PCWSC, in August 1981.

A report submitted in February 1982 recommended an Immediate Improvement Project (IIP) to concentrate on remedying problems with the existing water supply and sanitation systems in Port City. PCWSC has begun implementing the IIP (estimated to cost Z9.7 million) with financial assistance (Z4.1 million) agreed by the Productivia Agency for International Development (PAID) in June 1982. The IIP should be essentially complete by mid-1984.

In accordance with the terms of reference a Pre-feasibility Report for the major project for Port City was issued ten months ago in April 1982. Analyses, based on the limited data then existing, were used to prepare a strategic plan for water supply and sanitation developments to the year 2000 and to select priority items in the long term program which would comprise the project to be built in the near term. Preliminary analyses were completed of a project which could be implemented by 1986.

The Pre-feasibility Report was essentially an interim report to this one. Much of the information and analysis in that report, which were crucial to preparing the strategic plan and identifying the proposed project, is not repeated here. Readers interested in such background information, including coverage of regional development prospects, land use plans, existing water supply and sanitation systems, and alternative service standards and technologies, are referred to the Pre-feasibility Report. Coverage of such topics is intentionally brief in this report.

The second and final stage of the feasibility study, reported herein, has concentrated on three related topics:

- confirmation that the strategic plan remains essentially as earlier proposed, based on more detailed information obtained during the study;
- refinements in the design, scheduling, and cost estimates for the proposed project; and
- confirmation that the project is feasible in all technical, institutional and financial respects.

Again, the consultants have benefited from the advice and instructions of the Steering Committee and its Technical Advisory Panel.

In April 1982 a Pre-feasibility Report was also issued for a water supply and sanitation project in Farmville, about 20 km north of Port City. Implementation of that project, with an estimated total cost of Z4.4 million, has recently begun. Financial assistance is being provided for that project by the Regional Development Fund.

Chapter Two
THE PORT CITY AREA AND THE NEED FOR A PROJECT

2.A INTRODUCTION

This chapter provides the background information used in Chapter Three to estimate future water supply and sanitation demands, and in Chapter Four to develop the specific proposals for this project covering the period 1984-86.

This chapter therefore discusses conditions in the residential zones, the future population of the zones, and existing water and sanitation service levels and consumption patterns. These are subjects which could only be covered very roughly at the pre-feasibility stage, pending the results of several surveys and the comprehensive analysis of PCWSC's records.

The data presented here are, therefore, more up to date (basically 1981) and more reliable than the 1980 estimates presented in the Pre-feasibility Report. Unless otherwise stated, all cost data in this report are at mid-1982 prices.

The data are largely based on a 0.3% sample of Port City's 160,000 households carried out specifically for this feasibility study between January and June 1982 by Social Researchers (sub-consultants). The sample size was determined by the need to have survey data of the same level of accuracy as that used elsewhere in the report. Details are contained in their full report which forms Technical Appendix D to this report (not included in this Volume). Total population data are based on the 1980 census, adjusted to reflect one year's growth. Data on water and sanitation service coverage and standards were also collected during the survey and are presented in Sections 2.D and 2.E below.

Aside from numerical data, however, this chapter does not repeat the information provided in the Pre-feasibility Report on Port City's water sources, storage and transmission systems, or the major components of its sewerage system.

The planning period adopted is the next 20 years, as in the Pre-feasibility Report. The strategic plan for this period defines the project which is expected to be implemented during the three years 1984-86 to satisfy needs to the year 1991. An Immediate Improvement Project is now underway and will be finished by early 1984.

2.B HOUSING, INCOMES, AND SOCIAL AND ECONOMIC CONDITIONS IN THE RESIDENTIAL ZONES

Port City and the nearby region is shown on Figure 2-1. Figure 2-2 shows the topography within Port City, and Figure 2-3 depicts existing land use.

Western Province is the most affluent in Optima with a per capita GNP in 1981 of Z400 compared to a national average of Z320. Port City is in turn the most affluent part of Western Province with an average per capita income in 1981 of Z620. Yet there are extremes of income and social conditions within its 160,000 households. This section briefly describes 1981 housing, family size, and income conditions in the eight residential zones identified by the 1980 land use study of Port City.

Table 2-1 summarizes residential zone populations, households, and incomes for 1981. Each zone is now briefly discussed in turn. The existing residential zones are shown on Figure 2-4.

Upper Residential. Located on the Green Mountain foothills in the northeast of the city, this is exclusively an upper income residential area containing 66,000 people in owner-occupied single family dwellings with an average household income of Z25,000. There are no commercial or industrial establishments.

Middle Residential. This large area in the southern part of the city contains the bulk of Port City's middle class (280,000 people). It began to be occupied as a residential area in 1943 with a minimum of commercial use and is characterized by single family dwellings, the vast majority owner-occupied. The university is contiguous to this zone, abutting the Green Mountains. Population densities vary within the sector from 50-200 persons/ha, averaging 156. Average household income is Z 6300.

Lower Residential. This is where 777,000 people or over one half of the city's population live. This lower income group (household income Z3900) is mainly employed in industry and the service sector. The zone consists of low cost housing estates and rental compounds, with higher densities (averaging 311 persons/ha in 1980) and poor infrastructure. The rental compounds each contain up to four houses and evolved as a result of densification and deterioration; the area nearest the sea was in the 1920s and 1930s an upper income zone, with each house having a large colonial-style compound. As pressure on the land increased, landlords tended to move to the Upper Residential zone and constructed additional low cost houses within the compounds to rent out to low income tenants. Unemployment and poor infrastructure (too few schools and health centres, for example) contribute to occasional outbursts of social unrest. Some 68% of the residents are Christians, 17% are Hindu, and 14% Moslem. Recognizable neighbourhoods exist in the Lower Residen-

Table 2.1 PORT CITY: EXISTING RESIDENTIAL ZONES, 1981							
Zone	Area (ha)	Population (000)	Pop. Density (person/ha)	Average Household Size (no. of persons)	Households (no.)	Average Household Income (Z)	Average Per Capita Income (Z)
Upper Residential	1600	66	41	6.4	10,300	25,000	3,900
Middle Residential	1800	280	156	7.8	35,980	6,300	810
Lower Residential	2500	777	311	9.7	80,100	3,900	400
Business	230	24	104	7.8	3,100	6,200	800
Old Town	350	72	206	9.8	7,300	3,500	360
Railville	170	106	624	10.5	10,100	2,300	220
Blight Heights	275	99	360	12.3	8,000	2,200	180
Seaview	100	31	310	7.5	4,100	5,900	790
Port City Residential Zones	7025	1455	207	9.1	158,900	5,650	620

Source: Technical Appendix D: Household Water Supply and Sanitation Services Survey.

tial zone although these are not as strongly defined as in the squatter settlements. The Hindus and Moslems, in particular, prefer to live together in distinctive enclaves.

Business. This area grew up with the development of the port and international commerce in the first decade of this century. It consists principally of two-storeyed buildings, though a few apartment blocks have been constructed recently. The commercial area has few residents (only 24,000) but is the hub of the city, containing over 150,000 people during working hours. Those who do live there are middle class with an average household income of Z6200.

Old Town is the zone immediately surrounded by the Business zone. Port City was confined within the boundaries of Old Town for most of the nineteenth century. Buildings in the zone are now very old and dilapidated. They consist primarily of low income rented houses of two storeys on the street and one storey in the compounds behind. The zone houses 72,000 people with an average household income of Z3500. The zone contains infrastructure - it was once the entire city, after all - but it is old and deteriorating and needs considerable repair.

Railville and Blight Heights are the two squatter communities. Their residents are migrants driven from the rural areas by decreasing economic opportunities and lured to the city by hopes of some form of employment. The migrants when they come to the city join relatives or friends from their own region. This has led to the development of strongly defined neighbourhood units based on extended family ties and ethnic groupings. The boundaries of these neighbourhoods are jealously guarded, and disputes between neighbourhoods are frequent.

The ethnic and religious composition of the residents reflects their rural roots. Some 38% of the residents are Moslems and 37% are Hindus. The remainder are Christians.

Railville is a squatter settlement which grew up during the 1950s on previously unutilized land belonging to the Port Authority. The zone now contains 106,000 people on only 170 hectares, for an average density of 624 persons/ha. It was allowed to develop as it provided a source of cheap unskilled labour for the port and the city's industry. The average household income is Z2300. It is divided into two sectors, each containing about half the population:

a) Sector A, the western half, has been settled by migrants from the rural areas of Optima and contains three separate groups. Very few residents of Sector A have land tenure, and such organizations that do exist have the aquisition of land tenure for the residents as their primary aim. There are no identifiable street plans, disputes over lot boundaries are common, and roads have become narrow twisted alleys. Housing is universally substandard. Social unrest and lawlessness are common. Municipal authorities are planning a major urban renewal program for the late 1980s to upgrade infrastructure in this sector. The squatter settlement upgrading project will include acquisition of land tenure, realignment of roads, allocation of communal areas (markets, recreational areas, bus and jeepney depots, schools, health centres, etc.), in-filling under houses, and housing reconstruction.

b) Sector B, closer to Main Street and the older part of the settlement, underwent upgrading through a major initiative led by the Institute of Social Development during 1975-80. Land tenure was the primary objective and was universally achieved. Subsequently, the households were found to be willing and able to invest in infrastructural improvements which included road realignment and reconstruction, housing improvements, and infilling under and between houses. Most housing remains severely substandard, however.

Blight Heights is a squatter zone which has grown up since 1960 on privately owned land. Squatters here have no land tenure and live in shacks made of timber and plastic sheets. Families are large - 12.3 persons per household; average household income is Z2200. There is no infrastructure of any kind. Conditions are much unhealthier than in Railville Sector A. The zone has grown very rapidly and can hardly accommodate many more than the 99,000 people living there in 1981 with a population density of 360 persons/ha. Its population is very mixed, consisting of migrants recently arrived from rural areas and of squatters evicted from other sites in the city by landowners. Unemployment is very high among Blight Heights residents.

Seaview is a small (31,000), fairly self-contained, lower middle class community mostly of owner-occupied single family houses, located to the southwest of the city. Household income averages Z5900. Seaview has developed in a planned way since 1975 as a residential area, mainly for civil servants. The population density of 301 persons/ha is high but manageable because the zone is well-planned.

In addition to these eight zones, by the year 2000, some presently unoccupied areas will be devoted to residential use, especially along the western foothills of the Green Mountains. These are known by planners as the Extra Zones. By 2000, Port City is also projected to have expanded outside its current boundaries with the planned development of a middle class suburb, tentatively known as New Town, on land currently devoted to sugar production. A new industrial estate is forecast adjacent to New Town. Prospective land use in the year 2000 is shown on Figure 2-5.

The major sources of employment in Port City are manufacturing, commerce, transportation, and services, reflecting Port City's role as Optima's only port, its principal commercial and trading center and major industrial site. All these employers demand a constant supply of unskilled labour and attract rural migrants to Port City. Official unemployment in 1980 was 64,200 out of a labour force of 340,100, a rate of almost 19%. But the labour force figures cannot be taken as definitive as there is massive underemployment, and also because large numbers of unemployed in the squatter communities are not included in the data. Reliable information on female employment is lacking, but some recent estimates by University of Optima research studies suggest that some 37% of women are employed, the majority as unskilled workers in commerce and services.

The majority of the squatters in Railville and Blight Heights fall under the urban poverty threshold of Z300/capita/year, as do approximately 100,000 poorer people in the Old Town and Lower Residential zones. The urban poverty group is therefore estimated at some 300,000 people, or 21% of the city's total population of 1.4 million.

The primary and secondary educational system in Port City is discussed in Section 2G of the Pre-feasibility Report. Technical and tertiary education are discussed in Annex 5 of this report insofar as they are relevant to PCWSC's needs. The literacy rate in Port City is estimated at 63%. No breakdown is available by zone within the city, but it can be assumed that literacy is related to family income level, as elsewhere in Optima. Most squatters are illiterate.

Health conditions in Port City are discussed in the Pre-feasibility Report. No significant changes have occurred. The presence of typhoid, and gastro-enteritis is worrying, especially that typhoid outbreaks occurred two years running. There is a low incidence of filariasis, but all the epidemiological factors exist to cause a major outbreak. Gastro-enteritis is widespread among infants and young children. Public health conditions are aggravated not only by poor sanitation but also by inadequate garbage and drainage services. These are outside the scope of this report, but it is recommended that they be studied and improved (Annex 1).

2.C POPULATION PROJECTIONS BY ZONE

The population model developed for the Pre-feasibility Report was adapted to project population growth in the separate zones. The results are presented in Table 2.2 for 1981 (actual), 1987 (immediately post-project), and 2000 (end of planning period). The projection is depicted on Figure 2-6.

Table 2.2 POPULATION BY RESIDENTIAL ZONE 1981-2000 (thousands)

Zone	1981 (Actual)	1987 ---- (Projected) ---	2000
Upper Residential	66	94	192
Middle Residential	280	321	442
Lower Residential	777	922	1,350
Business	24	26	31
Old Town	72	80	105
Railville	106	117	153
Blight Heights	99	103	121
Seaview	31	33	40
Extra Zones	-	100	210
New Town	-	-	200
Total	1,455	1,796	2,844

Source: Consultant's estimates

2.D WATER SUPPLY

2.D.1 Physical Systems

Port City's existing water sources, shown on Figure 2-7, are fully exploited: surface water from the Little and Wrong rivers and groundwater from the Town Wells within Port City and the New Wells just outside. Shortages have occurred every year since 1975, in part due to equipment breakdowns which are now being corrected through the Immediate Improvement Project, but principally because the present sources do not provide adequate storage to meet dry season demands. An increasing problem is contamination of the groundwater, by saline intrusion at the New Wells and by nitrates at the Town Wells. The major alternatives for a new source of water supply are the Large River or a wellfield in the North River Valley.

The existing water supply system within Port City is shown in Figure 2-8. The distribution system covers 77% of Port City and is comprised of five pressure zones.

A detailed account of the physical system is contained in Annex P3 of the Pre-feasibility Report. No significant changes have occurred since that report. Measures being implemented as part of the Immediate Improvement Project (see report of February 1982) are designed to improve systems operation, reduce water losses, increase distribution system pressures, and extend the number of connections and standpipes.

2.D.2 Population Served and Water Used

The Pre-feasibility Report was only able to take account of preliminary data on service standards. Surveys since conducted have led to more precise information being available on water consumption per capita in the different zones.

PCWSC normally records water consumption for each connection and retains these records for at least ten years. The raw data are provided by the cards in the meter readers' books. These meter records are transferred to consumer bills by the accounting department, which began implementing a computerized billing system in 1977. Fairly reliable consumption records for all consumers are available from the computer from 1979 onwards, but for previous years reference must be made to consumer accounts prepared manually and/or the meter readers' books.

All connections are supposed to have an individual meter, tested for accuracy at least once every five years. The consumption of the 23% of 1981 connections which were not actually metered was initially estimated on the basis of previous patterns for the same connection (where the meter failed on an existing connection) or, for new connections, on the basis of metered consumption for comparable properties. A number of meters installed during the IIP have also provided valuable information on actual water use at previously unmetered connections. The meter testing schedule of once every five years is not adhered to.

These analyses revealed that water consumption per unmetered connection was on average 35% greater than PCWSC had estimated for billing purposes. Data used in the pre-feasibility study were revised upward to take account of this discovery. Water unaccounted-for has been correspondingly reduced from the levels reported in the Pre-feasibility Report (see Table 2.4 below).

PCWSC distinguishes in its records between two categories of consumer: domestic and industrial/institutional. The second category covers all properties which are not obviously residential. It includes industrial plants and commercial premises, including hotels as well as shops. It also includes public facilities such as schools, government offices, hospitals, military camps, etc. Nearly 100% of the industrial and institutional connections are metered. These meters are read separately from nearby residential consumers and separate records are maintained.

Temporary staff (mainly students) were engaged to review and analyze the meter records. The total number of connections and the total quantity of water sold over the year were summarized for each category of consumer and for the residential consumers, by urban zone. In order to estimate consumption per capita it was necessary to first estimate the number of people actually being served from connections. PCWSC records do not include such information, but it was collected as part of the 0.3% household survey.

The results of this analysis, summarized in Table 2.3, reveal that connections in the Seaview, Middle Residential, and Upper Residential zones tend to serve single family dwellings (including servants). In the Lower Residential zone about 20 people are served per connection, which is consistent with survey results showing several buildings on most of the lots in this area of the city. Similarly in Railville several properties often share the same connection (although this is contrary to PCWSC regulations). In the Business and Old Town zones, where densification has been underway for some time, multi-family units of housing are increasingly common, resulting in large numbers of people served per connection.

The number of people served at public standpipes was estimated from surveys of some 140 standpipes (about 30% of the total). It appears that each standpipe serves an average of 546 people, each of whom uses an average of 15 l each day. Approximately 33% of those using standpipes live within 200 m of a standpipe. They almost all collect their water themselves and consume an average of 20 lcd. The 67% who live over 200 m from a standpipe consist of those who must carry water themselves and those who purchase it from vendors who carry and sell water; average consumption is 13 lcd. Vendors serve approximately 25% of all standpipe water consumers. The number of people served by standpipes (262,000) is considerably fewer than was estimated in the Pre-feasibility Report.

The standpipe survey confirmed that the individuals who collected water for their own use from standpipes were mostly women (69%) and children (28%) while all water vendors, delivering water on a retail basis, were men. The survey also revealed that many different designs of standpipes are in use, each having one to three taps, and that many are in poor repair. Broken and leaking taps were noted at 25% of the standpipes and puddles of stagnant water, caused by poor drainage arrangements, at more than half.

PCWSC statistics provide information on the numbers of connections in previous years. Data for the numbers of people served per connection in each zone in 1981 were adjusted for conditions in 1970 and 1975, allowing for trends in housing, to estimate the population served by connections and the water use per capita in each zone. The results are presented in Table 2.4. (Total water use for residential consumers is higher than estimated at pre-feasibility because it was found that PCWSC records underestimated use because of faulty meters and unmetered connections. The data in these tables reflect consumption of water, not the sales volumes recorded on the bills.) This stagnation in service

Table 2.3 RESIDENTIAL WATER SUPPLY SERVICE COVERAGE AND STANDARDS IN 1981

Urban Zone	Total Population	Population Served: PCWSC System: House Connections	Population Served: PCWSC System: Standpipes within 200 m	Population Served: PCWSC System: Standpipes beyond 200 m	Population Served: Private Wells: House Connections	Population Served: Private Wells: Carrying from Wells	PCWSC System: House Connections: Number	PCWSC System: House Connections: People Served per Connection	PCWSC System: House Connections: Water Use per Connection (m^3/day)	PCWSC System: House Connections: Water Use per capita (lcd)	PCWSC System: House Connections: Total Water Use (000 m^3/day)	PCWSC System: Standpipes within 200 m: Number	PCWSC System: Standpipes within 200 m: Water Use per Capita (lcd)	PCWSC System: Standpipes within 200 m: Total Water Use (000 m^3/day)	PCWSC System: Standpipes beyond 200 m: Number	PCWSC System: Standpipes beyond 200 m: Water Use per Capita (lcd)	PCWSC System: Standpipes beyond 200 m: Total Water Use (000 m^3/day)	Total Water Use: Connections plus Standpipes (000 m^3/day)
		thousands	thousands	thousands	thousands	thousands												
Upper Residential	66	40	-	5	17	4	6,250	6.4	2.2	345	13.8	-	-	-	8	60	0.3	14.1
Middle Residential	280	247	4	7	12	10	32,050	7.8	1.6	210	51.9	7	30	0.1	11	30	0.2	52.3
Lower Residential	777	611	42	38	-	87	28,990	21.1	1.4	70	42.9	60	20	0.8	82	13	0.5	44.2
Business	24	24	-	-	-	-	640	37.5	4.8	130	3.1	-	-	-	-	-	-	3.1
Old Town	72	72	-	-	-	-	2,500	28.8	3.4	120	8.6	-	-	-	-	-	-	8.6
Railville	106	13	26	56	-	11	1,140	10.5	2.2	70	0.9	51	18	0.5	102	10	0.6	2.0
Blight Heights	99	-	15	69	-	15	-	-	-	-	-	33	18	0.3	126	10	0.7	1.0
Seaview	31	31	-	-	-	-	4,130	7.5	1.4	180	5.6	-	-	-	-	-	-	5.6
Extra Zones	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL RESIDENTIAL	1,455	1,037	87	175	29	127	75,700	13.7	1.7	119.7	126.8	151	20	1.7	329	13	2.3	130.8
% of Total	100	71	6	12	2	9					96.9			1.3			1.8	100.0

Table 2.4 PCWSC: WATER USE ANALYSIS, 1970-81

Category of Consumer	1970				1975				1981			
	Population		Water Use		Population		Water Use		Population		Water Use	
	Total	Served by House Connections	Per person (lcd)	Total (000 m^3/d)	Total	Served by House Connections	Per person (lcd)	Total (000 m^3/d)	Total	Served by House Connections	Per person (lcd)	Total (000 m^3/d)
	------000-------				------000-------				------000-------			
A. Domestic Connections (By Urban Zone)												
Upper Residential	46	24	395	9.5	54	3	395	11.9	66	40	345	13.8
Middle Residential	198	180	200	36.1	232	21	220	46.2	280	247	210	51.9
Lower Residential	597	505	50	25.3	668	550	65	35.8	777	610	70	42.9
Business	19	19	120	2.2	21	21	125	2.6	24	24	130	3.1
Old Town	57	57	115	6.6	63	63	120	7.6	72	72	120	8.6
Railville	70	5	50	2.5	84	7	65	0.5	106	13	70	0.9
Blight Heights	25	-	-	-	48	-	-	-	99	-	-	-
Seaview	-	-	-	-	23	19	200	3.8	31	31	180	5.6
Sub-total	1,012	790		82.2	1,192	900		108.4	1,455	1,037		126.8
B. Standpipes		162		2.6		223		3.4		262		4.0
C. Industrial and Institutional		-		14.8		-		26.0		-		44.7
TOTAL		952	98	99.6		1,123	115	137.8		1,299		175.5
Water Production				177.0				238.8				317.5
Water Unaccounted-for				77.5 (44%)				101.0 (43%)				142.0 (45%)

coverage, forcing greater proportions of the population to rely on standpipes and private sources, reflects the fact that the PCWSC distribution system has not expanded to keep up with urban developments in the past few years.

Eleven percent of the population obtain water from private wells, including purchasing from vendors. Those with house connections to private wells are in the Upper and Middle Residential zones. No data on their consumption have been collected. (Recommendations for dealing with the private wells are contained in Section D of Annex 1.)

Knowing total water used in each residential zone (from consumer records) and the number of people per connection (estimated from the 1981 survey) allows realistic estimates to be prepared of per capita water use in each urban zone. Such data for 1970, 1975, and 1981 are also provided in Table 2.4. Per capita water use was highest in the Upper Residential zone as this high income area contains extensive private gardens and swimming pools. It is interesting to note that water use was higher in 1975 (395 lcd) than in 1981 (345 lcd). The decrease of 15% was probably due more to shortages in 1981 than to any other factor. A reduction in per capita water use also occurred in the Middle Residential zone from 220 to 210 lcd.

Further analysis of the 1981 data permits comparison between the number of connections in various zones and the quantity of water used. Over 80% of all domestic connections are in the Middle and Lower Residential zones, which together account for some 53% of total water sales. These data (Table 2.3) show that the water use per domestic connection falls within the range of 1.4 to 4.6 m^3 per day. The two major factors affecting water consumption per connection (water use per person and the number of people per connection) tend to work in opposite directions.

Industrial and institutional consumers accounted for 26% of all water consumed in 1981, though only 1.5% of the connections. Detailed industrial water consumption data were presented in the Pre-feasibility Report on the basis of accurate records.

While unaccounted-for figures have been revised to take account of survey findings of increased water use at unmetered connections, they are still very high at 45% of production in 1981.

2.D.3 Critique of Existing Systems

The four areas identified in the Pre-feasibility Report remain the principal problems with the existing water supply systems:

a) Source shortages, principally due to limitations in the yield of the existing sources, especially the erratic surface supply, which have caused demand restrictions since 1975;

b) Water quality, especially as a result of the contamination of groundwater sources;
c) The limited distribution system, with the network not covering some 21% of Port City's residential areas, a pent-up demand for new water connections, and two thirds of all standpipe user's houses located over 200 m from the standpipe; and
d) The level of losses, currently 45%, which have risen from 43% in 1975. (Though slightly lower than estimated in the Pre-feasibility Report, these losses are still extremely high.)

Major efforts are now underway by PCWSC to remedy these problems under the IIP. However, the source shortages and the limited distribution system are the two major problems with Port City's water supply system which require major investment to resolve and hence cannot be resolved under the presently planned programs of PCWSC.

2.E SANITATION

2.E.1 Physical Systems

The existing physical systems are described in Annex P4 of the Pre-feasibility Report. Table 2.5 lists the number of domestic sanitation systems and the population served in each zone, as revealed by the 0.3% household survey, including the number of units determined to be be in unsatisfactory condition.

On-site domestic systems in use include open defecation, unimproved pit latrines, cesspits, and septic tanks. Open defecation poses an obvious health hazard. Pit latrines are poorly designed, also threaten public health, cannot be upgraded, and should be replaced. Twenty seven percent of those with pit latrines also have a small sullage pit to dispose of non-toilet wastes. All others release their sullage on the ground in their yards. All open defecation and pit latrines are deemed unsatisfactory.

The household survey collected special information on the condition of cesspits and septic tanks. It confirmed that septic tanks are working much more satisfactorily than cesspits, the initial impression of the Pre-feasibility Report. Only 26% of cesspits are in satisfactory condition compared to 55% of septic tanks (Table 2.6). In part, this reflects the greater use of septic tanks in the Upper Residential zone where maintenance is more frequently conducted. Both are in very poor condition in the Lower and Middle Residential zones.

Table 2.5 RESIDENTIAL SANITATION SERVICE COVERAGE AND STANDARDS IN 1981: POPULATION AND FACILITIES

Urban Zone	Population	Population Served						Number of Facilities and Connections						Number (%) of Facilities and Connections in Unsatisfactory Condition				
		Households without Water Connections			Households with Water Connections			Households without Water Connections			Households with Water Connections			Households without Water Connections			Households with Water Connections	
		Open Defecation	Pit Latrines	Public Toilets	Septic Tanks	Cesspits	Conventional Sewers	Open Defecation	Pit Latrines	Public Toilets	Septic Tanks	Cesspits	Conventional Sewers	Open Defecation	Pit Latrines	Public Toilets	Septic Tanks	Cesspits
	thousands																	
Upper Residential	66	-	-	-	66	-	-	-	-	-	10,310	-	-	-	-	-	2,910(28)	-
Middle Residential	280	-	21	-	28	91	140	-	2,690	-	3,590	11,670	17,530	-	2,690(100)	-	2,540(70)	7,550(65)
Lower Residential	777	62	78	15	78	544	-	(62,000)	9,600	15	3,200	22,390	-	(62,000)(100)	9,600(100)	150(100)	2,250(70)	17,580(79)
Business	24	-	-	-	-	-	24	-	-	-	-	-	640	-	-	-	-	-
Old Town	72	-	-	-	-	-	72	-	-	-	-	-	2,300	-	-	-	-	-
Railville	106	32	62	-	-	12	-	(32,000)	5,900	-	-	1,140	-	(32,000)(100)	5,900(100)	-	-	920(81)
Blight Heights	99	64	35	-	-	-	-	(64,000)	2,850	-	-	-	-	(64,000)(100)	2,850(100)	-	-	-
Seaview	31	-	-	-	-	-	31	-	-	-	-	-	4,130	-	-	-	-	-
TOTAL RESIDENTIAL	1,455	158	196	15	172	647	267	(158,000)	21,040	15	17,100	35,200	24,600	(158,000)(100)	21,040(100)	15(100)	7,700(45)	26,050(74)
% of Total	100	11	14	1	12	44	18											

Table 2.6 OPERATIONAL EFFICIENCY OF SEPTIC TANKS AND CESSPITS

	Septic Tanks %	Cesspits %
Satisfactory operation	55	26
Significant structural failures	25	58
Evident fly breeding	85	100
Malodorous	60	75
Effluent port clogging	40	n/a
Tank full of sludge	35	65
Seepage trench defective	48	n/a
Ponding in vicinity	42	60
Effluent diverted off-site	30	45

The principal operating problems with septic tanks are structural failures (25%), sludge removal problems (35%), and defective seepage trenches (48%). Structural failures (58%) and excess sludge (65%) are the main difficulties with cesspits. Fly breeding is a major problem with both.

Off-site domestic systems include conventional sewer connections and the use of public toilets. Figure 2-9 shows the existing systems of sewers. Figure 2-10 provides more detail on the Central system of conventional sewers. Conventional sewerage works well at the household level, although there are problems elsewhere in the system, especially with the Meanthyme plant (see below). Public toilets have been poorly used and maintained, but measures to remedy this are now being implemented as part of the Immediate Improvement Project.

Industrial and institutional sanitation systems include conventional sewer connections and five private wastewater treatment plants (also shown on Figure 2-9). The private plants were described in Annex P4 of the Pre-feasibility Report and are summarized in Table 2.7. The oil refinery plant is in good condition and discharges to the harbour. The university's oxidation ponds are functioning well. Extended aeration plants at the Large Hotel, the bottling plant, and the brewery lack qualified operating personnel and are frequently subject to shock loading. All three operate below 40% efficiency.

There are two independent systems of sanitary sewers, including treatment plants, in Port City. Both are shown on Figure 2-9. The central system is not in good order. Problems with the trunk sewers and the Sweet Street pumping station are being remedied under the IIP. The Meanthyme plant is being temporarily rehabilitated so it will again be able to handle the 75,000 m^3/day of wastewater flows for which it was

Table 2.7 PRIVATELY OWNED WASTEWATER TREATMENT PLANTS				
Owner	Location	Treatment	Capacity (m^3/day)	Remarks
Petropin (oil refinery)	Port complex	Flotation and activated sludge	14,000	Harbour discharge satisfactory.
University	East Middle Residential Zone	Facultative ponds	4,000	Gully discharge satisfactory.
Large Hotel	Farmville and Poobah Roads	Extended aeration	30	Gully discharge 40% efficient, unsatisfactory. Plant needs upgrading.
Brewery	Port complex	Extended aeration	2,000	Harbour discharge unsatisfactory. To be connected to interceptor sewer.
Bottling Plant	Douglas and McNabb Roads	Extended aeration	120	Gully discharge unsatisfactory. To be connected to small bore sewer.
Source: Information from owners and observations by consultant.				

designed (compared to the actual capacity of about 34,000 m^3/day at present). Current flows averaged 57,000 m^3/day in 1981. Moreover, the quality of its effluent is very poor (only 25% of BOD is removed, although IIP works should raise this to 50%) and is severely polluting the harbour into which it is discharged. The Seaview system functions well with its own primary treatment plant, discharging by means of an outfall sewer to the sea.

Sludge from the Meanthyme and Seaview Treatment Plants and the public toilets is trucked to the tidal flats at Hog's Bay where it is dumped. (Seaview's sludge is supposed to be treated at Meanthyme, but the plant is unable to handle it.) Sludge from cesspits and septic tanks is also deposited on the flats and in drainage gullies throughout the city by private sludge pumping trucks. The result is severe localized environmental pollution and a compounding of the already serious harbour pollution problems.

2.E.2 Population Served

The numbers of people served by each domestic sanitation system in each residential zone were shown in Table 2.5. They are repeated in Table 2.8 where they are combined with water supply service coverage and standards to permit understanding of the eventual disposal of water supplied through house connections and standpipes.

2.E.3 Critique of Existing Systems

The four areas identified at the pre-feasibility stage are confirmed as the major problem with the existing systems:

a) the health hazard posed by 158,000 people defecating in the open and 196,000 using unimproved pit latrines;
b) the deteriorated condition of 74% of cesspits and 45% of septic tanks, especially in the Lower and Middle Residential zones;
c) the inadequate size and poor effluent quality of the Meanthyme sewage treatment plant which is increasingly polluting the harbour; and
d) the lack of an appropriate system for handling sludge, which is currently dumped on tidal flats where it also pollutes the harbour.

Components of the IIP will help restore the Meanthyme plant to its original capacity and to create a sludge lagoon to reduce harbour pollution. However, large additional investments are required to remedy the identified major problems.

2.F NEED FOR A PROJECT

Present water supply and sanitation systems are already inadequate to meet the needs of Port City's 1.5 million residents and its industry. Yet, the population is projected to reach 2.8 million by the year 2000, and the region is expected to experience very rapid industrial growth. A major expansion in the city's water supply and sanitation services is therefore necessary to meet existing and future demands. The precise levels of those demands in the domestic sector, which accounts for three-quarters of all water and sanitation requirements, depend on the service standards and technologies adopted. These are reviewed in Chapter Three which confirms the strategic plan developed in the Pre-feasibility Report.

Table 2.8 RESIDENTIAL WATER SUPPLY AND SANITATION SERVICE COVERAGE AND STANDARDS IN 1981												
Urban Zone	Total Population	WATER SUPPLY					SANITATION					
		Population Served					Population Served					
		PCWSC System			Private Wells		On-site Systems				Off-site Systems	
		House Connections	Standpipes within 200 m	Standpipes beyond 200 m	House Connections	Carrying from Wells	Open Defecation	Pit Latrines	Septic Tanks	Cess-pits	Conventional Sewers	Public Toilets
	thousands						thousands					
Upper Residential	66	40	–	5	17	4	–	–	66	–	–	–
Middle Residential	280	247	4	7	12	10	–	21	28	91	140	–
Lower Residential	777	610	42	38	–	87	62	78	78	544	–	15
Business	24	24	–	–	–	–	–	–	–	–	24	–
Old Town	72	72	–	–	–	–	–	–	–	–	72	–
Railville	106	13	26	56	–	11	32	62	–	13	–	–
Blight Heights	99	–	15	69	–	15	64	35	–	–	–	–
Seaview	31	31	–	–	–	–	–	–	–	–	31	–
TOTAL RESIDENTIAL	1,455	1,037	87	175	29	127	158	196	172	647	267	15
% of Total	100	71	6	12	2	9	11	14	12	44	18	1

Chapter Three
STRATEGIC PLAN

3.A INTRODUCTION

The purpose of developing the strategic plan through the year 2000 is to ensure that the project proposed for implementation in 1984-86 is the optimal project for that period, consistent with the optimal long term development of water supply and sanitation systems in Port City.

The outline strategic plan presented in this report confirms the plan developed in Chapter Three of the Pre-feasibility Report of April 1982. More and better quality data are now available. In particular a detailed projection of domestic water supply and sanitation requirements in the eight existing and the two projected new residential zones is now possible as a result of the demographic, income, water supply and sanitation system data collected in the 0.3% household survey conducted between January and June 1982. (The survey's results are summarized in Chapter Two and presented in Technical Appendix D.) On the basis of this projection, more accurate water supply and wastewater requirements are calculated, leading to confirmation of the selection of new water supply sources and a new wastewater treatment plant.

3.B DOMESTIC SERVICE STANDARDS

3.B.1 Selection of Service Standards

The selection of residential water supply and sanitation service standards was presented in the Pre-feasibility Report. The five criteria used were:

a) Water and sanitation standards are considered together in order to ensure that there is a means for disposing of wastes resulting from water supplied through house connections;
b) Technologies selected must be technically acceptable in Port City conditions, e.g., on-site sanitation systems must be appropriate for existing soil permeabilities;
c) Service standards and technologies must be acceptable to their intended users;
d) Technologies selected must represent economic least cost solutions for the service standards selected; and
e) Service standards and technologies must be affordable by their users.

The technically acceptable water supply technologies for use in Port City are house connections, yard taps, and standpipes. Those for sanitation are ventilated improved pit (VIP) latrines (Figure 3-1), pour-flush toilets (Figure 3-2), pour-flush toilets with sullage soakaways (Figure 3-3), small bore sewers (Figure 3-4), conventional sewers, cesspits (Figure 3-5), septic tanks (Figure 3-6), and public toilets (Figure 3-7). The first five sanitation technologies are not currently used in Port City. They are described in detail in Annex P5 of the Pre-feasibility Report. Trials have been conducted over the past year which confirm that all are technically acceptable in Port City. (Problems of user acceptance are possible, however, and may necessitate support programs in parallel with the installation of facilities.)

Application of the above criteria to the range of possible water supply and sanitation technologies and instructions from the Steering Committee led to the following conclusions:

a) All residences should have water connections, unless they are unable to afford the necessary accompanying sanitation system to dispose of all resulting wastewater.
b) Residences with water connections should have conventional sewer connections if they are in already sewered areas (Middle Residential, Business, Old Town, and Seaview zones).
c) Residences with water connections in presently unsewered areas should have small bore sewer connections by the year 2000 (Upper Residential, Lower Residential, Railville, Extra Zones, and New Town). This is the current recommendation, but it should be re-evaluated again in the post-project period. In particular, the economic advantage of small bore sewers over septic tanks in the low density Upper Residential and Extra Zones is very slight, and will require re-evaluation once more septic tanks have been installed in these areas during the project period. (This strategic plan is not a master plan and does not imply an unchangeable program of developments.)
d) During the project period, small bore sewer connections should be restricted to residences in a 600 ha priority area of the Lower Residential and Railville zones. (While small bore sewer connections are the least cost sanitation technology for residences with water connections, the Steering Committee directed that they not be extended to the whole of Port City during the project period because of their untried nature in local conditions and the impossibility of installing a sewer system throughout much of a city in only a three-year period).
e) Residences which today have a water connection but which cannot be served by a conventional or small bore sewer connection should, during the project period, improve their sanitation by upgrading their existing cesspits or septic tanks. In later years they will be connected to the extended system of small bore sewers.

f) Residences which do not have a water connection today but are to be supplied with one by 1987 should, for the immediate future, be served by new pour-flush toilets with sullage soakaways if they do not install flushing toilets. They should use new cesspits or septic tanks if they do install internal flush toilets. The choice between cesspits or septic tanks for the latter depends on whether enough land is available for the more efficient and more cost-effective septic tanks. (Sufficient land is generally available in the less dense Upper Residential zone but only infrequently in the Lower Residential zone.)

g) Those who are unable to afford the sanitation system that must accompany a water connection will have to rely on standpipes for their water supply. The nearest standpipe should be located no further than 200 m away. Standpipes will be provided on both sides of the road. Such residents will principally use either VIP latrines or pour-flush toilets for sanitation (parts of Railville, all of Blight Heights, Extra Zones). The choice between VIP latrines and pour-flush toilets will be left to the individual householder. A few such residents will also use public toilets.

A more detailed statement of the proposed systems for each zone is given in Section 3.C.1 below.

3.B.2 Affordability

Most current residents of areas provided with water networks already have domestic water connections (Z100), full internal plumbing and a relatively expensive cesspit (Z2,000 in 1982 prices), septic tank (Z1,600) or sewer connection (Z300). The Z300 sewer connection fee represents the average cost of providing a connection. This indicates that residents of these areas who will obtain new water connections in the future will be able to afford an appropriate sanitation system if it costs no more than their existing systems. The only new system to be introduced in these areas during the project period is the pour-flush toilet with sullage soakaway. At Z1,500 per unit, this system is cheaper than both cesspits and septic tanks, and so presumably is affordable.

Over the period to 2000, all residences which have water connections today will acquire either conventional or small bore sewer connections. The conversion from a cesspit or septic tank to a conventional sewer connection can be expected to meet considerable resistance. A connection fee of Z300 will have to be paid, yet most residents are broadly satisfied with the system they now have. While the users are satisfied, the systems pose increasing public health hazards (Chapter Two). This reluctance to pay for sewer connections has already proved to be a problem in the Middle Residential zone. It is therefore recommended that loans at commercial interest rates be offered by PCWSC to encourage people to take conventional sewer connections and pay off the fee on their water bill rather than as an initial lump sum.

The fee for a small bore sewer connection has yet to be determined. The cost of the necessary facilities on a property amount to about Z360, assuming one interceptor tank per residence (Z230), 5 m of pipe connecting the residence to the tank (Z100) and 7 m of pipe between the tank and the property line (Z30). As this is less than the on-site alternatives which residents of these areas routinely install, it is affordable. Again, however, user resistance can be expected against the adoption of a new system when the existing system is perceived as being satisfactory, even though present arrangements produce environmental and public health nuisances. To overcome this, and to promote the introduction of the novel small bore sewer technology in Port City, it is recommended that the connection fee be set at Z200, or less than the cost of providing either the small bore connection facilities or conventional sewer connections. It is further recommended that loans again be offered by PCWSC to enable customers to pay the fee in installments on their water bills.

Affordability is a serious question only for residents of areas which do not at present have water networks permitting house connections but which will acquire them in the future. These consist of Railville, parts of the Lower Residential zone, and the projected Extra Zones and New Town. (The residents of Blight Heights are assumed not to be able to afford sanitation systems of the kind required if a water connection is to be provided. These squatters are not expected to obtain tenure rights to the land they occupy before the year 2000; hence, they will be unwilling to invest in their houses, including plumbing.)

As shown in Table 2.1, the average household income in Railville in 1981 was Z2300 (approximately Z2550 in 1982, allowing for inflation). In the Lower Residential zone the average household income was Z3900 in 1981 (Z4300 in 1982). Price levels in 1982 are used throughout this report. Household water consumption in these zones will average 700 litres per day (an average of 10 persons each consuming 70 lcd) or 256 m^3/year. If water and sewerage is charged for at Z0.32 per m^3 (the current level), these households will have to spend about Z82 on water alone, or 3.2% of incomes in Railville and 2.0% in the Lower Residential zone.

In general, households should not be expected to spend more than 5-6% of their incomes on water and sanitation. Application of this criterion makes it impossible for a household in either Railville or the Lower Residential zone to afford the proposed Z200 per small bore sewer connection, a water connection fee of Z100, and the projected water and sewerage bill of Z82, plus internal plumbing within the house (Z250) in the year of installation. (Internal plumbing costs in Port City vary between Z200 - Z500. It is here assumed that the average for a low income household is Z250.) The total of Z632 required would be 24.8% of Railville incomes and 14.7% of those in Lower Residential zones. Loans are therefore recommended in order that Railville and Lower Residential households can obtain water and small bore sewer connections by paying their connection fees with loans to be repaid on the water bill. Assuming loans of Z500 (all but Z50 of the initial installation costs) at 8% interest with 12 year terms, annual repayment would be Z66. Added to the water bill of Z82, this comes to Z148, or 5.8% of Railville incomes and 3.4% of Lower Residential ones, within the affordable range.

Similar arguments should apply to new residents of the Extra Zones in the future. This analysis, which has assumed small bore sewer fees are set at Z200, confirms that the fees should not be as high as actual small bore sewer costs (Z360) if households are to afford small bore sewers. The small bore sewer connection fee should be set below the cost of installing the technology as small bore sewers are the least cost solution when all system costs are included.

Low income residents of Railville, Blight Heights, and the Extra Zones who will obtain water from standpipes are assumed to be able to afford the Z45 necessary for building the superstructures of the VIP latrines and pour-flush toilets proposed for their sanitation. PCWSC would provide the below ground components for these facilities. The Z45 is but 2% of the annual household income in Blight Heights, the poorest of these zones. To encourage householder investment, it is recommended that material for the superstructure be provided free to those who dig their own pits. The cost of these materials to PCWSC will be more than offset by the savings resulting from not having to dig the pit.

Affordability should not therefore be an issue in Port City, provided small bore sewer connection fees are set at Z200 and loans are made available to cover the costs of conventional and small bore sewer connection fees. Bank loans may also be considered for the installation of internal plumbing, but this will be the principal responsibility of the householder.

3.C FUTURE DEMAND FOR SERVICES

3.C.1 Water Supply and Sanitation Services in Residential Zones

Tables 3.1 to 3.4 summarize the water supply and sanitation services proposed for each residential zone in 1987 (after project completion) and 2000. Tables 3.1 and 3.2 include an estimate of resulting water demand. The tables represent the result of many iterations of possible service standards and coverage for both water supply and sanitation, and their impacts on each other.

Table 3.1 PROJECTED RESIDENTIAL WATER SUPPLY SERVICE COVERAGE AND STANDARDS IN 1987

Urban Zone	Total Population	Population Served: POWSC System: House Connections	Population Served: POWSC System: Standpipes within 200 m	Population Served: Private Wells: House Connections and Carrying	POWSC System: House Connections: Number	People Served per Connection	Water Use per Connection (m^3/day)	Water Use Per capita (lcd)	Total Water Use (000 m^3/day)	POWSC System: Standpipes within 200 m: Number	Water Use per Capita (lcd)	Total Water Use (000 m^3/day)	Total Water Use: Connections plus Standpipes (000 m^3/day)
	thousands	thousands	thousands	thousands									
Upper Residential	94	80	-	14	10,700	7.5	2.25	300	24.1	-	-	-	24.1
Middle Residential	321	305	5	11	37,200	8.2	1.64	200	61.0	47	30	0.2	61.2
Lower Residential	922	904	18	-	56,700	15.9	1.12	70	63.3	56	20	0.4	63.7
Business	26	26	-	-	700	37.1	4.85	130	3.4	-	-	-	3.4
Old Town	80	80	-	-	3,100	25.8	3.10	120	9.6	-	-	-	9.6
Railville	117	59	58	-	5,900	10.0	0.51	70	3.0	181	18	1.0	4.0
Blight Heights	103	-	103	-	-	-	-	-	-	322	18	1.6	1.6
Seaview	33	33	-	-	4,300	7.6	1.37	180	5.9	-	-	-	5.9
Extra Zones	100	65	21	14	6,100	10.6	1.92	180	11.7	69	18	0.1	11.8
TOTAL RESIDENTIAL	1,796	1,552	205	39	124,700	12.4	1.46	117	182.1	675	16	3.3	185.4
% of Total	100.0	86.4	11.4	2.2					98.2			1.8	100.0

Table 3.2 PROJECTED RESIDENTIAL WATER SUPPLY SERVICE COVERAGE AND STANDARDS IN 2000

Urban Zone	Total Population	Population Served: PCWSC System: House Connections	Population Served: PCWSC System: Standpipes within 200 m	Population Served: Private Wells: House Connections and Carrying	PCWSC System: House Connections: Number	People Served per Connection	Water Use per Connection (m^3/day)	Water Use Per capita (lcd)	Total Water Use (000 m^3/day)	PCWSC System: Standpipes within 200 m: Number	Water Use per Capita (lcd)	Total Water Use (000 m^3/day)	Total Water Use: Connections plus Standpipes (000 m^3/day)
	thousands	thousands	thousands	thousands									
Upper Residential	192	172	-	20	23,600	7.3	2.0	275	47.3	-	-	-	47.3
Middle Residential	442	432	-	10	55,400	7.8	1.7	220	95.0	-	-	-	95.0
Lower Residential	1,350	1,330	20	-	75,600	17.6	1.5	85	113.1	67	20	0.4	113.5
Business	31	31	-	-	800	37.5	5.6	145	4.5	-	-	-	4.5
Old Town	105	105	-	-	3,700	28.5	4.1	145	15.2	-	-	-	15.2
Railville	153	138	15	-	13,100	10.5	0.7	70	9.7	51	18	0.3	10.0
Blight Heights	121	-	121	-	-	-	-	-	-	415	18	2.2	2.2
Seaview	40	40	-	-	5,300	7.5	1.7	220	8.8	-	-	-	8.8
Extra Zones	210	180	20	10	22,500	8.0	1.6	200	36.0	67	18	0.4	36.4
New Town	200	200	-	-	25,000	8.0	1.2	150	30.0	-	-	-	30.0
TOTAL RESIDENTIAL	2,844	2,628	176	40	225,000	11.7	1.6	137	359.6	600	19	3.3	326.9
% of Total	100.0	92.4	6.2	1.4					99.1			0.9	100.0

Table 3.3 PROJECTED RESIDENTIAL SANITATION SERVICE COVERAGE AND STANDARDS IN 1987

Urban Zone	Total Population	Population Served (thousands)								Number of Facilities or Connections (units)							
		Households without Water Connections			Households with PCWSC or Private Water Connections					Households without water Connections			Households with PCWSC or Private Water Connections				
		Ventilated Improved Pit Latrines	Pour-flush Toilets	Public Toilets	Septic Tanks	Cesspits	Pour-flush Toilets with Sullage Soakaways	Conventional Sewers	Small Bore Sewers	Ventilated Improved Pit Latrines	Pour-flush Toilets	Public Toilets	Septic Tanks	Cesspits	Pour-flush Toilets with Sullage Soakaways	Conventional Sewers	Small Bore Sewers
Upper Residential	94	-	-	-	94	-	-	-	-	-	-	-	14,690	-	-	-	-
Middle Residential	321	-	-	-	11	20	-	290	-	-	-	-	1,410	2,560	-	29,650	-
Lower Residential	922	-	-	18	116	567	41	-	180	-	-	18	4,780	23,360	1,710	-	7,400
Business	26	-	-	-	-	-	-	26	-	-	-	-	-	-	-	690	-
Old Town	80	-	-	-	-	-	-	80	-	-	-	-	-	-	-	2,800	-
Railville	117	12	34	12	-	-	-	-	59	1,140	3,240	12	-	-	-	-	2,260
Blight Heights	103	46	47	10	-	-	-	-	-	3,700	3,820	10	-	-	-	-	-
Seaview	33	-	-	-	-	-	-	33	-	-	-	-	-	-	-	4,400	-
Extra Zones	100	-	15	-	70	-	15	-	-	-	1,870	-	8,760	-	1,870	-	-
TOTAL RESIDENTIAL	1,796	58	96	40	291	587	56	429	239	4,840	8,930	40	29,640	25,920	3,580	41,600	9,660
% of Total	100.0	3	5	2	16	33	3	24	13								

Table 3.4 PROJECTED RESIDENTIAL SANITATION SERVICE COVERAGE AND STANDARDS IN 2000

Urban Zone	Total Population	Population Served								Number of Facilities or Connections							
		Households without Water Connections			Households with PCWSC or Private Water Connections					Households without water Connections			Households with PCWSC or Private Water Connections				
		Ventilated Improved Pit Latrines	Pour-flush Toilets	Public Toilets	Septic Tanks	Cesspits	Pour-flush Toilets with Sullage Soakaways	Conventional Sewers	Small Bore Sewers	Ventilated Improved Pit Latrines	Pour-flush Toilets	Public Toilets	Septic Tanks	Cesspits	Pour-flush Toilets with Sullage Soakaways	Conventional Sewers	Small Bore Sewers
		thousands								units							
Upper Residential	192	-	-	-	-	-	-	-	192	-	-	-	-	-	-	-	30,000
Middle Residential	442	-	-	-	-	-	-	442	-	-	-	-	-	-	-	56,700	-
Lower Residential	1,350	-	-	20	5	-	20	-	1,305	-	-	20	200	-	820	-	53,700
Business	31	-	-	-	-	-	-	31	-	-	-	-	-	-	-	830	-
Old Town	105	-	-	-	-	-	-	105	-	-	-	-	-	-	-	3,680	-
Railville	153	-	15	-	-	-	-	-	138	-	1,430	-	-	-	-	-	13,100
Blight Heights	121	12	109	-	-	-	-	-	-	970	8,860	-	-	-	-	-	-
Seaview	40	-	-	-	-	-	-	40	-	-	-	-	-	-	-	5,300	-
Extra Zones	210	-	20	-	-	-	-	-	190	-	2,500	-	-	-	-	-	23,700
New Town	200	-	-	-	-	-	-	-	200	-	-	-	-	-	-	-	25,000
TOTAL RESIDENTIAL	2,844	12	144	20	5	-	20	618	2,025	970	12,790	20	200	-	820	66,510	145,500
% of Total	100.0	-	5	1	-	-	1	22	71								

The water demand projections assume also that measures are adopted that encourage water conservation. This is especially important, given the high percentage of households that will have to use on-site sanitation systems. Conservation should be encouraged both through a public relations campaign promoting the use of water-saving devices in toilet cisterns and shower heads and through an expected increase in water tariffs.

Some rough limitations on the feasibility of constructing new facilities within limited time periods are also reflected in the tables; this is especially true of the proposed use of small bore sewers. Although this technology has been proved elsewhere (e.g., Australia) and is cost-effective compared to conventional sewers, the Steering Committee instructed that its introduction to Port City during the project period should be confined to a limited area of about 600 ha. Priority has been given to the Lower Residential and Railville zones, serving 239,000 people (13% of the population) by 1987. It is projected that, once the technology is successfully proven in Port City conditions, some 2.1 million people will use the small bore sewers by 2000, or 72% of the population. Water supply and sanitation services for each zone are now discussed in turn.

Upper Residential Zone. This affluent zone is already well served with PCWSC house connections and private wells for water. A few households now purchase water from vendors with trucks who obtain it both from PCWSC connections and from private wells. Those currently with private wells will continue to use them until major repairs are needed, (reflecting the extensive investments they have made), while those now purchasing from vendors and the new households to be established in the zone will all have full PCWSC house connections. Water use per capita is expected to fall slightly from its present level of 345 lcd to 275 lcd by 2000 as densification reduces the number of gardens that are watered and other discretionary use of water.

The area is not sewered, but all households have septic tanks that function reasonably well in large yards. Though relatively expensive, they pose no problem of affordability to affluent households with average annual incomes in 1981 of Z25,000. Environmental and health conditions within the zone are excellent. The low densities of the zone, even combined with high per capita water use, allow the soil to absorb the wastewater loading.

It would be technically feasible to serve new residents of the Upper Residential zone with extensions to the small bore sewer system. This is anticipated by the year 2000. This conclusion will need re-evaluation in the future, however, once more septic tanks have been installed in the low density zone; the economic case for preferring small bore sewers over septic tanks is not strong and would change in the future. During the project period, limited investment funds and the good condition of 72% of the existing septic tanks (Table 2.5) means that other areas' needs must come first. New households, therefore, should continue to use septic tanks until at least 1987. In anticipation of the possible future small bore sewer network in this zone, however, it is recommended that new septic tanks be designed for eventual conversion into interceptor tanks for small bore sewers. About 900 septic tanks will be installed by 1987.

Middle Residential Zone. This middle income zone is already almost entirely served with water house connections. As the population expands, it is anticipated that house connections will continue to be the norm. Those with private wells will continue to use them. Water consumption is expected to increase modestly from the current level of 200 lcd to 220 lcd by the year 2000 as densification proceeds.

One half of this zone's population is currently connected to the PCWSC sewerage network which covers all properties. Two factors have deterred others: the high cost of connections and relative satisfaction with existing systems that are actually unsatisfactory in environmental terms. Measures under the IIP have begun the process by which all households in the zone will be connected to the existing sewer network by the year 2000 (and most by 1987). As a result, the poorly maintained cesspits and septic tanks which presently serve those not connected into the sewerage system will decline rapidly in number, removing a growing health risk and source of pollution. A few will remain through the 1980s as not every household will accept sewer connections, even though they will be under considerable pressure to do so.

Business, Old Town, Seaview Zones. These three zones are now fully served by house connections for both water and sewerage. This will continue. Water use per capita is projected to increase from 130 and 120 lcd in the Business and Old Town zones to 145 lcd in both by 2000. In Seaview (a less dense, planned community) water use will rise from 180 to 220 lcd.

Lower Residential Zone. Half of Port City's population live in the Lower Residential zone, a proportion that is expected to remain constant. The bulk of the zone's 777,000 residents (80%) have house connections, but a large number depend on standpipes. Given this high proportion already served by house connections, it is projected that almost all the population of the zone will have house connections within the near future. Most of those now using standpipes will therefore acquire water connections. Those still using standpipes by the late 1980s will tend to be transients, for whom public toilets will be the main sanitation system.

The principal sanitation system in use in the Lower Residential zone is the cesspit which poses an increasing health hazard. As all houses have or will have house connections for water, an improved sanitation technology capable of removing sullage is necessary. In the long run, small bore sewers are appropriate. (For this zone, Annex 4 demonstrates convincingly that small bore sewers are preferable to conventional sewers, the former costing Z26 per person and the latter Z40 when detailed alternative designs for a 75 ha area are compared.)

By the year 2000, it is therefore projected that almost all the residents of this zone (97%) will use small bore sewers. During the project period, 180,000 people will use about 7,400 small bore sewer connections, including about 10,000 conversions of septic tanks and cesspits into interceptor tanks.

The others will use cesspits, septic tanks, and pour-flush toilets with sullage soakaways. These will be the principal sanitation systems in effect at the end of the project, as they are today. Alternatively, 16,000 existing cesspits and 1,400 septic tanks will be upgraded to prolong their useful life. 1,700 new cesspits, 1,700 new septic tanks, and 1,700 new pour-flush toilets with sullage soakaways will be installed. They will later be converted into interceptor tanks.

Railville. This low income squatter community is divided into two sectors, A and B. Municipal authorities are planning a major urban renewal program to upgrade infrastructure in Sector A, the western section without an identifiable street plan, during the late 1980s. Its population now depends on standpipes for water. Full water and sanitation services must await this squatter settlement upgrading project. Until then, a lower standard of service must be accepted (standpipes, VIP latrines, and pour-flush toilets). House connections in Sector A will not be made until the 1990s. Thereafter, it is assumed that small bore sewers will be necessary by 2000 to remove the sullage resulting from house connections. If residents have secure land tenure by then, they will be willing to invest in the on-site costs of small bore sewers. The immediate choice for the project period between VIP latrines and pour-flush toilets will be left to the individual household. However, it is expected that most Hindu families will choose the VIP latrine, and most Moslems the pour-flush toilet. Some 12 new public toilets will also be necessary by 1987.

Sector B of Railville was improved during the late 1970s through an urban upgrading project executed by the Institute of Social Development. Some 12,000 of its people already have house connections for water and all are projected to do so by 1987. The bulk of the new small bore sewer network will be for these households. Future growth to 2000 is anticipated to continue to require full water and small bore sewer connections. The residents of Sector B are now willing to invest in infrastructure as they have tenure. The organizational structure developed through the upgrading project can be used for future projects. As noted in Section 3.B.2, however, loans will be necessary to enable the residents of Railville to afford small bore sewer connection fees.

Per capita water use in Railville is projected to remain constant at 70 lcd where there are house connections, and to rise to 18 lcd for those who use standpipes.

Blight Heights. This is the lowest income squatter area within Port City, and few of its residents have land tenure. At present, the bulk of Blight Height's residents obtain water from vendors and distant standpipes, often purchased from vendors. If they were to be provided with full house connections for water, a method of disposing of the resulting wastewater would be necessary. The people in Blight Heights will not be prepared, however, to invest in the necesary house plumbing or in any other improvements to the property they occupy without land tenure. Therefore, the use of standpipes is expected to continue, but the network will be expanded to provide standpipes closer to people's homes. Present sanitation through pit latrines and defecation in the open will be replaced by low cost on-site systems: VIP latrines, pour-flush toilets, and public toilets. Residents' choices between the first two will be on the same grounds as in Railville Sector A. Water use per capita will increase slightly to 18 lcd as all residents are on standpipes within 200 m.

In the squatter communities, considerable efforts will have to be made to obtain community acceptance for the new on-site sanitation facilities and to guarantee continuing care and maintenance for the new standpipes.

Squatter families are conservative and traditional in outlook, and the new technologies will need to be carefully promoted through existing neighbourhood and other social and ethnic groupings if they are to be adopted, and, most importantly, maintained. Designing and locating standpipe facilities will need to be done in consultation with the users, if the ideal of community care is to be achieved.

In this context, it is worth emphasizing that in the past no projects in the squatter communities have succeeded without the support of the local community leaders.

Extra Zones. There are various areas within and on the edge of Port City which are not currently occupied. These will likely be used by the expanding population for settlement. They are projected to receive most of their water from house connections with some use of standpipes and private wells, depending on precise location. Sanitation will initially be provided through pour-flush toilets, pour-flush toilets with sullage soakaways, and septic tanks, and eventually by small bore sewers or septic tanks. Water use per capita will vary widely among the zones, but is anticipated to average 195 lcd by 1987 and 200 lcd by 2000. Planning for the Extra Zones will have to be flexible, however, depending on their actual development. Re-evaluation of the sanitation alternative will be essential as small bore sewers have only a minor economic advantage over septic tanks, where septic tanks and drainfields are feasible.

New Town. By the year 2000, a new planned community of 200,000 people outside the existing city boundary (Figure 2-5) is projected to help cope with Port City's growing population. As it will be a planned middle class development, full house connections for water and small bore sewers for sanitation are projected from the beginning. Water use is estimated at 150 lcd by 2000.

3.C.2 Water Supply and Sanitation Services for Industry and Institutions

Historically, eight large industries and institutions have accounted for some 80% of industrial and institutional water demand. Inspection of these industries' connection records and discussions with their management about future expansion plans have resulted in the industrial water demand projections of Table 3.5.

Table 3.5 INDUSTRIAL AND INSTITUTIONAL WATER SALES AND PROJECTIONS, 1970 - 2000

Consumer	Water Use per Average Day ($000\ m^3$)						
	Actual			Projected			
	1970	1975	1981	1987	1990	1995	2000
Port Authority	2.8	4.3	6.0	14.0	16.3	20.2	24.2
Oil Refinery	2.6	5.4	8.9	14.5	14.8	15.6	22.0
Brewery	0.6	0.9	1.0	3.1	4.5	6.3	8.3
Cement Factory	1.9	3.0	5.3	9.7	10.8	15.2	19.0
Army Camp	1.5	2.2	4.0	7.2	9.1	12.4	15.6
Hotels	1.1	1.5	2.7	4.9	7.1	10.9	14.6
University	0.6	1.1	2.0	3.6	4.2	5.3	6.4
Textiles	0.7	1.3	2.3	4.1	4.8	5.9	7.1
Miscellaneous	3.0	6.3	12.5	19.4	22.0	30.0	34.6
	14.8	26.0	44.7	80.5	93.6	121.8	151.8

Five industries and institutions have private wastewater treatment plants. It is recommended that two of these will be connected into the sewer systems, two will continue to operate satisfactorily as separate plants, and the fifth will be upgraded with assistance from PCWSC. Information on these plants was summarized in Table 2.7. All other industrial wastewater will continue to flow through Port City's sewer systems. Projected industrial and institutional wastewater flows are as shown in Table 3.6.

Table 3.6 PROJECTED INDUSTRIAL WASTEWATER FLOWS IN PCWSC SEWERS, 1981-2000

Year	Average Flow ($000\ m^3$/day)	Daily BOD (tons/day)
1981	20.0	5.0
1987	41.2	6.9
1990	45.1	7.9
2000	98.1	16.6

Note: Dry weather flow on average day.

3.C.3 Total Water Supply Requirements

The projections of residential and industrial and institutional water demand summarized in Tables 3.1, 3.2, and 3.5 are combined in Table 3.7 and compared with existing water sources. Table 3.7 contains assumptions about unaccounted-for water which are discussed further in Section 3.D.1.1. It can be seen that new sources of water are necessary in the immediate future to supply 100,000 m^3/day by 1987; 245,000 m^3/day by 1993; and 474,000 m^3/day by 2000. Existing source capacity is 335,000 m^3/day.

Table 3.7 assumes that the new source will also provide water to meet Farmville's growing needs (see Farmville Pre-feasibility Report, April 1982) and that the program to reduce unaccounted-for water begun in the IIP continues to be implemented. The loss reduction program is expected produce results more quickly in the near term than in the long term because the larger leaks will be found first.

3.C.4 Total Sanitation Requirements

The numbers of on-site sanitation systems required in 1987 and 2000 are shown in Tables 3.3 and 3.4

Projected domestic off-site wastewater flows through the sewer systems are presented in Table 3.8. They are combined with those for industry (Table 3.6) in Table 3.9 which gives projected total wastewater flows.

Table 3.7 ACTUAL AND PROJECTED WATER PRODUCTION, SALES AND POPULATION SERVED, 1970-2000

	1970	1975	1981	1983	1987	2000
Population (thousands)						
Residential Population	1,012	1,192	1,455	1,561	1,796	2,844
Served by PCWSC System						
Private Connections	790	900	1,037	1,111	1,552	2,628
Standpipes	162	223	262	246	205	176
Total Served by PCWSC	952	1,123	1,299	1,446	1,757	2,804
% of Residential Population	94.1	94.2	89.3	94.6	97.8	98.6
Number of Connections						
Domestic	57,809	65,680	75,679	82,600	124,700	225,000
Standpipes	341	392	480	560	675	600
Industry and Institutions	438	697	1,363	1,400	1,900	3,500
Total	58,588	66,769	77,522	84,560	127,275	229,100
Water Sales (000 m^3/average day)						
A. Port City						
Domestic Connections	82.1	108.4	126.8	133.1	182.1	359.6
Standpipes	2.6	3.4	4.0	4.1	3.3	3.3
Industry and Institutions	14.8	26.0	44.7	48.2	80.5	151.8
Sub-total	99.5	137.8	175.5	185.4	265.9	514.7
B. Farmville (bulk supply from PCWSC)	-	-	-	-	1.5	11.3
Total, Port City plus Farmville	99.5	137.8	175.5	185.4	267.4	526.0
Water Production (000 m^3/average day)						
A. Existing Sources	177.0	238.8	317.5	325.0	335.0	335.0
B. New Sources	-	-	-	-	100.0	474.0
Total, Existing plus New Sources	177.0	238.8	317.5	325.0	435.0	809.0
Water Unaccounted-for						
Amount (000 m^3/average day)	77.5	101.0	142.0	139.6	169.3	273.0
% of Total Water Production	43.9	42.3	44.7	43.0	39.0	35.0

Notes: 1. 1970, 1975, and 1981 data from PCWSC records, adjusted to reflect revised estimates of water use at unmetered connections.
2. Projections beyond 1981 by consultant.
3. Actual water sales in 1981 and projected sales in 1983 constrained by supply limitations as well as weaknesses in distribution system.

Table 3.8 PROJECTED DOMESTIC WASTEWATER FLOWS, 1981-2000								
	Average Flow (000 m^3/day)				BOD (tons/day)			
	1981	1987	1990	2000	1981	1987	1990	2000
Conventional Sewers								
Middle Residential	26.5	52.2	60.8	87.5	6.3	13.0	14.4	19.8
Business	2.8	3.0	3.5	4.0	1.0	1.0	1.2	1.2
Old Town	7.7	8.6	12.2	13.7	2.8	3.2	4.2	4.2
Sub-total	37.0	63.8	76.5	105.2	10.1	17.2	19.8	25.2
Small Bore Sewers								
Upper Residential	-	-	-	47.5	-	-	-	4.8
Lower Residential	-	11.3	14.4	100.2	-	4.5	5.0	32.7
Railville	-	2.7	3.5	9.6	-	1.5	1.6	3.8
Extra Zones	-	-	-	37.8	-	-	-	5.2
New Town	-	-	-	27.0	-	-	-	5.0
Sub-total	-	14.0	17.9	222.1	-	6.0	6.6	51.5
Sub-total: Central System	37.0	77.8	94.4	327.3	10.1	23.2	26.4	76.7
Seaview System	5.0	5.3	6.1	7.9	0.5	1.5	1.5	1.8
Note: Dry weather flow on average day.								

Table 3.9 PROJECTED TOTAL WASTEWATER FLOWS, 1981-2000				
Year	Average Flow (000 m^3/day)		BOD (tons/day)	
	Central System	Seaview System	Central System	Seaview System
1981	57.0	5.0	15.1	0.5
1987	119.0	5.3	30.1	1.5
1990	139.5	6.1	34.3	1.5
2000	425.4	7.9	93.3	1.8
Note: Dry weather flow on average day.				

The average dry weather flow is estimated at 425,000 m^3/day for the central system by the year 2000. This is 350,000 m^3/day more than the maximum capacity of the existing Meanthyme Treatment Plant. The effluent quality of the existing plant exceeds Ministry of Environment standards and is polluting the harbour. The plant cannot be improved to meet effluent standards. A new treatment plant is therefore necessary.

The existing Seaview Treatment Plant (capacity 7,200 m^3/day) will be adequate for projected flows in Seaview. Its operation is satisfactory at present, except for minor problems with sludge disposal that the IIP is addressing.

3.D STRATEGIC PLAN TO THE YEAR 2000

3.D.1 Water Supply

Water sources expected to be in service for Port City in the year 2000 are shown in Figure 3-8. The distribution system will cover virtually all of the urban area at that time (Figure 2-5).

3.D.1.1 Sources

Table 3.7 indicates that the required water production by the year 2000 will be 809,000 m^3/day, compared to present source capacities of 335,000 m^3/day. Test drilling within the Port City has indicated that four additional wells could be constructed in parks within the city to each yield an extra 5,000 m^3/day (Section 4.E.1). However, this supply could only be provided on peak days and is relatively small compared to projected total needs.

Unaccounted-for water, comprising physical losses plus water which is used but not purchased (administrative losses), reached 142,000 m^3/day or 45% of total water production in 1981. Consultants have been at work on this problem for about half a year under the IIP (Black & White Inc. of Productivia were engaged by PCWSC in July, 1982). At this early stage in their assignment the consultants are unable to estimate with confidence how much of the unaccounted-for water is due to leakage which can be prevented. Preliminary indications are that between one-third and one-half of the total losses are due to leaks, or up to some 70,000 m^3/day (the rest being water which is actually used even though it produces no revenue). The consultants caution that recovery of all of the physical losses is not feasible but are so far unable to determine the quantity of leakage which can be recaptured by the loss reduction program now underway.

PCWSC must accordingly seek major new sources of water while at the same time concentrating on measures to reduce water demands (through conservation and and pricing) and to reduce unaccounted-for water. The projections of water demand and unaccounted-for water in Table 3.7 allow for these measures but are conservative concerning their effectiveness. It may be that PCWSC could require less total production in the long run: this matter should be reviewed continuously. But it is nevertheless clear that a major new source is required to be developed in the near term.

As noted in the Pre-feasibility Report, the two principal alternative new sources of water for Port City are surface water from the Large River (which could be developed in two stages, the first without a dam and reservoir) and groundwater from wells in the North River Valley. The ultimate capacity of a Large River scheme is 300,000 m^3/day; that of a North River Valley Wellfield is 200,000 m^3/day. As 460,000 m^3/day more of water production will be necessary by 2000, it is clear that both the Large River and the North River Wellfield schemes will have to be exploited over the period of the strategic plan.

Figure 3-8 shows the development of the North River Wellfield first during 1983-86, followed by the Large River scheme (Stage I in 1989-91 and Stage II in 1994-96). The alternative is to develop the Large River scheme initially (Stage I in 1983-86 and Stage II in 1987-89), followed by the Wellfield in 1994-95. These alternatives are referred to as Sequences A and B, respectively, hereafter. The revised water production requirements of this Feasibility Report have shifted the timing of these sequences slightly from those reported in the Pre-feasibility Report.

The North River Wellfield, described in detail in Chapter Four, is illustrated in Figure 3-9. Its costs, totalling Z38.6 million in mid-1982 prices, are included in the project cost estimate of

Table 4.6. The North River scheme costs are distributed as follows over a four year construction period:

Year 1	0.8
2	4.9
3	26.6
4	6.3
	38.6

The Large River scheme was described in Annex P4 of the Pre-feasibility Report and is illustrated in Figure 3-10. Cost estimates in mid-1982 prices for the Large River Scheme are presented in Table 3.10. They have changed marginally from those in the Pre-feasibility Report due to refined costing techniques, in addition to inflationary increases since that report was prepared. It is assumed that the construction of each stage will require three years, with 20% of costs being incurred in the first year and 40% in each of the second and third years.

The transmission and distribution system necessary for each alternative would involve similar costs and is therefore ignored for this comparison. Most operating and maintenance costs are also excluded as they will be comparable for both sequences (e.g. pipeline maintenance). Energy for pumping at the Wellfield and treatment costs for the Large River are included, however. New pumps are assumed to be necessary for the wells after 12 years.

Table 3.11 demonstrates that Sequence A is the least cost alternative for discount rates of 8-12%, confirming the results of the Pre-feasibility Report. It is therefore the preferred alternative and the North River Wellfield should be developed first, followed by the Large River surface scheme.

Water sources to be developed at the outset of the strategic plan period should therefore consist of a few wells within Port City (1984-85), and the North River Wellfield (1984-86).

PCWSC's strategy for reducing water losses should be reassessed when the IIP is complete in 1984, at which time the specialist consultants already engaged should recommend continuing measures to detect and repair leaks. Relatively large expenditures can be justified for such a campaign, expenditures up to the unit cost for providing Port City with water from additional sources. Although such investments cannot be rationalized at this time, because of PCWSC's lack of data and lack of experience in a comprehensive loss reduction program, this analysis needs to be completed before decisions are made concerning the development of future sources. Present indications are that implementation of the Large River scheme should proceed in two stages (Stage I in 1989-91 and Stage II in 1994-96) but no decision to implement this next major

Table 3.10 LARGE RIVER SURFACE SCHEME: COST ESTIMATE (Z million of mid-1982)

Stage I	
Diversion weir and temporary intake	3.4
Steel pipeline (1.8 m diameter, 19.5 km long)	19.8
Tunnel (2.5 m diam., 2. km long)	11.7
Treatment plant (capacity 225,000 m^3/d)	10.3
Treated water reservoir (capacity 40,000 m^3)	3.5
Sub-total	48.7
Contingencies and Engineering	15.6
Total	64.3
Stage II	
Embankment dam and spillway	75.2
Intake tower and connection to pipeline	1.3
Treatment plant extension (capacity 225,000 m^3/day)	9.9
Treated water reservoir (capacity 40,000 m^3)	3.3
Sub-total	89.7
Contingencies and Engineering	28.7
Total	118.4
Total Cost: Stages I and II	182.7

Distribution over a 3-year construction period for each stage:

Stage I	Year 1	12.9
	Year 2	25.7
	Year 3	25.7
Stage II	Year 1	23.6
	Year 2	47.4
	Year 3	47.4

source should be taken until future requirements, particularly unaccounted-for water quantities and the capacity of existing sources, are reviewed in detail.

3.D.1.2 Storage, Transmission and Distribution Systems

The transmission and distribution system was analyzed by a specially developed computer model in order to optimize the system over the next 20 years and integrate its development with the new sources.

Table 3.11 LEAST COST COMPARISON OF ALTERNATIVE WATER SOURCE DEVELOPMENT SEQUENCES

Year	Sequence A: North River Wellfield followed by Large River Surface Scheme					Sequence B: Large River Surface Scheme followed by North River Wellfield				
	North River Wellfield		Large River Surface Scheme		Total	North River Wellfield		Large River Surface Scheme		Total
	Capital Costs	Operating Costs	Capital Costs	Operating Costs	Total Costs	Capital Costs	Operating Costs	Capital Costs	Operating Costs	Total Costs
	Z million					Z million				
1983	0.8				0.8					-
84	4.9				4.9			12.9		12.9
85	26.6				26.6			25.7		25.7
86	6.3				6.3			25.7		25.7
87		1.8			1.8			23.7	0.6	24.3
88		1.8			1.8			47.4	0.6	48.0
89		1.8	12.9		14.7			47.4	0.6	48.0
90		1.8	25.7		27.5				1.2	1.2
91		1.8	25.7		27.5				1.2	1.2
92		1.8		0.6	2.4	0.8			1.2	2.0
93		1.8		0.6	2.4	4.9			1.2	6.1
94		1.8	23.7	0.6	26.1	26.6			1.2	27.8
95		1.8	47.4	0.6	49.8	6.3			1.2	7.5
96		1.8	47.4	0.6	49.8		1.8		1.2	3.0
97		1.8		1.2	3.0		1.8		1.2	3.0
98	0.3	1.8		1.2	3.3		1.8		1.2	3.0
99		1.8		1.2	3.0		1.8		1.2	3.0
2000		1.8		1.2	3.0		1.8		1.2	3.0
01		1.8		1.2	3.0		1.8		1.2	3.0
02		1.8		1.2	3.0		1.8		1.2	3.0
Net present value at discount rate of:				8%	132.6	Net present value at discount rate of:			8%	161.4
				10%	114.8				10%	146.9
				12%	100.2				12%	134.4

Note: Net present value obtained by discounting total cost in each year to 1984, according to formula

$$NPV = CF_0 + \frac{CF_1}{(1+i)^1} + \frac{CF_2}{(1+i)^2} + \ldots + \frac{CF_n}{(1+i)^n}$$

Where NPV = Net present value

CF_j = Cash flow (total cost at year j)

i = discount rate.

Its results are attached as Technical Appendix B. It has been determined that the system in operation in 2000 will include:

a) new transmission lines within Port City, totalling 41.7 km in length and varying in diameter from 400 to 1200 mm, including a line to New Town in the early 1990s;

b) treated water storage reservoirs of 80,000 m^3 capacity which, together with those at Creektop for the North River Wellfield scheme (capacity 100,000 m^3) and at the Large River Treatment Plant (capacity 80,000 m^3), would give PCWSC treated water storage equivalent to about 12 hours of average day water demands by 2000 (215,000 m^3/day); and

c) distribution network extensions to areas not presently covered (1770 ha) and new areas expected to be inhabited by the year 2000, mainly the Extra Zones and New Town (some 1260 ha).

Some 150,000 additional water connections will be necessary between 1981 and 2000 to serve the majority of Port City's expanding population with piped water supply at their houses.

There will be continuing requirements for operation and maintenance facilities and equipment.

3.D.1.3 Water Supply Program Costs

Cost estimates for Port City's water supply program through the year 2000 are summarized in Table 3.12. These include the proposed 1984-86 project (Table A2.3 gives details) and the post-project period of 1987-2000. They exclude the IIP whose costs were estimated in the separate report of February 1982. Costs for the project period include an allowance of 15% for physical contingencies; those for the post-project period include 25%.

Total costs to the year 2000 amount to Z325 million, of which Z69 million is to be incurred during the project period. These exclude any costs incurred by householders, principally for plumbing inside the house.

Table 3.12 WATER SUPPLY PROGRAM COSTS, 1984 - 2000
(Z million)

	1984-86	1987-2000	Total
Sources and Treatment			
City Wells	0.9	-	0.9
North River Wellfield	31.9	-	31.9
Large River Scheme: Stage I (1989-91)	-	48.7	48.7
Stage II (1994-96)	-	89.7	89.7
Storage Reservoirs	3.0	10.0	13.0
Transmission and Distribution Pipelines			
Within Port City	12.3	22.0	34.3
To New Town	-	11.0	11.0
New Connections and Consumer Meters	4.2	15.6	19.8
Rationalization of Existing Networks	1.3	-	1.3
O&M Facilities and Equipment	2.8	-	2.8
Sub-total	56.4	197.0	253.4
Consulting Services	4.0	9.9	13.9
Physical Contingencies	8.6	49.3	57.9
Total	69.0	256.2	325.2

Costs expressed in price levels of mid-1982

3.D.2 Sanitation

Domestic sanitation systems expected to be in use in Port City in the year 2000 are described hereafter. By then, all of the urban area (Figure 2-5) is expected to be served by small bore sewers, as explained in Section 3.B.1, except for the area already served by conventional sewers (Figure 2-9) and also where residents will be unlikely to afford private water connections and associated sanitation facilities (mostly in Blight Heights and Railville).

3.D.2.1 Wastewater Treatment and Disposal

Table 3.9 shows projected average dry weather wastewater flows at 425,000 m^3/day in the year 2000. The existing Meanthyme Treatment Plant occupies 2.2 ha, has a capacity of only 75,000 m^3/day, and discharges effluent of very poor quality that does not meet current environmental regulations. There is not enough land at Meanthyme to expand or replace the plant.

A new treatment plant at a new location is therefore necessary. Least cost comparison in the Pre-feasibility Report decisively eliminated locations other than the Hog's Bay site to the north of the city.

Up to 500 ha of land is available for purchase at Hog's Bay from the military for whom it is reserved, but who use it only intermittently for training. The available groundwater is brackish, and 15-20% of the land is swampy, and so the area has no agricultural use. All sewage treatment processes could therefore be utilized at this site: primary treatment, or secondary treatment by activated sludge, trickling filters, biodiscs, stabilization ponds or aerated ponds.

The selection of a treatment process has to be made in concert with the selection of a method of effluent discharge. There are two possibilities for this: directly into the Inner Harbour (probably via the North River) or by outfall into the Outer Harbour. The Pre-feasibility Report determined that stabilization ponds are the least cost treatment method for meeting Inner Harbour effluent quality criteria of 30 mg/l for BOD, no floatables, and 30 mg/l for solids. Only primary treatment would be necessary to meet Outer Harbour effluent quality criteria of 50 mg/l of BOD, no floatables, and 75 mg/l of solids. A 7-km long submerged pipe of 180 mm diameter would be necessary for the outfall.

The costs of each alternative to meet the requirements of the year 2000 are shown in Table 3.13, which also compares them in economic least cost terms, assuming a discount rate of 10% and a life for each treatment plant of 20 years. Stabilization pond treatment with direct discharge into the Inner Harbour is confirmed as the least cost solution. Possible reuse of the effluent is discussed in Annex 3.

3.D.2.2 Wastewater Collection

The conventional sewerage network should not be extended in residential areas in the future, because it is not the least cost solution for households with water connections. New connections to the existing network should be made, however, in the Middle Residential, Business, Old Town, and Seaview zones. The existing network covers most of the foreseeable sites for industrial and commercial development within Port City. It is likely, however, that limited areas of extremely high residential densities or commercial developments may warrant conventional sewers in the future. Such limited areas cannot be identified at this time.

Table 3.13 LEAST COST COMPARISON OF HOG'S BAY WASTEWATER TREATMENT AND DISPOSAL ALTERNATIVES

Disposal Location	Inner Harbour	Outer Harbour
Effluent Quality Criteria		
BOD (excluding algae)	30 mg/l	50 mg/l
Floatables	none	none
Solids	30 mg/l	75 mg/l
Treatment Method	Stabilization Ponds	Primary
Capital Cost		
Outfall	-	11.4
Land	4.8	0.7
Treatment Plant	9.2	7.7
	14.0	19.6
Annualized Capital Cost (10% discount rate)	1.6	2.3
Annual Operating and Maintenance Cost	0.1	1.0
Total Annual Cost	1.7	3.3

By the year 2000, virtually all households with water connections that are located outside the area served by the present sewerage network should have small bore sewer connections. This implies a network covering some 5,500 ha, including the Extra Zones and New Town into which Port City is expected to expand. Some 600 ha of the new network will be built in the Lower Residential and Railville zones during the 1984-86 project, and the remaining 4,900 ha in the 1987-2000 period. Households with cesspits, septic tanks, and sullage soakaways will have these upgraded into interceptor tanks. Households obtaining new water connections in the small bore sewer areas will have new interceptor tanks. Laterals and mains will be necessary to collect the sewage from the households.

All existing and new public toilets (approximately 25 will be necessary during the project period and none thereafter) will be connected into the existing conventional or the proposed new small bore sewer systems by the year 2000. In addition, as noted, two out of five existing private wastewater treatment plants will be connected into the sewer system.

The proposed new treatment plant at Hog's Bay would be connected to the existing system of conventional sewers and the proposed small bore sewers by a new interceptor sewer to run along Main Street from the site of the present Meanthyme plant. The sewer would be large enough to handle projected flows through the year 2000. Another interceptor sewer would be needed during the project period to connect the proposed small bore sewers in Railville to the new treatment plant. (Both interceptor sewers are discussed in Section 4.E.2). In the period 1987-2000, additional main trunk sewers would be required to run to the Hog's Bay plant from the New Town area, the northern end of Lower Residential zone and the upper levels of the city.

3.D.2.3 On-Site Sanitation

By the year 2000, it is anticipated that all households with water connections will probably have conventional or small bore sewer connections. Cesspits, septic tanks, and pour-flush toilets with sullage soakaways will only be required during the project period for households in areas not to be covered with the initial small bore sewer network nor presently covered by conventional sewers. These on-site systems will be converted into interceptor tanks for small bore sewers. Very few on-site systems of these three types will be required in the post-project period, assuming that the next stage of the small bore sewer system is begun shortly after the project is implemented. As noted, this extension of the small bore sewers should be reevaluated before it is begun. This is particularly true of the Upper Residential and Extra Zones where septic tanks may prove preferable even in the long term.

Households without water connections require VIP latrines or pour-flush toilets. The bulk of these will be installed during the project period. By the year 2000, however, it is anticipated that only the residents of Blight Heights and of parts of the Extra Zones will still obtain water from standpipes. Wherever possible and desired by users, VIP latrines will be upgraded in the future to pour-flush toilets and pour-flush toilets to small bore sewer connections.

It is anticipated that low income householders will be provided with the below ground components of VIP latrines and pour-flush toilets, but will themselves be responsible for constructing the superstructures. Program cost estimates to the year 2000, therefore, include only the below ground components. (Low income people at present use open defecation or ineffective unimproved pit latrines; public health considerations based on an extensive survey by ISD imply that they should be provided with improved systems of an effective design rather than expected to build the facilities themselves. Nonetheless, free superstructure materials should be provided as an incentive to those who dig the pits themselves). No other on-site sanitation systems are included within the program costs.

3.D.2.4 Sanitation Program Costs

Cost estimates for Port City's sanitation through the year 2000 are summarized in Table 3.14. Like those for water supply in Table 3.12, they include the 1984-86 project (see Table A3.8 for costs) and the post-project period from 1987 to the end of the planning horizon in 2000. Project costs include an allowance of 15% for physical contingencies; costs for 1987-2000 include 25%.

Table 3.14 SANITATION PROGRAM COSTS, 1984-2000
(Z million)

Item	1984-86	1987-2000	Total
On-Site Sanitation Systems			
Support Activities	0.65	0.05	0.70
Construction of Below Ground Facilities	1.80	0.15	1.95
Upgrading of Existing Facilities	2.90	-	2.90
Off-Site Sanitation Systems			
Support Activities	0.20	1.00	1.20
Connections to Conventional Sewers	4.30	7.50	11.80
Extensions to Conventional Sewers	0.30	1.00	1.30
Interceptor and Trunk Sewers	6.40	4.50	10.90
Hog's Bay Treatment Plant	5.45	8.55	14.00
Meanthyme Treatment Plant Dismantling	0.10	-	0.10
Public Toilets	0.60	-	0.60
Small Bore Sewer System	3.95	49.40	53.35
O & M Facilities and Equipment	0.35	0.75	1.10
Sub-total	27.00	72.90	99.90
Consulting Services	1.70	3.60	5.30
Physical Contingencies	4.10	18.00	22.10
TOTAL	32.80	94.50	127.30

Note: Costs are expressed in price levels of mid-1982.

Total costs to the year 2000 amount to Z127 million, of which Z33 million will be incurred during the project period. These exclude any costs incurred by householders, principally for plumbing inside the house, for the superstructures of VIP latrines and pour-flush toilets, and for new cesspits, septic tanks, and pour-flush toilets with sullage soakaways. These will almost all fall during the project period as no new on-site sanitation is expected in 1987-2000 other than for some pour-flush toilets. During the project period, the costs of on-site sanitation systems (but not plumbing) incurred by householders are provisionally estimated at Z26 million (Section 4.G).

3.D.3 Total Program Costs

The water supply cost estimates of Table 3.12 and the sanitation cost estimates of Table 3.14 combine to give total program costs of Z452 million (1982 prices) over the planning period to the year 2000 as summarized in Table 3.15. Costs through 1983, including the Immediate Improvement Program, are excluded. All costs are expressed in prices prevailing in mid-1987; actual costs would depend upon rates of inflation.

Table 3.15 TOTAL COSTS OF WATER SUPPLY AND SANITATION PROGRAM: 1984-2000

	Project Period 1984-86	Longer Term 1987-2000	Total 1984-2000
	Z million of 1982		
Water Supply	69.0	256.2	325.2
Sanitation	32.8	94.5	127.3
	101.8	350.7	452.5

Total costs for water supply are much greater than for sanitation because of the need to develop two major sources distant from the city, the North River Wellfield and the Large River scheme, which together account for two-thirds of all water supply costs to the year 2000 (Table 3.12). The largest item in the sanitation program, the small bore sewer system, accounts for about 54% of the total costs (Table 3.14).

Chapter Four
THE PROPOSED PROJECT

4.A OBJECTIVES

The implementation period for the project is expected to cover the three years 1984-86. The principal social and economic objectives of the project are to provide and maintain safe drinking water and adequate sanitation facilities at affordable prices for all residents in Port City, including water supply and wastewater disposal services to support industrial and commercial developments within the city. This involves improvements in standards of water supply and sanitation services throughout the city, augmentation of water sources, and improvements in wastewater disposal.

Concurrently, a major objective is to strengthen the institutional arrangements for providing water supply and sanitation systems so consumers can be assured of the continuous provision of these basic services.

A complementary objective of the project is to increase levels of public health, since these health problems are due in large part to inadequate water and sanitation services. But health levels depend on complex mix of factors, including public awareness, nutrition, and living conditions generally. The project objective is to substantially reduce water and sanitation-related diseases in the city, but specific targets are not feasible. However, the project does provide for health education activities.

The principal operational objectives are elaborated hereafter in quantitative terms.

4.A.1 Improvements in Water Supply Service Levels and Coverage

Severe limitations in the PCWSC distribution system will be overcome by the project in order that all residents will have access to safe drinking water. Table 4.1 compares water supply service levels and coverage in 1981, prior to the present study, with those anticipated at mid-1987 when the project should be complete. The differences can be attributed to the Immediate Improvement Project (now underway) and the proposed project, the impacts of which are difficult to quantify separately.

In broad terms the data in Table 4.1 indicate that over the period 1981-87, some 515,000 additional people are expected to be served by connections to the expanded PCWSC system and a further 118,000 to have access to standpipes within 200 m. Private wells, which cannot be protected and monitored continuously for assurance that they provide safe drinking water, will by 1987 be used only by those who have made

Table 4.1 WATER SUPPLY SERVICE LEVELS AND COVERAGE, 1981 AND 1987			
	Actual 1981	Projected 1987	Projected Increase 1981-87
	---- Population in Thousands -----		
Population Served			
PCWSC System			
House Connections	1,037	1,552	515
Standpipes within 200 m	87	205	118
Standpipes further than 200 m	175	-	-175
Sub-Total	1,299	1,757	458
% of Total	89	98	
Private Systems			
Private wells and plumbing systems	29	39	10
Carrying from private wells	127	-	-127
Sub-Total	156	39	-117
% of Total	11	2	
Total	1,455	1,796	341

considerable investments in terms of pumps and pumping stations. In practice, this will probably mean that only industries and high income residents in the Upper and Middle Residential zones will use private wells after the project is operational. Almost all other residents without private connections will have access to nearby standpipes on the PCWSC system.

4.A.2 Improvements in Sanitation Service Levels and Coverage

A variety of sanitation systems of differing effectiveness presently serve Port City residents. The simple goal of the project is to provide adequate facilities for all by the end of 1987. The numbers to be served by the various systems are summarized in Table 4.2, which clearly indicates that all unsatisfactory on-site systems, including open defecation, should be upgraded or eliminated by 1987. Over the period 1981-87, some 426,000 extra people will be served by off-site systems and some 819,000 additional people by new or improved on-site systems.

Table 4.2 SANITATION SERVICE STANDARDS AND COVERAGE, 1981 AND 1987

	1981 (Actual)							1987 (Estimated)								
	Total Population	On-Site Systems				Off-Site Systems		Total Population	On-Site Systems					Off-Site Systems		
		Open Defecation	Pit Latrines	Septic Tanks	Cess-pits	Conventional Sewers	Public Toilets (a)		Ventilated Improved Pit Latrines	Pour-Flush Toilets	Pour-flush Toilets with Sullage Soakaways	Septic Tanks	Ces-pits	Small Bore Sewers	Conventional Sewers	Public Toilets (a)
Upper Residential	66	-	-	66	-	-	-	94	-	-	-	94	-	-	-	-
Middle Residential	280	-	21	28	91	140	-	321	-	-	-	11	20	-	290	-
Lower Residential	777	62	78	78	544	-	15	922	-	-	41	116	567	180	-	18
Business	24	-	-	-	-	24	-	26	-	-	-	-	-	-	26	-
Old Town	72	-	-	-	-	72	-	80	-	-	-	-	-	-	80	-
Railville	106	32	62	-	12	-	-	117	12	34	-	-	-	59	-	12
Blight Heights	99	64	35	-	-	-	-	103	46	47	-	-	-	-	-	10
Seaview	31	-	-	-	-	31	-	33	-	-	-	-	-	-	33	-
Extra Zones	-	-	-	-	-	-	-	100	-	15	15	70	-	-	-	-
New Town	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	1,455	158	196	172	647	267	15	1,796	58	96	56	291	587	239	429	40
% of Total	100.0	10.9	13.5	11.8	44.4	18.4	1.0	100.0	3.2	5.3	3.1	16.2	32.8	13.3	23.9	2.2

Note (a) Each Public Toilet facility serves 1,000 persons

4.A.3 Augmentation of Water Sources

Port City water users have experienced increasing shortages of water since 1975, but these shortages are expected to be eliminated as a result of the project. Most of the improvement will be due to the development of new sources, but a marked reduction in water losses will also effectively augment the supply.

The projected increases in water demands and corresponding requirements for water sources in future years were presented in Table 3.7. Existing sources have a total average capacity of 335,000 m^3 daily. Completion of the North River Wellfield scheme should increase the production capacity of the system by 200,000 m^3 daily, sufficient to meet all demands until the year 1991, as shown on Figure 3-9. At the same time, the loss reduction program already underway under the IIP and expected to continue in the project should be able to reduce unaccounted-for water to some 38% of water production by the year 1991, at which time total water sales, are projected at about 300,000 m^3/day. The proposed project thus permits an increase of about 125,000 m^3/day in water sales or 71% compared to the 1981 figure of 175,000 m^3/day. (If water losses can be further reduced, or if the capacity of the North River scheme can be increased, development of the next source can be delayed accordingly).

4.A.4 Improvements in Wastewater Treatment and Disposal

Existing systems of wastewater treatment and disposal in Port City are unsatisfactory, as explained in Section 2.E.3. The PCWSC treatment plants at Seaview and Meanthyme do not provide adequate treatment; private wastewater treatment plants around the city fail to operate satisfactorily; and wastes pumped from on-site facilities are disposed of indiscriminately. The rationalization of sanitation systems proposed in the project is intended to eliminate these problems of wastewater disposal.

One indicator of the project objectives is the quantities of wastewater or sludge expected to be treated and disposed of by various systems. Table 4.3 summarizes these data for 1981 and for 1987, the first full year in which all project improvements should be fully operational.

4.A.5 Institutional Improvements

A major contributing factor to the existing water supply and sanitation problems is weaknesses in the institutional framework for sector services in Port City and within the various organizations involved. The project is intended to serve as a catalyst in terms of rationalizing the responsibilities for providing such services, particularly sanitation. Furthermore, each organization with a role in

Table 4.3 WASTEWATER TREATMENT AND DISPOSAL, 1981 AND 1987	Actual for 1981	Projected for 1987	Projected Increase 1981-87
Wastewater Flows from Sewer Systems (000 m^3/day)			
Flows through Treatment Plants:			
Seaview	5.0	5.3	0.3
Meanthyme	57.0	-	-57.0
Hog's Bay	-	119.0	119.0
	62.0	124.3	62.3
Flows treated (%)	37.0 (60)	124.3 (100)	
Sludge Collected and Treated m^3/day			
Public Toilet Facilities	15.0	25.0	10.0
Pit Latrine and VIP	5.4	1.6	-3.8
Septic Tanks	14.1	23.9	9.8
Cesspit	26.6	24.1	-2.5
Pour-flush and Soakaway	-	2.3	2.3
Seaview Treatment Plant	31.0	33.0	2.0
Hog's Bay Treatment Plant	-	450.0	450.0
Meanthyme Treatment Plant	236.0	-	-236.0
Small Bore Sewer Sludge	-	16.4	16.4
Total Sludge Collected	328.1	576.3	248.2
Sludge Treated (%)	85.3 (26)	576.3 (100)	491.0

providing water supply and sanitation services will be strengthened. The overall intention is to assure the continuous provision of these basic services to all consumers.

PCWSC is the principal sector organization and the focus of most intended improvements. One goal for PCWSC is to discharge all responsibilities effectively. Another is to collect sufficient revenues for services provided to cover all operating expenses and generate a portion of funds required for future extensions. A third is to ensure the implementation of support activities, such as health education.

4.B INSTITUTIONAL FRAMEWORK

The present roles of all agencies involved in water supply and sanitation services in Port City are examined in detail in Annex 1. PCWSC, the semi-autonomous government corporation established in 1955, is the key organization. PCWSC is presently responsible for all public water supply in Port City, but its responsibility concerning sanitation is limited to systems of conventional sewerage. Throughout Optima the Ministry of Health (MOH) is supposed to set standards and provide assistance for on-site sanitation systems. Within Port City MOH is hardly active in waste disposal, instead concentrating its limited resources on other public health matters such as food handling, restaurants, housing standards, and the like.

By the year 2000, it is anticipated that almost all of Port City's residences will have either conventional or small bore sewer connections. On-site sanitation facilities to be installed during the project period will later be converted into interceptor tanks for small bore sewerage. It is clear, therefore, that improvements in sanitation require a systematic integration of on-site and off-site technologies. The effective planning, construction, and operation of these various sanitation systems needs to be concentrated in order that a single agency has overall responsibility. Although not essential, it is obviously advisable to have the agency responsible for sanitation be also responsible for water supply because of the close linkages between the two.

In Port City the best solution for rationalizing the institutional arrangements for water supply and sanitation systems is to have PCWSC become responsible for both. One possibility would be to pass new legislation to this effect. A simpler arrangement would be to have MOH formally delegate the responsibility for assisting in on-site sanitation systems to PCWSC while reserving functional responsibility for inspecting sanitation systems and the quality of water supplies to ensure that public health is not jeopardized. MOH and PCWSC officials have informally indicated that the proposed change in responsibilities would be acceptable, provided the policy were endorsed officially and PCWSC given the necessary resources to undertake such an expanded role in sanitation. As part of this realignment in responsibilities, MOH would undertake major activities in health education and personal hygiene training of population served by on-site systems, particularly of women, to ensure that the full benefits of the project are realized. Voluntary organizations and womens groups will be enlisted in this effort.

Necessary changes to strengthen PCWSC are discussed in Chapter Five of this report. With these changes, the expansion of PCWSC's responsibilities is feasible. It is assumed that PCWSC can effectively become responsible for on-site sanitation by the end of 1983, or within ten months of the release of this report.

In order to give PCWSC the power and the financial resources required to manage sanitation services as well as water supply throughout Port City, several specific changes are recommended:

a) PCWSC must be satisfied that suitable sanitation facilities exist for all consumers with water connections. This would require consumers to connect to conventional or small bore sewers where they exist or to construct technically acceptable on-site systems. PCWSC could refuse to provide water if consumers fail to adopt suitable arrangements for sanitation.

b) PCWSC would become responsible, by 1985 at the latest, for maintaining all sanitation systems for consumers with water connections. This would involve periodic emptying of septic tanks, cesspits and interceptor tanks for small bore sewers and sullage soakaways and operating and maintaining the existing system for conventional sewers.

c) In order to finance its sanitation operations, PCWSC would collect a common surcharge on the water bill of all consumers, regardless of the particular sanitation system they use. The rationale for this is that PCWSC is providing a service - supply of water and the disposal of resulting wastewater. The precise technologies used to provide this service should not affect the changes made to individual consumers. PCWSC would effectively be obligated to provide acceptable sanitation services to all consumers and would collect revenues for such services.

A number of other improvements in the institutional framework are also recommended, including:

- Ministry of Water Development (MWD) to license and monitor all groundwater extraction, including private wells;

- Ministry of Environment (MOE) to be responsible for ground and surface water quality, including controls over all wastewater effluent discharges;

- revisions to building code in Port City to cover standards for water and sanitation facilities, including on-site systems;

- building permit approvals to depend on PCWSC being satisfied with proposed water and sanitation arrangements;

- Ministry of Health and Ministry of Education to strengthen their programs for hygiene education for children and adults (with many of the programs executed by ISD);

- Ministry of Industry to improve national standards for equipment used in water supply and sanitation systems.

Those and other suggestions are explained in more detail in Annex 1. The implementation of these changes will have to involve a substantial information program directed at diverse audiences, including public officials, contractors, and the general public.

The Steering Committee which has directed the present feasibility study could probably be a useful group to oversee and integrate the various changes required in the institutional framework and the associated information program.

The project described hereafter is essentially limited to those activities for which PCWSC can be made responsible by the proposed changes in the institutional framework.

4.C PROJECT USERS AND THEIR PERSPECTIVES

The numbers of people expected to benefit from the improved water supply and sanitation services to be provided by the project are estimated in Tables 4.1 and 4.2, respectively. The detailed analyses of sector services by residential zones in Tables 2.3 and 2.5 for 1981 and Tables 3.1 and 3.3 for 1987 reveal that the greatest impact in water supply improvements will occur in those newer areas which presently lack a proper distribution system, particularly the Lower Residential, Railville, and Blight Heights zones. Sanitation improvements will be widespread, varied, and affect more people because existing service standards are generally lower than for water supply. The most significant impacts of the project will be experienced by residents in the high density and lower income areas of the city.

Industrial and commercial consumers of water have been the most vocal proponents of improvements as most feel constrained by unreliable water supplies and increasing shortages. For such consumers the question of service standards has hardly arisen, as they expect piped water supply and are indifferent to the wastewater system as long as it works effectively.

Those consumers who will benefit least from the project are those who are presently best served, particularly those in the Middle Residential zone who have water and sewer connections. The main effect of the project for these people will be the provision of services on a more dependable basis. Residents in the Upper and Middle Residential zones who continue to rely on private wells and on-site sanitation systems will not benefit directly from the project.

Throughout this study there have been various inputs from user groups which have affected the recommendations for future developments. The household survey which was carried out to determine existing water use and sanitation practices (see Sections 2.D.2 and 2.E.2) elicited valuable comments on residents' preferences for improved services. The questionnaires were not intended to determine opinions on alternative service standards, but most people interviewed (adult females in about 75% of the responses) made it clear that they expected to receive house or yard connections for water supply, in line with the present practice for the majority of Port City residents. Opinions were less pronounced on sanitation standards, except that respondents with unsuitable on-site systems were hopeful that PCWSC would be able to sewer their areas, since they were aware that properties connected to the sewers (in the Middle Residential zone) did not have problems of stagnant wastewater, noxious odors, etc. However, such residents are not yet aware that alternative technologies can resolve their sanitation problems satisfactorily. Many were also satisfied with existing systems that nonetheless threatened the environment and polluted the acquifer.

Special emphasis was placed on exploring community preference and prospects for improving services in the squatter areas of Port City. The Institute of Social Development (ISD) was engaged to interview community leaders and advise on local preferences, including the willingness and ability of these residents to pay for improved services.

The results of the survey emphasized the need to actively promote the new sanitation technologies in the communities and to consult with the users during all phases of the project. Promotion of the VIP latrine and the pour-flush toilet should be undertaken at two levels. Demonstration facilities should be constructed at health centers in Railville and Blight Heights to assist in training local contractors, artisans and other skilled labor. In addition, in each neighborhood a demonstration toilet of the type most appropriate to the culture of the community should be built at the home of an influential community leader. Project components have been selected in light of this information. Extensive further involvement of ISD and the local residents will be required to implement the project effectively.

The decreased reliance on standpipes that will result from the project, together with the greater proximity of standpipes to the homes of users, will probably put 50-100 water vendors out of work. This problem will need resolution, perhaps through efforts by the city government and agencies (including PCWSC) to absorgb the vendors into their work forces.

4.D REHABILITATION OF EXISTING WATER SUPPLY AND SANITATION SYSTEMS

A number of deficiencies in the existing water supply and sewerage facilities of PCWSC are presently being corrected under the Immediate Improvement Project. The report of February 1982 on this subject provides details.

The Productivia Agency for International Development agreed to help finance the implementation of the IIP, including consulting services. In July 1982, PCWSC signed the contract for this work with a joint venture of consulting firms, Black and White Inc. of Productivia and our firm, XYZ Consultants Ltd.

Progress on the IIP has been good and is the subject of reports issued every two months. There have been no substantive changes in the work recommended in the IIP report. The rehabilitation of the wells and water treatment plants will essentially be complete by March 1983.

The experience being gained in the ongoing implementation of the IIP, particularly the water loss reduction program, has been of great value in planning the proposed major project discussed hereafter.

At the time the IIP report was prepared the only sanitation system for which PCWSC was responsible was conventional sewerage. Sewer system repairs proceeding under the IIP should be complete before the end of 1983. However, several other sanitation systems within Port City need to be renovated, including the package treatment plants of private developers and various on-site systems. PCWSC is expected to become responsible for all sanitation systems in Port City in future. The project accordingly includes the rehabilitation and upgrading of several sanitation systems which are explained in the context of the sanitation component of the project (Section 4.E.2).

4.E PROJECT DESCRIPTION

The project comprises several related components, each described separately. Extensive planning and analysis has been undertaken during the feasibility study in order to confirm the technical feasibility and cost estimates for all components. Preliminary engineering designs have been completed for all facilities and detailed designs for facilities to be commenced during the first year of the project are already sufficiently advanced that tender documents can be prepared within three months of a decision to proceed.

This report provides technical information consisting mainly of summary data and drawings. However, considerable engineering data and analyses on which this part of the report is based are available in several Technical Appendices which are published separately.

4.E.1 Water Supply System

Figure 4-1 shows the water supply system in 1987, including components of the project. Annex 2 describes each component.

The rationale for the water sources to be developed during the project period was provided in Section 3.D.1.1.

Four wells with a total capacity of 20,000 m^3/day will be drilled and equipped in Suburban Park near the centre of the city to help meet peak requirements in the near term. The locations are some 4 km inland from the coast and ground levels exceed 100 m above sea level. Each well will be 200 mm in diameter and should yield some 5,000 m^3 daily of good quality water from the limestone aquifer. Electric submersible pumps, water meters, and individual chlorinators will be installed on each well. Two wells will pump into the existing Parkland reservoir (Figure 4-1), and two will feed directly into the adjacent distribution system. Pumping will initially be limited to periods of peak demand, about 1,000 hours per year or 10% of the time, because of Ministry of Water Development concerns about possible over-pumping of the aquifer.

The North River Wellfield will provide the major augmentation for PCWSC's water sources. Permission to extract this groundwater has been agreed in principle by the Ministry of Water Development but must be formally granted before implementation can commence. Detailed field investigations, including test pumping, are recorded separately in "Technical Appendix A: North River Wellfield System," along with preliminary engineering designs for the entire scheme. Thirty wells with a total reliable yield of 200,000 m^3/day will be installed along the North River and its tributaries, some 15 km northeast (upstream) from Farmville (see Figure 3-9). The wells will be equipped with electrically powered pumps and will deliver water to the sump of the wellfield pumping station by collector pipelines totalling 8 km in length. The pumphouse will contain four large centrifugal pumps (capacity 100,000 m^3/day each) with a maintenance facility adjacent. Water will be pumped to terminal reservoirs at the Creektop location on the north edge of Port City.

Improved water supply and sanitation facilities will be provided to the 25 villages in the North River Valley where the PCWSC wellfield is to be located. Shallow wells with hand pumps and VIP latrines are the recommended facilities. A health centre will be installed near the middle of the region as part of the planned health education program.

The transmission pipeline between the North River Wellfield and Port City will have a capacity of 300,000 m^3/day although the wellfield will initially be operated to yield an average of only 200,000 m^3/day. The pipeline, 19.5 km long and 1600 mm in diameter, will follow a route on the east side of the North River, as shown on Figure 3-9.

The pipeline will be equipped with air and washout valves at high and low points and sluice valves at 5-km intervals to isolate pipeline sections for maintenance. An offtake will be provided as a future connection to supply the town of Farmville.

The Creektop Reservoir at the end of the transmission pipeline is located on a hill by the national highway to Farmville at the north edge of Port City (Figure 4-1). The initial capacity of two identical reservoirs will total 50,000 m^3/day, but the site (presently owned by the city) will include provision for additional reservoirs in future.

The North River Wellfield scheme will be operated from a control room at the pumping station. Water levels in each well and at the Creektop Reservoir will be continuously monitored, and all pumps will be controlled by trained operators. The operating staff will be in contact with the PCWSC operations center in Port City by telephone and radio.

The transmission and distribution system within Port City has been the subject of intensive analysis, using considerable information generated as part of the Immediate Improvement Project. Accurate maps have been prepared for the entire system. Alternative improvements were investigated by means of a computer model of the network. Details concerning the existing system and analyses of alternative improvements are provided separately in "Technical Appendix B: Port City Water Distribution System."

Eastern Reservoir will provide 30,000 m^3 of storage at a city-owned site on the eastern site of Port City (Figure 4-1). The combination of the Creektop and Eastern reservoirs will add a total of 80,000 m^3 of treated water storage in the PCWSC system, more than double the storage available at the existing treatment plants and reservoirs. The Creektop Reservoir will supply the lower pressure zones in the distribution system and the Eastern Reservoir the higher ones, providing storage to balance peak demands throughout the system.

Three principal transmission pipelines within Port City are included in the project. Their locations are shown on Figure 4-1, and details are provided in Annex 2. They would connect:

a) the new Creektop Reservoir to the centre of the existing network (total length 6.0 km, diameters 1600 mm to 800 mm);

b) the new Eastern Reservoir to Mountain Road (length 4.0 km, diameter 600 mm); and

c) existing pipelines in the southwest part of the city, near Long Mountain (length 4.3 km, diameter 400 mm).

Distribution network extensions are planned to ensure that all parts of the city are provided with water. The main areas to be served by the extensions are summarized in Table 4.4 and shown in Figure 4-1.

Table 4.4 DISTRIBUTION NETWORK EXTENSIONS IN PROJECT

Residential Zone	Area to be Served (ha)	Approximate Length of Distribution Pipelines (km)
Upper Residential	580	41
Lower Residential	500	67
Railville	150	34
Blight Heights	280	15
Extra Zones	260	36
Total	1,770	193

Detailed analyses of each zone, including interviews with residents, have confirmed that individual water connections are desired and affordable in most zones in conjunction with suitable arrangements for sanitation. In Blight Heights, however, the squatters lack land tenure and are mostly unwilling or unable to afford private connections. Accordingly, the distribution system for Blight Heights is designed to supply public standpipes initially, but could be upgraded in future to provide for private connections. In the New Zones the residential pattern is expected to be mixed, with some customers able to afford water connections and appropriate sanitation systems, and others expected to rely on public standpipes. In all other zones the network is designed to provide individual connections from the outset.

Potential consumers in the areas where water lines are to be laid will be canvassed by PCWSC prior to the construction of networks. The contractors will install connections up to the meter at the property boundary for all those who have applied for the connection at the time that the pipelines are being laid. PCWSC staff will continue to provide new connections within the existing network as well as to those properties on the network extensions who do not have a connection installed initially by the contractor. The total number of connections to be installed during the three years 1984-86 is estimated at 35,000. Approximately 150 public standpipes of a standard model will also be provided.

PCWSC needs water meters for these new connections and to replace old meters which are beyond repair. The number of meters required during the project period totals some 60,000. More than 90% of these will be very small meters for domestic connections, but some of all sizes will be required. Meters from a limited number of manufacturers (probably 3) will be used in each size in order to standardize equipment.

Special equipment and efforts are required to rationalize the existing distribution network, including isolation of pressure zones and reduction of unaccounted-for water. The consulting assignment being carried out since July 1982 under the IIP will specify the work in more detail. In general, there will be a need to purchase and install master meters, isolating valves, pressure-reducing valves, and pressure recording gauges. There will also be some sections of old and badly leaking pipes which will still need to be replaced even after the IIP has been implemented, tentatively some 22 km of various diameters. The necessary equipment will be purchased and installed throughout the period 1984-86.

4.E.2 Sanitation Systems

There are many different elements in the sanitation component of the project, all of which are described in detail in Annex 3. Figure 4-2 provides a schematic diagram of wastewater flows in the various sanitation systems in 1987, after the project has been implemented. Table 4.5 provides a summary of the sanitation elements included in the project, which can be classified in three categories: rehabilitation of existing systems; construction of new on-site systems; and construction of new off-site systems. Each is discussed separately.

4.E.2.a. Rehabilitation of Existing Sanitation Systems

Existing sewers, the Sweet Street pumping station and the Meanthyme Treatment Plant in the conventional sewerage of PCWSC are all being repaired under the IIP. Three privately owned wastewater treatment plants need to be connected to sewers or upgraded, as explained in Annex 3.

Table 4.2 indicates that 60% of Port City's residents will continue to rely on on-site systems of sanitation immediately after the project period because sewers (conventional and small bore) will only serve a minority of the area and population. Thousands of existing cesspits and septic tanks will have to continue being used until at least 1987, at which time the second stage of the small bore sewer system might be underway. Those on-site systems need to be upgraded by suitable repairs in order that they can function adequately until being converted to interceptor tanks in a future system of small bore sewers.

Table 4.5 SANITATION UNITS TO BE INSTALLED IN PROJECT PERIOD, 1984-86

Zone	Number of people served per sanitation unit (average)	ON-SITE SYSTEMS							OFF-SITE SYSTEMS				
		Without House Connection		With Water Supply by House Connection					Small Bore Sewer			Conventional Sewerage	
		VIP latrine	Pour-flush toilets	Pour-flush and soakaway (a)	Cesspits		Septic tanks		Cesspit Conversions	Septic Tank Conversions	Interceptor tank	Connections (b)	Public Toilet Facilities(c)
					new (a)	upgraded	new (a)	upgraded					
Upper Residential	6.4	-	-	-	-	-	940	-	-	-	-	-	-
Middle Residential	7.8	-	-	-	-	-	-	-	-	-	-	12,490	-
Lower Residential	24.3	-	-	1,710	1,710	16,000 (e)	1,690	1,700(f)	930	180	6,290	-	3
Business	37.5	-	-	-	-	-	-	-	-	-	-	40	-
Old Town	28.5	-	-	-	-	-	-	-	-	-	-	300	-
Railville	10.5	1,140	3,240	-	-	-	-	-	1,140	-	1,120(d)	-	12
Blight Heights	12.3	3,700	3,820	-	-	-	-	-	-	-	-	-	10
Seaview	7.5	-	-	-	-	-	-	-	-	-	-	200	-
Extra Zones	8.0	-	1,870	1,870	-	-	8,760	-	-	-	-	-	-
Total		4,840	8,930	3,580	1,710	16,000	11,390	1,700	2,070	180	7,410	13,030	25

Note: (a) Not funded or constructed by PCWSC.
(b) Immediate improvement program expected to have completed 4,000 connections before project period.
(c) Each public toilet facility serves 1,000 persons.
(d) Serving four houses each.
(e) Out of 21,650 existing cesspits.
(f) Out of 3,890 existing septic tanks.

4.E.2.b. Construction of New On-Site Systems

Two types of on-site sanitation systems are envisaged. Consumers with individual water connections but without access to sewers will be required to have wet on-site systems capable of disposing of sullage water as well as toilet wastes. Septic tanks provide the preferred system where available land and soil conditions permit; their seepage trenches require considerable space. In many locations, however, cesspits are the only feasible technical solution, even though they aggravate groundwater quality problems and require frequent pumping because of clogging of the sites. For residences without flush toilets, the construction of the pour-flush toilet with a sullage soakaway is the least cost solution.

VIP latrines, the only acceptable dry on-site sanitation system capable of handling excreta effectively but not sullage will serve only those residents without private water connections, and will accordingly be limited to the lower income residents. Pour-flush toilets would also be appropriate for such areas and the choice will be made by the residents. The pour-flush toilet will be of particular interest for new housing because the toilet itself can be located within the house. Recommended designs are shown in Figures 3-1 and 3-2. Residents will be provided with below ground structures, but they will be expected to provide superstructures themselves. (Those who dig the pits themselves will be provided with the materials for the superstructures).

4.E.2.c. Construction of Off-Site Systems

Only some 3-km of minor extensions will be made to the conventional sewers. These extensions of street sewers will accommodate new developments at the north end of the Middle Residential zone. Unserved buildings on streets within the present sewer system will be connected. Under the ongoing Immediate Improvement Project, there is a major campaign to encourage such new connections. An extension of this campaign is expected to result in some 13,000 additional sewer connections during the project period.

The existing Meanthyme Sewage Treatment Plant has worked very badly and cannot meet existing discharge standards even after it is rehabilitated in the IIP. The site is inadequate for a treatment plant to handle the increasing quantities of wastewater to be collected by Port City's sewers. The project accordingly includes a new wastewater treatment plant to be built at Hog's Bay as shown on Figure 4-3. The plant site is on marginal lands between the railway and the sea, just north of the city boundary. The land is presently controlled by the military who are negotiating to sell it. Construction of sludge lagoons is planned to begin at this site next year under the Immediate Improvement Project.

The Hog's Bay plant will consist of stabilization ponds. Wastewater will flow in series through anaerobic, facultative, maturation, and polishing ponds before the effluent flows into the North River and thence into Hog's Bay. Sludge will be digested and then dried in ponds before ultimate disposal, either as landfill or soil conditioner. The initial capacity of the plant will be 130,000 m^3/day, the design flow in 1990, but the plant is designed for an ultimate capacity of 323,000 m^3/day. The plant layout and process diagram are shown on Figures 4-4 and 4-5, respectively. The effluent could possibly be used for the irrigation of nearby fields or for groundwater recharge (as explained in Annex 3) but such reuse is not included in the proposed project, as further analysis is required.

The existing Meanthyme Treatment Plant will be demolished after the Hog's Bay plant begins operating, as treatment of its present flows can be accomplished to higher standards at lower costs in the new plant. The Meanthyme site will be used by PCWSC as a maintenance base in the future.

A major interceptor sewer will be laid between the existing Meanthyme plant and the Hog's Bay oxidation ponds, generally along Main Street. The plan and profile of this 7-km long sewer, 1800 and 1900 mm in diameter, are shown on Figure 4-6. All wastewater from the existing network of conventional sewers, plus the majority of the new small bore sewer flows, will be conveyed by the Main Street interceptor sewer to the new treatment plant at Hog's Bay.

An area of 488 ha in the northwest section of the Lower Residential zone and an adjacent area of 86 ha in Railville B have been selected as the first part of Port City to be served by small bore sewers. This area, with a projected 1987 population of 239,000, is shown on Figure 4.7. Most of this area presently lacks a water supply network. Both sets of pipes (water and sewer) will be installed throughout some 520 ha during the project.

Wastewater from the Railville B section of the small bore system, will flow to the Hog's Bay plant through a 2-km interceptor sewer, 500 mm in diameter. The Lower NW section will drain to the new Main Street Interceptor sewer and then to the Hog's Bay plant. The interceptor sewers and areas served are shown on Figure 4-7.

The design methodology for small bore sewers is explained for a layout of 73 ha along with a detailed example for an area of 3.5 ha in Annex 4. A cost comparison between small bore and conventional sewers is also provided. Details of the small bore sewers included in the project are provided in Annex 3. New interceptor tanks are to serve from one to four houses (depending on the configuration of local buildings and property boundaries) which presently lack wet on-site sanitation facilities (septic tanks and cesspits). Where such exist, they will be converted to serve as interceptor tanks and then connected to the small bore sewers in the streets. Figures 4-8 and 4-9 show interceptor tanks for single and multi-family residences, respectively.

A total of 236 km of small bore sewers (of which 146 km have a minimum diameter of 50 mm) is required to serve the total of 574 ha included in the project.

The 15 existing public toilets in Port City are being renovated under the IIP. The project includes a further 25 public toilets. Figure 4-10 locates the public toilets, and Figure 3-7 shows a recommended design.

Fourteen of the public toilets will be connected to the small bore sewer system which will drain the settled effluents. Sludge will be removed from these by vacuum truck for treatment at Hog's Bay. The 26 others will be connected after the project period as the sewer system is expanded. Until then, all their wastes will be trucked to the Hog's Bay Treatment Plant. Water reducing devices and larger waste storage vaults have therefore been included in their design. Laundry and shower facilities will be made available to the public only after connection to the sewer system.

4.E.2.d. Implementation Support Program

Specialized support programs are required to implement portions of the sanitation project: the VIP latrines and pour-flush toilets; the upgrading of existing on-site sanitation systems; and the conversion of on-site systems for connection to small bore sewers. This will involve community surveys, informational and promotional activities (especially in Blight Heights and Railville), demonstration facilities, technical and financial assistance to householders where applicable, and inspection/monitoring. These activities, proposed to be subcontracted to the Institute for Social Development (ISD) are described in greater detail in Annex 3.

Similarly, hygiene education is an integral part of the sanitation component of the project. It will comprise an informational campaign during the project and an educational program, initiated during the project but extending thereafter on a permanent basis. The campaign will be aimed primarily at the mother and child, and the extended educational program at the primary school child. The hygiene education activity will be carried out by the ISD in parallel with the above program support. Further details on hygiene education are given in Annex 3.

4.E.3 Operation and Maintenance Facilities and Equipment

In the future, PCWSC staff in customer services and local operations and maintenance will work from two regional offices, as explained in Annex 5 on the organization of PCSWSC. One of these regional offices, serving the southern region of Port City, will be at the Railway Treatment Plant, present site of most PCWSC offices. The northern regional office and repair depot will be located at an existing facility on Farmville Road. The purchase and modification of this 0.7-ha site and its buildings are included in the project.

Major modifications are required at the existing Railroad plant complex of PCWSC buildings, as explained in Annex 2. An operational control centre will be established there to monitor and direct activities at all PCWSC water sources, reservoirs, and pumping stations. The existing control room of the Railway treatment plant will be expanded for this purpose and linked to other operating facilities by telephone and radio. Extensive instrumentation needs to be incorporated in the operational control centre, which will be staffed continuously.

The addition of some 3,000 square metres of office accommodation is required for PCWSC head office at the existing Railway site. The new office building will be integrated with the existing headquarters. The site is adequate for this expansion.

After the Meanthyme Sewage Treatment Plant is made redundant by the Hog's Bay plant, the Meanthyme site will become PCWSC's principal maintenance base for sewerage and sanitation systems throughout Port City. It will also serve as the main workshops and equipment store, including meter and vehicle workshops, as described in Annex 2.

A comprehensive set of equipment has to be purchased by PCWSC to improve operations and maintenance. Equipment for water supply and general operations is outlined in Annex 2, and that for sanitation operations in Annex 3. The maintenance of large numbers of on-site sanitation facilities will probably be handled most efficiently by contractors engaged by PCWSC, but a basic fleet of sanitation equipment must nevertheless be maintained, as well as equipment to maintain the expanded system of sewers.

4.F RESPONSIBILITIES FOR PROJECT IMPLEMENTATION AND OPERATION

PCWSC will retain the overall responsibility for implementing the total project. Large construction activities are normally managed within PCWSC by the Design, Construction, and Procurement Division of the Technical Services Department and this arrangement can work satisfactorily, provided this group is suitably strengthened. The organization and management of PCWSC are discussed further in Section 5.A and in Annex 5.

PCWSC needs to obtain assistance from consultants for several tasks during the project period. Engineering consultants will assist in final design, procurement, construction supervision, and commissioning of the principal elements of the water supply and sanitation components. This major assignment will require a large team of consultants working in Port City.

Consultants specializing in operational assistance are required to help PCWSC improve the operation and maintenance of its existing systems. Such assistance will basically be a continuation of the assignment presently underway as part of the IIP.

Management consultants will help PCWSC to implement the proposed improvements in the PCWSC organization and staffing which are described in Annex 5. Such assistance includes a major training program.

Engineering consultants should be engaged near the end of the project period to review projected future requirements for water and sanitation services and identify the investments required for future system improvements. Essentially, this task is to identify the next project.

Certain local organizations will be given responsibility by PCWSC to assist in implementing aspects of the project.

In the North River Valley, PCWSC will drill the wells required for water supply for the 25 villages, since this work can logically be included in the contract for the development of the production wells for Port City. All other aspects of the water supply and sanitation component for the villages will be carried out by the Ministry of Health, including the health education program. This is discussed further in Annex 2.

The sanitation component in Port City will involve PCWSC in several technologies in which it has no previous experience. Furthermore, the cooperation of the beneficiaries is crucial to the effective implementation of the component. The Institute of Social Development (ISD) is an autonomous organization with considerable experience in working with local groups in the low income areas of Port City where much of the sanitation component is concentrated. PCWSC should sub-contract with ISD for various support activities involving community residents, as explained in Annex 3.

As at present, PCWSC will operate and maintain all components of the water supply system after the project is constructed. Similarly, PCWSC will continue to operate and maintain the conventional sewers and wastewater treatment plant. Major improvements are required in these aspects of PCWSC's activities.

The Commission's operational role will also be expanded considerably when it becomes responsible for on-site sanitation systems and the small bore sewers. This will require periodic emptying of cesspits, septic tanks and interceptor tanks, and the transport of sludge by truck to the Hog's Bay Treatment Plant. Significant changes in the PCWSC organization are recommended to accommodate these enlarged responsibilities, as discussed in Section 5.A. Many routine activities, such as removing sludge from tanks, can be provided by local firms in Port City under contract to PCWSC. Legal changes will also be necessary to enable PCWSC to enter private property in order to clear up sanitation problems which endanger public health.

4.G COST ESTIMATES

The estimated capital costs are presented in considerable detail for the water supply and sanitation components of the project in Annexes 2 and 3, respectively. Table 4.6 summarizes these estimated costs of the project, which total Z134 million. Capital costs for the water supply component represent roughly twice as much as costs for the sanitation component. Interest during construction is excluded from this cost summary, and is discussed in section 5.E in the context of the financing plan.

Detailed estimates of operating and maintenance costs for the project and PCWSC as a whole are shown in the projected income statement (Table A7.2) in Annex 7. Costs were estimated separately for the water supply and sanitation system and due account taken of volumes of water and wastewater and staff (Annex 5) required to operate the expanded system.

The capital cost estimates are based on preliminary designs prepared during the feasibility study. These estimates are considered to be reliable within 15% of the actual costs at constant prices. Unit prices used for this estimate are based on comparable recent contracts in Optima and on budgetary estimates provided by contractors and suppliers. The cost of land which needs to be purchased has been estimated separately for the wellfield and wastewater treatment plant.

An allowance of 15% of the basic cost estimate to cover physical contingencies (unexpected costs) is reasonable, based on the status of the designs for the project components.

The foreign exchange component of the cost estimate includes both a direct component (imported material for use in the project, foreign experts, etc.), as well as an indirect component (depreciation on imported construction equipment, imported fuels, etc.). The overall foreign exchange component of the project is estimated at Z55.0 million or some 41% of the total costs. However, the foreign exchange element

Table 4.6 SUMMARY OF ESTIMATED PROJECT COSTS

Item	Local	Foreign	Total
	-----	Z million	-----
1. Water Supply Systems			
City Wells	0.20	0.70	0.90
North River Wellfield	4.70	6.50	11.20
Village Water Supply and Sanitation	0.60	0.20	0.80
Pipeline from North River Wellfield to Port City	4.30	10.20	14.50
Communications and Control for North River System	0.10	0.30	0.40
Creektop Reservoir	4.00	1.00	5.00
Eastern Reservoir	2.40	0.60	3.00
Transmission Pipelines within Port City	2.40	3.50	5.90
Distribution Network Extensions	3.80	2.60	6.40
New Connections and Consumer Meters	2.20	2.00	4.20
Rationalization of Existing Networks	0.90	0.40	1.30
Sub-total (Item 1)	25.60	28.00	53.60
2. On-Site Sanitation Systems			
Support Activities	0.60	0.05	0.65
Construction of Below Ground Facilities	1.60	0.20	1.80
Upgrading of Existing Facilities	2.60	0.30	2.90
Sub-total (Item 2)	4.80	0.55	5.35
3. Off-Site Sanitation Systems			
Support Activities	0.20	-	0.20
Connections to Conventional Sewers	3.40	0.90	4.30
Extensions to Conventional Sewers	0.20	0.10	0.30
Interceptor Sewers	4.60	1.80	6.40
Hog's Bay Treatment Plant	4.75	0.70	5.45
Dismantling of Meanthyme Treatment Plant	0.10	-	0.10
Public Toilets	0.55	0.05	0.60
Small Bore Sewer System	3.10	0.85	3.95
Sub-total (Item 3)	16.90	4.40	21.30
4. O&M Facilities & Equipment	1.80	1.35	3.15
Sub-total (Items 1-4)	49.10	34.30	83.40
5. Consulting Services	3.10	2.60	5.70
6. Physical Contingencies	7.50	5.20	12.70
Sub-total (Items 1-6)	59.70	42.10	101.80
7. Price Increases	19.30	12.90	32.20
Total	79.00	55.00	134.00

of cost varies considerably between project components. It is highest for facilities with much imported equipment and lowest for the sanitation systems (about 10% for on-site systems and 20% for off-site systems), because these systems will require mainly local materials and local contractors.

The cost estimate is prepared in prices prevailing in mid-1982. The pattern of expenditures has been estimated for each contract (details in Annexes 2 and 3) from final engineering, beginning in 1983, through completion of construction in 1986. The actual final costs will depend on changes in price levels during the project implementation period. Following advice from economists in the Ministry of Finance and the Bank of Optima, future price increases have been assumed as follows:

Year	Probable Rate of Price Increases (%)	
	Domestic	International
1983	12.0	8.0
1984	11.0	7.5
1985	10.0	7.0
1986	9.0	6.0

Table 4.7 shows the expected annual expenditures in each year from 1983 to 1986.

Table 4.7 ANNUAL PROJECT EXPENDITURES, 1983-86
(Z million)

	1983	1984	1985	1986	Total
Water Supply	1.3	7.5	42.7	17.5	69.0
Sanitation	2.6	5.8	14.7	9.7	32.8
Sub-total (1982 prices)	3.9	13.3	57.4	27.2	101.8
Allowance for price increases	0.4	2.7	17.6	11.5	32.2
Total (current prices)	4.3	16.0	75.0	38.7	134.0

These costs exclude internal plumbing within residences. Also excluded are costs expected to be incurred by householders for new cesspits, septic tanks, pour-flush toilets with sullage soakaways, and the superstructures of VIP latrines and pour-flush toilets. These are estimated at Z26 million during the project period.

4.H IMPLEMENTATION SCHEDULE

In preparing a realistic schedule for implementing the project, detailed consideration has been given to the manner in which the construction activities will be organized by PCWSC. The basic assumption is that most construction will be carried out by contractors supervised by PCWSC and its consultants. However, certain activities such as repairs to the existing facilities, will probably be undertaken by PCWSC staff directly.

Realistic allowances are provided for each step in the contract process, including: completion of final design; preparation and approval of tender documents; tender period; tender evaluation; recommendation and approval of contract award; negotiation and contract signature; and mobilization by contractor. For large contracts these steps are expected to require a total of up to one year after the decision to proceed with the recommended project.

For the water supply component a provisional total of 35 separate contracts has been identified and the construction schedule is shown in Figure 4-11. The priority items for this component are the city wells, which can augment the supply of water by early 1985, and the North River wellfield scheme, which should be operational early in 1986. PCWSC will face increasingly severe water shortages until these additional sources are available. However improvements to the existing sources under the IIP, reduction of unaccounted-for water and rationalization of the distribution network should improve the supply situation somewhat in the near term.

Project implementation cannot begin until the proposed project has been approved, financing has been arranged and consultants engaged to finalize designs and prepare tender documents. First year design work is already underway. The construction schedule assumes that consultants can be engaged by June 1983, six months after the release of the draft version of this feasibility report and four months after the final report is published. It is also assumed that all necessary financing (local and international) is assured before the end of 1983 and that construction contracts can be signed from 1984 onwards.

Many specific actions need to be taken before the water supply component can be completed, such as purchasing land, obtaining approvals for wells, arranging pipeline routes, etc. Details of each specific action, including assignment of responsibility and a deadline, are provided in Annex 2.

For the sanitation component a provisional total of 18 contracts has been identified as shown in the construction schedule of Figure 4-12. Implementation of this component is complicated by the fact that PCWSC is presently responsible only for sewers and not for various on-site systems of sanitation. Hence the construction schedule assumes that consultants are engaged by June 1983 to finalize the sewerage component, but that further work on the on-site component does not commence until 1984, after PCWSC is given responsibility for these systems.

The largest elements in the sanitation component are the new treatment plant at Hog's Bay and the interceptor sewers which flow there. PCWSC could complete construction of the first stage of the plant and the interceptor from Railville in the second half of 1985. But the most critical contract is the very large interceptor sewer along Main Street which will convey all flows from the existing conventional sewers and the Lower NW portion of the new small bore system of sewers. This interceptor sewer is scheduled to take some 18 months to construct, because of its large size and location in a principal city road but efforts should be made to accelerate completion. Only after this sewer and the Hog's Bay plant are operational can connections be made to the new small bore system, and the old Meanthyme plant be fully converted to an operation and maintenance base.

Many elements in the sanitation component can be packaged in relatively small contracts suitable for local contractors, particularly the on-site facilities and the small bore sewers and interceptor tanks. However, the management of such contracts will require close collaboration with the Institute of Social Development (ISD), working with the residents who will ultimately use the facilities, as well as training for the contractors at the outset. Progress on these elements is expected to begin slowly and increase gradually during the project period. A special unit might be required within the Design, Construction, and Procurement Division of PCWSC's Technical Services Department to manage the contracts with ISD.

The construction schedules of Figures 4-11 and 4-12 for the water supply and sanitation components will not be difficult to achieve, provided PCWSC designates suitable staff to manage the overall project and engages qualified consultants to provide the necessary assistance. A well-organized team is required to prepare and supervise the technical and administrative aspects of the many contracts.

4.I CAPABILITY OF OPTIMA'S CONSTRUCTION INDUSTRY

Considerable attention has been paid to the prospects for utilizing the capacity of Optima's suppliers and contractors in the proposed project. The Ministry of Industry provided much useful information, as did representatives of consultants and contractors with experience in Optima. Based on this information and on analysis of construction activities throughout Optima during the past five years, it is believed that the local construction industry will play a major role in the project.

Asbestos cement and PVC water and sewer pipes are produced in Optima and could be satisfactory for networks in Port City, provided suitable measures are taken to control the quality of the production. A mill in Capital City produces reinforcing steel from recycled scrap metal, but Optima is still a net importer of steel products. Cement is produced locally, as are oil and gas products, although the refinery in Port City imports its crude oil. Ductile iron and steel pipes have to be imported, as do most valves, pumps, motors, and water meters. However, the quantities of certain equipment required for this project (such as domestic water meters) might be sufficient to encourage local businessmen to set up manufacturing or at least assembly plants for certain items. This matter should be explored further before final designs and specifications are completed.

A few large and critical contracts, such as those for well drilling and pump installing in the North River Wellfield, installing the pipeline from the wellfield to Port City, and installing the Main Street interceptor sewer, are beyond the previous experience of local contractors in Optima. For such important contracts it would be appropriate for foreign and local firms to enter suitable working arrangements, such as a joint venture, in order to ensure efficiency. For most of the civil contracts within the project, however, contractors within Optima have sufficient experience, equipment and key staff to carry out the work satisfactorily. It will probably be advisable to prequalify local contractors according to their capacity and experience so they can be utilized as effectively as possible in implementing the project.

The feasibility of mobilising the construction force necessary to carry out what is a very large construction project for Port City, has been examined in detail. The critical year for construction resources is 1985 when most of the 35 water supply and 18 sanitation contracts will be underway. The value of work scheduled to be carried out in that year is Z48 million (primarily well drilling, pipe laying and earth moving).

A labour force of approximately 9,000 will be needed in 1985, about 40% of Port City's construction resource (estimated at 22,500 in 1980 in the Pre-feasibility Report). There will be no problem in finding unskilled labour, but skilled labour, tradesmen, foremen and construction managers at various levels could pose a difficulty. Fortunately 1985 is going to be a low point in other construction activities in Port City. A major program of road construction and restoration throughout Port City is scheduled for completion in late 1984 and the current wharf and sea wall piling projects are coming to an end and should be finished by early 1985. There are no other new major projects scheduled for the Port City area until the proposed widening and upgrading of the road to Capital City comes under construction which at present is tentatively scheduled to begin in 1987.

4.J ENVIRONMENTAL IMPACTS

The most obvious environmental impact of the project will be the improvements expected in the public health of the residents of Port City through the increased service standards for water supply and sanitation (see Tables 4.1 and 4.2). This will be particularly true for the villagers in the North River Valley, whose present facilities are primitive and contribute directly to high rates of gastro-enteric infections.

Development of the North River Wellfield is expected to lower water levels in that alluvial aquifer by a few meters in the dry season, lessening dry weather flows somewhat in the North River. However ,this minor change in groundwater levels will be only a seasonal (not permanent) phenomenon; it is not expected to have any adverse impact.

Construction activities on the North River water supply scheme will interrupt farming for one to three years over a total of less than 100 ha of agricultural land. Farmers will be compensated, and the land can be used for controlled agriculture after the construction is complete.

Excavations for pipelines and sewers throughout the project area will cause soil erosion, but such erosion will be limited by minimizing excavation on steeply sloping land during the rainy season and by requiring reasonable soil conservation measures by the contractors.

The Hog's Bay Treatment Plant will convert some 140 ha of marginal lands into carefully controlled stabilization ponds. This will expand to 330 ha by the year 2000.

These marshlands presently provide habitat for several species of birds and animals (including migrating birds twice each year). This habitat will be permanently transformed by the project, to the detriment of those fauna. However, the construction of the plant, beginning with the sludge lagoon underway in the IIP, would eliminate the present indiscriminate dumping of septic sludge on the tidal flats and gully estuaries, thus restoring the carrying capacity of the important components of the local environment for many of the same fauna (and also fish).

The stabilization ponds will be stocked with larvae eating fish. The banks will be lined with rip rap and any vegetation cut regularly to minimize the habitat for mosquitoes. Such management of the ponds will minimize their use by disease carrying vectors. Seabirds are expected to visit the ponds regularly. The overall environmental impact of the Hog's Bay Treatment Plant is expected to be positive.

The renovations to the existing wastewater treatment plants and the replacement of the Meanthyme primary plant by the Hog's Bay oxidation ponds will make a major improvement on the receiving water of the harbour, as indicated by the data in Table 4.3. The major nutrient sources causing eutrophication and sludge deposits in the harbour are to be eliminated.

Improvements to existing on-site sanitation facilities will eliminate stagnant and foul water, reduce disease hazards, and improve aesthetics for over 100,000 houses throughout Port City. Improvements in present sludge disposal practices, by concentrating all such wastes in properly managed lagoons at Hog's Bay, will also contribute to noticeable improvements in the environment.

Construction activities will affect traffic patterns and cause some limited but unavoidable congestion in different parts of the city as the project is built. Such inconvenience to residents and commerce will be minimized by proper planning and efficient construction scheduling.

The overall environmental impact of the project on the Port City region will be significant and positive.

Chapter Five
INSTITUTIONAL AND FINANCIAL ASPECTS

5.A PCWSC ORGANIZATION AND MANAGEMENT

The present organization chart for PCWSC is provided in Figure 5-1. The Commission has a number of related problems at present, including:

- shortages of professional and highly trained staff;
- excessive numbers of unskilled workers;
- lack of training programs;
- shortages of resources for system operations and maintenance;
- ineffective control over costs;
- inefficient procedures for meter reading, billing and collection;
- inadequate management information systems;
- internal auditor's function lacks independence and;
- poorly located and ineffective maintenance functions.

These and other aspects of the existing PCWSC organization have been reviewed in detail and are explained in Annex 5.

As explained in Section 4.B, significant expansions in the scope and scale of PCWSC's responsibilities are expected as a result of the proposed project. The most immediate stage, project implementation, can be managed relatively simply within the present organizational arrangements. The head of the Design, Construction, and Procurement Division (see Figure 5-1) will in effect become the Project Manager. This division will need to be strengthened considerably, mostly by using engineering consultants for procurement and construction supervision. Administrative procedures within PCWSC will also have to be streamlined in order to deal effectively with the large numbers of contracts.

Certain basic modifications have to be made within PCWSC to allow the organization to discharge its expanded responsibilities successfully. The name should be modified from the Port City Water and Sewerage Commission to the Port City Water and Sanitation Commission, reflecting the diversity of sanitation systems, including sewerage, for which the Commission will be responsible.

Extensive improvements in the organization and management of PCWSC are required to overcome identified problems and to cope with the organization's expanded responsibilities. Several significant changes in the organizational structure of PCWSC are recommended. These changes, illustrated in the proposed organization chart in Figure 5-2, include:

a) Creation of a Customer Services Department to combine all technical and administrative functions serving the consumer directly. It will provide water supply and sanitation services to consumers, make charges, and receive payments. A Public Relations Division will be set up within the Department.

b) Establishment of regional offices in the southern and northern sections of Port City to decentralize most activities of the Customer Services Department and bring this part of the PCWSC organization closer to the people being served. These regional offices will also handle local aspects of system operation and maintenance. The southern office will be located in the present PCWSC complex at the Railway Treatment Plant, and the northern office will be located at a site to be obtained along the Farmville Road.

c) The combination of financial and administrative functions in one department to include three divisions which do not exist in the present organization:

- Management Accounting Division to design and monitor all financial and information systems and prepare reports for senior management and the Board;

- Treasury Division to handle the cash and debt management functions within the present Expenditures Division; and

- Training Division, as explained below in Section 5.B.

d) The Internal Auditor to report directly to the Board of Directors.

e) Setting up a Loss Reduction Unit under the Water Supply Division in the Operations Department in order to concentrate on reducing unaccounted-for water.

f) Creation of a new unit to maintain on-site sanitation systems in the Operations Department.

Annex 5 provides a more detailed description of the organization and management improvements proposed for PCWSC, including basic changes in financial systems.

5.B STAFFING AND TRAINING IMPLICATIONS

The effectiveness of any organization depends fundamentally on its staff. The recommended improvements within PCWSC, which are necessary to achieve the objectives of the project, cannot be achieved without significant changes in the staffing of the Commission.

In mid-1982, the staff engaged by PCWSC totalled 2,022, of whom some 47% were temporary workers, all unskilled. Further information on the classification and departmental allocation of the present staff is provided in Annex 5.

A comprehensive analysis has been completed of the numbers and qualifications of staff required by PCWSC to discharge its expanded responsibilities effectively in the years ahead. In 1987, the first year in which the project will be fully operational, the projected staffing plan requires a total of 2,150 employees. Comparison with the 1982 situation reveals several interesting points:

a) Staffing proposed for 1987 is only 6% larger than in 1982, despite the increased scale of activities. The relatively small increase is due primarily to much more effective use of staff and to delegation to contractors of certain routine tasks, such as maintenance of on-site sanitation facilities.

b) The proportion of unskilled workers is projected to drop from 69% in 1982 to 30% by 1987, with a corresponding increase in the number of professional, technical, administrative, and clerical staff.

To implement the proposed staffing improvements is probably the largest single challenge faced by PCWSC. Many existing staff need to be reoriented, motivated, and retrained, while more need to be hired, trained, and managed. Training is particularly essential in the on-site sanitation technologies for which PCWSC will assume responsibility.

The basic planning for the major staff development program has already been completed. Job descriptions, including required qualifications and experience, have been prepared for some 120 key positions in the revised organization. Staffing and training needs have been defined by comparing the proposed future staffing to current conditions within PCWSC. Training resources in Port City and elsewhere in Optima have been assessed in order to determine how they can be used to assist PCWSC. Institutions that can help include the University of Optima, the Capital City Management Institute, Polytechnics in Port City and Capital City, the National Trades School, and several Schools of Commerce. Outlines for external and in-service training courses have been prepared. Details are provided in Annex 5.

The necessary staff development program cannot succeed unless several essential conditions are met:

a) The Board of Directors must endorse a revised organization plan for PCWSC and agree on the staffing implications, in order that the policy and framework for the training will have formal approval.

b) A properly qualified professional needs to be selected as Chief of the Training Division. An appointment from outside PCWSC is recommended.

c) Senior managers of PCWSC should be appointed on a part-time basis to a Personnel Task Force which would coordinate the staff development program. Many improvements are required in personnel management throughout the Commission, in addition to an intensive training program, and the senior managers have to be involved in planning and implementing the program if it is to succeed.

d) Manpower development consultants need to be engaged to assist PCWSC to manage the program, including orientation of existing managers and supervisors, training of PCWSC trainers, and detailed planning for training courses.

PCWSC cannot expect to complete a major upgrading of its staff without incurring significant expenditures. The training program will involve up to 300 people in the peak years (1985 and 1986). The training activities will have costs, and there will likely be a slight reduction in performance by the staff being trained in the short term. (However, the long term gains in productivity will be substantial.) The most profound financial impact, however, will be on PCWSC's payroll. The Commission will have to increase its salary budget significantly in order to recruit and retain properly qualified staff.

PCWSC salary scales for managerial, technical, and administrative staff are, on average, about 15% lower than in comparable organizations (public utilities, railway, Port Authority) and should be adjusted selectively in order to be competitive. Unionized employees (clerical workers, artisans, and unskilled workers) already receive wages which are at or above the market rates. The increase in staff costs will result mainly from the revised structure of the organization, with much more emphasis on professional and highly qualified staff. The financial projections allow for considerable real increases in wages between 1982 and 1987 to reflect the anticipated improvements in the quality of PCWSC staff.

The recommended investments in the staff development program will probably produce greatest returns and have a more significant impact on the quality of water supply and sanitation services in Optima than any other feature in the project.

5.C FINANCIAL HISTORY OF PCWSC

Since 1974, PCWSC has had a uniform water supply charge of Z0.25/m^3 applied to both residential and commercial and industrial customers. Of the residential consumers in 1982, 91% were metered, but about 15% of the meters were not functioning. These latter consumers are billed on the same basis as the unmetered consumers, which for billing purposes are assumed to use about half the consumption of metered connections. This practice results in a substantial loss in revenues when meters are not functioning. All commercial and industrial accounts are metered. About one-fourth of standpipe consumption is metered, but all supplies are provided without charge. Because of this, PCWSC's average revenue for water delivered is Z0.244 per m^3. About one-third of PCWSC's customers have sewerage connections. A sewerage charge of Z0.15/m^3, equal to 60% of the water charge, is billed to these customers on the basis of water consumed.

Tariff increase proposals are prepared by PCWSC management and approved by its Board. They are then submitted to the Ministry of Finance for approval. In late 1980 and in early 1982, tariff increase proposals to cover rising costs were submitted to the Ministry of Finance, but were rejected on the grounds of controlling inflation.

Between 1979 and 1982, revenues from water sales increased only 4%, which was in line with the increase in sales volume as tariffs remained constant throughout the period. Volumes actually delivered probably increased from 6-7%, but since 1979 the number of connections with meters not working increased by 22%, and the number of connections without meters more than doubled. The result was that unaccounted-for water (the difference between water produced and that actually billed) increased from an already high 44% in 1979 to 45% in 1982. In order to maintain revenues, minimize tariff increases, and control wastage, it is essential that most, if not all, of PCWSC's consumers be metered and billed on a volume basis. A program to replace defective meters (now 15% of those installed) and install new meters (9% of connections are unmetered) should be undertaken on a priority basis.

Revenues from sewerage services, which account for just under 20% of combined water and sewerage revenues, were up only 1.4% between 1979 and 1982. This modest increase reflects the fact that there were only a few new connections during this period and that tariffs remained stable.

While total revenues increased only slightly between 1979 and 1982, total costs and unit costs were increasing. Working expenses (excluding depreciation) increased by 32%, and total operating expenses by 29%. On a unit cost basis (production), working expenses increased from Z0.12 per m^3 of production in 1979 to Z0.16 per m^3 in 1982 and total operating expenses on a unit basis from Z0.15 per m^3 to Z0.19 per m^3, both gains of about 25%. Considering that general price increases since

1979 have been 40%, PCWSC has done an excellent job of controlling costs. Nevertheless, the financial performance of PCWSC has deteriorated sharply since 1979. The operating ratio increased from 0.84 in 1979 to 1.02 in 1982; and from a Z2.7 million net income position in 1979, PCWSC moved to a net loss of Z0.8 million in 1982. From 1974 to 1982 PCWSC's rate of return on net fixed assets in operation fell from 4.6% to a negative 0.6% on an historical cost basis and from 3.8% to a negative 2.0% on a revalued basis.

Summary financial statements for the years 1979-1982 are presented in Table 5.1, and detailed statements are given in Annex 7.

Table 5.1 PCWSC INCOME AND EXPENSE 1979-1982

	1979	1980	1981	1982
	Z million			
Operating Revenues	20.0	20.4	20.8	21.3
Working Expenses	13.7	14.5	16.6	18.2
Depreciation	3.1	3.2	3.4	3.5
Operating Income	3.2	2.6	0.8	(0.4)
Interest Expense	0.5	0.5	0.4	0.4
Net Income	2.7	2.2	0.4	(0.8)

Source: Table A7.2 in Annex 7.

Although there is no formal cost accounting system, an attempt has been made to classify expenses between water and sewerage. On the assumption that administrative expenses and depreciation are allocated in proportion to direct costs, it appears that water operations resulted in an operating deficit of Z1.3 million in 1982, while sewerage operations produced operating income of Z0.9 million. Water and sewerage revenues and expenses for 1982 are summarized in Table 5.2.

Since 1979, PCWSC's internal cash generation has steadily declined. In 1982 it was Z3.1 million, which was half of the 1979 level. The result of the deteriorating cash flow was a reduction in major maintenance and renewals and in capital expenditures.

PCWSC's collection experience has been deteriorating, with accounts receivable of Z10.2 million in 1982 representing about 6.7 months' billings versus 4 months' billings in 1979. This issue needs to be

Table 5.2 WATER AND SEWERAGE ESTIMATED OPERATING INCOME, 1982

	Water	Sewerage	Total
	---------	Z million	----------
Revenues	17,129	4,129	21,258
Working Expenses	15,443	2,745	18,188
Depreciation	2,965	523	3,488
Operating Income	(1,279)	861	(418)

Source: Table A7.2 in Annex 7.

addressed immediately with improved billing, and enforcement of payment deadlines through shutting off connections of overdue customers. The proposed organizational changes outlined in Annex 5 should facilitate these financial improvements.

Because of its reduced cash inflow, PCWSC has been slow to pay its obligations; accounts payable now are more than twice the level they were in 1979 and represent 4.0 months' working expenses versus 2.5 months' in 1979. As a result of this, coupled with the very low level of capital expenditures, PCWSC's liquidity has not been impaired. Cash balances have changed only slightly since 1979 and are still adequate. In the future, however, major capital expenditures are clearly going to be necessary, including the proposed project. Moreover, there is little room for increases in accounts payable. Without a tariff increase or increased borrowing, therefore, liquidity levels will soon become unsatisfactory.

PCWSC's balance sheet position is strong. Equity, which consists of government grants, consumer contributions, and retained earnings, was Z77.4 million at the end of 1982, whereas debt was only Z6.0 million. This low debt/equity ratio provides a sound base for the expansion of debt to be incurred to meet PCWSC's investment requirements in the subsequent four years.

5.D TARIFFS AND FUTURE FINANCIAL SITUATION

Financial projections for PCWSC have been prepared for the period 1983 through 1989 in current Z. The detailed financial statements, together with the operating data and the underlying basic assumptions, are presented in Annex 7. The principal basic assumptions are:

a) water sales growth of about 7% per annum;
b) reduction in unaccounted-for water from 45% in 1982 to 38% in 1989;

c) assumption by PCWSC of responsibility for all sanitation services for Port City in 1985; and
d) annual inflation rates of 12% in 1983, declining by 1% annually to 9% in 1986, and remaining at that level in subsequent years.

The present tariff of Z0.40/m^3 for water and sewerage combined is below the long run margincal cost of supply, which is estimated to be Z 0.99/m^3 at a discount rate of 10%, as indicated in Table 5.3. Accordingly, an immediate tariff increase is required if tariffs are to be brought more into line with financial requirements and economic costs.

In 1983, operating losses are expected to deteriorate from Z0.4 million in 1982 to losses of Z1.3 million and the net loss to double to Z1.7 million. In 1984 the increase in average domestic tariffs per m^3 is projected to be 16%, and in industrial and commercial tariffs 40%, for an overall increase of 20%. Operating expenses are projected to increase by 16%, and the projected result for 1984 is an operating income of Z1.1 million and net income of Z0.8 million. In subsequent years, tariff increases and revenues are projected to outpace expense growth, and substantial operating income is projected for all years after 1985. PCWSC's rate of return on net fixed assets in operation and on a revaluted basis remains negative through 1984, increases to 4.6% in 1985 and gradually declines in subsequent years. Net income will experience a sharp drop in 1987 as almost Z11.0 million of interest on new loans is charged against current revenues, as opposed to being capitalized during the period of construction of new facilities. Summary income statements for PCWSC are presented in Table 5.4.

The Steering Committee instructed, however, that a method of charging for water be adopted that would meet financial rather than economic criteria, i.e., that charges should be set at a level sufficient to generate revenues to meet operating costs, internally financed capital investments and debt service obligations.

Table 5.3 LONG RUN MARGINAL COST OF WATER SUPPLY AND SANITATION

Annual Water Sales (million m^3)			Incremental Costs (Z million of 1982)		
Year	Total	Incremental	Capital	Operating	Total
81	64.1	-	-	-	-
82	64.9	-	2.1	-	2.1
83	67.7	-	8.4	-	8.4
84	73.0	-	15.8	-	15.8
85	79.2	6.2	57.4	1.6	59.0
86	86.1	13.1	27.2	3.4	30.6
87	97.6	24.6	11.9	6.4	18.3
88	99.3	26.3	11.9	6.8	18.7
89	102.4	29.4	24.8	7.6	32.4
90	109.3	36.3	37.7	9.9	47.1
91	116.7	43.7	37.7	11.4	49.1
92	124.6	51.6	11.9	13.4	25.3
93	133.0	60.0	11.9	15.6	27.5
94	140.2	67.2	35.6	17.5	53.1
95	147.7	74.7	59.4	19.9	78.8
96	155.7	82.7	59.4	21.5	80.9
97	169.0	91.0	11.9	23.7	35.6
98	172.9	99.9	11.9	26.0	37.9
99	182.2	109.2	11.9	28.4	40.3
2000	192.0	119.0	11.9	30.9	42.8

Present value at discount rate of		Total Water Sales (million m^3)	Total Water and Sanitaion Costs (Z million)	Marginal cost (Z per m^3)
	8%	329.2	306.4	0.93
	10%	260.5	256.6	0.99
	12%	208.2	217.2	1.04

Note: This marginal cost includes all sanitation project and program costs on the ground that the costs of excreta and wastewater disposal must be considered as well as the costs of supplying water.

Table 5.4 STATEMENT OF PCWSC PROJECTED INCOME AND EXPENSE, 1983-89

	1983	1984	1985	1986	1987	1988	1989
	Z million						
Operating Revenues	22.7	29.1	43.9	50.1	59.8	67.2	78.2
Working Expenses	20.4	24.2	28.6	32.7	41.1	45.1	52.8
Depreciation	3.6	3.7	4.0	4.5	6.1	8.2	9.1
Operating Income	(1.3)	1.1	11.3	12.9	12.6	13.9	16.2
Interest	.4	.3	.8	.7	11.5	11.2	10.9
Net Income (loss)	(1.7)	.8	10.5	12.2	1.1	2.7	5.3
Rate of Return (historical	(1.8)	1.5	14.3	14.1	9.1	6.9	7.2
Rate of Return (revalued)	(2.9)	(1.5)	4.6	4.4	3.1	2.6	2.5

Source: Table A7.2 in Annex 7.

Metering and charging for water and sanitation services, according to the volume of water consumed is equitable, provides correct economic signals, and is administratively convenient. The costs of providing meters for even low volume consumers are more than offset by the benefits that result from charging according to actual use. The possibility of alternative methods of charging for these services have been considered and rejected. Non-metering alternatives such as charging all consumers a fixed charge for water and sanitation services are unsuitable because they are inequitable, with large volume consumers being subsidized by low volume ones. Property tax surcharges are rejected on the same ground and also because they would involve other branches of Port City's local government in the water and sanitation sector, complicating administrative arrangements and probably in increasing associated costs.

It is assumed that tariffs will not be revised before project implementation begins in 1984 and that they will then be increased annually. To meet the financial objectives, water tariffs will have to be increased from the present level of Z0.25/m^3 to Z0.45/m^3 in 1989. Because prices are expected to increase 72% by 1989, the real tariff in 1979 would be Z0.26/m^3, representing a real increase of only 4%. The sanitation surcharge is projected to remain at 55% of the water charge, but because PCWSC will greatly expand its sanitation services, this charge will be levied on all water users commencing in 1985 rather than just on those with sewerage connections, resulting in a much more rapid increase in sanitation revenues than in those from water.

The resulting average annual tariffs (z/m^3) are shown in the following schedule:

	Water	Sanitation
1984	0.30	0.17
1985	0.34	0.19
1986	0.35	0.19
1987	0.37	0.20
1988	0.40	0.22
1989	0.45	0.22

PCWSC's cash sources and requirements are projected to be in balance during the forecast period. PCWSC's financing plan for the period of construction, 1983 through 1986, is presented in Section 5.F. The major contributors to the satisfactory level of internal cash generation are the volume increases of 33% in water and 238% in sewerage/sanitation during the 1982-86 period, the tariff increase referred to previously, and the improvement in collection of accounts receivable from 6.7 months' billings at present to 2.8 months' by 1986. In 1987, when the debt service on the new loan commences (about Z15.0 million annually), PCWSC's debt service ratio will reach a low 1.2 but will increase in subsequent years.

PCWSC's liquidity is projected to be satisfactory throughout the forecast period, although the cash position will be tight in 1983, before the tariff increase, and in 1984, as accounts payable are reduced. Between 1983 and 1989, PCWSC's net fixed assets in operation will triple to Z225.0 million, and long-term debt will increase by Z107.3 million to Z113.3 million. Reflecting a doubling of the equity base to Z124.0 million, through consumer contributions and retained earnings,PCWSC's debt/equity ratio in 1989 is projected to be a satisfactory 50/50.

The financial projections indicate that with a modest 4% real increase in tariffs, the proposed expansion can be undertaken without impairing liquidity and PCWSC will have the capacity to service the new debt to be incurred. The financial risk, apart from the possibility of cost overruns or project delays, is that there could be delays in approvals of tariff increases by the government. Accordingly, it is essential that the government make a commitment to a general tariff increase program indicated by these projections as a precondition to approaching external lenders for financing. Tariffs should be reviewed annually during the construction period and adjusted to meet the requirements of revised financial forecasts. It seems likely that a major tariff increase will be necessary in the early 1990s to bring tariffs even more in line with marginal costs and to permit investments in the next water source for Port City.

The projections made here show that a 4% real increase in tariffs will suffice to ensure that PCWSC has the capacity to meet its financial obligations. Such an increase will, however, lead to only a low rate of return on net fixed assets in operation in the 2-5% range (Table 5.4). Ideally this rate should be in the 6-8% range, indicating a higher tariff. Marginal cost calculations also indicate that the tariff should be at least doubled in real terms (Section 5.C). The 4% increase is, however, consistent with the Steering Committee's instruction that the minimum tariff increase necessary to finance the project should be adopted. While only representing a 4% real increase, these minimum increases will about double current tariffs and the Steering Committee believed that further increases would produce hardship for low income consumers and jeopardize future industrial growth. The Steering Committee directed that larger increases should not be implemented without further study.

Structural changes in the tariff are also required. Water tariffs should be made more progressive to discourage consumption above basic requirements and to have the charges for higher blocks of consumption more nearly approach marginal costs. The estimate of consumption of consumers whose meters are not working or which do not have meters needs to be revised upwards to approximate actual consumption. A cost study for sanitation services needs to be made to ensure proper pricing of sanitation services in relation to costs, as opposed to retaining the surcharge on water. A further study is recommended to determine a tariff structure which will meet PCWSC's revenue requirements, take into account long run marginal costs, and provide affordable services to low income consumers. Draft terms of reference for this study are provided in Annex 6. The study should be begun in 1983, completed in 1984 and its results implemented for 1985. The present report contains preliminary estimates of the work that should be conducted in depth in the tariff study.

5.E FINANCING PLAN

Total financial requirements during the period 1983 through 1986 amount to Z175.1 million of which Z161.6 million is for new investment. These requirements are proposed to be met by a combination of internal cash generation, government loans and grants, consumer contributions, and foreign loans, as indicated in Table 5.5. Annex 7 provides the basic assumptions, indicating the terms of all debts. The project will have no financial impact on the Port City municipal budget.

PCWSC's internal cash generation and consumer contributions will meet 24% of financing requirements, with an almost equivalent amount being provided by government. Foreign loans will cover the estimated foreign exchange cost of the capital expenditures (50%) and meet 46% of PCWSC's total financing requirements. The Productivia Agency for

International Development (PAID) is financing the Immediate Improvement Project. The tentative sources for new external loans are the Oceania Development Fund, which has expressed interest in financing the sanitation component, and the International Bank, which provided an engineering loan to help finance project preparation. Once commitments are made by external lenders, the financing plan is feasible, contingent on the government's agreement to a program of tariff increases and the provision of grants/loans, to PCWSC which together will cover local investment costs and meet working capital and debt service requirements.

Table 5.5 PCWSC FINANCING PLAN, 1983-1986

Requirements	Amount (Z millions)	%
Capital Expenditures[1/]	161.6	92
Debt Service	4.6	3
Consumer Loans	8.9	5
Total Requirements	175.1	100
Sources		
Internal Cash Generation	39.9	23
Government Grants	2.4	1
Government Loans	41.0	24
Consumer Contributions	5.4	3
Working Capital	1.4	1
Foreign Loans:		
PAID Loan (IIP)	4.1	2
Oceania Development Fund	21.6	12
International Bank	59.3	34
Total Sources	175.1	100

1/ IIP costs and project costs (Table 4.6) including capitalized interest.

Source: Table A7.5 in Annex 7.

Chapter Six
CONCLUSIONS AND RECOMMENDATIONS

6.A JUSTIFICATION

Both the strategic plan through the year 2000 and the proposed project for 1984-86 represent the least cost alternatives to meeting Port City's water supply and sanitation needs, defined as safe water supply and improved sanitation for all the city's residents and adequate water and wastewater arrangements for industry. This feasibility study has confirmed this finding of the Pre-feasibility Report for these major elements of the project and strategic plan:

a) New water source: The North River Wellfield should be constructed first as part of the project, to be followed by the two stages of the Large River scheme as water needs increase, tentatively scheduled for 1989-91 and 1994-96.

b) Domestic sanitation systems: For households with water connections but not in currently sewered areas, the least cost sanitation system which removes both sullage and wastewater is the small bore sewer. This is proposed for the year 2000. For the project period, however, a limited small bore sewer network of 600 ha to serve 239,000 people is proposed.

c) Wastewater treatment and disposal. The proposed Hog's Bay stabilization pond treatment plant discharging to the Inner Harbour should be constructed, rather than the principal alternative of a primary treatment plant at the same location with outfall discharge to the Outer Harbour.

The project is estimated to cost Z134 million between 1984-86, of which Z55 million (41%) represents foreign exchange costs.

The project has an internal financial rate of return of 5.5%, including as revenues the sales of water and sanitation services which result from the major project and the increased revenues and cost savings which result from the IIP (Table 6.1).

The internal financial rate of return is that discount rate at which the present value of the project's costs equals the present value of its revenues, i.e., the present value of the project is zero. The positive rate of return of this project indicates that it is justified as an investment. The rate of return is relatively low, however, because PCWSC's financial health is such that only a 4% real increase in tariffs is necessary to make the project financially feasible. A larger tariff increase would increase the rate of return.

Table 6.1 INTERNAL FINANCIAL RATE OF RETURN (a)

(1) Year	(2) Capital Costs (Z million)	(3) Incremental Water Sales (million m³)	(4) Net Revenues from Water Sales(b) (Z million)	(5) Incremental Water Sales for Sanitation Surcharge (million m³)	(6) Net Revenues from Sanitation (c) (Z million)	(7) Increased Revenues from IIP (d) (Z million)	(8) Cost Savings from IIP(e) (Z million)	(9) Net Revenues minus Costs(f) (Z million)
1982	2.1	–	–	–	–	–	–	(2.1)
1983	8.4	–	–	–	–	0.2	0.1	(8.1)
1984	15.8	–	–	–	–	2.2	0.1	(13.5)
1985	57.4	6.2	0.2	46.9	3.8	–	0.1	(53.3)
1986	27.2	13.1	0.5	53.8	4.3	–	0.1	(22.3)
1987	–	24.6	1.0	64.8	5.2	–	0.1	6.3
1988	–	26.3	1.1	66.6	5.3	–	0.1	6.5
1989	–	29.4	1.2	69.6	5.6	–	0.1	6.9
1990	–	36.3	1.5	76.1	6.1	–	0.1	7.7
1991	–	43.7	1.7	83.4	6.7	–	0.1	8.5
1992	–	51.6	2.1	91.1	7.3	–	0.1	9.5
1993-2014(g)	–	52.2	2.1	99.3	7.9	–	0.1	10.1

Internal Rate of Return: 5.5%

Notes: (a) Costs of project and IIP expressed in 1982 prices.
(b) Column (3) x Z 0.04 (The margin between water revenues and operating expenses in 1986 is Z 0.06 i.e., Z 0.04 in 1982 prices).
(c) Column (5) x Z 0.08 (1986 sanitation margin is Z 1.12, i.e., Z 0.08 in 1982 prices).
(d) Increased revenues resulting from a reduction in unaccounted-for water as a result of the IIP.
(e) Cost savings resulting from the need to treat less water to make sales as a result of the IIP.
(f) Columns (4) + (6) + (7) + (8) - (1).
(g) The rate of return is computed for the 30 years (1985-2014) of expected project life.

6.B ISSUES, RISKS, AND SENSITIVITY ANALYSIS

With a project as large and complex as this, there are real risks that have to be recognized and overcome if the project is to succeed.

The key institutional change critical to the success of the entire project is the de facto transfer of all water supply and sanitation responsibility to PCWSC. This was identified as an urgent need in the Pre-feasibility Report. Without it, both project implementation and project operation and maintenance cannot succeed. No action has yet been taken. Numerous other changes in the institutional framework are also necessary, as detailed in Chapter 4 and Annex 1.

A second major issue related to sanitation is the widespread introduction of technologies new to the Port City region. Promotional and educational support activities are essential to this. They have been extensively included within the proposed project. Nonetheless, because these activities are themselves new to Port City, unforeseen problems may arise.

The project depends also on the acquisition of two parcels of land outside the city: for the North River Wellfield and for the new Hog's Bay Treatment Plant. Rights of way for the pipeline from the North River wellfield to the city are also required. Negotiations to acquire these should begin even before funding is assured.

Major problems are not anticipated in the squatter areas which will be served with water supply and sanitation by the project. There are as always, some potential risks with these project components because of the difficult social and political environment. These are likely to be much greater in Blight Heights, where community organization and leadership are weak and where the absence of land tenure means that squatters are unlikely to be prepared to invest in improvements to the property they occupy.

A series of financial issues and risks exists. The projections in Chapter 5 indicate that the financial health of PCWSC depends on an increase in its tariff from a flat rate of Z0.25 per m^3 to a graduated tariff of Z0.20 per m^3 for the first 20 m^3 per month (lifeline tariff for low income residents), plus Z0.35 per m^3 for all consumption above 20 m^3 in 1984, with increases scheduled on a regular basis. PCWSC revenues might not reach projected levels for three possible reasons:

1) the proposed tariff increases might not be approved and implemented for political reasons;

2) revenue collection may not prove as efficient as anticipated;

3) water demand projections may prove to have been over estimated.

It is, therefore, essential to the successful operation of PCWSC, and hence of the project, that the proposed tariff increases be adopted. Moreover, they must be adopted without a delay, as this would also reduce PCWSC's projected revenues. Furthermore, the major efforts proposed to improve PCWSC's billing and collection procedures are a critical element in ensuring project success.

The water demand (and hence wastewater flow) projections are based on carefully derived population and water use projections. Experience has shown, however, that actual water sales frequently vary from earlier projections. If sales are significantly below those projected, then PCWSC's finances will again be in difficulty.

Continuous refinement of the water demand projections to take account of actual population growth and water consumption is essential. This is not likely to be a problem during the project period, however, as many of its components are designed to help Port City's water supply and sanitation system catch up with existing needs. It will be important in the post-project period and would affect the timing of investment in the Large River surface source ,indicated as PCWSC's next major water supply project.

Higher costs than projected, as well as lower revenues, could also jeopardize PCWSC's finances and hence the project. Project cost estimates could prove too low. Those used in this feasibility study are considered reliable within ±15% at constant prices. Nonetheless, considerable uncertainties surround the estimates in current prices because of the difficulty of forecasting future inflation rates. Delays in implementation could also lead to cost overruns. High domestic inflation rates could also lead to a devaluation of the Zinar, making repayment of the foreign loans anticipated for the project more expensive. In addition, the terms assumed for these loans are based on current interest rates charged by the international financing sources which have expressed an interest in the project. The actual terms of the loans secured for the project may turn out to be more onerous than these assumptions. Finally, costs could be higher than projected if major elements in the operating costs (e.g. energy or chemicals) increase for unanticipated reasons.

Table 6.2 indicates the effects on net income, the operating ratio, and the debt service ratio of a 10% reduction in revenues or a 10% increase in operating expenses. In terms of net income, three of the five forecast years would show a loss for PCWSC. The operating ratio would be above 1.00 through 1984, but would be satisfactory in subsequent years. A serious situation regarding debt service would exist in 1987, when internal cash generation would not meet requirements.

Table 6.2 SENSITIVITY OF FINANCIAL RATIOS		1983	1984	1985	1986	1987
Base Case	Revenues (Z 000)	22,698	29,082	43,855	50,088	59,834
	Operating Expenses (Z 000)	24,016	27,937	32,573	37,028	47,202
	Net Income (Z 000)	(1,675)	825	10,550	12,217	1,124
	Operating Ratio	1.06	0.96	0.74	0.74	0.79
	Debt Service Ratio	3.0	6.4	10.0	11.4	1.2
Revenues Reduced by 10%	Revenues (Z 000)	20,428	26,174	39,469	45,079	53,851
	Operating Expenses (Z 000)	24,016	27,937	32,573	37,028	47,202
	Net Income (Z 000)	(3,945)	(2,083)	6,164	7,208	(4,895)
	Operating Ratio	1.18	1.07	0.83	0.83	0.88
	Debt Service Ratio	0.0	2.6	7.2	8.1	0.8
Operating Expenses Increased by 10%	Revenues (Z 000)	22,698	29,082	43,855	50,088	59,834
	Operating Expenses (Z 000)	26,418	30,731	35,830	40,929	51,922
	Net Income (Z 000)	4,077	1,969	7,293	8,496	(3,596)
	Operating Ratio	1.16	1.06	0.82	0.82	0.87
	Debt Service Ratio	(0.1)	2.7	7.9	9.0	0.92

During the 1983-87 period, a 10% reduction in revenues would reduce internal cash generation by Z16.9 million. Either would necessitate and equivalent amount of additional financing to cover capital expenditures during the period. An additional risk is that of cost overruns on capital expenditures; a 10% increase in project costs, for example would require additional internal cash generation, presumably through tariff increases, or additional financing of Z13.4 million.

6.C RECOMMENDED ACTIONS

Detailed actions necessary to implement the project are described in Chapters Four and Five and associated annexes. Several steps are essential if the project is to be successfully and efficiently implemented:

a) Approval of the project must be obtained from the government of Optima;

b) The Ministry of Water Development must formally grant permission for the extraction of groundwater from the North River Valley;

c) Project finance must be arranged by PCWSC, from the Ministry of Finance for local currency costs and from international lending agencies for the foreign currency costs;

d) Approval of the PCWSC Board and the Ministry of Finance must be obtained for the proposed tariff increase for 1984;

e) The tariff study recommended in Annex 6 must promptly commence and be completed by mid-1984 to permit adoption of a new tariff structure and schedule from 1985 onwards;

f) The necessary changes in institutional responsibilities for sanitation must be implemented as soon as possible to enable PCWSC to control and implement the project;

g) PCWSC's organization must be modified and strengthened, with extensive training and retraining of staff; and

h) Preliminary steps must be taken toward acquiring the land necessary for the North River Wellfield and the Hog's Bay Wastewater Treatment Plant.

FEASIBILITY REPORT FOR PORT CITY

INSTITUTIONAL RESPONSIBILITIES RELATED TO WATER SUPPLY AND SANITATION

Annex 1

INSTITUTIONAL RESPONSIBILITIES RELATED TO WATER SUPPLY AND SANITATION

Table of Contents

INSTITUTIONAL RESPONSIBILITIES RELATED TO WATER SUPPLY AND SANITATION

A. INTRODUCTION

This annex discusses the institutional, legislative, and regulatory framework of the proposed project. It covers a wide range of topics, from the relative responsibilities of PCWSC and the Ministry of Health through the property rights of squatter communities to the local building and plumbing code, reflecting the many areas that may affect the project's outcome. Each topic is discussed in a separate section of this annex, but according to a standard format.

In each section, the current situation is first described, including any difficulties which it does or may cause. Alternatives are listed and one is recommended, including the rationale for its choice. Legislative, regulatory, and institutional changes necessary to implement the recommended action are then noted.

In general, the criteria used in making each recommendation are presented in each section (under "Rationale"). Two overriding criteria were, however, applied throughout the analysis:

a) Insofar as possible, PCWSC should be the only agency responsible for providing water supply and sanitation services in Port City;

b) Existing formal responsibilities should, wherever possible, be left intact, while ad hoc arrangements are made to achieve the desired changes, without recourse to new legislation which inevitably invites delays.

B. OVERALL RESPONSIBILITIES FOR WATER SUPPLY AND SANITATION

Current Situation:

- The Port City Water and Sewerage Commission (PCWSC) is responsible for all public water supply and sewerage. (Basic legislation was passed in 1955 transferring responsibility to PCWSC from the then Ministry of Public Works.) PCWSC provides all water and sewer connections.
- Private well owners are responsible for their own water supply.
- Five industries and institutions have private wastewater treatment plants.
- The Ministry of Health (MOH), as part of its public health work, is responsible for setting and maintaining operating standards for on-site sanitation systems (cesspits and septic tanks). In

practice, MOH is hardly active in waste disposal within Port City, concentrating its limited resources instead on other public health matters like food inspection.

- The Port City Local Government is responsible for the local building and plumbing code which includes construction specifications for septic tanks. (Cesspits are formally illegal under the code, although they are the most common on-site sanitation system in use in Port City.)
- Property owners are responsible for septic tank and cesspit emptying, using private sludge truck operators.

Alternatives:

1. Current situation.
2. Current situation, with improved MOH staffing to allow it to properly discharge its public health duties with respect to on-site sanitation.
3. One agency (PCWSC) in de facto control of all water supply and all sanitation services in Port City, linking the provision of a house water connection to the existence of an approved sanitation system for the disposal of wastewater. (Mainly independent wells and wastewater treatment facilities are now in private hands.) This could be achieved by having MOH formally delegate responsibility for assisting in on-site sanitation systems to PCWSC, while reserving functional responsibility for inspection of sanitation systems and water supplies to insure that public health is not jeopardized. PCWSC could then include a sanitation surcharge on the water bill of all houses with water connections, compulsorily providing sewerage services in the sewered areas and maintenance services (desludging) for on-site sanitation systems elsewhere.
4. As 3, with all responsibilities legally transferred to PCWSC.

Recommend: Alternative 3.

Rationale:

1. Avoids disputes over responsibilities by placing one agency in firm control (PCWSC).
2. Little or no legislative change is necessary, and yet the relative ineffectiveness of MOH is overcome.
3. Mainly technical work is necessary for on-site sanitation, and PCWSC has engineering expertise, unlike MOH.
4. Some areas are to have on-site technologies in the project, but have small bore sewers by the year 2000. It is better to have the same institution responsible for both as the on-site systems will be converted into interceptor tanks for small bore sewers.

5. All water and sanitation charges can be collected by one agency through a sanitation surcharge on all water bills.
6. PCWSC can use the same arrangements to clean out existing septic tanks and cesspits as for future sullage soakaways and interceptor tanks; pumping out need not be charged for separately, but it will be provided as one service under the sanitation surcharge.

Necessary Changes:

1. Delegation of MOH inspection and enforcement authority to PCWSC (approval of PCWSC Board and of Minister of Health necessary).
2. PCWSC to be empowered to withhold water supply until it is satisfied that a property's sanitation system is satisfactory for removing resulting wastewater.
3. A requirement that a property must connect to the conventional or small bore sewer if it is in a sewered area.
4. Mandatory charging for sanitation for all consumers with water connections, probably through a surcharge on the water bill.
5. Expansion in the organization and staff of PCWSC - see Annex 5.
6. Possible financial implication for PCWSC - see Annex 7.

C. CONSTRUCTION AND FINANCING OF ON-SITE SANITATION FACILITIES

C.1 On-site Components of Off-site Technologies (conventional and small bore sewerage)

Current Situation:

- Property owner provides (through a contractor) and pays for all on-site sewerage components within the property line; PCWSC provides components up to the property line and connects up on payment of a connection fee.

Alternatives:

1. Current situation.
2. Current situation ammended so that PCWSC could itself provide or arrange for local banks to provide loans (possibly subsidized) to assist low income users with installation costs. (These will be high with small bore sewerage because of the expensive interceptor tanks.)
3. PCWSC provides (through its own staff or through contractors) all installations off and on the property up to the house, and the property owner pays the full cost, possibly assisted with a PCWSC or bank loan to be repaid on the water bill.

4. As 3, except property owner pays a connection fee less than the full cost, possibly with a loan to be repaid on the water bill.
5. As 3, except property owner pays no connection fee.

Recommend: Alternative 4

Rationale:

- This ensures that installations are properly constructed; yet the property owner remains responsible for continued maintenance of pipes, etc., on his property (desludging of the interceptor tanks would be a PCWSC responsibility as discussed in Section B).
- Eliminates potential inequity as on-property costs of small bore sewerage are higher than those of conventional sewerage because of the interceptor tank (although small bore sewerage is the least cost economic solution when all on-site and off-site property costs are included).

Necessary changes:

- Legislation is possibly required to permit PCWSC to operate on private property. This needs further investigation, but it will probably be enough for the property owner to sign an agreement allowing this.

C.2 Septic Tanks, Cesspits and Pour-flush Toilets with Sullage Soakaways

Current situation:

- Property owner provides and pays for the installation and maintenance of these facilities which would be required where properties have water connections but not sewer connections.

Alternatives:

1. As now.
2. Property owner provides the facilities, but PCWSC inspects them before first use and then maintains them, imposing a sanitation surcharge on the water bill.
3. PCWSC provides and maintains the facilities.

Recommend: Alternative 2 (Alternative 1 will continue to obtain where there is a private rather than a PCWSC water connection).

Rationale:

- Few new facilities are necessary and most will be in affluent areas where property owners can afford them. Conventional practice is for developers to provide these facilities for a new house.
- PCWSC gains control of the operation of these facilities without incurring the expense of providing them.

Necessary changes:

- Those discussed in section B above would achieve this recommended alternative.

C.3 VIP Latrines and Pour-flush Toilets

Current situation:

- These technologies are required by residents who do not have water connections on their properties. None presently exist as such residents defecate in the open or use unimproved pit latries which are unsatisfactory. (Residents using public toilets have no sanitation facilities on their properties.)

Alternatives:

1. Householder provides and pays for facility.
2. PCWSC provides facility and householder pays.
3. PCWSC provides and pays for facility.
4. PCWSC provides and pays for slab and underground components; householder provides and pays for superstructure. As an incentive to encourage self-help, PCWSC should provide free bricks and other materials for the superstructure to those who dig the pit for the substructure themselves.

Recommend: Alternative 4

Rationale:

- Necessary quality of construction is achieved for public health purposes (existing unimproved pit latrines indicate that householders do not construct facilities of appropriate standard).
- incentive for householder to save himself and PCWSC costs while maintaining standards.
- Householder involved but bears limited financial costs.

Necessary changes:

- Section B recommendations would achieve this.

D. WATER RESOURCES MANAGEMENT AND PROTECTION

Current situation:

Surface: Ministry of Water Development (MWD) licenses abstractions under the Water Resources Act, 1968 (if more than 100 m^3/day).
- Ministry of Environment (MOE) responsible for water quality and pollution control under the Water Pollution Control Act, 1976, but is ineffective in enforcement.
- Ministry of Health (MOH) can order any source shut down if it is a health hazard under public health legislation.

Ground Water:
- No quality controls at present as there is no legislation in existence (drafts are under preparation as part of a UNDP/FAO project).
- MWD has issued non-binding recommendations for specific sources, pending the passage of the new legislation.
- MOE is responsible for pollution control but ineffective.
- No charges for groundwater use.

Harbour: MOE is responsible for pollution control in general but it lacks laboratory facilities in Port City. PCWSC is responsible for monitoring its own sewage treatment plant effluent discharges. No enforcement of pollution control regulations.

Alternatives:

1. As now.
2. As now, with proper enforcement by MOE.
3. MWD responsible for all abstraction, including licensing, and metering of private wells, of all amounts, even below 100 m^3/day, MOE responsible for all water quality, especially control over wastewater. MOH continues to have right to halt use of any water source on health grounds. (MWD has fees to distinguish among those with existing wells, those constructing new wells, and industrial use of non-potable water).
4. MWD responsible for all abstraction and water quality.

Recommend: Alternative 3

Rationale:

- Logical division of responsibility between management and protection of water resources; brings private groundwater use under control.

Necessary changes:

1. Enact groundwater legislation empowering MWD to issue and charge for licenses for abstraction for all water, regardless of volume.
2. Empower MOH to shut down any ground (as well as surface) source for public health reasons. Strengthen MOH staff in Port City.
3. MWD should set up proper groundwater staff to license abstractions, inventory existing sources and use, and keep records on private wells, or it should delegate this responsibility in Port City to PCWSC.
4. MOE to have a laboratory in Port City and to expand its staff to be able to provide proper resources to monitor and enforce water quality standards, including effluent discharges.
5. MOH to be informed of location of all sources inventoried by MWD or PCWSC.

E. DRINKING WATER QUALITY

Current situation:

- Ministry of Health (MOH) is responsible for standards and enforcement for all drinking water, regardless of whether publicly or privately provided. In practice, it only monitors PCWSC water, and even here very little is done.

Alternatives:

1. As now, with improved monitoring.
2. As now, with coverage extended to all drinking water (PCWSC and private).
3. Transfer responsibility to PCWSC.

Recommend: Alternative 2

Rationale:

- Simple solution which avoids administrative overlaps but meets public health objectives.
- No legislative changes are necessary.

Necessary changes:

1. Strengthen MOH local staff in Port City.

F. PORT CITY MUNICIPAL BUILDING AND PLUMBING CODE

Current situation:

- The code is relatively silent on water and sanitation. Proposed new developments and buildings are not supposed to be approved unless there are "suitable arrangements for disposing of sewage."
- The code does set standards for septic tanks and sewers but there is little enforcement. The code prohibits cesspits; yet they are very common.
- Enforcement of the code is the responsibility of Port City Local Government (Section B above).

Alternatives:

1. As now.
2. As now, with better enforcement.
3. Leave Local Government with formal responsibility, but have it delegate practical enforcement of water and sanitation aspects to PCWSC. Rewrite the code to include standards for all water and sanitation facilities, especially new sanitation systems to be introduced in Port City (pour-flush toilets with sullage soakaways and small bore sewers) and cesspits which, though illegal, are very prevalent. Instruct PCWSC to refuse to provide a house water connection until an acceptable sanitation system is in place.
4. As 3, but transfer formal responsibility to PCWSC.

Recommend: Alternative 3

Rationale:

- No legislative problems; yet gives practical control to PCWSC while avoiding potential disputes over responsibilities.

Necessary changes:

1. New regulations to cover all sanitation systems within a revised code.
2. Minor staff requirements for PCWSC (see Annex 5).
3. Education of local planning authority, inspectors, and contractors in new code.

G. URBAN DEVELOPMENT

Current situation:

- Port City Local Government both prepares urban plans and issues building permits.
- Nor formal inclusion of water and sanitation in permit issuance procedures, except for sewerage and septic tanks (see F above).

Alternatives:

1. As now.
2. As now, with Local Government to consider water and all sanitation when issuing permits.
3. As now, with Local Government consulting with PCWSC re water supply and sanitation implications of future urban plans. Also, Local Government to issue specific building permit only after approval of water supply and sanitation plans by PCWSC. (The key enforcement mechanism is for PCWSC to refuse to approve proposed arrangements unless a method for disposing of wastewater is provided whenever there is a house water connection.)

Recommend: Alternative 3

Rationale:

- This is the only effective alternative.

Necessary changes:

1. Change Port City Local Government by-laws to ensure that PCWSC will approve proposed water supply and sanitation arrangements before Local Government can issue a building permit.
2. Amend building and plumbing code (see F above).
3. Minor staff implications for PCWSC (see Annex 5).

H. EDUCATION

H.1 Formal and Informal

Current situation:

- Responsibility of Ministry of Education.

Recommend: No change in responsibility. Introduction of water-related health topics in school curricula.

Rationale:

- Need to inform students of value of water supply and sanitation systems.

H.2 Hygiene Education

Current situation:

- Responsibility of Ministry of Health but there is little or no activity in Port City.

Alternatives:

1. As now.
2. As now, but do more.
3. Formally as now but have MOH cooperate with and support the Ministry of Education in carrying out hygiene education for children in the schools. MOH would provide curriculum advice and assist in teacher training. Improve adult information program under MOH itself.
4. Transfer responsibility to Ministry of Education.

Recommend: Alternative 3

Rationale:

- Improve situation through inter-Ministry cooperation without requiring legislative changes.

Necessary changes:

1. Agreement between Ministries of Health and Education.
2. Hygiene education for staff of MOH necessary in Port City.

H.3 Training

See Annex 5 for discussion of training needs of PCWSC staff. PCWSC to train contractors by means of demonstration projects for new sanitation technologies.

I. MUNICIPAL SERVICES

Current situation:

- Physical services (garbage, roads, drainage, etc.) are supplied by Local Government. Garbage and drainage services are inadequate and compound unsanitary public health conditions.
- Social services are also provided by Local Government, but lack of trust in government among the low income squatter communities makes this difficult. (Some special projects are also implemented by other agencies, e.g., a family planning project by the Ministry of Health and an urban upgrading project by the Institute of Social Development.)
- Standpipe water is provided and charged for by PCWSC under an agreement with the Local Government. Despite this agreement, the Local Government has not paid PCWSC for standpipe water for several years.

Alternatives:

1. As now.
2. As now, plus further improvements in quality of services and delivery to low income communities.
3. As 2, plus transfer formal authority for standpipes from the Local Government to PCWSC to permit it to cross-subsidize within the water sector. Use the Institute for Social Development (ISD) for project delivery in squatter zones (as described in Chapter 4). Study garbage and drainage services with a view to improvement measures.

Recommend: Alternative 3

Rationale:

- Uses existing ISD expertise and familiarity with low income communities.
- Administratively straightforward: a sub-contract between PCWSC and ISD is all that should be required.
- Rationalize existing standpipe situation.
- Sets up study of necessary parallel services in order that public health improvements to result from the project will not be jeopardized by poor garbage and drainage.

Necessary changes:

- Contract between PCWSC and ISD re project implementation.
- Local Government to employ consultants to study garbage and drainage.

J. PROPERTY OWNERSHIP AND TAXATION

J.1 Land

Current situation:

- System of private ownership.
- No problems in most of Port City, but squatters do not have tenure in Railville A and in Blight Heights.

Alternatives:

1. No change.
2. Grant tenure to squatters over time. The procedure for this is for the government (national or Port City Local Government) to purchase squatted land from its owners; finance is necessary. Plots are then allocated to squatters, measured, and recorded. At the same time, infrastructure is provided or upgraded. The government then attempts to recover land costs through a combined monthly land and infrastructure charge to the resident.
3. Grant "occupancy rights" to squatters (say 20 years).

Recommend: Alternative 2

Rationale:

- Squatters will not be prepared to invest in or look after water supply and sanitation on property they do not consider their own.

Necessary changes:

1. Probably none: enabling legislation existed for Railville B upgrading when squatters got tenure.
2. Organization necessary to conduct upgrading of squatter sites.

J.2 Rental Housing

Current situation:

- Landlord pays for water supply and sanitation services (tenant pays through rent).

Alternatives:

1. As now.

2. Tenant to pay water bill where there is one residential unit per meter, but landlord to provide initial water and sanitation facilities (landlord to pay where multi-family buildings all on single meters).

Recommend: Alternative 2

Rationale:

- Encourage water consumption according to price by having users of service pay the associated charges.

Necessary changes:

- PCWSC to enter into agreements with tenants and to meter all multiple unit properties to ensure that there is one meter on every building with water supply.

J.3 Property Taxes

Current situation:

- Taxes, collected by Local Government, do not include an element for water supply and sanitation.

Alternatives:

1. As now.
2. Include water and/or sanitation element in property tax.

Recommend: Alternative 1

Rationale:

- It is administratively simpler to have PCWSC handle all water and sanitation charges.
- Linking water and sanitation charges to water use permits some control of water use through pricing which, would be lost if there were a flat property tax charge for water and sanitation.

K. CONSTRUCTION AND INDUSTRIAL STANDARDS

Current situation:

- Ministry of Industry sets and enforces standards in Optima.
- The standards are too low and result in poor quality water meters and pipes.

Alternatives:

1. As now.
2. Upgrade the standards to international levels.

Recommend: Alternative 2

Rationale:

- Present quality of Optima manufacturers is inadequate.

Necessary changes:

- Ministry of Industry to issue new set of standards for relevant products.
- Ministry of Industry to encourage and educate manufacturers to adopt the revised standards.

FEASIBILITY REPORT FOR PORT CITY

WATER SUPPLY COMPONENTS OF PROJECT

Annex 2

WATER SUPPLY COMPONENT OF PROJECT

Table of Contents

WATER SUPPLY COMPONENT OF PROJECT

A. INTRODUCTION

This annex deals with water supply facilities to be built in Port City in the project period 1984-86. Basic technical information is first provided for each component; then the implementation schedule is explained; and finally cost estimates are presented. More detailed technical data and engineering designs are published separately in Technical Appendices.

At the present time, PCWSC is implementing the Immediate Improvement Project (IIP) which is expected to be completed by mid-1984. The major project described hereafter is compatible with but distinct from the IIP.

B. DESCRIPTION OF COMPONENTS

1. City Wells

Four wells will be constructed in Suburban Park, the city's largest park, located on the eastern side of the city. Two wells will be near the existing Parkland Reservoir (wells P1 and P2), and another two (wells P3 and P4) some 500 m south along the southern boundary of the park. These well sites and other components of the project are shown on Figure 4-1.

The well sites were selected after extensive groundwater investigations and analysis, based mainly on the study of existing private wells in the upper section of the city. Based on these analyses, the expected conditions for the new wells in limestone beneath overlying alluvial soils are as follows:

Wells	Ground Level (masl)	Depth of Alluvium (m)	Depth of Water Table (m)	Depth of Well (m)
P1 and P2	130	50	95	110
P3 and P4	100	50	75	80

The proposed wells are located on public land in Suburban Park which has been reserved for open space according to the land use plan for the city. The site for wells P1 and P2 at the Parkland Reservoir is already controlled by PCWSC, and no problems are anticipated in acquiring the site for wells P3 and P4 from the city. All wells are located within the third pressure zone of the distribution system.

Water quality from the limestone aquifer is expected to be good, without the problems currently affecting the existing PCWSC wells (high nitrates in the older alluvial wells near the port and high chlorides in the newer limestone wells on the northern side of the city).

Based on experience with comparable private wells in Port City, each new well will be 200 mm in diameter and is expected to yield 5,000 m^3 daily.

Electric submersible pumps will be installed at each well, powered from the existing electric distribution network. Individual chlorinators will be installed at each well.

Water meters will be installed on the outlet from each well and water levels within each well and other existing wells in the area, (none are within 500 m of the proposed sites) will be closely monitored. The Ministry of Water Development is concerned about possible over-pumping from the aquifer beneath Port City and has indicated that PCWSC should not plan to pump for more than 1000 hours yearly, about 10% of the time, until further information is available about aquifer characteristics and water balance. Accordingly, the wells will initially be restricted to operating during periods of peak demand.

Wells P1 and P2 will feed directly to the adjacent Parkland Reservoir. Wells P3 and P4 will be connected to an existing 200 mm distribution line which runs along the southern edge of Suburban Park, approximately 150 m from each of the proposed well sites.

2. North River Wellfield

The North River Valley is located on Figure 2-1, and the proposed development of this major groundwater system is shown in Figure 3-9.

The North River Wellfield lies in alluvial plain formed by the North River. The drainage area upstream of the narrow valley where the Farmville dam is sited covers more than 600 km^2 and is responsible for virtually all of the average flow of 1,550 m^3/day in the North River.

The relatively permeable alluvium in the valley plain upstream of Farmville is known to provide most of the dry season base flow in the North River. Existing wells, built to supply the railroad and a few individual farmers in the area, all produce significant quantities of water at shallow depths (up to 25 m). A preliminary analysis of the groundwater potential in the North River Plain was completed in 1975 by Geohydrological Consultants for the Ministry of Water Development. Their report concluded that some 300,000 m^3/day (100 million m^3/year) could be developed by properly designed wells in this aquifer.

A simulation model of the aquifer was prepared as part of this study. Detailed field examinations within the wellfield included monitoring 17 existing wells, installing ten piezometers for monitoring groundwater levels and drilling and test pumping of two new wells, each 200 mm in diameter. Four existing wells were also test pumped. The results of all field tests and design studies, including a model of the aquifer, are provided in "Technical Appendix A - North River Wellfield System" which has been published separately.

Preliminary analyses, based on the model simulation, suggests that the effect of pumping an average of 300,000 m^3/day from the aquifer would be to lower water levels in the vicinity of the wellfield marginally in wet seasons but by up to four metres during a dry year, with a corresponding reduction in the flows in the North River. Hydrologic analysis of flows to the Farmville Reservoir indicates that available storage would be filled in the February-April rains preceding the main irrigation season in 19 years out of 20 if the wellfield were developed. The tentative conclusion is that development of a wellfield of 300,000 m^3/day capacity in the North River plains would be possible without jeopardizing downstream riparian interests. The alluvial gravels would be operated as a sub-surface reservoir, with recharge mainly from the tributary rivers in the wet season.

The preliminary design of the wellfield and conveyance system is based on a production capacity of 300,000 m^3/day, but PCWSC will initially depend on an average yield from this source of only 200,000 m^3/day. It is likely that such conservative operating criteria can be relaxed after PCWSC gains experience in utilizing this major groundwater source.

On the basis of field investigations and model studies, it is expected that new production wells in the North River scheme can each produce an average of 10,000 m^3/day. A typical well would have the following characteristics:

Diameter	- 200 mm
Ground elevation	- 60 m
Depth of water table	- 5 m
Depth of drilled well	- 15 m

A wellfield site to accommodate 30 wells has been located along the major tributaries to the North River, as shown on the plan and profile in Figure 3-9. The wells would be located along both sides of the North River and its tributary, the Panda River, about 100 m back from the river (to avoid flooding of the top of the well). The wells would be spaced about 200 m apart. Land for the wellfield is presently used by small farmers, mainly for rainfed maize. No buildings are presently located in the proposed wellfield. It would be necessary to expropriate about 45 ha of land for the wellfield, but this land could subsequently be made available to existing local farmers for continued agricultural use under control of PCWSC.

Electrically powered pumps with a capacity of 7 m^3/minute would be installed in each well. The output from each well will be metered.

An electric power distribution system, including step-down transformer and about 4 km of power line, are required for connection to the existing high voltage lines along the railway.

Access to the wells would be provided by gravel tracks to be built in the wellfield along either side of the river. The wellfield would be fenced to limit access to PCWSC staff and farmers leasing the land.

The collector pipelines from the wells will convey the water to a wellfield pumping station. The collector pipes, totalling 8 km in length, range in diameter from 200 to 800 mm and will be of steel, externally wrapped and internally lined.

The wellfield pumping station to deliver the water to the Creektop Reservoir in Port City will incorporate a clear water sump and have the following characteristics:

Sump capacity	- 10,000 m^3
No. of Pumps	- Four (three for peak operation plus one spare)
Type of Pumps	- Vertical centrifugal, electrically driven
Capacity of Pumps	- 100,000 m^3/day each

Venturi meters will be installed to record flows into and out of the pumping station. Gas chlorinators will be used to disinfect the water as it leaves the pumping station.

A connection from the transmission lines of the Optima Power Company will be required for the pumping station, involving 1.2 km of power line plus a transformer. An access road to the pumping station will be built along the power line.

The pumping station site will occupy 1.5 ha of land (which has to be expropriated from a local farmer) and will accommodate operation and maintenance equipment in a combination workshop and spare parts building. No accommodation will be built at the site for operating staff as they will be expected to reside nearby or in Farmville (about 15 km away). Security at the site will be stringent, including fencing, night lighting, and permanent guards.

3. Village Water Supply and Sanitation

Improved water supply and sanitation facilities will be provided to the 25 villages in the North River Valley in conjunction with the development of the wellfield for PCWSC. The villages, each with an average of 400 people, are widely dispersed and sited in an area overlying of good alluvial aquifer. A piped water supply was considered but rejected because of its high costs and the availability of a suitable alternative solution.

The water supply improvements will consist a small diameter drilled wells equipped with hand pumps. The water table depth below the villages averages about 5 m. Each village will have at least two wells, sited, in consultation with the villagers, so no resident is further than 500 m from a well.

A total of 60 wells are required. In order to minimize costs, it is expected that the drilling and casing of these wells will be done under contract by the same driller who wins the contract for the PCWSC wells at the North River Wellfield. Thereafter, the responsibility for finishing each well will rest with the Ministry of Health who will arrange with local residents to:

- select the well sites in each village;
- train crews of local people in pump installation and repair and well maintenance;
- protect the well by constructing a concrete apron, drainage channel, and soakaway pit;
- installing the handpump;
- maintaining the pump and well; and
- organize personal hygiene training programs.

Materials including the pump, cement and hand tools will be provided through the project, but all labour will have to be provided by the future users of the wells.

The recommended facility for disposal of excreta by the villagers is the ventilated improved pit latrine. A cement lining is required for the pit in the alluvial soils in the area. The slab forming the base could be made of concrete or logs and the superstructure of bricks or mud and wattle, the common type of construction for local buildings.

Sanitation improvements are expected to result from a health education program, to be undertaken by the Ministry of Health, including:

- Installation of a health centre near the middle of the region. Manned by a health auxiliary, health inspector, and midwife, this health centre would have demonstration facilities and also serve as a source of materials for completing wells and latrines. The materials would be provided, at no cost to the villagers for construction of facilities according to plans approved by the health inspector;

- Adult educatin program in proper hygiene practices, based at the health center;

- Improvements in the health curriculum of local primary schools, including teacher training and the installation of hand pumps and recommended latrines; and

- Community involvement in the planning, design, construction, and maintenance of water and sanitation facilities.

The details of the health education program will have to be finalized by the Ministry of Health in consultation with PCWSC.

4. Pipeline from North River Wellfield to Port City

Water will be pumped from the North River Wellfield to the Creektop Reservoir, to be built on a hill above Swamp Creek at the northern edge of Port City (Figure 4-1). A suitable pipeline route has been located and surveyed and is shown on Figure 3-9. The pipeline will be on the south or left bank of the North River at the edge of the valley and will have the following characteristics:

Length	- 19.5 km
Capacity	- 300,000 m^3/day
Diameter	- 1600 mm
Type of Pipe	- Steel, externally wrapped and internally lined

The town of Farmville is expected to obtain its future water supply from the pipeline. A connection for Farmville, including a water meter, will be provided at Km 12.8 from the pumping station.

Air valves and washout valves are planned at high and low points along the pipeline and sluice valves approximately every 5 km so the pipeline can be shut down for repairs if necessary.

A strip of land some 10 m wide will have to be obtained for the pipeline and access road. The land is mostly owned by the government, above the farmland of the valley, but rights of way will have to be negotiated with local owners along 1.8 km of the route.

It is possible that the pipeline could be used to supply more 300,000 m^3 daily in future years, either by increasing production in the North River Wellfield or using the pipeline to convey additional water from other sources. The hydraulic capacity of the pipeline is limited to 300,000 m^3/day by the location of the pipeline terminus at the site of Creektop Reservoir, as illustrated in the hydraulic grade line on Figure 3-9. However, the pipeline capacity could be increased significantly if booster pumps were installed at Swamp Creek, near the end of the pipeline. In such a case, the final 0.8 km of the pipeline, from Swamp Creek to the reservoir, would require additional capacity which could be provided by higher pressure (thicker) pipe in the initial construction or the installation of a second pipeline for the remainder of the line. The second alternative is recommended; so the only additional expense included in the proposed project is the purchase of 0.6 ha of land near Swamp Creek for possible future use as a booster pumping station.

5. Communications and Control for North River Wellfield System

The Creektop Reservoir will supply water by gravity directly to the transmission pipelines of the PCWSC network. The wellfield pumping station will be operated to fill the Creektop Reservoir. The wells, in turn, will be operated to fill the sump in the wellfield pumping station. Water levels in the reservoir will be transmitted by land line to the control room in the wellfield pumping station where the operators will manually control the main pumps. Pumps in individual wells will be controlled remotely from the pumping station by the same operator. Water levels in each well, in the collecting sump, and at the Creektop Reservoir will be monitored continuously from the control room, which will be operated on a 24 hour basis. Communications will be mainly by telephone, backed up by a radio link to the proposed operations center at PCWSC headquarters at the Railway plant in the city.

6. Creektop Reservoir

The Creektop Reservoir at the terminus of the North River pipeline (Figure 4-1) will have an initial capacity of 50,000 m^3 (equivalent to six hours of average flow from the wellfield at the initial production rate of 200,000 m^3/day), and the site will include provision for further reservoirs in the future. Two reinforced concrete reservoirs, each with a capacity of 25,000 m^3, are planned initially. Each reservoir will be 100 m long by 32 m wide by 8 m high. Top water level in the reservoirs will be 75 m in order that the coastal distribution zone, containing most industrial consumers and some 25% of all domestic consumers, can be supplied by gravity, as can much of the second pressure zone.

Venturi meters will be installed to record pipeline flows into and out of the reservoir site.

The 2.8 ha reservoir site has been surveyed. The land is owned by the city and will have to be formally deeded to PCWSC. The site is within 150 m of the highway; access will be simple.

7. Eastern Reservoir

The distribution network analysis for Port City highlights the need to provide more storage of treated water, particularly for higher level zones. The proposed Eastern Reservoir would be located on a 1.5 ha site owned by the city on the eastern edge of the city (Figure 4-1). The reservoir capacity will total 30,000 m^3. Two identical reservoirs of reinforced concrete are proposed, each 50 m long by 38 m wide by 8 m high. Venturi meters will record inlet and outlet flows.

Supplied from a connection to the existing 300 mm diameter pipeline from the Mountain Treatment Plant, the new reservoir would have a top water level of 230 m and would supply consumers in the fourth and lower level pressure zones through a new 600 mm diameter pipeline.

8. Transmission Pipelines within Port City

Weaknesses in the existing distribution system and alternative possible remedies have been carefully analyzed by means of a network model, as described separately in "Technical Appendix B - Port City Water Distribution System." Three major pipelines with a total length of 14.3 km are proposed for installation within the project period, all shown on Figure 4-1. These transmission lines would only be connected to smaller distribution lines and would not serve any consumers directly.

Cost comparisons indicate that lines greater than 600 mm diameter would be of steel and smaller ones of ductile iron. The principal features of the lines to be built during the project are as follows:

a) From the new Creektop Reservoir to connect with the centre of the existing network and supply the coastal and lower pressure zones, involving three sections of pipeline totalling 6.0 km in length:

   i) 3.5 km of 1600 mm diameter steel pipe along Farmville Road;
   ii) 1.7 km of 1200 mm diameter steel pipe which runs from Farmville Road at the south edge of Blight Heights, west to the railway and then south to Shop Street; and

iii) 0.8 km of 800 mm diameter ductile iron pipe proceeding to the coast down Shop Street between the existing 800 mm pipe on Main Street and the existing 300 mm pipe east of the railway.

b) From the new Eastern Reservoir to connect with the existing 1000 mm line along Mountain Road, requiring 4.0 km of 600 mm diameter ductile iron pipe. This line will improve pressures in the top three pressure zones.

c) On the city edge of Long Mountain, a 4.3 km line of 400 mm ductile iron pipe to improve supply in Seaview and the southernmost sections of the city.

The routes of these transmission lines have already been surveyed to confirm their location. City approvals will be required before the work can proceed, in accordance with established procedures.

9. Distribution Network Extensions

The project objective is that all residents of Port City will have access to water from the distribution system by 1987. This will require the construction of comprehensive distribution networks in five areas not presently served, plus minor extensions to complete networks in areas already partially served. A skeleton system of public standpipes is expected to be completed to serve all areas by mid-1984 under the ongoing Immediate Improvement Project.

The service standard selected for most zones will be individual connections to permit consumers to install multiple taps. In a few cases the consumers are expected to install yard taps only at first but experience elsewhere in the city shows that inside plumbing is usually installed within five years of a water connection being made available.

In Blight Heights and Railville A socio-economic surveys have indicated that few residents can afford to install house connections. Complicating the situation is the fact that these residents are squatters and lack land tenure; so their willingness to invest in housing and facilities, such as plumbing, is minimal. In these circumstances, PCWSC intends to install public standpipes on both sides of the road and an initial network capable of being upgraded in future.

Design parameters for the Blight Heights network are as follows:

Urban area	: 273 ha
Population density	: 1980 - 350 people/ha (actual);
	: 2000 - 450 people/ha (projected)

Water consumption	: standpipes - 25 lcd
	: yard connections - 100 lcd
Maximum consumers per standpipe	: 400
Maximum distance between standpipes	: 500 m
Ratio of peak hourly flow to average daily flow	: 3.0
Minimum pipe diameter	: 50 mm

The design of the staged system was easily completed and compared to alternative designs using a computer program developed with financing from the World Bank. The range of pipe diameters in the basic network to be constructed initially is from 50 mm to 150 mm. The network for Railville A, also designed for standpipes, is based on similar design parameters. A standard modestly priced standpipe should be used.

Individual connections in Blight Heights could be provided to any residents requesting them as in other zones. When sufficient demand for such connections exists, the network would be upgraded, including looping all lines and placing pipes in every street. However, this second stage is beyond the project.

In the Extra Zones, the pattern of service standards will be mixed. Some residents are expected to be relatively affluent, with expensive houses, conventional plumbing, and requiring private connections. Other parts of the Extra Zones will be inhabited by low income residents, using water from standpipes and needing on-site sanitation systems.

For the remainder of the urban areas, the network extensions will be built initially to cope with individual connections. Detail designs will be carried out, using computer programs already familiar to PCWSC designers. Pipes will be of locally manufactured PVC or asbestos cement, except where subject to traffic loads, in which case imported ductile iron pipes will be used.

Design criteria for each zone will be based on the existing patterns of land use and population and those projected for the year 2000. The total length of pipes in each zone will depend basically on the street layouts, with pipe diameters chosen according to design flows and hydraulic analysis. The minimum pipe diameter will be 100, mm and more than 80% of the pipes are expected to be this size and 150 mm.

The rate at which connections are made for consumers will depend upon the phasing of construction, and the rate at which consumers request new connections. Previous PCWSC experience indicates that a modest public information program will suffice to encourage residents to obtain connections as soon as the network in each zone is complete.

The contractors will be instructed to install private connections at the time of network construction for all consumers who have by that time formally requested a connection from PCWSC. Each connection involves tapping the distribution pipeline and laying a service line to the shut-off valve and water meter, which will be installed in a protective box at the boundary of the consumer's property.

A preliminary review of the population and street layouts indicates pipe lengths and connections for the new distribution systems will be in accordance with Table A2.1.

Table A2.1 DISTRIBUTION NETWORK EXTENSIONS IN PROJECT, 1984-86

Zone	Area to be served (ha)	Projected 1986 Population in Area to be served		Approximate Length of Distribution Pipelines (km)	Estimated Numbers of New Connections to be Installed Initially	
		Connections (000)	Standpipes (000)		Individual	Standpipes
Upper Residential	580	20	-	41	2,900	-
Lower Residential	500	145	5	67	15,700	10
Railville	150	45	55	34	4,400	60
Blight Heights	280	-	90	15	-	120
Extra Zones	260	65	10	36	8,000	60
Total	1,770	275	110	193	32,000	250

Note: Excludes pipelines and house connections to be completed 1982-84 under the Immediate Improvement Project.
Includes 110 standpipes to be installed during the IIP.
Also excludes those items built during project period in other zones where network exists.

In addition to the pipelines and connections to be installed within the major extensions outlined in Table A2.1, approximately 15 km of distribution pipes will be laid in minor extensions throughout the city to improve the present system. The nature and location of these minor extensions have not yet been identified.

New connections, of course, will continue to be made to the existing system throughout the city as well as to the new water mains. Those connections requested when the networks are being installed will be installed by the contractor doing the network. Connections subsequently requested, and those to the existing network elsewhere, will be installed by PCWSC staff of licensed plumbers.

In the Lower Residential zone, most individual lots contain three or four rental buildings. Present PCWSC practice is to provide only one connection per property. In areas being provided with new distribution networks under the project, it is recommended that individual connections be provided for each separate building.

On-site plumbing costs beyond the water meter at the property boundary are not included in the project for which PCWSC will be responsible.

10. New Connections and Consumer Meters

Connections installed with the major network extensions (item 9) will be done by the contractor laying the distribution pipes. It is estimated that some 32,000 individual connections and 140 standpipes will be installed in this manner during the project period (Table A2.1). For these connections, the contractor will be responsible for supplying all materials except the meters, which will be purchased by PCWSC separately and provided to the contractor. The average cost of a residential connection totals Z95, of which Z25 represents the cost of the meter.

In addition to the 32,000 connections in the new distribution zones, PCWSC is expected to install some 5,000 connections throughout other parts of the city, for a total of 37,000 connections in the three years 1984-86.

PCWSC intends to test all meters once every five years and expects to replace up to 25,000 existing meters during the project period. The supply of 25,000 meters recently contracted by PCWSC under the IIP is only sufficient until about mid-1984; so PCWSC needs to arrange for the delivery of additional meters for new connections and replacements, a total of about 60,000 for a three-year period. Roughly 35,000 meters will be needed for new connections during the project and a further 25,000 to replace old meters (assuming a service life averaging ten years for existing meters). Most of the 60,000 such meters will be small domestic meters, but the entire range of sizes will be covered in the total order.

11. Rationalization of Existing Network

Specialist consultants (Black and White Inc., of Productivia) were engaged by PCWSC in July 1982 to concentrate on a program to reduce unaccounted-for water under the Immediate Improvement Project, which is scheduled for completion in mid-1984. This part of the Feasibility Report is based in part on the very preliminary work of these specialist consultants.

In the course of the detailed analysis of the existing network, it has been found that many existing problems involving unaccounted-for water and extreme pressures (high as well as low) are due to deficiencies in the isolating valves along the pipelines. The network, as described in detail in Technical Appendix B, is extremely complex.

Major efforts, basically a continuation and expansion of the IIP already underway, are required to rationalize the existing network. It is estimated that five well trained and equipped crews of PCWSC will be required more or less continuously during the project period to locate leaks and at least five repair gangs will be engaged on making the necessary repairs. In addition, two specialty crews of experienced technicians are needed to help locate anomalies in the distribution networks which can be rectified so that the network can be rationalized. This involves the separation of the network into distinct distribution zones so that losses can be analyzed and reduced and pressures can be better controlled.

This component of the project will be defined in greater detail following further analysis in the IIP (as the consultants for that project have only been at work on this complex matter for half a year). The principal materials required for the network rationalization are provisionally estimated as follows:

a) Master meters to record flows. Fifteen meter locations have been determined, generally along major transmission pipelines, ranging in diameter from 300 mm to 1000 mm.

b) Sluice valves for isolating pipeline sections. Roughly 40 existing valves need to be replaced and a further 100 new valves need to be installed. Special adaptor sections and valve boxes are required at most locations.

c) Pressure reducing valves to supply lower level pressure zones with water from upper level sources. Approximately 30 of these valves, which operate automatically to deliver water at constant pressures on the downstream side, will help to control excessive pressures, and hence reduce wastage.

d) Pressure recording gauges to provide continuous data re network performance. Some additional 40 pressure gauges are required, of which about half will be permanently at key points in the network to provide continuous data, while the others will be moved from place to place in order to test pressures throughout the system.

All this equipment is additional to that already planned under the IIP, which concentrates primarily on reducing unaccounted-for water.

Another type of problem needing rectification in the present system concerns old pipes which need to be replaced because of corrosion and/or poor joints which result in leakage. Frequency-of-repair records indicate that some of the older cast iron sections in the port area are the most troublesome, but incidences of leaks and breaks indicate local problems in many parts of the city. Repairs to individual pipes will be made where appropriate but provision is also made for replacing entire sections of line. Ductile iron pipes will be used for pipes beneath roadways and larger diameter pipes and PVC pipe, for smaller diameter pipes not subject to traffic roads.

The preliminary estimate of pipe sections required totals 10 km of ductile iron pipes and 12 km of PVC or asbestos cement pipes. A variety of special adaptors will be purchased for connecting these replacement pipes to the existing network.

12. Operations and Maintenance Facilities and Equipment

Included in this topic are items which refer to the overall operations of PCWSC, as well as those dealing basically with water supply. A summary of requirements follows a description of the various improvements. Specialized O&M equipment for sanitation systems is discussed separately in Annex 3 concerning the sanitation component of the project.

The organization and management studies have suggested, among other things, that PCWSC should rationalize its organization and locate its different functions throughout the city.

Two regional offices will improve local operations. These offices will deal with all matters affecting consumers, including requests for connections, payment of accounts, and service problems. The same locations will also be the bases for the maintenance staff dealing with the water distribution network, particularly the leak detection crews. The location of the two customer services offices are at the existing Railway Treatment Plant for the south of the city and at a new site along Farmville Road for the northern areas. The Farmville Road office requires the purchase of a 0.7 ha site, formerly occupied by a dairy which is being relocated outside the city. Minor improvements will be necessary to convert the present facilities to a regional office and repair depot.

The existing complex at the Railway Treatment Plant presently serves as PCWSC headquarters, consumer services centres and maintenance base; it has the basic facilities needed for its future role as a regional office. However, the Farmville Road site to serve consumers in the northern area of Port City will involve modifications to the existing buildings for the necessary offices and workshops. A small computer will be purchased; so local consumer records can be kept current at this northern office.

Better organized leak detection and pipe repair crews, based at the two regional offices, will require small maintenance depots with properly organized stores of materials for new connections and repairs to small diameter pipes, including meters, valves, and pipe selection. Improved transport will also be required, principally small trucks.

PCWSC needs improved and expanded office accommodation for the centralized functions in the head office. According to the management consultant's analysis, the head office staff should total some 500 people in 1990 and be limited in growth to less than 3 percent annually thereafter. The accommodation planned for this staff in 1990 totals 5,000 m^2, of which only 2,000 m^2 can be provided from present buildings after the regional operations office is established. Thus, an office building providing 3,000 m^2 is proposed to be added to the existing facilities at the Railway Treatment Plant. Preliminary plans have been prepared for the new structure, which will be integrated with the existing offices.

At present, the operating rules for the PCWSC water supply system are simple: all sources are operated to their capacity. More sophisticated procedures will be appropriate, particularly when the new sources in the project become operational and better controls are implemented within the distribution system. Accordingly, an operational control center is proposed to be installed in conjunction with the existing control room for the Railway Treatment Plant. This major augmentation will involve substantial changes to the present facilities, including telephone and radio communications to link the control centre with the major water sources. Preliminary plans have been prepared for centralizing all operating data at the new control center, which will be staffed on a 24 hour basis.

The Meanthyme Sewage Treatment Plant will be replaced by the proposed Hog's Bay plant, as described in Annex 3. Subsequently, the Meanthyme site will be used as the principal maintenance base for PCWSC sewerage and sanitation systems throughout the city. However, the 2.2 ha site will also serve PCWSC's primary workshops and equipment store, as with the following functions:

a) New meter testing and repair workshop;
b) Repair depot for heavy equipment (trucks and excavator as well as pumps, motors, valves, etc.);
c) Maintenance base for major water supply repairs, including larger diameter pipelines, pumping equipment, etc. Stockpipes of equipment for major repairs will be maintained;
d) Stockpile for water and sewer pipes imported through nearby port.

The Meanthyme sewage plant will be dismantled in 1986 when the interceptor sewer and the new plant at Hog's Bay begin to operate. Major stockpiles of materials can only be stored after the Meanthyme plant is dismantled, but the proposed meter workshop and repair depot can be accommodated at the site under existing conditions, provided existing structures, access roads, and fences are modified in accordance with the long term utilization of the site.

The facilities and equipment required to improve PCWSC water supply operations and maintenance are as follows:

<u>Facilities</u>

- Headquarters buildings at Railway plant (3,000 m^2);
- Operations control center at Railway plant;
- Northern regional office and maintenance base, Farmville Road (0.7 ha); and
- Meter workshops and equipment repair workshop at Meanthyme Sewage Treatment Plant.

Equipment

- 5 five-ton trucks (major repairs);
- 10 one-half-ton trucks (consumer connections, leak detection crews, and minor repairs);
- Meter testing and repair equipment;
- Workshop equipment for repairing vehicles and water supply equipment;
- Communications systems between operating control center and water supply facilities; and
- Computer and office systems equipment.

13. Consulting Services

Four distinct types of consulting services are recommended to assist PCWSC during the project implementation period 1983-86:

a) Engineering consultants for final design, procurement, construction supervision, and commissioning of the major components of the water supply project previously described in this annex. (Final design work has already begun on the components scheduled for construction during the first year of implementation.)

b) Operational assistance consultants to provide guidance and training concerning the operations and maintenance of existing and expanded system. The proposed assignment could be a continuation of the current assignment of the consultants engaged in July 1982 under the Immediate Improvement Project. Their current contract runs until June 1984.

c) Management consultants for guidance during the implementation of proposed improvements in the PCWSC organization, including decentralization of customer services and network repairs to regional offices, and improvements in financial procedures and controls. Staff training would also be included, primarily by the training of local trainers, as described in Annex 5.

d) Review of PCWSC systems and projected future demands in 1986 in order to identify possible future requirements.

C. IMPLEMENTATION SCHEDULE

The construction schedule for the water supply component is shown in Figure 4-11, which breaks the work down into 35 separate contracts. This provisional definition of contracts might be reduced somewhat if PCWSC chooses to combine certain elements of the work but it is clear that a major construction program involving a large number of contractors and suppliers is required to implement the proposed project.

PCWSC will contract for most of the project construction, but it will be directly responsible for certain aspects, as noted in the construction schedule, including:

- repairs and improvements to the existing networks;
- installation of new connections on existing lines;
- testing, repair, and replacement of consumer meters; and
- modifications and extensions of existing offices and workshops.

The Ministry of Health will be responsible for implementation of all the village water supply and sanitation programs in the North River Wellfield, except for the well drilling, which will be undertaken by a contractor working for PCWSC.

It is expected that electricity supply for the North River wellfield and pumping station will be provided by the Optima Power Company directly, effectively acting as a contractor for PCWSC.

The schedule for each specific contract allows for time for all steps necessary to select and employ the contractors, including:

- completion of final designs;
- preparation, review, and approval of contract documents;
- tender period (at least two months for major contracts);
- review of bids and approval of choice of contractor;
- contract negotiation and signature; and,
- mobilization by contractor.

The time between having the designs and tender documents ready for review and signing the contract is expected to be six months in most cases, and somewhat longer for major contracts.

The activities on the construction schedule of Figure 4.11 relate to the execution of individual contracts. Many other activities must be completed in conjunction with these contracts. Table A2.2 summarizes these actions, including indications of responsibilities and deadlines.

Table A2.2 IMPLEMENTATION ACTIVITIES FOR WATER SUPPLY COMPONENT			
TOPIC	**ACTIVITY**	**RESPONSIBILITY**	**DEADLINE**
Overall Project	1. Confirm project definition and commence implementation	PCWSC and Government	March 1983
	2. Engage engineering consultants for project implementation	PCWSC	June 1983
	3. Provide local finances for project implementation	PCWSC and Ministry of Finance	June 1983
	4. Provide loan to cover foreign exchange costs	PCWSC, Ministry of Finance and International Lenders	December 1983
City Wells	1. Obtain land in Surburban Park from city	PCWSC and City	October 1983
	2. Approval to develop wells	PCWSC and Ministry of Water Development	October 1983
North River Wellfield	1. Approval to develop wells	PCWSC and Ministry of Water Development	October 1983
	2. Confirm electricity supply to wellfield and pumping station	PCWSC and Optima Power Company	November 1983
	3. Obtain land for wellfield and pumping station	PCWSC and Ministry of Agriculture	June 1984
Village Water Supply and Sanitation	1. Finalize arrangements for health education program, including well and latrine construction	PCWSC and Ministry of Health	August 1984
Pipeline from North River Wellfield to Port City	1. Obtain land and access for pipeline	PCWSC and Ministry of Agriculture	June 1984
Transmission and Distribution Pipelines within Port City	1. Approval of route by city	PCWSC and City	Prior to tenders
	2. Coordinate traffic during construction	PCWSC and Police	Prior to construction
	3. Road resurfacing by city	PCWSC and City	After pipeline costruction
Creektop and Eastern Reservoirs	1. Obtain land and access	PCWSC and City	March 1984
O & M Facilities	1. Purchase existing site and buildings for customer services office and maintenance base for northern region	PCWSC	September 1983
	2. Reorganize Meanthyme site to permit construction of water and repair workshops prior to dismantling of existing sewage treatment plant	PCWSC	June 1984

Critical activities are highlighted hereafter.

Project implementation cannot begin until financing has been arranged. This is assumed to be confirmed by the Ministry of Finance and one or more international development agencies before the end of 1983.

Final designs and tender documents need to be completed before construction can begin. Engineering consultants should be engaged for these tasks as soon as possible. The schedule assumes that the consultants commence their major work by July 1983. (Work has already begun on final design for the first year of implementation.) This means that PCWSC may have to enter contracts for these services prior to having project funding assured. However, the alternative of securing project funding first could cause a serious delay in project implementation.

The principal water supply problem is the shortage of supply. Four city wells can be operating early in 1985 if tender documents can be prepared by November 1983. The main time requirement is for the delivery of imported pumps and motors.

The North River Wellfield scheme is the next major water source for Port City. Six separate contracts are anticipated for the development of the wellfield, one for the pipeline to the city, one for the Creektop Reservoir at the pipeline terminus, and one for communications equipment for system control. The wellfield pumping station and 19.5 km pipeline are the critical elements in the system; so their procurement must begin as soon as practicable, with tender documents scheduled to be available by January 1984. Imported pumps, motors and pipes will be the main determinants of the construction schedule, but preliminary conversations with suppliers indicate that the scheduled completion date early in 1986 (three years from now) is attainable, provided constant attention is paid to these contracts.

It is suggested that the two reservoirs (Creektop and Eastern) be designed and tendered in parallel due to their similarities.

Separate contracts have been assumed for supply and installation of the three main transmission pipelines within Port City and for distribution extensions in the five specified zones. The transmission contracts are scheduled for bidding concurrently, allowing for possible savings if one contractor wins more than one contract.

Distribution network contracts are staged; so the design and tendering for each zone occur at two-month intervals, for the administrative convenience of PCWSC. These pipeline schedules are not critical and can be modified subsequently to suit local priorities and also to accommodate the capacity of the local construction industry.

D. COST ESTIMATE

Cost estimates have been prepared for all elements of the proposed project on the basis of preliminary designs prepared during the feasibility study. Detail designs would be prepared for construction, but the existing designs are sufficient to permit quantities to be reliably estimated.

Costs have been estimated using several approaches. For routine items such as pipe laying, actual cost experience of PCWSC and other water supply agencies in Optima over the past ten years has been analyzed and modified as appropriate for the proposed project. Suppliers of equipment, such as pipes, pumps, and meters, have provided budget quotations for specific items, as have contractors, such as well drillers. Also, all costs have been checked by means of estimating procedures which examine the work and costs from the perspective of the contractors.

Physical contingencies provide for various types of unexpected work. Because the proposed project is fairly straightforward and preliminary designs based on field surveys exist for major components, the allowance of 15% for physical contingencies is realistic.

All cost estimates are expressed in price levels prevailing in mid-1982. The as-built costs will depend on changes in price levels up to the time of construction of the various components. The following estimates of probable future increases have been prepared, after consultation with economists in the Ministry of Planning and the Bank of Optima:

Year	Probable Rate of Price Increases (%)	
	Domestic	International
1983	12.0	8.0
1984	11.0	7.5
1985	10.0	7.0
1986	9.0	6.0

Table A2.3 summarizes water supply project costs in terms of the local and foreign cost components. The latter includes both direct costs, for imported goods and services, plus indirect costs, such as the component of fuels and oils from Optima's refinery due to imported crude oil, imported construction equipment, etc.

Table A2.3 SUMMARY OF CONSTRUCTION COSTS FOR WATER SUPPLY COMPONENT

Item	Local	Foreign	Total
	-------	Z million	--------
City Wells	0.2	0.7	0.9
North River Wellfield	4.7	6.5	11.2
Village Water Supply and Sanitation	0.6	0.2	0.8
Pipeline from North River Wellfield to Port City	4.3	10.2	14.5
Communications and Control for North River System	0.1	0.3	0.4
Creektop Reservoir	4.0	1.0	5.0
Eastern Reservoir	2.4	0.6	3.0
Transmission Pipelines within Port City	2.4	3.5	5.9
Distribution Network Extensions	3.8	2.6	6.4
New Connections and Consumer Meters	2.2	2.0	4.2
Rationalization of Existing Networks	0.9	0.4	1.3
O & M Facilities and Equipment	1.6	1.2	2.8
Sub-total	27.2	29.2	56.4
Consulting Services	2.2	1.8	4.0
Physical Contingencies	4.2	4.4	8.6
Sub-total (mid-1982 prices)	33.6	35.4	69.0
Price Increases	10.2	10.8	21.0
Total (current prices)	43.8	46.2	90.0

Note: Costs presented in more detail and on annual basis in Table A2.4.

Table A2.4 presents the costs of project components on an annual basis, in accordance with the construction schedule of Figure 4-11.

Table A2.4 CONSTRUCTION COSTS FOR WATER SUPPLY COMPONENT ON ANNUAL BASIS

Contract No.	Item	1983	1984	1985	1986	Total, 1983-86
		Z million (mid-1982 prices)				
	<u>City Wells</u>					
W1	Supply Pumps and Motors	-	0.1	0.1	-	0.2
W2	Well Drilling and Pump Installation	-	0.3	0.4	-	0.7
	<u>North River Wellfield</u>					
	Land Acquisition	0.4	-	-	-	0.4
W3	Site Preparation (access, fencing, etc)	-	0.2	-	-	0.2
W4	Supply Well Pumps and Motors	-	0.3	0.5	0.1	0.9
W5	Well Drilling and Pump Installation	-	-	3.0	0.4	3.4
W6	Electricity Supply to Wellfield and Pump Station (by Optima Power Company)	-	0.5	-	-	0.5
W7	Supply and Install Collector Pipeline	-	0.2	0.3	0.1	0.6
W8	Civil Works for Pump Station	-	0.4	3.0	0.7	4.1
W9	Supply and Install Pump Station Equipment	-	0.4	0.6	0.1	1.1
	<u>Village Water Supply and Sanitation</u>					
W10	Well Drilling and casing (probably under Contract W5)	-	-	0.2	-	0.2
W11	Supply Handpumps	-	-	0.1	-	0.1
W12	Health Education including Well Completion and Latrine Construction (by Ministry of Health)	-	0.1	0.2	0.2	0.5
	<u>Pipeline From North River Wellfield to Port City</u>					
	Land Acquisition	-	0.3	-	-	0.3
W13	Supply and Install Pipeline	-	1.4	10.4	2.4	14.2
	<u>Communications and Control for Wellfield System</u>					
W14	Supply and Install Equipment	-	-	0.2	0.2	0.4
	<u>Creektop Reservoir</u>					
W15	Civil Works and Equipment	-	-	4.0	1.0	5.0
	<u>Eastern Reservoir</u>					
W16	Civil Works and Equipment	-	-	2.4	0.6	3.0
	<u>Transmission Pipelines within Port City</u>					
	Supply and Install Pipelines:					
W17	a) Creektop Reservoir - Farmville Road - Shop Street - Railway - Main Street	-	-	3.0	1.5	4.5
W18	b) Eastern Reservoir - Mountain Road	-	-	0.8	0.1	0.9
W19	c) Long Mountain - City South	-	-	0.5	-	0.5
	<u>Distribution Network Extensions</u>					
	Supply and Install Pipelines and Connections:					
W20	Upper Residential	-	-	0.6	0.7	1.3
W21	Lower Residential	-	0.2	1.0	1.0	2.2
W22	Railville	-	-	0.5	0.5	1.0
W23	Blight Heights	-	-	0.3	0.1	0.4
W24	Extra Zones	-	-	0.4	0.7	1.1
W25	Miscellaneous Minor Extensions (PCWSC staff)	-	0.1	0.1	0.2	0.4
	<u>New Connections and Consumer Meters</u>					
W26	Purchase of Meters	-	-	0.9	0.7	1.6
W27	Installation of New Connections (Network Contractors and PCWSC staff)	-	0.6	0.8	1.2	2.6
	<u>Rationalization of Existing Network</u>					
W28	Materials and Equipment Supply	-	0.2	0.3	0.3	0.8
W29	Equipment Installation (PCWSC staff)	-	0.1	0.2	0.2	0.5
	<u>O & M Facilities and Equipment</u>					
W30	Railway Plant: Headquarters Extensions and Operations Control Center	-	-	0.4	0.6	1.0
	Northern Regional Office: Purchase Site and Buildings	0.4	-	-	-	0.4
W31	Northern Regional Office: Conversions (PCWSC staff)	0.1	-	-	-	0.1
W32	Meter and Repair Workshops and Equipment at Meanthyme Site	-	0.1	0.2	0.1	0.4
W33	Supply of Trucks	-	-	0.3	-	0.3
W34	Supply of Communications Equipment for Operations Control Center	-	-	0.1	0.2	0.3
W35	Supply of Miscellaneous Office and Workshop Equipment	-	0.1	0.1	0.1	0.3
	Sub-total	0.9	5.6	35.9	14.0	56.4
	<u>Consulting Services</u>					
	Engineering for Project Implementation	0.4	1.0	0.8	0.6	2.8
	Operational Assistance	-	0.1	0.2	0.2	0.6
	Management Assistance	-	0.2	0.2	0.1	0.4
	Future Project Identification	-	-	-	0.2	0.2
	<u>Physical Contingencies</u>	-	0.6	5.6	2.4	8.6
	Sub-total (mid-1982 prices)	1.3	7.5	42.7	17.5	69.0
	<u>Price Increases</u>	0.1	1.4	12.6	6.9	21.0
	TOTAL COSTS (current prices)	1.4	8.9	55.3	24.4	90.0

The cost estimate for the new connections and consumer meters includes 50,000 meters to be purchased and an estimated 32,000 connections to be installed during the project period 1984-86. As discussed previously, the contractors installing the new networks will also install the new connections. The network cost estimates exclude these connection costs which are presented separately.

FEASIBILITY REPORT FOR PORT CITY

SANITATION COMPONENT OF PROJECT

Annex 3

SANITATION COMPONENT OF PROJECT

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SANITATION COMPONENT OF PROJECT

A. OBJECTIVES

The basic objective of the sanitation component is to provide all residents of Port City with access to facilities for the hygienic disposal of body wastes. More specifically, the project's objectives are to:

1) introduce sanitation technologies that are efficient, reliable, and affordable, emphasizing those zones within Port City in greatest need of sanitation and pollution control improvements;

2) eliminate the practice of open defecation in Port City;

3) provide adequate drainage and improvements to soakaway systems to eliminate health hazards and environmental nuisances associated with pooled sewage on residential lots;

4) halt the increase in numbers of cesspits in the residential areas and improve cesspits in these areas which will not be served by sewers on project completion;

5) introduce public toilets and washing facilities where necessary in the lower income areas;

6) institute a hygiene education program which will extend beyond the project period and have a permanent impact on water use and hygiene practices in the communities served by the project; and

7) minimize surface water pollution throughout Port City and environs by introducing effective wastewater collection and treatment, and reduce groundwater pollution in those areas in which it is considered a health hazard.

B. DESCRIPTION OF COMPONENTS

B.1 Introduction

Following a review of alternative technologies, a variety of solutions are proposed to improve sanitation throughout Port City. The various system components are discussed separately, commencing with on-site systems.

Basic technical information is provided for each component. More detailed technical data and engineering drawings are published separately in Technical Appendices.

Sanitation service levels and the number of people to be served are summarized in Table A3.1. The various systems of sanitation in service in 1987, after the project is completed, will receive estimated wastewater quantities as indicated in Figure 4-2.

The city has been divided into eight residential zones. There are four types of on-site sanitation systems and two off-site systems for wastewater disposal in Port City at this time. These alternative systems, described in Annex P4 of the Pre-feasibility Report of April 1982, are listed in Table A3.2.

The project is the first step in the long term strategic plan for sanitation throughout Port City. By the year 2000, the whole of Port City is planned to have an acceptable form of wastewater disposal system. Waterborne sanitation systems (including pour-flush toilets) should serve all but 12,000 inhabitants of the city by that time. Small bore sewers will serve most residents in the Lower Residential zone. With the exception of Seaview, wastewater from the 94% of the population served by sewers in Port City will be collected by new interceptors and treated at the new Hog's Bay Sewage Treatment Plant, with effluent discharging to the harbour or (possibly in the long run) being reused for irrigation. Septic tanks and combinations of pour-flush toilets and sullage soakaways will service 1% of Port City's population, while pour-flush toilets and ventilated improved pit latrines will be used by people without water connections in Blight Heights and Railville (5%). Additionally 15 public toilet facilities will service a small fraction of the population considered destitute or transient.

The project (1984-86) has been designed as the initial and major step towards the goals of the strategic plan. By 1987, seven different kinds of sanitation systems will be in use. These are categorized into on-site and off-site systems and are described below. Table A3.2 summarizes the various sanitation units to be installed or upgraded during the project period.

The project is defined to include all facilities for which PCWSC will be responsible. Those on-site systems to be built and financed entirely by the residents, specifically new septic tanks, cesspits, and pour-flush toilets with soakaways, are not included in the defined project but are obviously part of the total program of sanitation improvements in Port City.

Table A3.1 SANITATION SERVICE COVERAGE AND STANDARDS, 1981 AND 1987

	1981 (Actual)							1987 (Estimated)								
	Total Population	On-Site Systems				Off-Site Systems		Total Population	On-Site Systems					Off-Site Systems		
		Open Defecation	Pit Latrines	Septic Tanks	Cess-pits	Conventional Sewers	Public Toilets (a)		Ventilated Improved Pit Latrines	Pour-Flush Toilets	Pour-flush Toilets with Sullage Soakaways	Septic Tanks	Cess-pits	Small Bore Sewers	Conventional Sewers	Public Toilets (a)
Upper Residential	66	–	–	66	–	–	–	94	–	–	–	94	–	–	–	–
Middle Residential	280	–	21	28	91	140	–	321	–	–	–	11	20	–	290	–
Lower Residential	777	62	78	78	544	–	15	922	–	–	41	116	567	180	–	18
Business	24	–	–	–	–	24	–	26	–	–	–	–	–	–	26	–
Old Town	72	–	–	–	–	72	–	80	–	–	–	–	–	–	80	–
Railville	106	32	62	–	12	–	–	117	12	34	–	–	–	59	–	12
Blight Heights	99	64	35	–	–	–	–	103	46	47	–	–	–	–	–	10
Seaview	31	–	–	–	–	31	–	33	–	–	–	–	–	–	33	–
Extra Zones	–	–	–	–	–	–	–	100	–	15	15	70	–	–	–	–
New Town	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Total	1,455	158	196	172	647	267	15	1,796	58	96	56	291	587	239	429	40
% of Total	100.0	10.9	13.5	11.8	44.4	18.4	1.0	100.0	3.2	5.3	3.1	16.2	32.8	13.3	23.9	2.2

Note: (a) Each Public Toilet facility serves 1,000 persons

Table A3.2 SANITATION UNITS TO BE INSTALLED IN PROJECT PERIOD, 1984-86

	Number of people served per sanitation unit (average)	ON-SITE SYSTEMS							OFF-SITE SYSTEMS				
		Without House Connection		With Water Supply by House Connection					Small Bore Sewer			Conventional Sewerage	
		VIP latrine	Pour-flush toilets	Pour-flush and soakaway (a)	Cesspits new (a)	Cesspits upgraded	Septic tanks new (a)	Septic tanks upgraded	Cesspit Conversions	Septic Tank Conversions	Interceptor tank	Connections (b)	Public Toilet Facilities(c)
Upper Residential	6.4	-	-	-	-	-	940	-	-	-	-	-	-
Middle Residential	7.8	-	-	-	-	-	-	-	-	-	-	12,490	-
Lower Residential	24.3	-	-	1,710	1,710	16,000 (e)	1,690	1,700(f)	930	180	6,290	-	3
Business	37.5	-	-	-	-	-	-	-	-	-	-	40	-
Old Town	28.5	-	-	-	-	-	-	-	-	-	-	300	-
Railville	10.5	1,140	3,240	-	-	-	-	-	1,140	-	1,120(d)	-	12
Blight Heights	12.3	3,700	3,820	-	-	-	-	-	-	-	-	-	10
Seaview	7.5	-	-	-	-	-	-	-	-	-	-	200	-
Extra Zones	8.0	-	1,870	1,870	-	-	8,760	-	-	-	-	-	-
Total		4,840	8,930	3,580	1,710	16,000	11,390	1,700	2,070	180	7,410	13,030	25

Note (a) Not funded or constructed by PCWSC.
(b) Immediate improvement program expected to have completed 4,000 connections before project period.
(c) Each public toilet facility serves 1,000 persons.
(d) Serving four houses each.
(e) Out of 21,650 existing cesspits.
(f) Out of 3,890 existing septic tanks.

At the present time PCWSC is implementing the Immediate Improvement Project (IIP) to rehabilitate the existing sewer system and increase sewer connections. IIP activities, described in a separate report of February 1982 and expected to be completed by mid-1984, are compatible with but separate from the major project as described hereafter.

B.2 On-site Systems

B.2.1 VIP Latrines and Pour-flush Toilets

Neither of these technologies accommodates sullage (greywater), but they are relatively inexpensive and pertinent to the lower income residents who will obtain their water by standpipes rather than a house connection. As listed in Table A4.2, a total of 4,840 VIP latrines and 8,930 pour-flush toilets are expected to be installed in Railville(A) and Blight Heights, although the actual numbers will depend on the choices made between these technologies by the residents. These low income zones are considered together in the following discussion, in view of their similarity in conditions within the squatter settlements and common sanitation technologies to be installed. Additionally 1,870 pour-flush toilets are expected to be constructed in the Extra Zones where 15% of the population not served by piped water supply will probably opt for the pour-flush toilet in preference to the VIP latrine alternative.

The recommended VIP latrine is of cement block or brick and mortar construction, and is shown in Figure 3-1. Required storage capacities vary with the actual family size. However, standardized designs are recommended, with pit volumes of a minimum of 3 m^3.

It is recommended that trials be undertaken early in the project period by PCWSC, in collaboration with the Environmental Health section of the Ministry of Health, to determine the least cost alternatives for methods of construction and materials. Preliminary work by ISD indicates that, in view of the nature of squatter settlements and the relatively low ability to pay for sanitation facilities, the best course would be for PCWSC contractors to provide the below ground components while the householders would be responsible for the superstructure or above ground components. As an incentive to self-help, however, householders should be provided with free superstructure materials if they themselves dig the pit. All VIPs should meet three essential criteria:

a) a 150 mm vent pipe should be installed;

b) the superstructure, pit lining, and appurtenances should be built to avoid collapse or failure; and

c) overland stormwater runoff should not be able to enter the pit.

Emptying of the latrine pits should be the responsibility of the householder who should hire an independent sludge collection firm or call on the PCWSC vacuum trucks. Alternatively, the householder would have the option of moving the superstructure over to a new hole and filling in the old. In that case, the superstructure should be built with materials that are either lightweight or easily disassembled and reassembled, such as wood, asbestos, cement sheeting etc., rather than cement block.

The squat plate (the toilet) may be located inside the house or in a separate structure, as the user prefers. The recommended pour-flush toilet design is shown in Figure 3-2. PCWSC, in collaboration with the Ministry of Health, should initiate trials to determine least cost materials and construction methods. However, it is anticipated that these will not vary much from those indicated in the figure. The below ground components would be built by PCWSC, probably by a contractor, and the householder would be responsible for the superstructure. Again, the householder who digs his own pit would be given materials for the superstructure. Minor on-site adaptations can be permitted. However, all on-site facilities should be inspected by PCWSC on completion of construction. Minimum requirements should include:

a) physical integrity of the foundation, diversion chamber, superstructure, squat plate bowl, piping, and pits and their covers to avoid failure or collapse;

b) minimum sludge storage volume of 1.5 m^3 in each pit; and

c) any adaptation to the inside of the toilet enclosure must ensure that the squat plate and bowl is designed so that it can be easily kept clean.

Pit emptying should present no problem as the two pits would be used alternately. After a rest of some 12 months, the digested contents in the full pit would be suitable for use as a soil conditioner on nearby gardens. However, PCWSC should retain staff and capability of emptying pits in extreme cases.

Implementation of both VIP latrines and Pour-flush Toilets in the squatter areas will probably require a special program, as discussed in Section D2 below.

B.2.2 Septic Tanks

An estimated total of 11,390 new septic tanks are to be constructed during the project period. These will be built in response to increased densification of the Upper Residential, Lower Residential, and Extra Zones during the project period. The financing of these septic tanks is assumed to be the responsibility, as part of the cost of the associated new housing, of the house owner. Accordingly, the project cost estimate excludes the cost of new septic tanks. PCWSC will ensure that new water connections are not granted until the house has adequate provisions for wastewater disposal.

The present septic tank design is illustrated in Figure 3-6 which is currently considered a standard design for Port City. Of particular importance are the seepage trench dimensions. Percolation studies carried out as part of this feasibility study illustrated the uniformly dense soil (silt clay) in the residential areas. Where percolation rates are not actually determined on-site, a long term infiltration rate of 10 litres/m^3 of trend sidewall can be assumed in the silt clay areas. This conservative rate should be applied to all areas except the Upper Residential zone above 100 m in elevation where 15 litres/m^3 can be assumed, reflecting the coarser soils at higher elevation.

The small bore sewer system is planned to eventually cover the entire Lower Residential area. Within the project period, however, only a portion of this area will be served. Many existing septic tanks in such areas will have to continue to be used for waste disposal until the small bore sewer system is extended between 1987 and 2000.

An estimated 3,090 of the existing septic tanks in the Lower Residential Zone will not be connected to the small bore sewer system as part of this project. Based on a survey of existing facilities, it is anticipated that roughly 1,700 will require upgrading during the project period. This will involve structural repair (average Z150/tank), desludging (Z40) and repair or reconstruction to the seepage trench (average Z200). As part of PCWSC's program to improve existing sanitation standards, PCWSC will be responsible for this work, through a contractor.

It is recognized that some 450 of the 1,700 septic tanks to be upgraded will still not provide satisfactory treatment and disposal because densification has led to inadequate space to relocate trenches. Effluent from these 450 septic tanks is to be drained off by pipe to the nearest gully or ditch. It is emphasized that septic tanks provide partial treatment only, the effluent still containing pathogens and unacceptable BOD levels even under normal circumstances. This method of effluent disposal is considered a temporary solution only until such time as the septic tank can be connected to the small bore sewer system. Evapotranspiration through vegetation may also prove a solution to these 450 tanks with inadequate seepage trenches.

B.2.3 Cesspits

Although cesspits are not officially sanctioned for disposal of domestic wastes in Port City, it is anticipated that private contractors and individual households will continue to construct cesspits as a locally accepted method of disposing of human wastes and wastewater in high density areas not served by sewers. A typical cesspit is illustrated in Figure 3-5. Lack of space for drainage trenches in such areas precludes the use of septic tanks.

As with septic tanks, PCWSC will become responsible for upgrading existing cesspits as required, but new ones will have to be built and paid for by the house owner before a water connection is provided. An estimated 1,710 new cesspits will be built to accommodate densification in those areas not planned for small bore sewers. These will likely operate satisfactorily for five to eight years.

Some 21,600 cesspits exist outside the planned sewered areas. A survey of the operational efficiency of these units has revealed that only 26% were operating satisfactorily. Most of the remainder exhibited effluent pooling in the vicinity of the pit. Attempts had been made to divert the effluent off-site either into a neighbouring lot or to a nearby gully in 45% of cases. Clogging of the sidewalls of pits and failure to remove sludge (due to high costs) are the primary causes of cesspit failure.

Trials were undertaken on 45 cesspits to determine if they were upgradable. In over 85% of cases the local practice of partial removal of liquid by vacuum truck and submerged pressure jet spraying of the side walls significantly improved the absorptive capacity of the pits. Prototype tests using sewage for spraying the pit walls allowed predictions to be made that the life of the pit so upgraded could be extended to three to five years before pumping again became necessary. Upgrading of the cesspit structure most frequently involves repair or replacement of the top cover over the pit which has collapsed in many cases and never existed in others.

Accordingly, the project includes the upgrading of existing cesspits which are not to be used in conjunction with small bore sewers. Cesspit upgrading will be undertaken by contractors employed by PCWSC. The 8,210 cesspits which were found to be operating satisfactorily and are not going to be connected to the small bore sewer system will not be upgraded in the project.

Similar but simplified support program activities to those necessary for VIP latrines and pour-flush toilets will be required for the upgrading of septic tanks and cesspits in the relatively poor Lower Residential zone (Section D2 below).

B.2.4 Pour-flush Toilets with Sullage Soakaway

Where cistern toilets are not used, pour-flush toilets (Figure 3-2) can be used for excreta disposal and soakaways for all sullage. Figure 3-3 shows a suitable sullage soakaway which, because of reduced sullage loading, requires less volume than a cesspit because its sidewalls clog less. The sullage soakaway can easily be converted to an interceptor tank for use with small bore sewers. An estimated 3,580 combinations of pour-flush toilet with sullage soakaway are expected to be built in the project period, mainly for the lower income residents in the Extra Zones and Lower Residential Zone.

B.3 Off-Site Systems

Existing off-site sanitation systems in Port City provide conventional sewerage in the Middle Residential, Business, Old Town, and Seaview zones. During the project period small bore sewers are to be constructed in the Lower NW portion of the Lower Residential zone and Railville B. Wherever possible, public toilet facilities that are built as part of the project will be connected to small bore sewerage systems in the Lower Residential zone.

Existing package treatment plants for wastewater are discussed in Section B.3.6 of this annex.

All sanitation systems expected in place following project completion are listed in Table A3.2 and schematically illustrated in Figure 4-2. The extent of the sewered areas in 1987 is shown in Figure 4-3. Briefly, in 1987 Port City's off-site sanitation systems will comprise:

1. Conventional sewerage, the mains and laterals of which are already in place. Connections to more than 4,000 properties not already using the sewers in the Middle Residential, Business, and Old Town areas in 1981 should be completed by 1984 as a consequence of the IIP now underway. This connection program will extend into the project which will see approximately 13,000 additional connections made.

2. The small bore sewer system will be constructed in Railville B and Lower NW areas. Both conventional and small bore sewers will feed into the interceptors leading to the Hog's Bay Sewage Treatment Plant. Existing cesspits and septic tanks will be converted, and new interceptor tanks constructed. Their sludge will be trucked to the new treatment plant. Sludge from the interceptor tanks as well as the converted cesspits and septic tanks will be trucked to the new treatment plant.

3. Public toilet facilities will be drained by small bore sewers. Their sludge will be trucked directly to the new treatment plant.

4. The separate Seaview sewer system will have 200 additional house connections made to it during the project, resulting from future densification. Settled sludge from the existing treatment plant, which needs no expansion, will be trucked to the Hog's Bay Treatment Plant.

5. Existing industrial and institutional package plants will be converted for discharge into the new small bore sewer system (bottling plant), rehabilitated, and allowed to discharge into the storm water system (large hotel), or permitted to discharge directly into the interceptor (brewery and Port Authority complex).

Each of these off-site systems is dealt with separately and in greater detail.

B.3.1 Conventional Sewerage

The existing sewerage system was described in Annex P4 of the Pre-feasibility Report. Minor extensions to existing street laterals will be necessary during the project. Some 3 km of 200 mm pipe will be required at the upstream end of street laterals to accommodate residential developments at the higher elevations along the southern and southeast periphery of the Middle Residential zone. No extensions will be required in Seaview as land use zoning limits the size of that area to its existing boundaries which is already fully sewered.

The connection campaign to be carried out as part of the Immediate Improvement Project will raise the 1981 level of 24,600 connections to 29,000. The remainder of the overdue connections, approximately 13,000, will be made during the project.

Flows from all sewers in 1987 and their BOD load expected on project completion are listed in Table A3.3.

Table A3.3 ESTIMATED 1987 AVERAGE WASTEWATER FLOWS AND BOD LOADS

	Conventional Sewerage			Small Bore Sewers	
	Flow 000 m^3/d	Infiltration (000 m^3/d)	BOD (tons/d)	Flow (000 m^3/d)	BOD (tons/d)
Middle Residential	52.2	7.5	13.0		
Business	3.0	1.0	1.0		
Old Town	8.6	1.6	3.2		
Lower Residential	-	-	-	11.3	4.5
Railville B	-	-	-	2.7	1.5
Industrial and Institutional	40.7	-	6.8	0.5	0.1
Total to Hog's Bay	104.5	10.1	24.0	14.5	6.1
Seaview	5.3	0.5	-	-	-

Flows are conservatively estimated on the basis of approximately 90% capture of water supplied. Infiltration is assumed to affect only the conventional sewers as the entire small bore sewer system is to be constructed of PVC pipe. These flows imply 90%, 100%, 100%, 23%, and 50% of the Middle Residential, Business, Old Town, Lower Residential, and Railville zones, respectively, will be connected to sewers. BOD loads have been estimated on the basis of 45 gm per capita per day in residential areas, apart from those served by small bore sewers, for whom it is assumed that 45% of BOD is trapped by interceptor tanks, converted cesspits, and septic tanks before entering the system. Industrial flows include the large hotel, brewery and bottling plant. They also include institutional and commercial wastewaters, some of which are cooling water accounting for the relatively low BOD of industrial wastewaters.

Figure 4-3 shows the overall locations of the conventional and small bore sewer systems. Further detail is shown on Figure 2-10 for conventional sewerage and Figure 4-7 for small bore sewers.

B.3.2 Interceptor Sewers

The Main Street interceptor is to be laid along Main Street from the existing Meanthyme Treatment Plant to the new Hog's Bay Treatment Plant. Figure 4-6 shows the plan and profile of this sewer, which represents the single most expensive component of the sewerage collection and treatment system. The sewer will be constructed of precast concrete circular sections 1,800 mm and 1,900 mm in diameter, with an open channel at the plant boundary, and a total length of 7.0 km.

Sewer construction will be by shored and open cut trenches with the maximum depth of excavation of some 3.2 m. Little difficulty with groundwater is expected, except during the heavier rainy season when portable pumps will have to be used during construction. The average overburden on the pipe will be 1.5 m. The average overall cost of the installed interceptor is estimated to be Z 850 per metre, including road repairs.

The Railville interceptor (500 mm diameter, 2.0 km long) will be constructed of PVC bedded pipe, having an average overburden of 1 m. Its unit cost installed is estimated at Z225/m.

B.3.3 Small Bore Sewers

A schematic diagram of the small bore sewer system is provided in Figure 3-4. The small bore sewer system shown in Figure 4-7 is to be installed to serve a total area of 574 ha in Railville B and the northwest section of the Lower Residential zone, hereafter referred to as Lower NW. These areas are both low in elevation, less than 0.5% in slope, low in permeability, and silt-clay in subsoil. They will be served by the central water supply system through house connections. Lower NW has been selected for installation of small bore sewers as a consequence of severe environmental and health dangers caused by perennial pooling of water in backyards where houses already have water connections. Similar problems are predicted for Railville B on installation of water supply if wastewater is not removed from the area. The total number of people to be served and the number of installations required are listed in Tables A3.1 and A3.2.

The design methodology for small bore sewers is explained in Annex 4. Flows and BOD loads are given in Table A3.3.

Four Lower NW mains ranging in size from 200 mm to 400 mm will feed into the Main Street/Farmville Road interceptor and serve an area of 488 ha. Six mains will drain Railville B (86 ha) into the Railville interceptor which then joins the Main Street interceptor before draining to Hog's Bay Treatment Plant.

The total pipe lengths and sizes for mains, and laterals to be built during the project period are listed in Table A3.4.

Table A3.4 SEWER PIPES INCLUDED IN PROJECT 1984-86

Pipe Size mm	Area			
	Conventional Sewerage	Small Bore Sewers		
	Middle Residential, Business, Old Town m	Lower NW m	Railville B m	Total m
50	-	113,200	33,000	146,200
75	-	17,980	5,240	23,220
100	-	12,650	3,690	16,340
125	-	10,490	3,060	13,550
150	-	19,690	11,300	30,990
175	-	2,150	-	2,150
200	3,000	1,200	-	4,200
250	-	600	-	600
300	-	-	-	-
325	-	-	2,050	2,050
400	-	950	-	950
450	-	600	1,300	1,900
Total	3,000	179,510	59,640	242,150

Note: Sewers exclude house connections and interceptor sewers.

Small bore sewers in Lower NW will drain 930 converted cesspits, 180 converted septic tanks, and 6,290 new interceptor tanks. They will drain 1,140 converted cesspits and 1,120 new interceptor tanks in Railville B. Converting existing cesspits and septic tanks will involve structural repairs to 25% of septic tanks and 58% of cesspits. Effluent lines, 50 mm in diameter, will be installed on all 9,660 pits and tanks. These, like the laterals, will be buried a minimum of 1 m deep, following the natural topography of the land throughout both sewered areas. For effluent pipes, 100 mm trench diggers will be used, having a maximum wheel width of 2 m. Pipe bedding will not be necessary as the subsoil is clay silt. Backfilling will consist of replacing the soil and compacting by manual labour.

Investigations into alternative interceptor tank designs for mass production have resulted in the least cost, single household units being identified as made of cast concrete pipe sections as illustrated in Figure 4-8. An interceptor tank serving ten people would comprise two vertically placed 1.5 m diameter concrete pipe sections, each 1 m long.

Larger interceptor tanks used for two, three and four houses will be constructed on the property using mortared stone, bricks or concrete blocks in a cylindrical pit as illustrated in Figure 4-9. The effluent pipe of 50 mm diameter is laid 1 m below ground at a minimum of 1% slope. It is joined by a Tee connection to the street laterals. Interceptor tanks serving 20 persons or more can be constructed on site by local masons. The tank tops, 2 m diameter and 5 cm thick with an access port, can be fabricated on-site or off-site.

Construction of the small bore sewer system will be carried out mainly by contractors for PCWSC. It is estimated that 7,410 interceptor tanks will require two years to complete. Ten PCWSC inspectors should be available full time during the project for monitoring and evaluation. Five demonstration units have been built by PCWSC in collaboration with the consultants for the purpose of identifying least cost materials and construction methods. These have been used to develop the project designs described in more detail in Annex 4. The demonstration units should be used for training purposes. Contractors should become fully familiar with them prior to tendering for construction contracts.

B.3.4 Hog's Bay Treatment Plant

Wastewater treatment will take place in a sewage stabilization pond system incorporating anaerobic, facultative, maturation, and polishing ponds. The Hog's Bay Treatment Plant has been designed for the initial operating period of 1987-1990. Thereafter, an extension of ponds needs to be made to accommodate additional wastewater flows. The plant layout is shown in Figure 4-4; and the process diagram, including areas, loadings and effluent BOD's, is shown in Figure 4-5. It is designed to meet the recommended effluent quality standards for the Inner Harbour of 30 mg/l BOD, 30 mg/l suspended solids, zero floatables and 50 faecal coliforms per ml.

Wastewater from the Main Street and Railville interceptors will be measured by Parshall flume before entering the distribution channels to the anaerobic ponds. The anaerobic ponds will remove and treat a major portion of the settleable solids. By 1987 seven anaerobic ponds will be operating in parallel, feeding into seven facultative ponds. A maximum degree of flexibility in pond operation has been designed into the system so that failing ponds can be removed from operation for recovery while other ponds assume the additional load. The facultative ponds treating anaerobic pond effluents will be larger to permit effective algae/bacterial symbiosis in the surface layers and anaerobic treatment of settled solids on the bottom. Maturation ponds and polishing ponds are intended to further improve the effluent quality to acceptable levels for direct discharge to the harbour.

The total area of the extended proposed treatment plant (for design year 2000) comprises 330 ha of nearly flat (.003%) land located on the north shore of Hog's Bay as illustrated in Figure 4-4. Now owned by the Ministry of Defence, this land is not usable for agriculture due to high soil salinities. The average tidal reach is 20 m along the shoreline; flooding is not common as the land is bordered by both the North River and Swamp Creek, although 20% of the land is classified as marsh. Subsoils are silt-clay, the water table varies between 0.3 and 1 m in depth through the year. Being used thus far only as military basic training grounds, no permanent structures have been built apart from 3 m high chain-link and barbed wire fencing along the NW, NE and Southern boundaries. Negotiations for release of 140 ha of this land are proceeding as the IIP sludge ponds are ready for construction. An option for the additional 190 ha is being included to permit their eventual purchase in 1990. Pond configuration design takes this expansion into account. The military will continue to use the 190 ha as training grounds between 1983 and 1990.

Sludge ponds of 1.0 ha size are being constructed as part of the IIP. These will be expanded by a further 1.0 ha in 1984-85. The 124 ha of anaerobic, facultative, maturation, and polishing ponds should be built to receive wastewater from the existing conventional and small bore sewer systems from 1986. The series of ponds are designed to operate in parallel. Thus, each additional series of ponds can be put into operation according to the increased flow as more urban areas become connected to the sewerage system. Pond construction does not require specialized techniques or methods which are novel to Optima's civil works contractors. The only imported or specialized equipment is the flow measuring devices for the Parshall flume which also should cause no difficulty in installation. Additionally, a pumping station will be installed at the treatment plant for recycling maturation pond effluent to minimize anaerobic pond odours. This will require low lift pumps totalling 600 l/m capacity with standby capacity.

Effluent disposal will be made through short outfall to the North River. The effluent will contain approximately 10 mg/l BOD (excluding algae), 15 mg/l suspended solids and less than 50 faecal coliforms per ml. It will therefore not adversely effect the Inner Harbour. No settleable solids should be discharged to the North River. Sludge will be dried after thorough (minimum 150 days) digestion in ponds through pond decanting and sludge drying on-site. The dried sludge will then be trucked for landfill or fertilizer or soil conditioner as demand permits. An estimated 400 m^3/month will be available for such purposes.

Several previous studies have been undertaken on the potential for reuse of Port City's wastewater, as elaborated in Technical Appendix F. Although consideration of such reuse is not part of the terms of reference of this feasibility study, two possible options have been identified for the reuse of effluent from the polishing ponds:

- irrigation of nearby sugar estates (during the dry season); or
- groundwater rechardge to reduce aquifer salinity.

These reuse options and the use of the maturation and polishing ponds for culture of the freshwater fish, Tilapia, for eventual sale as food or feed, warrant serious consideration, but are beyond the scope of this feasibility report.

B.3.5 Public Toilet Facilities

As part of the ongoing IIP, all 15 Public Toilet Faciltles (PTF) in the Lower Residential zone are to be upgraded. The operation and maintenance of these facilities are to be monitored which will provide useful data for the detailed design and operation methods to be used for the total of 25 public toilets to be constructed in the project: 3 in the Lower Residential area, 12 in Railville, and 10 in Blight Heights. The recommended design of these facilities is given in Figure 3-6. The existing 15 public toilets in the Lower Residential zone are unsanitary and are badly underused. To ensure that the new toilets are fully utilized and properly maintained ISD carried out a questionnaire and observation survey of user views, preferences, and perceptions of public toilets in the Lower Residential, Railville, and Blight Heights zones. The results of the survey were used in designing and planning locations for the additional toilets. Each is to serve approximately 1,000 people. Their locations are illustrated in Figure 4-10.

The existing PTFs which are located in the areas without sewers will have to rely on truck collection until such time as sewers become available. The new PTFs in the Lower Residential zone will be located in the Lower NW section; they will be directly connected to the small bore sewer system. However, these will require desludging on a two-week basis. It is recommended that only one or two contractors be given the contract for constructing the PTFs within the project so that uniformity in construction and an economy of scale can be achieved.

B.3.6 Privately Owned Wastewater Treatment Plants

Five privately owned wastewater teatment plants exist in Port City, all previously described in Annex P4 of the Pre-feasibility Report. The oxidation ponds of the university and the oil refinery wastewater treatment systems are operating satisfactorily. These will continue to discharge treated wastes into local stormwater gullies and direct to the harbour, respectively, as now.

The Large Hotel treatment plant is to be upgraded so that its waste can be satisfactorily accepted by the nearby stormwater gully for eventual discharge to the sea. It is anticipated that the sewer system will be expanded to include this hotel by 1995. Until then, PCWSC will provide technical assistance and training to plant operators. Such assistance should be made available to the hotel and any other new industrial/commercial treatment plants on a regular basis. The soft drink bottling wastewater treatment plant will be converted to provide primary treatment only, the effluent discharging direct to the small bore system, and the sludge collected by truck for disposal into the sludge ponds at the Hog's Bay Treatment Plant. The brewery treatment plant will be dismantled, and brewery effluent discharged direct to the Main Street Interceptor for treatment by the Hog's Bay plant.

Whereas PCWSC will assume responsibility for technical assistance and training plant operators, the industrial and commercial establishments will be fully responsible for all wastewater treatment and disposal, including costs, under the schemes described above. Inspection of industrial effluent quality standards, under the jurisdiction of the Ministry of Health, should be transferred to the Ministry of the Environment prior to 1984. Enforcement through prosecution will be the responsibility of the Ministry of Environment. Inspection of treatment plants and ensuring that sludge is not discharged to the small bore sewer system will be the responsiblity of the PCWSC. The Commission will become responsible for removing and disposing of sludge as required, a service to be paid for by sanitation surcharges on all water users.

B.4 Operation and Maintenance Equipment

Apart from pour-flush toilets and VIP latrines the responsibility for maintaining the on-site sanitation facilities will fall on PCWSC. Whereas most septage clean-out will be largely contracted out to local firms, PCWSC should maintain an in-house capacity. These new duties will require two-well equipped maintenance teams to provide emergency service and maintenance, particularly the emptying of sludge from cesspits and septic tanks. Operation and maintenance equipment requirements are listed on Table A3.5.

The off-site sewer systems will also require maintenance teams, fully equipped for sewer inspection, flushing, cleaning, and minor repairs. The stabilization pond system will need one truck and minor equipment for pond maintenance. Similarly allocations are recommended for regular maintenance supplies for the pumping station as indicated in Table A3.5. The existing Meanthyme Treatment Plant will be dismantled and converted into a maintenance base during the project. All heavy equipment repair will be carried out at this Meanthyme maintenance depot (see Section B12 of Annex 2).

Table A3.5 SANITATION OPERATION AND MAINTENANCE REQUIREMENTS
Sewerage Maintenance and Supply Depot (Meanthyme Site)
Administrative offices and supplies
Pipe and appurtenance storage facilities
Mechanical supplies and spares
2 two-ton trucks
2 one-ton trucks: personnel transport
Sewer cleaning equipment and supplies
3 vacuum trucks; septage clean-out
3 one-ton trucks: personnel transport
Pumping Station (Sweet Street)
Staff offices and facilities
Mechanical equipment and supplies
Hog's Bay Treatment Plant
Staff accommodation
Maintenance supplies, including mechanical equipment
1 two-ton truck

C. CHARGES FOR SANITATION IMPROVEMENTS

C.1 On-Site Systems

The below ground components of the VIP latrines and pour-flush toilets will be installed, through an agreement with the householder, without cost to the householder. The above ground components are to be installed by the householder at his cost, although a loan to cover material costs may be made available through PCWSC, and materials will be provided free to those who dig their own pits. All commitments by each party will be covered under an agreement.

PCWSC will have the responsibility of inspecting and approving the installation, once constructed, and taking over responsibility for on-site sanitation throughout the area on behalf of the Ministry of Health. Maintenance will be the responsibility of the householder except where water is provided by a house connection, in which case PCWSC will be responsible for sanitation maintenance and will collect a surcharge on the water bill for this service. (See also Annex 1.)

The upgrading and conversion of cesspits and septic tanks will be undertaken by PCWSC who will also provide for inspection and maintenance, including desludging. Costs will be borne by the householder through a surcharge on water rates. Again PCWSC (in combination with the Institute of Social Development, discussed in Section D), will sign agreements with the householders.

The construction of new septic tanks, new cesspits, and pour-flush/sullage soakaways will be the responsibility of the householder. All new units are to be inspected by the PCWSC before it provides water connection and takes over maintenance responsibility. Maintenance costs will be recovered by a surcharge on the water bill.

Industries and institutions with private wastewater treatment plants will also pay a standard sanitation surcharge. PCWSC will remove sludge from these plants and provide technical assistance, including training for operating staff.

C.2 Off-Site Systems

PCWSC will be responsible for all sewers and system components off the property being served.

For the small bore sewers in Railville B and Lower NW, PCWSC will be responsible for constructing facilities on residential properties, including effluent pipes and interceptor tanks. Charges of Z200 per connection will be made, a figure lower than actual costs. The partial subsidy reflects the savings to PCWSC of using small bore rather than conventional sewers. Existing cesspits and septic tanks will be upgraded or converted by PCWSC as part of the project. These and new interceptor tanks will be connected to lateral small bore sewers. Capital and operating costs, including sludge removal and maintenance costs, will be recovered through additions to the water rates. The householder will be responsible for plumbing from the house/toilet to the interceptor tank.

House owners of properties adjacent to existing conventional sewers will have to bear costs of making the connections (which are overdue and should have been made when the sewer was laid originally). The cost of a connection, from the plumbing at the edge of the building to the street sewer, is expected to average Z300. PCWSC will be prepared to arrange loans to cover the costs of connections to conventional and small bore sewers, in cooperation with local banks.

Industrial, commercial and institutional customers of PCWSC will have to pay the full costs of sewer connections, either conventional or small bore, depending on their location. The average connection charge for such consumers will be Z1,400.

All Public Toilet Facilities will be built at the expense of PCWSC. They will be maintained by the municipality at no cost to the users.

D. IMPLEMENTATION

D.1 Schedule

The construction schedule for the sanitation component is shown on Figure 4-12, which breaks down the work into separate contracts, tentatively 17 in total.

The Institute of Social Development will be responsible for the program support activities under contract to PCWSC as discussed in Section D.2.a. The staff will operate from the two regional offices of PCWSC, one at the Railway water treatment plant and the other at the proposed new office on Farmville road for the northern part of Port City.

PCWSC is expected to engage contractors for most other activities, although staff may also be used for some sewer connections and upgrading of existing septic tanks and cesspits.

The schedule for each specific contract allows time for all steps necessary to select and employ the contractors, including:

- completion of final designs (already begun for the first year of implementation);
- preparation, review, and approval of contract documents;
- tender period (at least two months for major contracts);
- review of bids and approval of choice of contractor;
- contract negotiation and signature; and
- mobilization of contractor.

Off-site sanitation improvements will be commenced first because PCWSC is already responsible for sewerage. PCWSC can begin project implementation as soon as the project is approved (tentatively March 1983) and engineering consultants are engaged (tentatively June 1983). These two actions are critical to all subsequent progress.

The schedule further assumes that all local and foreign funding for the project can be arranged by December 1983 (or ten months after the release of this feasibility report). No tenders will be released for building before early 1984, but several are scheduled at that time, after designs are complete and tendering procedures can be agreed with the funding agencies.

The critical contracts are the two largest, those for the interceptor sewers and the Hog's Bay Treatment Plant.

The Hog's Bay plant is to be constructed in two phases. The first will aim to complete 60 ha of anaerobic, facultative, and maturation ponds before August 1985 when wastewater is first expected to enter the system by the interceptor sewer from Railville. The remaining ponds and the polishing pond will be complete by mid-1986 when the Main Street interceptor is completed.

The small bore sewer system will probably involve three contractors, one each for (a) the new interceptor tanks, (b) upgrading and converting the existing septic tanks and cesspits, and (c) the installation of the sewers, including the connections to the tanks. It is expected that this work will require most of the three-year project period for completion. As an alternative to three lengthy contracts, PCWSC might consider engaging contractors on several smaller contracts of shorter duration.

The small bore sewers are to be installed in areas where water supply distribution networks are also being installed. It is probable that there would be economies and minimum disruption of streets and traffic if a single contractor were selected for water and sewer networks in specific areas. Close integration of these contracts should be further considered during final design.

The on-site sanitation system activities are not scheduled to commence until 1984, by which time the PCWSC is assumed to have received the necessary legislative authority to proceed with these systems. Contracts suitable for small scale contractors would be awarded for these on-site systems.

Activities on the construction schedule of Figure 4-12 are dependent on a number of related activities which are summarized in Table A3.6. Most of these relate to the on-site sanitation system and support activities, a complex matter in view of the novel institutional arrangements.

PCWSC must obtain the land for the Hog's Bay Treatment Plant as soon as practicable, and definitely before the end of 1983, or the schedule will be seriously delayed.

D.2 Support Programs in Low Income Areas

The squatter zones of Railville and Blight Heights and the low income Lower Residential zones are to have three different programs of sanitation improvements:

Table A3.6 IMPLEMENTATION ACTIVITIES FOR SANITATION COMPONENT

TOPIC	ACTIVITY	RESPONSIBILITY	DEADLINE
On-Site Sanitation	1. Agreement with City and Ministry of Health to collaborate in project	PCWSC, Ministry of Health and City	November 1983
	2. Legislation to enable PCWSC to undertake on-site component	PCWSC and Government	December 1983
	3. Training and informing contractors of project and novel technologies	PCWSC	December 1983
	4. Training and strengthening staff in novel technologies/approaches	PCWSC, ISD, MoH	December 1983
	5. Initiation of manufacture of toilet appurtenances	PCWSC and Manufacturers	June 1984
	6. Teacher training for hygiene education	PCWSC and Ministry of Education	June 1985
	7. Inspection and take-over by Ministry of Health	Ministry of Health	August 1986
Off-Site sanitation	1. Approval of proposed treatment plant at Hog's Bay	Ministry of Health and Ministry of Environment	September 1987
	2. Acquisition of Hog's Bay plant land	PCWSC and army	October 1983
	3. Acquisition of Interceptor easements	PCWSC and city	October 1983
	4. (a) Approval of sewer locations	City and PCWSC	Prior to tenders
	(b) Coordination of traffic	PCWSC and police	Prior to construction
	(c) Road resurfacing	PCWSC and city	After construction
O & M Facilities and Services	1. O & M - off-site components	PCWSC	After construction

a) VIP latrines and pour-flush toilets (Railville, Blight Heights, Extra Zones);
b) Installation of new cesspits and septic tanks and upgrading of existing ones (Lower Residential); and
c) Installation of small bore sewerage (Railville, Lower Residential).

Each will require a support program.

D.2.1 VIP Latrines and Pour-flush Toilets

PCWSC and the Local Government have encountered difficulties in mounting infrastructure projects in Railville and Blight Heights in the past as a consequence of the lack of effective linkages between the people in these zones and the municipal government. Two development programs have succeeded, however. These were the squatter upgrading program for Railville's Sector B and the family planning program of 1974-78 in all low income areas of Port City. The settlement upgrading program relied heavily on the Institute of Social Development (ISD) as its executing agency. ISD was initially formed as part of the municipality to act as a liaison between low income groups and city authorities. It was quickly determined that an autonomous body was required for this purpose and ISD was made independent. ISD still maintains a skeleton staff of a sociologist (Director), an economist, an urban planner, and five technical support staff.

The successful family planning project relied on a specialized Bureau of Family Planning within the Ministry of Health. It comprised three nurses (health visitors), supervised by a physician and a communication specialist. The nurses were supported by 25 nursing assistants in the field and 300 temporary field workers specially trained in audio-visual techniques and specific family planning messages. The Bureau has been all but disbanded, but it can be a resource for this project.

ISD was retained to study the low income areas to determine implementation procedures. It is recommended that ISD be retained to provide project implementation in the future.

Interviews with household and community leaders were held by senior staff of ISD which focused on political aspects, identification of religious and other community organizations, community administrative capability and procedures, past development project successes and failures, relationships with government, community perceptions, and expectations in respect of water and sanitation infrastructure and available artisan and skilled labour resources.

Railville is the oldest squatter settlement in Port City. As such, its organizations, infrastructure, and services are more developed than Blight Heights. Sector A of Railville is planned for upgrading (including land tenure, land in-fill, road realignment, drainage, etc.) after project completion. The study demonstrated householder interest and willingness to participate in the project. There is relatively little political factionism within this sector as the vast majority of its inhabitants support one party. The demonstration effect of Sector B's upgrading has created raised expectations in Sector A and improved relations between these sector's inhabitants and the government to the point whereby two municipal offices have been established in the area which are operated by the Municipal Social Services Department. In general, the householders interviewed expressed a wish for improvements over the present arrangements, even if it meant their not being provided full water and sewerage initially. There are ten private and three municipal primary schools in the area. These form the basis for parents associations, and are used as community centres for political and other community meetings. Two Health Centres provide clinics, especially for maternal child care, and have become centres for two women's organizations. Although there appear to be little institutional and organizational infrastructure in the formal sense, communication links and informal hierarchy are very strong. For example, no development project instituted by outsiders or the government has succeeded without support of the local political and informal leaderships. There are two major religious denominations within the community, neither has experience in infrastructure improvement projects although both have instituted social welfare programs aimed at the poorest of the population.

Blight Heights is more sparsely populated and is a more recent settlement (from 1974 onwards). Whereas interest in the project is strong and the inhabitants are well motivated, its organizations, political and informal leadership, and cohesiveness are far weaker than those of Railville(A). Similarly, the population is unfamiliar with community-based development projects. In light of results of the initial survey, a project implementation support program is recommended as discussed below.

The area adjacent to Blight Heights, termed Extra Zones, is sparsely inhabited at this time although in-migration into this area, including spill-over from Blight Heights, is progressing rapidly. Data from Blight Heights are considered representative of anticipated conditions in these adjacent zones in 1985.

PCWSC should retain responsibility for support activities of the VIP latrine and pour-flush toilets of the project, which are discussed hereafter. However, it should subcontract responsiblity to the

Institute of Social Development. ISD should draw on the procedures used by the Bureau of Family Planning. It should be able to employ mahy of the temporary workers from the successful family planning project who have already been trained in the necessary techniques to carry out field work. On completion of the project the Ministry of Health should retain overall jurisdiction for water quality and on-site sanitation systems through its Environmental Health Section. Similarly, PCWSC should be responsible for constructing public toilet facilities, but the Ministry of Health take all operational responsiblities once installed.

Community surveys involving a much larger and more representative sample (20%) of the houses in the three areas should be based on household interviews and observations to collect socio-economic data, expectations and attitudes towards various options for water and sanitation, and preferred methods of introducing water and sanitation improvements. As far as possible the surveys should also disseminate information on the forthcoming project to the households. This survey and further discussions with the leadership should allow detailed design of the project's implementation strategy in these areas.

An information and promotional activity should be established within the three zones as early on in the project as possible. This should include pamphlets, loudspeaker trucks, and house-to-house visits by the field workers under direction of the social workers of the Institute of Social Development. Community meetings should be held in the schools supported by local leadership.

Two demonstration facilities should be constructed early in the project both to illustrate the sanitation options being proposed (VIP latrines and pour-flush toilets) and to assist in training courses in construction for householders, artisans, and skilled labour. Information and training should be free and promotional in nature. The demonstration facilities would best be located at the municipal offices in both Railville(A) and Blight Heights. They should be staffed by technicians, and technical assistance should be made available on a 7-day a week basis. If a project is to succeed in the squatter communities the local leaders must be persuaded of its worth and give their support. This will be easier in Railville than in Blight Heights. Additionally and to promote the on-site technologies, influential leaders in each local neighborhood should be encouraged to build demonstration toilets on their property.

Monitoring and provision of technical assistance to individual householders will be the responsibility of the ISD temporary field workers and, where necessary, technicians through household visits. Inspection of the facilities once constructed will be the responsibility of the Ministry of Health.

Each householder will be expected to bear the investment costs of above ground components of on-site installations. Financial assistance may be required in some instances. It is recommended that PCWSC consider making loans available to householders for purchase of materials for above ground components. This should be considered in more detail prior to the implementation of these on-site facilities. Householders who dig their own pits should be given superstructure materials free as an incentive.

The householder must be accurately and well informed of the technologies, choices, the benefits, costs, and the implications of commitments when entering into an agreement to construct on his property. The temporary ISD extension workers supervised by a social worker, will be responsible for ensuring that these requirements are met and for obtaining application for loans where necessary. Loan agreements would follow, supported by loan guarantors. Repayment will be made direct to PCWSC.

The pipes, slabs, and squatplates are not presently available locally. PCWSC should encourage local commercial manufacture of these items and, if not possible, fabricate them. The sanitation demonstration facilities at the municipal offices would be appropriate sites and distribution points for materials used for above ground components.

D.2.2 Cesspits, Septic Tanks and Pour-flush Toilets with Sullage Soakaways

A similar support program is necessary in the Lower Residential zone for these on-site sanitation technologies as for VIP latrines and pour-flush toilets in the squatter areas. It is again recommended that ISD be subcontracted.

D.2.3 Small Bore Sewerage

As in the case of the on-site systems, a support program comprising information and promotional activity should be undertaken by the PCWSC through ISD in those areas which are to be included in the small bore system. This should be carried out through door-to-door pamphlets and visits by PCWSC inspectors. Where necessary the Institute's extension workers or social workers should be available to assist. PCWSC should conduct an inventory of requirements during the promotional activity, and each houseowner should be accurately informed of the project, its implications, and expected commitment. An agreement setting this down in writing should be signed by the houseowner and PCWSC prior to any work being carried out on the property.

D.2.4 User Education Program

The Hygiene Education component of the program support component will comprise two distinct parts: (1) the campaign during the project and (2) the educational program to be initiated during the project, but extending thereafter on a permanent basis. The campaign will be tied closely to the Institute of Social Development's information program, but be directed primarily at the mother and child and secondarily at the male and the community as a whole. Its messages will be: (a) basic hygiene with an emphasis on defecation practices, (b) latrine maintenance, and (c) water quality protection and water use habits. The media will include radio, television, comics, posters, and any community or group meetings. Government offices associated with the project such as those of the PCWSC and Ministry of Health and their urban health centres will also be utilized as centres for project information and hygiene education. Again the field worker will be on the front line providing hygiene information to the women of the households on a house-to-house basis.

The Educational Program will be based in the primary schools and involve the teacher as the primary motivator. A preliminary review of the primary school education system has indicated that both teacher training and curriculum upgrading will be required. Teachers themselves are often unfamiliar with and do not practice adequate environmental hygiene. Teacher training in hygiene and hygiene education will be necessary as part of the project. Similarly, the curriculum in primary schools needs major changes to encourage hygiene becoming a functional part of daily life rather than an academic exercise in the classroom. All schools will require water and latrine upgrading or installation of new facilities. Care should be taken in their design to permit their becoming demonstration units in support of classroom activities. The curricula of the first four grades should be carefully redesigned to involve the children in educational experiences focusing on the basics of: (1) common water related disease transmission, (2) maintenance and operation of on-site water and sanitation facilities, and (3) personal hygiene. The primary school education program would begin as early as possible into the project to provide additional support to the project from the school through the child to the home.

Costs of carrying out the technology delivery support and educational program component of the project are estimated to be Z850,000 over the project period. Educational activities after completion of the project will be integrated into the Ministry of Education's regular program.

E. COST ESTIMATE

E.1 Unit Costs

Costs of sanitation system components have been based on data contained in past reports; from investigations using prototype units built of various locally available materials and construction methods; and also from detailed discussions with local contractors. Unit costs are listed in Table A3.7. It is noted that unit costs vary somewhat from the pre-feasibility study estimates as a consequence of more detailed investigation into costs.

The relatively low costs for small bore sewers warrant some explanation. Septic tank costs are considerably more expensive than interceptor tanks in light of conventional designs using rectangular shapes, materials including poured concrete, and the additional average Z700 for connection and seepage trench. The interceptor tank for small bore sewers is designed on a one-day retention period. For single residences the tank comprises precast concrete pipes, placed vertically. Larger tanks serving multiple residences are constructed of mortared rock walls, circular in shape, and without concrete floor. Further, the design objectives differ between septic and interceptor tank. The septic tank is designed to trap as many suspended solids as possible in order to avoid drainage trench clogging whereas the interceptor tank is designed to trap settleable solids but release as many suspended solids as feasible, thereby extending the period of sludge collection. In this instance interceptor tanks have been designed for sludge collection every three to four years. It is anticipated that periods between collection may be increased in practice due to the desirable slow release of suspended solids from the tank.

Costs of cesspits, septic tanks, and interceptor tanks include the connection between house and tank, but exclude the cost of changes to plumbing, estimated at Z50/household on average.

House connections for conventional sewerage are all 150 mm PVC, laid at a minimum of 1% slope and reach from the household itself to the street lateral. Unit costs include the saddle connection.

There are major differences in unit costs of installing small bore versus conventional sewers. Wherever feasible, the small bore sewer typically follows the local topography about 1 m below the surface. Pipes up to 75 mm diameter (by far the majority) can be placed in narrow trenches which do not require shoring of their sides to prevent collapse in the local clay-silt soils. The pipe is laid on the trench bottom with seldom a need for sand bedding. The infilling of sand is optional, the purpose being merely to provide an indicator as to the location of the pipe when it is dug up for repair by mechanical equipment. (Once sand appears, manual digging takes over to avoid pipe breakage.)

For conventional sewers, however, the constant slope and straightline requirements between manholes and larger pipe sizes makes both close vertical and horizontal control in placement and bedding mandatory. The minimum depth of cover over the top of the sewer pipes needs to be carefully considered, as well as the various materials for backfill and their method of compaction. The elevation of the pipe invert must be carefully controlled to avoid dips in the pipe.

E.2 Total Costs

Cost estimates have been prepared for all elements based on preliminary designs completed during the feasibility study. Unit costs are those summarized in Table A3.7.

Physical contingencies provide for various types of unexpected work. Because the proposed project is fairly straightforward and preliminary designs based on field surveys exist for major components, the allowance of 15% for physical contingencies is realistic.

All cost estimates are expressed in price levels prevailing in mid-1982. The as-built costs will depend on changes in price levels up to the time of construction of the various components. The following estimates of probable future increases have been prepared after consultation with economists in the Ministry of Planning and the Bank of Optima:

Year	Probable Rate of Price Increases (%)	
	Domestic	International
1983	12.0	8.0
1984	11.0	7.5
1985	10.0	7.0
1986	9.0	6.0

Table A3.8 summarizes sanitation component costs in terms of the local and foreign cost components. The latter includes both direct costs, for imported goods and services, plus indirect costs such as the component of fuels and oils from Optima's refinery due to imported crude oil, imported construction equipment, etc.

Table A3.9 presents the costs of project components on an annual basis, in accordance with the construction schedule of Figure 4-12.

Table A3.7 SANITATION UNIT COSTS

On-site Sanitation	Average Unit Cost (Z)
VIP Latrines[1] (Railville A and Blight Heights	95
Pour-flush Toilets[1] (Railville A and Blight Heights)	125
Cesspits, new (Lower Residential)[2]	2,000
Cesspits, upgraded (Lower Residential)	160
Septic Tanks, new (Upper Res, Lower Residential and Extra Zones)[2]	1,600
Septic Tanks, upgraded (Lower Residential)	200
Off-site Sanitation	
Conventional Sewerage	
Connections (Mid. Res and Seaview)	300/ea
Connections (Business and Old Town)	1,400/ea
Street laterals: 200 mm	34/m
Sewer - mains: 300 mm	40/m
350 mm	47/m
Manholes: 1-3 m	600/ea
3-6 m	800/ea
Small Bore Sewers	
Household Connections 150mm (0-1 m depth)	20/m
Cesspit conversion (Lower NW)	180/ea
Septic Tank, conversion (Lower NW)	150/ea
Interceptor Tank, new: single household	230/ea
2 households	250/ea
3 households	300/ea
4 households	350/ea
Effluent Pipe 50 mm (1-3 m)	4.50/m
75 mm	5.00/m
100 mm	6.00/m
125 mm	8.65/m
150 mm	10.50/m
175 mm	12.50/m
200 mm	15.00/m
250 mm	20.25/m
325 mm	30.50/m
400 mm	35.00/m
450 mm	40.00/m

1/ Below ground components. Superstructures not included in project costs.

2/ New cesspits and septic tanks to be built by house owners and not included in project.

Table A3.8 SUMMARY OF CONSTRUCTION COSTS
FOR SANITATION COMPONENT

Item	Local	Foreign	Total
	------- Z million	--------	
On-Site Sanitation Systems:			
Support Activities	0.60	0.05	0.65
Construction of Below Ground Facilities	1.60	0.20	1.80
Upgrading of Existing Facilities	2.60	0.30	2.90
Off-Site Sanitation Systems:			
Support Activities	0.20	-	0.20
Connections to Conventional Sewers	3.40	0.90	4.30
Extensions to Conventional Sewers	0.20	0.10	0.30
Interceptor Sewers	4.60	1.80	6.40
Hog's Bay Treatment Plant	4.75	0.70	5.45
Meanthyme Treatment Plant Dismantling	0.10	-	0.10
Public Toilets	0.55	0.05	0.60
Small Bore Sewer System	3.10	0.85	3.95
O & M Facilities and Equipment	0.20	0.15	0.35
Sub-total	21.90	5.10	27.00
Consulting Services	0.90	0.80	1.70
Physical Contingencies	3.30	0.80	4.10
Sub-total	26.10	6.70	32.80
Price Increases	9.10	2.10	11.20
TOTAL	35.20	8.80	44.00

Note: Costs presented in more detail and on annual basis in Table A4.9.

Table A3.9 CONSTRUCTION COSTS FOR SANITATION COMPONENTS ON ANNUAL BASIS

Contract No.	Item	1983	1984	1985	1986	Total, 1983-86
		Z million (mid-1982 prices)				
	On-Site Sanitation Systems					
S1	Support Activities (ISD)	-	0.20	0.35	0.10	0.65
	Construction of below ground facilities:					
S2	Blight Heights	-	0.10	0.30	0.20	0.60
S3	Railville A	-	0.10	0.30	0.30	0.70
S4	Extra Zones	-	-	0.20	0.30	0.50
S5	Upgrading of Existing Septic Tanks and Cesspits	-	0.60	1.20	1.10	2.90
	Off-Site Sanitation Systems					
S6	Support Activities (ISD)	-	0.05	0.10	0.05	0.20
S7	Connections to Conventional Sewers	-	0.90	1.80	1.60	4.30
S8	Extensions to Conventional Sewers	-	0.20	0.10	-	0.30
S9A	Interceptor Sewer (Main Street)	-	1.20	3.00	1.75	5.95
S9B	Interceptor Sewer (Railville)	-	-	0.45	-	0.45
	Hog's Bay Treatment Plant:					
S10	Land Cost	2.10	-	-	-	2.10
S11	Construct Oxidation Pond	-	0.35	2.20	0.80	3.35
S12	Dismantle Meanthyme Treatment Plant	-	-	-	0.10	0.10
S13	Public Toilets	-	-	0.30	0.30	0.60
	Small Bore Sewer System:					
S14	Conversion of Existing Septic Tanks and Cesspits	-	0.10	0.10	-	0.20
S15	Construction of Interceptor Tanks	-	0.50	0.95	0.65	2.10
S16	Construction of Small Bore Sewers	-	0.30	0.70	0.65	1.65
	O & M Facilities and Equipment					
S17	Workshop and Store at Meanthyme Plant	-	-	0.10	0.05	0.15
S18	Purchase of Miscellaneous Equipment	-	-	0.10	0.10	0.20
	Sub-total	2.10	4.60	12.25	8.05	27.00
	Consulting Services					
	Engineering for Project Implementation	0.20	0.50	0.50	0.30	1.50
	Operational Assistance	-	-	0.10	0.10	0.20
	Physical Contingencies	0.30	0.70	1.85	1.25	4.10
	Sub-total	2.60	5.80	14.70	9.70	32.80
	Price Increase	0.30	1.30	5.00	4.60	11.20
	TOTAL COSTS (current prices)	2.90	7.10	19.70	14.30	44.00

FEASIBILITY REPORT FOR PORT CITY

DESIGN AND EVALUATION OF SMALL BORE SEWER SYSTEM

Annex 4

DESIGN AND EVALUATION OF SMALL BORE SEWER SYSTEM

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DESIGN AND EVALUATION OF SMALL BORE SEWER SYSTEM

A. PORT CITY SMALL BORE SEWERS

The existing conventional sewers in Port City are designed as sanitary sewers. Small bore sewers are likewise intended to be a separate system with stormwater handed by surface drainage.

The small bore sewer system comprises a household toilet (either pour-flush or cistern flush), an influent pipe to an interceptor tank in which settleable solids are retained, tank effluent pipes, street laterals, and mains (Figure 3-4). Removal of settleable solids in the interceptor tank (Figures 4-8 and 4-9) allows the effluent to flow by gravity and does not require the self-cleaning velocities necessary in conventional sewers. No large solids being discharged into the small bore sewer system also allows for reduction of pipe diameters (up to 60% in the case of street laterals and mains). Use of PVC pipes requires no special corrosion protection and prevents significant infiltration of groundwaters. Other variances from conventional sewerage design give rise to substantial savings, including reduced pipe slopes and depths and minimal requirements for manholes and pumping stations under normal conditions.

The strategic plan for the year 2000 in Port City calls for sewerage systems to service 2,668,000 people, of which 618,000 located in the Middle Residential, Business, Old Town, and Seaview zones will be served by conventional sewers. The areas presently served by conventional sewers (Figure 2-9) will not be expanded. Small bore sewers are planned for the remainder of the city, including the Lower Residential zone, Railville, Extra Zones, and New Town. The high densities, water use, and soil permeabilities will obviate on-site soakaway systems for wastewater in these zones by the year 2000.

Seaview wastewater will continue to be collected and treated in that separate system. All other wastewater from Port City will be treated at the Hog's Bay Treatment Plant. New Town is to be served by small bore sewers discharging through a separate main (500 mm, 2 km) direct to the Hog's Bay plant. Other sewage including that collected by conventional sewerage will be collected by a large interceptor sewer between the site of the Meanthyme plant and the Hog's Bay plant running north under Main Street.

As illustrated in Figure 4-3 and presented in more detail in Figure 2-10 and Figure 4-7, sewage from Mid and Lower trunks will be pumped to the gravity main leading to the existing Main Street collector. The High Level and Northern Trunk systems will continue to feed into the Main Street collector which will feed directly into the interceptor at the site of the Meanthyme Treatment Plant. Railville, Extra Zones and the Lower Residential Zone sewage will drain by small bore sewer into the Main street interceptor through 12 mains and sub-mains ranging in diameters from 150 mm to 800 mm. Common street lateral and interceptor tank effluent pipe sizes in the small bore sewer systems will be 75 mm and 50 mm, respectively. The influent pipe should be a minimum of 150 mm in diameter and 2% in slope to permit larger objects flushed down the toilet to reach the interceptor tank unimpeded. A design example is detailed below.

With respect to the proposed project (1984-86), the majority of houses in the Lower NW area of the Lower Residential zone will have their existing cesspits and septic tanks upgraded to function as interceptor tanks, overflowing directly into the small bore effluent pipes. New installations in this area and Railville B will require construction of interceptor tanks 2-3 m^3 in volume, depending on the size of the contributing population and influent flows. The interceptor tank can be circular or rectangular in horizontal cross section and be designed to settle all larger solids, but it should encourage release of colloidal and other unsettleable solids with the effluent (Figures 4-8 and 4-9). Sludge is to be collected by vacuum truck on a regular (3 to 5 year) basis. PCWSC will be responsible for inspection and sludge collection. All other on-site maintenance and repair to the system will be the householder's responsibility.

B. SMALL BORE SEWER DESIGN EXAMPLE

A 73 ha area within the Lower Residential Zone adjoining the Meanthyme Treatment Plant but north of Main Street has been selected for purposes of illustrating the design principles of the small bore sewer system. This area, shown in Figure 4-13, slopes towards the Main Street interceptor it borders at an average slope of 1.5% or 1:66.

The area is divided into multi-house lots, averaging 2.5 houses each by the year 2000. This is the result of housing densification on lots previously used by upper income residents who have since relocated uptown and now rent to lower income earners. Most existing cesspits or septic tanks will serve two or three households averaging 9.7 persons per house. The area's population density of 300 pers/ha in 1980 is expected to increase to 540 pers/ha over the next 20 years without appreciable area expansion. Despite this substantial infilling and the ensuing increase in the number of houses, ample space exists for the new interceptor tanks to serve single households.

The subsoil consists of silty clay of even consistency down to 50 m. The groundwater table fluctuates between 2 m and 1 m below the surface. High groundwater tables persist through the two-month wet season. A 3.5 ha area within the 73 ha has been selected as being representative in housing, density, street configuration and topography. This 3.5 ha is identified in Figure 4-13, and shown in greater detail in Figure 4-14 which is used for detailed house connection design below.

At the household level, either low volume flush, including pour-flush, or conventional cistern flush toilets will be in use. These will feed directly through 150 mm diameter PVC pipes sloped at a minimum 2% grade to interceptor tanks which will either be upgraded cesspits, septic tanks or new interceptor tanks. Sludge accumulation is estimated to be 40 litres per capita per year, requiring an average sludge storage volume of 3 m^3 in upgraded cesspits where sludge collection frequency is once every three years. Likewise, where interceptor tanks are constructed to serve single houses, they will require 1.2 m^3 of sludge storage volume. After upgrading, existing cesspits will provide a minimum of 10 m^3 of sludge storage volume. Existing septic tanks provide a minimum of 2 m^3 to 3 m^3 of sludge storage, necessitating collection with a frequency of once every two to three years. New interceptor tanks will be 1.5 m in diameter and 2 m deep, providing a minimum of 40 litres per capita per year of sludge storage volume and a two-day retention period to ensure adequate removal of settleable solids. The effluent pipe of the interceptor tank should be baffled to minimize the possiblity of scum leaving with the effluent. The interceptor tank bottom can be clay lined, and the sidewalls brick concrete block or 1.5 m concrete pipe sections.

Water use will rise to 100 lcd by 2000 in the Lower Residential zone, an estimated 90% of which will be discharged into the interceptor tanks and subsequently the small bore sewer system. It is conservatively assumed that instantaneous peak flows along street laterals will rise to 5 times the average daily flow of 90 lcd. This peak factor reduces to 2.5 for submains and mains. The interceptor tanks will remove an average of 50% of BOD from household wastes. The strength of domestic sewage collected by the small bore sewers is estimated to be 200 mg/1 BOD by the year 2000.

C. DESIGN PARAMETERS AND METHODOLOGY

Figure 4-14 illustrates all buildings, roads, paths, interceptor tanks, and converted cesspits and septic tanks expected in the design year 2000. Topographical contours are also illustrated. The sewerage pipe configuration is designed to accommodate the house connections, subsoil conditions, street, and path layout and take maximum advantage of local topography. Elevations of pertinent components (mains, interceptor tanks and upgraded cesspits, street elevations, etc.) are plotted on profiles. Pipe sizing is an iterative process in which Mannings' formula is used to design sizes which allow pipes to flow just full at peak flow while attempting to maintain a constant pipe depth of 1 m below existing ground.

The following design pertains to the 3.5 ha under consideration:

population: 1890
number of interceptor tanks and upgraded cesspits: 78
number of houses: 195
persons per house average: 9.7
peak flow: 450 lcd or 0.31 l/min

The lateral and house connection layout for small bore sewers is shown in Figure 4-15. The ground profile, interceptor tank and cesspit water elevations, and all connections are plotted in Figure 4-17.

A trial street lateral (A) profile is drawn using the effluent pipes as entry points. The lateral is divided into sections whose lengths are specified by significant changes in overall grades and major flow entry points. In this case, lateral A has been divided into two sections of 90 m and 130 m, and trial pipe diameters tested for capacities under the two slope conditions.

The pipe sizes and corresponding flows are determined for these sections using Mannings' formula for peak flow at their outlets by calculating required slopes at various pipe diameters which will result in full flow conditions. In designing sewers for full flow at peak flows care should be taken to ensure that there will be insignificant or no stormwater entry into the sewers through illegal connections. This is so in this case. The 90 m lower section outlet is predicted to have a peak flow of 90 houses x 9.7 persons per house x 450 lcd = 392.8 m^3/d or 272.8 l/min. The required slopes are:

Pipe diam (mm)	Slope (%)
75	3.08
100	0.66
125	0.20

The 100 mm diameter pipe most closely approximates the existing overall section slope of 0.65%.

It would be possible to check each section's effluent line connection points individually. However, it is neither necessary nor economical to do so. Each lateral length between house connection entry points can be mentally checked.

The pipe size of the second section of 130 m length can now be determined by Mannings' formula by selecting the size whose required overall slope most closely approximates that of the average slope between house connection entry points (1.03%). The peak flow from the contributing 47 houses will be 142.5 l/min which would flow full under the following conditions.

Pipe diam (mm)	Slope (%)
50	7.30
75	0.84
100	0.18

A 75 mm pipe diameter is selected for this section. The only length in which slight pressure might occur would be the first (lowest). However, its actual individual slope after construction will be 1.7% which will ensure that it would in fact flow less than full at peak flow.

All interceptor tank effluent pipes are 50 mm. Back-up is not expected along these pipes. A check of the pipe which is most likely to flow under pressure is possible. The worst condition may be found in the second effluent pipe entering lateral A. Its slope is 1.76% and peak flow 36.4 l/m. Mannings' formula indicates that the pipe size which would flow full under these conditions would be 39.1 mm in diameter. The actual pipe size being 50 mm indicates that the pipe will not back up under peak flow conditions.

Other laterals within the 73 ha (Figure 4-13) are designed to just flow full under peak flow conditions at slopes approximating the natural grade of the area, and to join the North-South Highbourne Street main, which varies in diameter from 125 mm to 300 mm leading to the interceptor.

No manholes are necessary for the small bore system, either for cleaning out or at junctions of sewers or at changes in grade. They were considered but their only use might be for inspection. Should the sewer clog, however, it can be unblocked by opening it up. The small bore sewer carries liquids only and so is unlikely to clog.

A comparison can be made with a conventional sewer design as shown in Figure 4-16. In this case house connections are 150 mm at 2% slope minimum, leading to 200 mm diameter and 1% slope minimum laterals and mains. These design criteria are based on a mixture of hydraulic principles involving required self-cleaning velocities and experience in practice which dictates that conventional sewer inspection and cleaning equipment must be able to pass through the pipes. Manholes are necessary for cleaning, at junctions and where the grade changes.

Small bore laterals are PVC and can be laid in trenches dug by trench digging machines with 10 or 15 cm blades. They need not be superior or pressure class pipes. Similarly, trench bedding is not required as long as the natural subsoil does not contain rocks. Backfill can be made, using the dug material, with compaction by foot around the pipe and later by tractor wheel on top of the trench once backfilled. On the other hand, conventional sewer construction requires straight alignment and grades, necessitating vertical control and a straight, graded, and compacted trench bed. This is normally accomplished by placing 15 cm of sand in the open trench, mechanically compacting it and checking its elevation along the trench before the sewer (200 to 500 mm) is laid. Compacted sand fill to half the pipe depth is required, thereby increasing the trench width to accommodate the mechanical compactor. Sand fill to the top of the pipe is required before subsoil is backfilled into the trench and compacted. The sizes of equipment for sand delivery, trench digging, and compacting raise the cost of sewer installation well above that of the small bore sewer.

D. COST COMPARISON BETWEEN CONVENTIONAL AND SMALL BORE SEWERS

Unit costs of the various components of small bore and conventional sewerage systems are listed in Table A4.1. Both system are for sewage only.

These are used in calculating and comparing the costs of small bore versus conventional sewerage for the 73 ha discussed above and illustrated in Figure 4-13. Comparative costs have been calculated for the following basic assumptions:

Number of houses:	4064
Area:	73 ha
Population:	39,420

Costs for conventional sewers for this area are estimated to total Z1.6 million, as shown in Table A4.2. Comparable costs for small bore sewers are estimated at roughly 60% this sum as shown in Table A4.3.

The major costs of conventional sewer systems are the street laterals and manholes. Small bore sewers are much more cost effective here. Unit costs of small bore sewer effluent pipes from pits and tanks are closer to those of water distribution pipes, in fact somewhat lower as pressure class pipes are not required. Conventional sewer street

Table A4.1 Unit Costs of Sanitation System Components

		Z
Conventional Sewers		
House connection hook-ups (avg)		300 ea
Street laterals	200 mm	34/m
Mains	300 mm	40/m
	350 mm	47/m
Manholes	1-3 m deep	600 ea
	3-6 m deep	800 ea
Small Bore Sewers		
Household connections (150 mm, 0-1 m depth)		20/m
Upgraded cesspits		730 ea
Upgraded septic tanks		150 ea
Interceptor tanks (avg 2.5 household)		275 ea
Effluent pipes	50 mm	6.75/m
	100 mm	9.00/m
	125 mm	13.00/m
	150 mm	15.75/m
	175 mm	18.75/m
	200 mm	22.50/m
	250 mm	30.40/m

Table A4.2 Conventional Sewer Costs for 73 ha Example

Item	Number or Length		Unit Cost	Cost
House Connections		4,064 units	300	1,219,200
Laterals	200 mm	7,400 m	34	251,000
Mains	200	55	34	1,900
	250	170	37	6,300
	300	95	40	3,800
	350	65	47	3,000
	400	475	57	2,700
Manholes 1-3 m deep		60	600	36,000
3 m or more		15	800	12,000
Road Crossings		21	1000	21,000
				1,581,000

Cost per person: Z40.11

Table A4.3 Small Bore Sewer Costs for 73 ha Example

Item	Number or Length		Unit Cost Z	Z Cost
Household Connections		20,320	20/m	406,400
Upgraded Cesspits		730	180	131,400
Upgraded Septic Tanks		104	150	15,600
Interceptor Tanks		792	275	217,800
Street Laterals	50 mm	17,000	6.75	114,750
	75	2,700	7.50	20,250
	100	1,900	9.00	17,100
	125	1,575	13.00	20,480
	150	900	15.75	14,180
	175	225	18.75	4,220
	200	100	22.50	2,250
Mains	150	55	15.75	900
	200	170	22.50	3,830
	250	225	30.40	6,840
	300	410	1000	16,900
Street Crossings		21		21,000
				1,013,900
Cost per person: Z25.72				

laterals are sized to facilitate solids cleaning equipment and are therefore very much larger than peak flows would require. The submains of conventional sewers are designed using peak flow factors of from 4 to 6. That is they are designed to accommodate peak flows which are 4 to 6 times greater than average daily flows. Storage capacity in the interceptor tanks reduces the expected instantaneous peak flow and allows for a reduction in the peak flow factor to 2.5 for submains and consequently smaller sewer diameters. Conventional sewerage requires larger diameter effluent pipes installed under more stringent bedding conditions and in wider trenches as described above. Unit costs of house connections are estimated at Z300 per household for conventional sewerage. Small bore sewer house connections are shorter (5 m avg), because pit and tanks are located close to houses. Small bore (50 mm) effluent pipes drain the tanks to street laterals. The overall lengths of pipe between houses and street laterals are somewhat higher in the case of conventional sewerage (48,550 m) than small bore sewers (37,320 m) due to inefficiencies of conventional sewerage hook-ups as compared to the small bore sewers' shared use of pits and tanks.

Port City slopes to the northeast at gradients ranging from about 0.5% to 3%. This topography is well suited to both conventional and small bore sewer alternatives. The advantages which small bore sewers have under flat topographic conditions are not highlighted by the example area selected being repesentative in topographical characteristics within Port City. Should the comparison have been made under flat topography the small bore sewers would have had an additional advantage over conventional sewers which would require steeper slopes and deeper trenches to meet self cleansing velocity requirements and consequently more pumping stations and deeper manholes.

Pits and tanks of the small bore sewer system require desludging every three years at an additional cost, but only at an estimated Z2/year per household, assuming Z6/m^3 of sludge removed. Maintenance and repair of the small bore sewer system would be less frequent and costly than that of a conventional sewer system because the latter is used for both liquids and solids, whereas the small bore sewer only contains liquids.

FEASIBILITY REPORT FOR PORT CITY

PCWSC ORGANIZATION, MANAGEMENT AND PERSONNEL

Annex 5

PCWSC ORGANIZATION, MANAGEMENT, AND PERSONNEL

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Note

This Annex is based on a comprehensive report entitled "PCWSC Organization, Management, Staffing and Training", which is presented separately in Technical Appendix C. (This Appendix is not reproduced).

PCWSC ORGANIZATION, MANAGEMENT, AND PERSONNEL

A. INTRODUCTION

A comprehensive review of the Port City Water and Sewerage Commission has been undertaken by Optima Management Consultants of Capital City in conjunction with International Management Consultants of London, England. This annex provides a summary of the results of this review, which is available in detail in Technical Appendix C (published separately).

The first part of this annex deals with the existing situation, including analysis of weaknesses.

The second part examines the future responsibilities of PCWSC in light of suggested institutional responsibilities for water supply sanitation in Port City (Annex 1). Recommendations are provided to assist the utility to discharge its future responsibilities efficiently.

B. EXISTING SITUATION

B.1 Legislative Framework

The Port City Water and Sewerage Commission (PCWSC) was established in 1955 to take over water and sewerage services within the city limits from the then Ministry of Public Works. It is a semi-autonomous government corporation, directed by a five-member board, three appointed by the Port City Local Government, and one each by the Ministries of Water Development and Health. The legislation authorizing PCWSC's activities is provided in Technical Appendix C, along with ociated regulations. The Ministry of Finance exercises considerable financial control over PCWSC: not only does it provide the Commission's capital investment funds, but it must approve PCWSC's budget and even minor construction works expenditures.

The service area for PCWSC is defined as the area within the boundary of Port City, although the utility is empowered to obtain water supplies outside the city limits.

PCWSC has the monopoly for providing water supplies to the public within Port City. Although no other organization may legally sell water to the public, individuals (corporate or personal) are allowed to provide their own water supplies on a private basis. Private water vendors who transport and sell water to people without connections are operating outside the law, but are permitted as a practical necessity.

The legislation establishing PCWSC gives it the exclusive responsibility for developing a system of sewers to remove and treat wastewater within Port City. Regulations make clear that a separate system is to be provided for storm drainage, and that the PCWSC sewers are to handle domestic and industrial wastewater.

As explained in Annex 1, PCWSC currently has no responsibilities and powers concerning on-site sanitation systems such as septic tanks, cesspits, and latrines.

PCWSC is supposed to generate all of its required operating income from tariffs. The regulations concerning tariffs, which can be revised from time to time at the request of PCWSC but need the approval of the Ministry of Finance, allow the agency to collect a surcharge on the water bill from properties which are served by sewers.

B.2 Organizational Structure

Figure 5-1 sets out PCWSC's current organization chart, the structural arrangements under which PCWSC has been operating for the past decade.

The Board of Directors meets weekly. Nominally responsible for matters of general policy and decisions on major items, the Board actually gets involved in many aspects of PCWSC operations, including staffing questions. PCWSC has powers to appoint and dismiss its own staff.

The Chairman of the PCWSC Board is also the Chief Executive Officer, and is empowered to make day-to-day decisions with the assistance of the General Manager and the Managers of the Finance, Administration, Technical Services, and Operations Departments.

Most of the functions of PCWSC are self-evident from the organization chart. Aspects of the more important activities are summarized in Section B4, which follows an overview of the staffing situation.

The staff employed by PCWSC in mid-1982 totalled 2022, broken down as shown in Table A5.1 (in accordance with existing classifications). All the supervisory, managerial, technical, clerical, and skilled workers are permanent employees. By contrast the utility employs only about 450 unskilled workers (the number fluctuates) on a permanent basis, the remaining 950 or so being nominally engaged for short term assignments. Many of these temporary staff have actually been on the payroll for years.

Table A5.1 PCWSC STAFF EMPLOYED IN JUNE 1982						
Classification	Department					
	Finance	Adminis-tration	Tech-nical	Opera-tions	Total	% of Total
Supervisory and Managerial	4	4	3	9	20	1
Technical and Clerical	106	23	52	41	222	11
Skilled Workers	56	26	105	197	384	19
Unskilled Workers	188	195	133	880	1396	69
Total	354	248	293	1127	2022	100
Source: PCWSC records.						

PCWSC staff are not part of the civil service, but pay and benefit are comparable to those of the Port City Local Government. However, the Commission's pay scales for managerial, technical, and clerical staff are lower than those paid by national utilities and the Port Authority and much lower than those paid by the private sector. As a result, and also because of the retirement of senior technical professionals, PCWSC suffers from a shortage of experienced and qualified manpower. In addition to the staff actually employed, PCWSC had 42 supervisory, managerial, and technical positions in mid-1982 which were unfilled.

PCWSC has no formal program to recruit and retain junior professional staff, particularly technical personnel, though it is constantly hiring new employees. It has no training programs except for its accounting staff. By contrast with the professional staff, PCWSC's non-supervisory personnel are unionized. Frequent disputes over pay have disrupted the organization's operations and increased costs as a result of wage settlements that have brought its unionized employees to pay levels above those prevailing in the civil service.

There is considerable political pressure to hire unskilled workers. In practice many of the unskilled workers are considerably underemployed. The causes are several: the management of such staff is not effective; transport and equipment shortages mean they have much idle time; and they are very poorly motivated.

The PCWSC headquarters is located at the site of the Railway Treatment Plant in central Port City. More than 90% of the staff are based at this headquarters, the exceptions being operating staff working at water sources and other treatment plants. Neither the offices nor the workshops at the headquarters are large or well equipped enough.

Transport is also inadequate. Hence, the productivity of the vast majority of the staff is severely constrained by the working environment.

B.3 Functional Responsibilities

a. Finance Department

The Finance Department has three divisions: Budget, Expenditures, and Billing and Revenues.

The Budget Division is responsible for preparing the annual operating and capital budgets for PCWSC, which by law must show a balanced position. The budget procedure itself is satisfactory. Both projected operating costs and capital expenditures are determined by the operating divisions responsible for the expenditures. A problem faced by the operating divisions is, however, the lack of availability of good cost data on which to base operating cost projections. The Budget Division coordinates the preparation of the budget and consolidates the submissions of the operating divisions. In practice, during the past three years, the fund requests in the budgets submitted by the operating divisions have been reduced by the Board of Directors, particularly for maintenance and capital expenditures. The fund constraint resulted from the PCWSC Board's decision to hold tariffs constant since 1978, in conformity with a government policy of restraining inflation.

The Budget Division is also charged with recording performance against budgets. A monthly statement is prepared for each operating cost center and capital expenditure category which compares actual expenditures with the budget. The procedure does not result in effective cost control, however, for three reasons. First, the Expenditures Division produces actual data, on average, ten weeks after the close of a month, and the monthly budget statement is three months late. Second, because of the improper expense coding, expenses are often not matched against the proper budget category. Finally, department heads have authority to transfer funds among budget categories, and this is often done on an ad hoc basis without a formal charge in the budget, resulting in large apparent overruns and underruns in different expense categories.

The Expenditures Division controls all significant expenditures and is responsible for keeping all expenditure accounts. The financial authority delegated to PCWSC managers depends on their position, but is generally quite low. Division chiefs can approve expenditures up to Z500 and departmental managers up to Z2,500. The General Manager's limit is Z10,000. Larger expenditures and all major contracts require Board approval.

The quality of accounting staff needs improvement. The Chief of the Expenditures Division is a former academic who has had no previous experience in a water and sewerage authority or in managing a division. There is no training program for junior staff apart from on-the-job training. Procedures are lax and deadlines are infrequently met. As a result, financial reports are issued late and are full of errors which must subsequently be revised.

PCWSC's accounting system is patterned after the standard water utility accounting system of the American Water Works Association, and is satisfactory. Accounting is semi-computerized, and the work of having all accounting functions placed on the computer is moving slowly, in part due to the inability of PCWSC to retain qualified computer technical staff. The accounting system is not used to its fullest extent in that many categories of expense are not utilized and expenses are aggregated too much. As a result it is difficult to accumulate costs by function and by category of expenses. Fixed asset registers are incomplete. An inventory of fixed assets with proper valuation is required to establish proper asset values and depreciation allowances.

The Expenditures Division is also responsible for cash and debt management and disbursements. These functions should not be under a manager who is also responsible for the recording of cash receipts and disbursements. The function of cash and debt management, however, is competently performed. A 12-month receipts and disbursement budget is drawn up on a monthly basis, and payments on account are made on a predetermined schedule. Because of inadequate tariffs coupled with a slowdown in collections, the function of cash management has become critical, and payments to creditors are currently being made well after the due date.

The Billing and Revenues Division is responsible for commercial operations - meter reading, billing, and collection. Meter reading is done by 15 readers, each with an assigned route. The residential meters are read every other month, and each reader is expected to read about 150 per working day. The meters of industries and other high volume customers are read monthly. The number of meters not functioning has risen from 10 to 15% of those installed since 1978. Consumers whose meter is not working, or who have no meter, are billed at a rate of 50% of the average metered consumption. The meter reading procedures need to be modified to ensure proper and accurate meter reading by assigning daily routes at random and by omitting previous meter readings from the cards given to readers.

The meter reader cards are hand posted to ledgers containing consumption records for each customer. The consumption is then put on a computer card and the bi-monthly charge is calculated, including sewerage charges for those consumers connected to the sewage system, and the bill is printed by the computer. The system is deficient in several respects. The consumption ledgers are unnecessary, and the consumption data could be entered directly on punched cards. Also, the computer program does not provide for including unpaid balances along with current billings. Thus, assessment of accounts receivable must be done manually and billings for old accounts must be inserted along with the current billings. The computer has the capacity to handle all the functions needed to record and control accounts receivable, and a program to do this is needed.

Bills are mailed to consumers on average 15 days after the meter is read. Consumers have 15 days to pay their bill and must make payment at PCWSC's headquarters where there are often long lines. A procedure whereby consumers may pay bills at local banks has been under study. Such a system is needed to facilitate collections. A provision exists to shut off the water of consumers when payment is more than one month overdue, but this is rarely enforced. Collection efficiency has been deteriorating and, at present, only about 80% of a given month's billings are collected in the subsequent month. A computerized accounts receivable system providing up-to-date data on outstanding accounts, coupled with enforcement of the cut-off policy, should improve collection efficiency.

New connections must be requested in writing from the Billing and Revenues Division, who in turn ask staff in the Distribution Networks Section of the Water Supply Division to inspect the premises and prepare a cost estimate. After the consumer pays the connection fee plus a deposit against future charges, the connection is installed by the Distribution Networks Section. The entire procedure can be completed, in theory, in ten days, but delays of weeks and even months are common. All transactions with the public take place only at the PCWSC headquarters at the Railway plant. Poor transport arrangements and communications between PCWSC staff also add to delays.

Analysis of a sample of recent connections indicated the average time between the request and completion of the work was ten weeks. In September 1982 there was a backlog of some 3,100 requests for connections, but the rate of new connections is currently being accelerated in the Immediate Improvement Project.

Management information systems within PCWSC are fragmented and rudimentary. Each of the three finance divisions produces and submits quarterly reports to management and the Board. The principal reports are financial statements, performance against budget statements, and billing and collection performance statements. The reports are not coordinated with the operating departments, contain little or no operating data and are always late. The reports contain too much detailed data presented in a confusing manner.

PCWSC has an Internal Auditor whose principal responsibility is limited to seeing that disbursements are properly supported. The Auditor is under the Financial Manager. This does not ensure proper independence. The scope of functions handled by the auditor's office should be expanded to cover fixed asset records, current accounts, budget and expense operations, and compliance with PCWSC's regulations. The office should also be removed from the control of the Financial Manager.

PCWSC's external auditors are the Port City firm of Malcolm Wallace & Co., who are affiliated with a large international accounting firm and appear to be well qualified. The audit of PCWSC's 1981 financial statements, however, was of marginal quality. The auditor stated that this was the result of PCWSC's unwillingness to pay the amount proposed by Malcolm Wallace & Co.

b. Administration Department

The Personnel Division deals with all matters related to staff recruitment, training, discipline, and benefits, including the compilation of employee records. In practice most hiring decisions are initiated by supervisors and managers in the other functional divisions. The division's tasks include preparing job descriptions for recruitment and dealing with the two principal unions (for technical/clerical staff and skilled workers). Very little formal training exists within PCWSC apart from on-the-job experience and guidance by supervisors. This means that there is little prospect for staff development within PCWSC. Those not fully qualified when they join are unlikely to have much opportunity for individual growth as members of PCWSC staff. In practice the majority of PCWSC technical, clerical, and skilled staff (accounting for the critical 30% of the total - see Table A5.1) are not fully qualified for the positions they hold when they join, because objective recruitment criteria tend to be ignored in favour of political pressures. They do not subsequently become qualified because of the lack of training. This is a fundamental cause of weakness in the present organization.

Job descriptions for all managerial, supervisory, technical, clerical, and skilled staff are prepared by the Personnel Department and provided in Appendix C. These descriptions are frequently inappropriate for the work actually being carried out. Revisions are suggested in the context of the recommended future organization, as discussed in Section C of this annex.

The Offices Services Division provides support staff, equipment, and supplies for all other divisions within PCWSC.

c. Technical Services Department

The Planning Division comprises water supply and sewerage sections which operate more or less independently. Most of the activities are performed by engineers and technicians with minimal practical experience who rely mainly on the statistics they compile on PCWSC operations and experience. The financial implications of future plans are hardly analyzed, apart from the preparation of estimates of capital costs.

The Design, Construction, and Procurement Division is normally concerned with extensions to the water supply and sewer systems. Major works are built by local contractors on the basis of competitive tendering. Minor extensions, comprising roughly 60% of PCWSC's capital budget, are carried out by force account using PCWSC staff.

Engineering consultants from Optima are used by PCWSC for the planning and design of major projects.

d. Operations Department

More than half of PCWSC's staff are assigned to the three divisions within this Department (Water Supply, Sewerage, and Support Services) whose activities deal essentially with the operation and maintenance of the water supply and sewerage systems. The engineering consultants involved in this feasibility study have reported that system operations leave much to be desired in terms of reliability and efficiency.

Analyses of the activities of the operating divisions indicate recurring problems which are generally due to several common causes, each discussed briefly hereafter.

Management strategies are not explicit, and the staff lack specific guidance on their objectives and responsibilities. The poor performance of the Meanthyme sewage treatment plant and the high quantities of unaccounted-for water are vivid examples. Yet the staff have not been instructed and encouraged to overcome these and related weaknesses. Such questions apparently receive inadequate attention from senior management and the Board, which may help to explain two major factors: shortages of skilled manpower and resources.

Manpower is abundant, but most are poorly trained and too few can discharge their responsibilities effectively. Despite high staffing levels (more than required for comparable systems elsewhere), the shortage of skilled and experienced staff results in poor performance overall. Equipment such as pumps, for example, is poorly maintained and often out of service as a result. The responsible operating staff are often incapable of doing their job effectively.

Shortages of resources obviously aggravates many operational problems. Budgets for spare parts and consumable materials such as chemicals are often cut, resulting in serious scarcities. These problems are compounded by difficulties in ordering and obtaining new supplies, particularly when they have to be imported. One example illustrates this point clearly. The most recent delivery of chlorine gas arrived at the PCWSC stores 173 days after the Chief of the Water Supply Division initiated the process to order it. Competitive tenders, foreign exchange approvals, shipping time from the foreign suppliers, and port clearance procedures all contributed to this long interval between order and receipt of a critical material.

The workshops and stores are plagued by inadequate facilities as well as poor procedures, all discussed in more detail in Appendix C. The net result is that maintenance of water and sewer systems is severely constrained by delays and shortages in obtaining materials for repairs on new installations.

Problems with the vehicles used for PCWSC operations illustrate the situation. On August 31, 1982, PCWSC's transportation fleet officially totalled 51 vehicles, according to the Transport Section. On that day the actual allocation of vehicles was as follows:

Operating Vehicles

7 - staff cars for chairman and senior managers
7 - general transport for head office staff in Finance, Administration, and Technical departments.
3 - construction crews in Technical Department
5 - water supply operations (including 2 for crews making connections and meter installations)
2 - sewerage operations
1 - workshop section for purchasing/collecting spare parts.
1 - stores section for obtaining materials
26 - sub-total

Non-operating Vehicles

3 - various locations awaiting tow to workshops
16 - at Railway workshops, in various stages of repair, for varying periods of time (mainly dependent on the availability of spare parts):
 4 - three days or less
 5 - four to ten days
 7 - over eleven days
6 - at Railway workshops for more than one month, judged unserviceable and awaiting permanent disposal.
25 - sub-total

51 - TOTAL

These figures show that almost half the vehicles were out of operation. Only 7 vehicles, or 14% of the total fleet, were actually available for PCWSC staff involved in systems operations and maintenance. This lack of transportation helps account for the low productivity of the greater part of the Commission's total work force.

B.4 General Comments

The comprehensive review of the PCWSC organization has revealed many opportunities for improvement. The Commission is not adequately performing its basic mandate of providing water supply and sewerage services reliably within Port City. Many thousands of potential consumers lack access to these services, and the entire population is aware of interruptions and failures in those services which are provided.

PCWSC needs more fully competent staff. This is a matter both of recruitment and the utilization of existing staff. There are many hundred staff, especially at the unskilled level, who have been hired for politically inspired reasons. At more senior levels also, technical competence has not been a prime criterion in recruitment. Even without these problems, however, PCWSC faces recruitment difficulties because low salaries make PCWSC opportunities unattractive to the limited number of qualified potential employees who do exist.

A wide range of improvements are possible. However, fundamental changes in the basic organizational structure and salary structures of PCWSC are required in connection with its expanded responsibilities in the years ahead. Accordingly, suggested measures to strengthen PCWSC are discussed within the context of the Commission's future role and structure.

C. FUTURE SITUATION

C.1 Responsibilities

It is recommended that PCWSC become responsible for all sanitation systems within Port City, on-site as well as off-site, in order to plan and implement a comprehensive program for water supply and sanitation. The major change from the existing situation is that PCWSC will in future set standards and provide technical and financial assistance for a range of sanitation systems, of which sewerage will be only one.

After the North River Wellfield scheme is operational, PCWSC will be able to provide a bulk supply of water to the town of Farmville through a metered connection on the transmission pipeline to Port City.

C.2 Legislative Framework

Several modifications are required to reflect the recommended arrangements for providing services. Most such modifications should be implemented in the near future, preferably by January 1, 1984. Details, including draft wording for new regulations, are provided in Appendix C.

The title of the organization should change from the Port City Water and Sewerage Commission to the Port City Water and Sanitation Commission. The rationale is to reflect the expanded mandate of the Commission to include on-site sanitation systems as well as conventional sewerage.

PCWSC must take over from the Port City Local Government the responsibility for setting and enforcing standards for on-site sanitation systems as well as sewerage in this connection. The Commission staff must have the right to inspect all existing or proposed systems for wastewater removal and disposal within Port City. The regulations of both PCWSC and the Local Government need to be modified accordingly. The majority of the PCWSC Board of Directors are appointed by the Local Government, and so coordination in this matter ought to be accomplished easily. No major difficulties are foreseen.

PCWSC should become responsible for the maintenance of all sanitation systems serving properties with a water connection, in order to facilitate more rational planning and operation of water and wastewater facilities in Port City. This means extending the operational responsibilities and expenditures of PCWSC. At the same time the Commission should be empowered to charge for sanitation services in the form of a surcharge on the water bill. The precise tariffs, like the present water supply and sewerage charges, would be varied from time to time at the initiative of PCWSC and with the approval of the Ministry of

Finance. The implementation of general charges for sanitation services (common charges regardless of the specific sanitation technology) should be introduced at the start of 1985, by which time PCWSC should be technically capable of providing the necessary services.

At present PCWSC has no means to compel property owners to utilize existing sewers. The regulations should be changed so that PCWSC can require the owner of a property to connect to a nearby sewer and abandon any on-site facilities. This change is required on public health and environmental protection grounds.

To strengthen PCWSC's ability to influence property owners to utilize sanitation facilities effectively, PCWSC should be given the power to refuse to supply water unless suitable arrangements are in place for wastewater disposal. This is likely a subject which could be dealt with as a PCWSC policy by the PCWSC Board, but would be stronger if included in the regulations governing PCWSC's activities.

PCWSC should be given authority to plan and implement a water supply and sanitation program in the North River Valley, site of the proposed wellfield which is the next major source of water supply for the PCWSC system. This should be arranged with the Ministry of Health which has responsibilities for these services in the villages.

Several minor changes in the framework under which PCWSC operates could probably be dealt with by directives from the PCWSC Board, including:

- setting a separate tariff for the sale of bulk water supplies to the Ministry of Water Development for Farmville;
- charging property owners without PCWSC water connections for the maintenance of on-site sanitation systems (for example, a standard charge for desludging septic tanks or cesspits of individuals relying on water from private wells);
- providing the sub-structure for on-site sanitation systems (either pour-flush toilets or VIP latrines) at no cost to low income residents relying on public standpipes for their water supply; and
- emptying these on-site sanitation systems for low income people at a nominal fee of Z10.

C.3 Organization Structure and Management Improvements

The recommended future structure for the organization of PCWSC is depicted on Figure 5-2. It was developed after considering many alternatives, involving extensive discussions with PCWSC management and two special meetings with the Board of Directors. The proposed structure and details for implementation are discussed extensively in Appendix C.

The proposed organization, designed to include the expanded role of PCWSC in sanitation and to cope with the increasing scale of activities, is similar to the existing situation (Figure 5-1). The major changes are:

a) The Customer Services Department will consolidate the activities of the technical and administrative staff who deal with the public. This involves the merger of the former Billing and Revenues Division with the workers dealing with customer connections in the former Distribution Network System. Among other things, this change should reduce the time needed to provide new connections or investigate questions about water bills.

The Public Relations Division will be created within the Customer Services Department to deal with a number of activities, including customer queries and complaints, information programs about PCWSC activities, and support activities related to the implementation of new sanitation systems, particularly on-site systems in low income areas.

b) Regional offices will be set up to decentralize customer service activities and local aspects of system operations and maintenance. Port City will be divided into two zones, north and south of the axis formed by Shop Street and Mountain Road, each served by a regional office. The office location for the Southern Region will be the site of the present PCWSC headquarters building at the Railway Treatment Plant. The Northern Region, where the greater part of the water distribution network and sanitation system improvements will occur during the project, requires a location for offices, vehicles and equipment. A suitable facility has already been located on the Farmville Road. The proposed major maintenance base for sanitation and water supply systems will be located at the site of the existing Meanthyme Sewage Treatment Plant. This emphasis on maintenance at the Meanthyme site will not be complete until the new treatment plant at Hog's Bay becomes operational in 1986, at which time the existing Meanthyme plant can be dismantled.

Staff from several parts of the existing central office will be based in the regional offices in the proposed future organization so that they can more effectively discharge their responsibilities. This includes staff in the existing Billing and Revenues Division, Water Supply Division, and Sewerage Division.

c) Financial and administrative functions are proposed to be integrated in a single department. Most of the present accounting functions dealing with revenues from customer services will actually be located in the regional offices. Each will have their own computer facilities for billing and revenue accounting (basically terminals and printers connected to the main computer at headquarters). The new Management Accounting Division will design the systems and be able to monitor all accounting on the central computer.

Two revisions to the existing organization of the financial and accounting functions are proposed, apart from the transfer of the Billing and Revenues Division to the Customer Services Department. First, the cash and debt management functions should be transferred from the former Expenditures Division to a new Treasury Division to recognize the separate character of the work and to remove the disbursement function from accounting. Second, the Office of the Internal Auditor should be removed from the supervision of the Financial Manager and report directly to the Board of Directors. Finally, a unit to coordinate management information needs to be established in the Management Accounting Division to determine the format and context of a simple operating and financial report for management, and to prepare it for submission on a timely and regular basis.

Other needed changes concerning financial functions include: (1) accelerated availability on a rigid schedule of cost data for budget comparisons, coupled with published guidelines on expense categories; (2) recruitment of a qualified deputy manager for the Expenditures Division; (3) establishment of a training program for accountants; (4) preparation of a fixed assets register; and (5) full computerization of the billing and accounts receivable operations.

d) A Training Division will be created and will have a major role, as discussed subsequently.

e) A Loss Reduction Unit will be centrally directed from the Water Supply Division but will have staff based in each region, complete with their own transport and equipment. These units will work closely with the meter reading and accounting staff to achieve major reductions in unaccounted-for water.

f) An On-Site Sanitation Systems Section will be created within the Sanitation Division. Its main task will be the periodic emptying of septic tanks, cesspits, and sullage soakaways. They will also empty the interceptor tanks associated with the small bore sewers. Much of the sludge pumping will actually be done by private operators of trucks working under contract to the Section.

g) The Design, Construction, and Procurement Division will have to be strengthened and expanded to implement the project. Consulting engineers involved in the major construction of this project will serve this division.

C.4 Staffing and Training Implications

The proposed modifications to the structure of PCWSC, its expanded activities, and the need for improvements to overcome existing weaknesses (Section B of this Annex) all depend essentially on the staff of PCWSC. To put it differently, all plans for improvements are doomed to failure unless significant changes are made in the motivation and performance of the people who make up PCWSC.

A careful analysis has been made of the quality and numbers of staff required for the proposed organizational structure, starting from a thorough review of the existing staff and their capabilities. Job descriptions, including required training and experience, have been prepared for key positions (roughly 120 different descriptions), and realistic estimates made of the staff required for all positions by years until 1990. This detailed information is provided in Technical Appendix C. For 1987, the first year in which the major project should be fully operational, the estimated staffing requirements are summarized in Table A5.2.

This projection assumes that PCWSC will rely extensively on contractors for many of its construction activities and also for a significant share of its operations and activities, particularly those concerning routine maintenance which can be planned in advance. Pipe cleaning, equipment repair (including vehicles), and sludge removal are three tasks, for example, which PCWSC is expected to delegate to local contractors.

A comparison between the existing staffing of PCWSC (Table A5.1) and that proposed for 1987 (Table A5.2) illustrates several key points:

- total staff in 1987 will be only 6% higher than in 1982, despite a major increase in scope and scale of activities;
- roughly 21% of the 1987 staff is expected to be in head office functions, and the remainder in regional offices and operations centers;
- the proportion of unskilled workers is expected to drop from 69% of the staff in 1982 to 30% by 1987.

Table A5.2 PROJECTED PCWSC STAFFING REQUIREMENTS FOR 1987						
Classification	Department				Total	% of Total
	Finance and Administration	Customer Services	Technical	Operations		
Professionals	27	12	36	30	105	5
Administrators	24	5	7	9	45	2
Technicians	-	36	180	240	456	21
Highly qualified office staff	75	58	26	22	181	8
Office support staff	80	117	77	46	320	15
Artisans/skilled workers	4	122	6	275	407	19
Unskilled workers	10	130	8	488	636	30
Total	220	480	340	1,110	2,150	100
Locations						
Head Office	60	25	340	25	450	21
Other	160	455	-	1,085	1,700	79
Total	220	480	340	1,110	2,150	100

It is obvious that these proposals require a major upgrading of the quality of staff within PCWSC. This is probably the largest challenge facing the Commission in the near future, as a failure to achieve the improvements in staffing will jeopardize all other activities.

The implications for PCWSC management are great. Beginning immediately, PCWSC should review the qualifications and potential of all staff, particularly those permanently employed, to ascertain who can be upgraded. A complete ban should be placed on all new hirings until this initial assessment is complete. Thereafter, the only staff to be hired are those whose qualifications meet the description of a job for which a vacancy exists and which cannot be filled by upgrading the skills of existing staff. Morale problems associated with the proposed reorganization and reclassification of staff will be severe. They should be minimized by making all possible efforts to allocate existing staff within the organization, provided they have the basic qualifications or can be trained for different positions within a reasonable period (say not more than four years of part-time or one year of full-time training).

No existing permanent staff need to be fired in order to implement the recommended changes. Job security for permanent staff is not an issue, provided existing personnel are prepared to accept revised job classifications and upgrade their skills if required. However, many temporary employees, those unskilled workers hired on a short-term basis, will not be required in future unless their skills can be improved.

PCWSC should immediately create a Personnel Task Force to begin the implementation of the recommended staff changes. A properly qualified professional should soon be selected to become Chief of the Training Division.

Available training facilities within Optima have been carefully reviewed in order to prepare an outline plan for staff training. Details are given in Appendix C. The principal existing institutions which need to be involved in training PCWSC staff are as follows:

- University of Optima for extension courses for existing supervisory and managerial staff as well as future professional staff;
- Capital City Management Institute for managers and administrators;
- Capital City Polytechnic and Port City Technical Institute for technicians and some artisans;
- National Trades School (run by the Ministry of Labour) for skilled workers;
- Schools of Commerce in Port City, Capital City, and elsewhere for administrative and clerical staff.

These and other local institutions have indicated a willingness to develop particular courses and programs for in-service training, including intensive (2, 4, and 6-week) sessions for special skills. Course outlines are provided in Appendix C.

Manpower development consultants are also required within PCWSC for several related tasks:

- sensitization of existing managers and supervisors to the need for major training efforts;
- training for trainers within PCWSC to accelerate manpower development programs;

- initial planning and presentation of training courses to existing PCWSC staff.

In addition to the in-service training of staff within PCWSC and in existing training institutions within Optima, it would be helpful if a few professionals received selected training outside Optima. A program for external training is proposed for up to six professionals per year, with the majority consisting of brief but intensive courses lasting up to three months. However, such external training is only recommended for existing professionals, or those occupying professional positions who are highly qualified and experienced but have no formal training in the function they now perform.

The recommended training program is extensive and will involve up to 300 people per year. During the first few years this training may somewhat disrupt the organization as many people will be involved in activities which are not entirely productive in the short term. There will probably be a need to make greater use than ever of contractors and consultants for routine activities, pending gradual improvement in the effectiveness of the regular staff during the first few years of this extensive training program. Thereafter, the need for training will diminish considerably. The organization will stabilize. The need will then be refresher training for existing staff and the training and orientation of new staff.

There are significant financial implications in the recommended training program. The cost of various training courses, within PCWSC and outside the organization, including consulting services, may reach up to Z500,000 per year for the first few years, but should decline significantly thereafter. Decreased staff productivity is another likely short term cost, but this will be reversed within about two years as improved efficiencies result.

In the longer term, however, more highly qualified staff will expect higher wages. It is estimated that PCWSC costs for staffing will approximately double between 1982 and 1987, due primarily to increased wages for better qualified staff. It is virtually certain, however, that no better investment could be made by PCWSC than in its own people.

FEASIBILITY REPORT FOR PORT CITY

DRAFT TERMS OF REFERENCE FOR STUDY OF WATER AND SANITATION TARIFFS

Annex 6

DRAFT TERMS OF REFERENCE FOR STUDY OF WATER AND SANITATION TARIFFS

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DRAFT TERMS OF REFERENCE FOR STUDY OF WATER AND SANITATION TARIFFS

A. INTRODUCTION

The government of Optima and the Port City Water and Sewerage Commission (PCWSC) are considering revision of the level and structure of water and sanitation tariffs, to better achieve the Government's resource allocation objectives and provide a sound basis for the expansion of water and sanitation services to adequate levels. For this purpose a tariff study should be conducted in accordance with the guidelines set out below.

B. OBJECTIVE

The purpose of the study is to examine in depth the relevant issues of economic costs and efficiency, the financial needs/viability of PCWSC and the sector, affordability (especially for the poorer sections of the population), and simplicity/ease of implementation, and formulate proposals for a tariff structure and level conducive to appropriate sectoral development in the near and the long term. Alternative formulations should be attempted. A time-phased plan for implementation of the recommendations should also be drawn up.

C. SCOPE OF WORK

The scope of work is outlined below.

1) Analysis of existing situation. This should include collection and study of information on existing tariffs, demand levels, customer consumption patterns, operating and capital costs, and other relevant aspects, e.g., quality of service, metering, billing and collection, connection policy, and effect of prices and incomes on water consumption.

2) Future demands and service levels. This should include:

   a) Projections of population and access to services (water/sanitation) that are planned;

   b) Service levels projected - basis of unit requirements for the different categories of users (residential, industrial, commercial, government, etc.);

c) Future demands, by main types of users.

3) Analysis of cost structure. This should include:

a) An analysis of the evolution of costs and the more important influences on them - staffing and wage levels, fuel costs, chemicals and materials, financial charges, etc.;

b) Relevant financial and 'economic' costs should be developed, using detailed cost projections for the future, both investment and operations. (Economic costs imply costs to the economy. Therefore, shadow prices for capital, labor, and foreign exchange may have to be used. In addition, any duties and taxes on PCWSC's inputs should be subtracted and subsidies added back.);

c) Cost estimates of the long run marginal costs (using the average incremental cost concept and a time horizon of 15 years) should be developed for alternative demand/service levels at different places.

4) Determination of financial requirements.

a) Determine the financial needs of the entity for covering operating expenses, debt service, working capital and investment expenditures, and prepare a set of financial projections. In the preparation of such projections, the important assumptions made should be spelled out, e.g., in regard to the financing plan for investment expenditures, and to operational efficiency. The sensitivity of the projections to important variables should be assessed. In preparing the projections the scope for cost reductions and the means of achieving such reductions should be considered. The extent of internal cash generation by the entity (from tariff related revenues) and its adequacy should be kept in view. The financial performance of the entity (in terms of a rate of return on revalued net fixed assets in use) should also be adequate;

b) Determine the average tariff needed to meet the financial requirements.

5) Analysis of affordability of tariffs

a) Analyze the position of particularly low income families to afford the charges for water and sanitation, using as a guideline a ceiling of 5-6% of family monthly income (considering also growth in income levels).

6) Recommendations regarding tariff structure and level.

a) Draw up alternative tariff structures which reconcile the financial, economic, and affordability concerns. In drawing up such tariffs, the following aspects should be considered:

i) a minimum 'affordable' tariff for 'lifeline' consumption of 10 m^3 of water per month per family;
ii) a progressive tariff with increasing block rates;
iii) industrial/commercial users being charged at least relevant marginal costs.

b) The following questions should also be considered:

i) charging for supplies from standpipes - alternative methods;
ii) charging a two-part tariff - one part for volumetric consumption and one part for fixed charges;
iii) the use of 'property tax' and/or 'betterment' charges for sanitation services in place of tariffs and the possibility of various levels of changes according to the sanitation system provided;
iv) separate charges for water and for sanitation services;
v) special charges for peak demands, etc.;
vi) charges for discharges from industrial plants into the wastewater system.

7) Administrative feasibility and implementation.

a) Metering, billing, and collection questions;

b) Time phasing of the implementation, transitional arrangements;

c) Administrative constraints and methods overcoming them;

d) Further steps needed, e.g., publicity, staff training.

8) Summary of Recommendations

D. DATA, LOCAL SERVICES, AND FACILITIES

1) Government and PCWSC will provide the consultants all studies and necessary data pertaining to the operations and plans in the water and sanitation sector and relevant details of budgets, costs, accounting, and financial information;

2) In connection with the work of consultants that may require the cooperation of other agencies, PCWSC will provide liaison and help beeded to ensure that all information needed by consultants is provided;

3) PCWSC will assign qualified counterparts in sufficient numbers to work with consultants on a full-time basis;

4) PCWSC will also provide the consultants with office facilities and equipment (to be defined).

E. REPORTS

The consultants will prepare the following reports in English:

1) A monthly progress report giving the statement of work performed, any particular problems met with, etc.;

2) A draft final report within 12 months after the starting date;

3) Comments on the draft final report will be furnished by PCWSC, the government, and international lending agencies within 60 days of the submission of such report;

4) The final report will be submitted within two months of the receipt of comments from PCWSC, the government, and international lending agencies.

F. SUGGESTED OUTLINE FOR THE WATER TARIFF STUDY

1. Summary and Conclusions. Approximately 10% of length of full report.

2. History of Water Prices (descriptive)

   - enabling legislation
   - enforcing authority
   - covenants and agreements with donors, lenders, etc.
   - experience with rate setting: methods, levels, and structure of tariffs
   - extent of metered charges; other bases for assessing charges (e.g., land value, household size, number of taps, or any other basis)
   - methods and efficiency of meter operation/reading/billing
   - success with other methods of assessing charges
   - commercial efficiency - timeliness of billings, collections; analysis of late payments by type of consumer (government, residential, commercial, etc.)
   - discussion of historical experience with tariff adjustments - how often made, what magnitude, political and popular reactions
   - charges, if any, for standpipes supplies
   - role of private vendors - pricing, volume consumed, public reaction
   - connections policy - charge, availability, method of finance, and role of multifamily connections.

3. History of Water Service

   - present information on usage by types of consumer, season, time of day, etc.
   - quality of service.

4. Future Demands and Service Levels

   - projections of population and access to services
   - service levels projected - basis of unit requirements for the different categories of users (residential, industrial, commercial, government, etc.)
   - evidence on the effect of price and income on water consumption
   - future demands, by main types of users.

5. Analysis of Cost Structure

- analysis of evolution of costs
- shadow price resources as necessary, spelling out assumptions, methods
- state discount rates employed
- calculate average incremental cost using alternative plausible demand projections (using 15-year horizon).

6. Analysis of Financial Requirement

- projection of water sales, rate of connections, etc.
- financial projections - income statement
  - sources and application of funds
  - balance sheets
  - investment program
  - financing plan
- basis of financial projections (assumptions)
- average tariff needed to meet financial needs.

7. Analysis of Affordability

- income levels and growth in incomes in area covered
- cost of water supply as a percent of income in comparison with other expenditures; separate analyses should be made for each income group.

8. Recommended Tariffs - Alternatives

- level
- structure
- charges other than tariffs.

9. Administrative Feasibility and Implementation

- metering, billing, and collection
- methods of financing connections
- administrative constraints and measures to overcome them
- implementation - phasing, measures needed
- transitional questions
- other aspects.

10. Concluding Recommendations

FEASIBILITY REPORT FOR PORT CITY

PCWSC OPERATING AND FINANCIAL DATA

Annex 7

PCWSC OPERATING AND FINANCIAL DATA

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PCWSC OPERATING AND FINANCIAL DATA

BASIC ASSUMPTIONS UNDERLYING FINANCIAL PROJECTIONS

A. OPERATING DATA

1. Assumptions regarding the following items are detailed in Table A7.1:

   a) Population, population growth rate, and population served by water and sanitation;
   b) Number of water and sewer connections, by category;
   c) Water sold per connection and per capita; and
   d) Water produced and sold.

2. New metered connections will serve 8.5 persons, versus the present average of 13.6, as most new connections will serve only individual simple family residences.

3. All standpipes will be metered by 1985, although standpipe consumption will not be billed.

4. Water sold per connection per year assumptions are as follows:

   a) Domestic Category 1 (meter working) is based on measured water use, adjusted to reflect an expected decline in average water sold per person as additional lower income groups are served and as the installation of more water connections with meters reduces the tendency to waste water;

   b) Domestic Category 2 (meter not working) is estimated for billing purposes at 50% of Domestic Category 1 consumption in the years 1979-82 and 80% in 1983-89; and

   c) Domestic Category 3 (no meter) is based on 50% of Category 1 consumption in 1979-84, and a flat 370 m^3 per year per connection in 1985-89.

5. Estimated water volume for billing sewerage and sanitation services:

a) Water volume for sewerage billing is estimated at90% of water sales to PCWSC consumers on conventional sewers from 1979-84;

b) Commencing in 1985, sanitation charges for all categories will be based on total water billed, regardless of the particular sanitation system used by the water consumer; and

c) Water sales to Farmville will begin in 1987.

6. Water production is derived from sales and the estimated volume of unaccounted-for water, which is expected to decline as a result of the Immediate Improvement Project already underway.

B. REVENUE DATA

1. Assumptions listed here are preliminary and will need revision in light of the proposed tariff study to be completed in1984.

2. From 1979 through 1983 all consumer categories for water are billed at Z0.25/m^3 on the basis given in A.4 above.

3. A block tariff is assumed in 1984 and subsequent years. The tariff for the basic block of 20 m^3 and the incremental tariff for higher blocks are given in Table A7.1 of this annex. In addition:

   a) Unmetered consumers will be billed for 20m^3/month at the basic rate;

   b) Industrial and institutional consumers will be billed at the tariff blocks above the basic rate;

   c) Water to Farmville will be sold in bulk at the rate for the basic block.

4. Commencing in 1985 all water consumers will be provided with sanitation services and will pay a sanitation surcharge equal to 55% of their water bill. The tariff rate for industrial and institutional consumers will be the same as for domestic consumers.

5. Small bore sewers will be installed on consumers' properties and will be considered a part of their property. However, PCWSC will be responsible for maintaining the small bore sewers,including sludge removal from interceptor tanks.

6. Two-thirds of a conventional sewer connections will be on consumers' properties, and will not be a PCWSC asset. Hence, only two-thirds of connection fees will be treated as revenue. Another one-third will be treated as 'consumers contribution.'

7. The connection fees paid by the consumers for a conventional sewer and a small bore sewer connection are Z300 and Z200,respectively.

8. PCWSC will extend loans to consumers to install sanitation systems, at 8% interest, repayable over 12 years.

C. OPERATING EXPENSES

1. General prices are expected to increase at 9-12% per annum as indicated on the inflation index on the Income Statement. (Table A7.2).

2. Wage and staff costs are projected to increase at 20% annually because of an expected increase in both the productivity and quality of staff members.

3. Chemical, energy and materials are projected to increase at the estimated rate of inflation plus the rate of water production.

4. Expenditures related to sewerage connections are included in the "Material and Maintenance" category.

5. "Transportation and equipment" and "others" are projected to increase at the rate of water production.

6. Depreciation is assumed at 3% of average fixed assets' value.

7. A zero tax rate is assumed.

D. FINANCING PLAN

1. The Immediate Improvement Project has a total cost of Z9.7 million. Three sources of finance are involved:

   a) PAID local Z5.0 million loan with an 8% interest rate, and a 12-year repayment period, to begin after the completion of the project - the disbursement period began in 1982 and is expected to be completed at the end of the project in 1984;

   b) PCWSC will finance Z1.8 million from internally generated funds between 1984-85; and

   c) The government will provide Z2.9 million in grants beginning in 1982.

2. The 1983-86 Investment Program requires the total of Z134.0 million for the major project described in Annex 2 (Water Supply) and Annex 3 (Sanitation). Four sources of finance are involved:

   a) Oceania Development Fund, a bilateral aid agency, is assumed to lend Z19.8 (15% of total project cost) with a 6% interest rate and a 15-year loan repayment period to begin after the completion of the project in 1986;

   b) International Bank, a multilateral aid agency, is assumed to provide Z51.3 million (38% of total project cost) with an interest rate of 10%, and a 20-year repayment period to begin after the completion of the project;

   c) The government of Optima is assumed to provide a loan of Z36.9 million (28% of total project cost) with an interest rate of 9%, and a 20-year repayment period to begin after the completion of the project; and

   d) PCWSC will finance Z26.0 million from internal cash generation beginning in 1983.

3. Other Financing Plan assumptions:

   a) All donors will finance interest during construction.

b) The disbursement pattern is based on the investment schedule shown in Table 4.7 and is the same for every loan.

c) Existing loans amount to Z5.5 million with an average interest rate of 9%, and an average of a 12-year repayment period.

E. CONSUMER LOANS

1. The unit costs for conventional and a small bore sewer connections are Z300 and Z200, respectively. As part of a promotional campaign, PCWSC will provide loans to consumers to install these sanitation systems. The loans will carry an interest rate of 8% and be repayable over 12 years, commencing one year after the connections are installed. It is assumed that 90% of consumers will use these loans.

2. For accounting purposes, income from consumer loans is based on the physical location of the connections. For a conventional sewer, two-thirds of the connection is located on the consumer's property; hence, this portion of the connection is not considered as a part of PCWSC's assets. Therefore, this income is treated as "revenue," and the balance as "consumers contribution." For a small bore sewer, the connection is physically located on the consumers' property; and hence, it will not become a part of PCWSC's assets either. Income from small bore sewer connection fees is therefore treated as "revenue." PCWSC, however, still has a responsibility to maintain these systems.

F. BALANCE SHEET

1. Fixed assets at the end of 1979 were Z103.0 million, with accumulated depreciation of Z34.8 million.

2. Depreciation is set at 3% of average fixed assets.

3. Work-in-Progress is based on the investment plans discussed in the Sources and Applications of Funds. A two-year cycle is assumed for transfering Work-in-Progress to fixed assets. For the Immediate Improvement Project a one-year cycle is assumed.

4. Accounts receivable are assumed to be reduced to 60 days' sales by 1985 and thereafter maintained at that level.

5. Inventories are increased at the rate of water production, plus the rate of inflation.

G. DEFINITIONS

1. The Working Ratio is:

$$\frac{\text{operating expenses (excluding depreciation and non-cash charges)}}{\text{operating revenue}}$$

2. The Operating Ratio is:

$$\frac{\text{operating expenses (including depreciation and non-cash charges)}}{\text{operating revenue}}$$

3. The Rate of Return on Net Fixed Assets is:

$$\frac{\text{net operating income}}{\text{average of Net Fixed Assets in service}}$$

4. The Debt Service Ration is:

$$\frac{\text{net income after taxes + interest on long term debt + depreciation}}{\text{debt service}}$$

BASIC DATA AND ASSUMPTIONS

COUNTRY: OPTIMA

PROJECT: PORT CITY WATER SUPPLY AND SANITATION PROJECT

BASIC DATA AND ASSUMPTIONS

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
POPULATION THOUSAND	1360	1405	1455	1507	1561	1617	1674	1734	1796	1860	1930
POPULATION GROWTH RATE (%)	3.3	3.3	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
WATER SUPPLY											
NUMBER OF CONNECTIONS-THOUSAND											
DOMESTIC CATEGORY 1-METER WORKING	60.5	59.3	58.5	60.3	66.7	77.5	90.1	103.9	118.7	122.8	128.8
DOMESTIC CATEGORY 2-METER NOT WORKING	8.6	10.9	10.9	10.5	10.1	9.1	9.5	6.8	5.3	4.8	4.8
DOMESTIC CATEGORY 3-NO METER	3.3	4.5	6.3	6.8	5.8	3.9	1.5	1.2	.5	.5	.5
SUBTOTAL DOMESTIC	72.4	74.7	75.7	77.6	82.6	90.5	100.1	111.9	124.5	128.1	134.1
STANDPIPES	.5	.5	.5	.5	.5	.6	.6	.7	.7	.7	.7
INDUSTRIAL AND INSTITUTIONAL	1.2	1.3	1.3	1.4	1.4	1.5	1.6	1.7	1.9	1.9	1.9
TOTAL	74.1	76.5	77.5	79.5	84.5	92.6	102.3	114.3	127.1	130.7	136.7
CONECTIONS METERED											
DOMESTIC CATEGORY 1 AS % OF TOTAL DOMESTIC	83.56	79.38	77.28	77.71	80.75	85.64	90.01	92.85	95.34	95.86	96.05
STANDPIPES	28.36	26.43	25.78	24.32	45.61	89.42	100.00	100.00	100.00	100.00	100.00
INDUSTRIAL AND INSTITUTIONAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
ESTIMATED POPULATION SERVED BY WATER-THOUSAND											
DOMESTIC CATEGORY 1	829	819	791	794	872	1012	1150	1291	1474	1535	1596
DOMESTIC CATEGORY 2	116	134	149	151	132	120	108	86	66	59	58
DOMESTIC CATEGORY 3	51	69	97	111	81	40	20	15	7	7	7
SUBTOTAL	996	1022	1037	1056	1085	1172	1278	1392	1547	1600	1660
STANDPIPES	295	276	262	253	246	234	228	220	205	189	177
TOTAL	1291	1298	1299	1309	1331	1406	1506	1612	1752	1789	1837
AVERAGE WATER SOLD PER CAPITA PER DAY (LCD)											
DOMESTIC CATEGORIES	126	124	122	121	123	121	120	119	118	114	114
STANDPIPES	14	15	15	16	17	17	16	16	16	15	15
NUMBER OF PERSONS PER CONNECTION	13.76	13.68	13.70	13.61	13.14	12.95	12.77	12.44	12.42	12.49	12.38
WATER SOLD PER CONNECTION PER YEAR											
DOMESTIC CATEGORY 1	692	688	691	675	625	595	570	550	539	525	520
DOMESTIC CATEGORY 2	346	344	345	338	500	476	456	440	431	420	416
DOMESTIC CATEGORY 3	346	344	345	338	313	297	370	370	370	370	370
STANDPIPES	2994	2936	2900	2946	2996	2387	2278	1843	1746	1477	1429
INDUSTRIAL AND INSTITUTIONAL	12119	12475	12538	12055	12569	13333	13799	14239	15464	16287	16553
VOLUME OF WATER SOLD (000 CU.M/YEAR)											
DOMESTIC CATEGORY 1	41838	40804	40415	40725	41718	46109	51361	57145	63990	64435	66922
DOMESTIC CATEGORY 2	2974	3750	3765	3546	5054	4331	3876	2992	2286	2016	1995
DOMESTIC CATEGORY 3	1141	1548	2174	2296	1814	1161	555	444	185	185	185
SUBTOTAL DOMESTIC	45953	46102	46354	46567	48586	51601	55792	60581	66461	66636	69102
STANDPIPES	1497	1468	1450	1473	1498	1432	1367	1290	1222	1034	1000
INDUSTRIAL AND INSTITUTIONAL	15027	16217	16300	16877	17597	20000	22079	24206	29382	30945	31450
FARMVILLE									548	694	803
TOTAL	62477	63787	64104	64917	67681	73033	79238	86077	97613	99309	102355
WATER PRODUCTION (000 CU.M/YEAR)	111858	113136	115898	117092	118625	123222	131000	141100	159100	162450	165900
UNACCOUNTED FOR WATER	0.44	0.44	0.45	0.45	0.43	0.41	0.40	0.39	0.39	0.39	0.38
TARIFF PER CU.M											
DOMESTIC CATEGORY 1 (FIRST 20 CU.M PER NO.PER CONN./OVER 20 CU.M)	0.25	0.25	0.25	0.25	0.25	.20/.35	.25/.38	.25/.40	.30/.40	.30/.45	.35/.50
DOMESTIC CATEGORY 2 (FIRST 20 CU.M PER NO.PER CONN./OVER 20 CU.M)	0.25	0.25	0.25	0.25	0.25	.20/.35	.25/.38	.25/.40	.30/.40	.30/.45	.35/.50
DOMESTIC CATEGORY 3	0.25	0.25	0.25	0.25	0.25	0.20	0.25	0.25	0.30	0.30	0.35
STANDPIPES	0	0	0	0	0	0	0	0	0	0	0
INDUSTRIAL AND INSTITUTIONAL	0.25	0.25	0.25	0.25	0.25	0.35	0.38	0.40	0.40	0.45	0.50
FARMVILLE									0.30	0.30	0.35
CONNECTION FEE											
DOMESTIC CATEGORIES	100	100	100	100	100	120	130	130	140	140	145
INDUSTRIAL	500	500	500	500	500	600	650	650	700	700	750
WATER SALE REVENUE (Z 000)											
FROM DOMESTIC CATEGORY 1	10460	10201	10104	10181	10430	13348	16706	19118	22747	24575	28824
FROM DOMESTIC CATEGORY 2	743	938	941	887	1263	1188	1208	952	787	734	825
FROM DOMESTIC CATEGORY 3	285	387	543	574	454	232	139	111	56	56	65
SUBTOTAL	11488	11526	11588	11642	12146	14768	18053	20181	23590	25365	29714
FROM STANDPIPES	0	0	0	0	0	0	0	0	0	0	0
FROM INDUSTRIAL AND INSTITUTIONAL	3757	4054	4075	4219	4399	7000	8390	9682	11753	13925	15725
FROM FARMVILLE									164	208	281
TOTAL	15245	15580	15663	15861	16546	21768	26443	29863	35507	39498	45720
AVERAGE TARIFF PER CU.M											
DOMESTIC	0.25	0.25	0.25	0.25	0.25	0.29	0.32	0.33	0.35	0.38	0.43
INDUSTRIAL AND INSTITUTIONAL	0.25	0.25	0.25	0.25	0.25	0.35	0.38	0.40	0.40	0.45	0.50
TOTAL	0.25	0.25	0.25	0.25	0.25	0.30	0.34	0.35	0.37	0.40	0.45

BASIC DATA AND ASSUMPTIONS (CONTINUED)

BASIC DATA AND ASSUMPTIONS (CONTINUED)

SANITATION

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
POPULATION SERVED -THOUSAND											
A) RESIDENTS WITH PCWSC WATER CONNECTIONS											
CONVENTIONAL SEWERS	NA	NA	267	276	286	297	339	384	429	440	451
SMALL BORE SEWERS	NA	NA	0	0	0	0	27	143	239	259	298
ON-SITE DISPOSAL SYSTEMS	NA	NA	770	780	799	875	912	865	879	901	911
SUBTOTAL	NA	NA	1037	1056	1085	1172	1278	1392	1547	1600	1660
B) RESIDENTS WITHOUT PCWSC WATER CONNECTIONS											
ON-SITE DISPOSAL SYSTEMS	NA	NA	230	254	265	250	346	354	209	241	255
PUBLIC TOILETS	NA	NA	15	15	15	15	20	30	40	40	40
SUBTOTAL	NA	NA	245	269	280	265	366	384	249	281	295
NUMBER OF SANITATION FACILITIES (THOUSANDS)											
A) RESIDENTS WITH PCWSC WATER CONNECTIONS											
CONNECTIONS TO OFF-SITE SYSTEMS											
CONVENTIONAL SEWERS	24.1	24.3	24.6	24.9	26.5	28.6	31.7	35.8	41.6	42.7	43.7
SMALL BORE SEWERS	0	0	0	0	0	0	1.1	5.8	9.7	10.5	12.1
ON-SITE DISPOSAL SYSTEMS	NA	NA	52.3	54.2	56.2	58.2	58.6	58.9	59.2	61.3	63.2
B) RESIDENTS WITHOUT PCWSC WATER CONNECTIONS											
ON-SITE DISPOSAL SYSTEMS	NA	NA	24.8	25.6	26.3	27.1	24.4	21.7	19.1	21.9	25.2
C) INDUSTRIAL AND INSITIUTIONAL WITH PCWSC WATER CONNECTIONS											
SEWER CONNECTIONS	.8	.8	.9	.9	1.1	1.1	1.2	1.3	1.4	1.4	1.5
ESTIMATED WATER VOLUME FOR BILLING SEWERAGE/SANITATION											
DOMESTIC	14842	14739	15000	15352	16163	17843	55792	60581	66461	66636	69102
INDUSTRIAL AND INSTITUTIONAL	9018	8984	10150	9767	12446	13191	22079	24206	29382	30945	31450
TOTAL VOLUME	23860	23723	25150	25119	28609	31034	77871	84787	95843	97581	100552
SEWERAGE/SANITATION TARIFF	0.15	0.15	0.15	0.15	0.15	0.17	0.19	0.19	0.20	0.22	0.25
REVENUES FROM WATER AND SANITATION (Z 1000)											
REVENUES FROM WATER	15245	15580	15663	15861	16546	21768	26443	29863	35507	39498	45720
REVENUES FROM SANITATION											
FROM DOMESTIC SEWERAGE	2226	2211	2250	2303	2424	3033					
FROM DOMESTIC SANITATION							9929	11100	12974	13950	16343
FROM CONVENTIONAL CONNECTION FEES							569	1276	2117	3076	4084
FROM INDUSTRIAL SEWERAGE	1353	1348	1523	1465	1867	2242					
FROM INDUSTRIAL SANITATION							4615	5325	6464	7659	8649
FROM SMALL BORE CONNECTION FEE							40	220	421	650	914
FROM INDUSTRIAL CONNECTION FEES	180	65	50	45	75	115	118	120	123	125	128
SUBTOTAL SANITATION	3759	3623	3823	3813	4366	5391	15271	18041	22099	25460	30117
TOTAL REVENUES FROM WATER AND SANITATION	19004	19203	19486	19674	20912	27159	41713	47904	57606	64958	75837

INCOME STATEMENTS, 1979-1989

COUNTRY: OPTIMA

PROJECT: PORT CITY WATER SUPPLY AND SANITATION PROJECT

INCOME STATEMENT (Z 1000)	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
INFLATION INDEX	1.10	1.11	1.13	1.12	1.12	1.11	1.10	1.09	1.09	1.09	1.09
WATER PRODUCTION INDEX	1.00	1.01	1.02	1.01	1.01	1.04	1.06	1.08	1.13	1.02	1.00
OPERATING REVENUES											
TOTAL REVENUES FROM WATER AND SANITATION	19004	19203	19486	19674	20912	27159	41713	47904	57606	64958	75837
OTHER OPERATIONAL REVENUES	983	1189	1310	1584	1786	1923	2142	2184	2228	2285	2318
TOTAL OPERATING REVENUES	19987	20392	20796	21258	22698	29082	43855	50088	59834	67243	78155
OPERATING EXPENSES											
WATER SUPPLY-DIRECT											
WAGE AND STAFF	6332	6687	7442	8106	8635	10442	12410	12965	16964	17411	18617
CHEMICAL	383	381	525	574	646	746	870	1024	1262	1403	1529
ENERGY	801	882	651	683	769	888	1035	1219	1501	1669	1819
MATERIAL AND MAINTENANCE	296	339	423	506	570	658	767	903	1112	1236	1348
SUBTOTAL	7812	8289	9041	9869	10620	12734	15082	16111	20839	21719	23313
SANITATION-DIRECT											
WAGE AND STAFF	501	563	753	848	882	978	1294	2535	3909	5775	8333
CONTRACTS								96	235	382	571
ENERGY AND CHEMICAL	252	271	379	402	448	498	547	597	650	709	773
MATERIAL AND MAINTENANCE	429	476	359	512	969	1356	1700	1863	2001	2181	2378
SUBTOTAL	1182	1310	1491	1762	2299	2832	3541	5091	6795	9047	12055
ADMINISTRATION											
WAGE AND STAFF	3676	3794	4613	4965	5710	6566	7551	8684	9986	10484	13207
TRANSPORTATION AND EQUIPMENT	601	649	818	870	980	1131	1319	1552	1912	2126	2317
OTHERS	461	518	631	722	813	939	1094	1288	1587	1764	1923
SUBTOTAL	4738	4961	6062	6557	7503	8636	9964	11525	13485	14374	17447
TOTAL WORKING EXPENSES	13732	14560	16594	18188	20422	24201	28588	32726	41120	45140	52815
DEPRECIATION : (ASSETS AT HISTORICAL COST)	3085	3189	3360	3488	3594	3736	3985	4482	6082	8181	9131
TOTAL OPERATING EXPENSES	16817	17749	19954	21676	24016	27937	32573	37208	47202	53321	61946
OPERATING INCOME (ASSETS AT HISTORICAL COST)	3170	2643	842	-418	-1318	1145	11282	12880	12632	13922	16209
NET NONOPERATING REVENUE	40	21	21	26	28	31	34	37	41	45	50
INCOME BEFORE INTEREST	3210	2664	863	-392	-1290	1175	11316	12917	12673	13967	16259
INTEREST EXPENSE	497	473	446	417	385	350	766	700	11549	11241	10905
NET INCOME	2713	2191	417	-809	-1675	825	10550	12217	1124	2726	5354
RATIOS											
WORKING RATIO %	0.69	0.71	0.80	0.86	0.90	0.83	0.65	0.65	0.69	0.67	0.68
OPERATING RATIO	0.84	0.87	0.96	1.02	1.06	0.96	0.74	0.74	0.79	0.79	0.79
RATE OF RETURN (%)	4.6	3.8	1.2	-0.6	1.8	1.5	14.3	14.1	9.1	6.9	7.2
ASSETS REVALUED											
OPERATING INCOME	2800	1974	-351	-2201	-3675	-2106	7307	8135	7847	8578	9633
RATE OF RETURN (%)	3.7	2.3	-0.4	-2.0	-2.9	-1.5	4.6	4.4	3.1	2.6	2.5

STATEMENTS OF CASH FLOW, 1979-1989

COUNTRY: OPTIMA

PROJECT: PORT CITY WATER SUPPLY AND SANITATION

STATEMENT OF CASH FLOW FOR YEARS ENDED DECEMBER 31

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
SOURCES OF FUNDS											
INCOME BEFORE INTEREST	3210	2664	863	-392	-1290	1175	11315	12918	12673	13967	16258
DEPRECIATION	3085	3189	3360	3488	3595	3736	3985	4482	6082	8181	9131
TOTAL INTERNAL RESOURCES	6295	5853	4223	3096	2305	4911	15300	17400	18755	22148	25389
GOVERNMENT GRANT	983	1013	750	293	569	1358	494				
P.A.I.D LOAN				1560	3240	880					
O.D.F LOAN					520	1580	15570	3900			
INTERNATIONAL BANK LOAN					2100	9130	34650	13490			
CONSUMER CONTRIBUTION	255	280	135	235	550	1013	1580	2303	2870	1991	2807
GOVERNMENT LOAN					1150	3230	18760	17840			
TOTAL SOURCES	7533	7146	5108	5184	10434	22102	86354	54933	21625	24139	28196
APPLICATIONS OF FUNDS											
PROJECT INVESTMENT-IMMEDIATE IMPROVEMENT				2200	4800	2700					
-MAJOR PROJECT					4300	16000	75000	38700			
CONNECTIONS- WATER	255	280	135	235	550	1013	1323	1616	1899	579	950
- SEWER							257	687	971	1412	1857
OTHER INVESTMENT	5595	5243	2917	1523	58	0	0	0	1781	3065	6457
CAPITALIZED INTEREST				60	420	1320	4380	8430			
TOTAL INVESTMENT	5850	5523	3052	4018	10128	21033	80960	49433	4651	5056	9264
INTEREST EXPENSE	497	473	446	417	385	350	766	700	11549	11241	10905
AMORTIZATION	275	299	326	355	387	422	759	825	3660	3968	4305
DEBT SERVICE (EXCLUDING CAPITALIZED INTEREST)	772	772	772	772	772	772	1525	1525	15209	15209	15210
CONSUMER LOANS	0	0	0	0	0	2801	2962	3114	3400	3053	2505
OTHERS	83	45									
TOTAL APPLICATION	6705	6340	3824	4790	10900	24606	85447	54072	23260	23318	26979
INCREASE IN WORKING CAPITAL *1	816	798	1308	225	-466	-2504	907	161	-992	378	617
ENDING CASH	836	844	820	989	989	989	989	1689	1046	1489	2089
BEGINNING CASH	824	836	844	820	989	989	989	989	1689	1046	1489
INCREASE IN CASH	12	8	-24	169	0	0	0	700	-643	443	600

*1
EXCLUDING CASH AND CURRENT MATURITIES

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
CHANGE IN ELEMENTS OF WORKING CAPITAL *2											
CURRENT ASSETS											
ACCOUNTS RECEIVABLE	686	579	2582	2386	283	-3442	80	549	127	785	1990
INVENTORIES	432	349	54	113	353	357	437	539	816	498	452
OTHERS	101	78	11	23	70	72	87	108	163	100	94
TOTAL CURRENT ASSETS	1219	1006	2647	2522	706	-3013	604	1196	1106	1383	2536
CURRENT LIABILITIES											
ACCOUNTS PAYABLE	328	173	1116	1914	1024	-156	-486	862	1749	837	1599
OTHERS	75	35	223	383	148	-353	183	173	349	168	320
TOTAL CURRENT LIABILITIES	403	208	1339	2297	1172	-509	-303	1035	2098	1005	1919
INCREASE IN WORKING CAPITAL	816	798	1308	225	-466	-2504	907	161	-992	378	617
DEBT SERVICE RATIO	8.2	7.6	5.5	4.6	3.0	6.4	10.0	11.4	1.2	1.5	1.7

*2
EXCLUDING CASH AND CURRENT MATURITIES OF LONG-TERM DEBT

Annex 7
Table A7.4

BALANCE SHEETS, 1979-1989

COUNTRY:OPTIMA

PROJECT: PORT CITY WATER SUPPLY AND SANITATION

BALANCE SHEET FOR YEARS END DECEMBER 31

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
ASSETS											
FIXED ASSETS											
PLANT IN OPERATION	103375	109225	114748	117800	121819	127226	138462	160323	245130	300311	308420
LESS: ACCUMULATED DEPRECIATION	34380	37569	40929	44417	48011	51747	55732	60214	66296	74477	83608
NET PLANT IN OPERATION	68995	71656	73819	73383	73808	75479	82730	100109	178834	225834	224812
WORK IN PROGRESS	5850	5523	3052	4018	10128	28555	101241	131937	55181	8109	11982
NET FIXED ASSETS	74845	77179	76871	77401	83936	104034	183971	232046	234015	233943	236794
CURRENT ASSETS											
CASH IN BANKS	836	844	820	989	989	989	989	1689	1046	1489	2089
ACCOUNTS RECEIVABLE (NET)	4681	5260	7842	10228	10509	7067	7147	7696	7823	8608	10598
INVENTORIES	1463	1857	1911	2024	2377	2734	3171	3710	4526	5024	5476
OTHERS	293	371	382	405	475	547	634	742	905	1005	1095
NET CURRENT ASSETS	7273	8332	10955	13646	14350	11337	11941	13837	14300	16126	19258
TOTAL ASSETS	82118	85511	87826	91047	98286	115371	195912	245883	248315	250069	256052
EQUITY AND LIABILITIES											
EQUITY											
GOVERNMENT GRANT	60724	61737	62487	62780	63349	64707	65201	65201	65201	65201	65201
CONSUMER CONTRIBUTIONS	3455	3735	3870	4105	4655	5668	7248	9551	12421	14412	17219
RETAINED EARNINGS	8678	10869	11286	10477	8802	9627	20176	32394	33518	36244	41597
TOTAL EQUITY	72857	76341	77643	77362	76806	80002	92625	107146	111140	115857	124017
LIABILITIES											
LONG-TERM DEBT (NET)											
CURRENT LOANS	5530	5204	4849	4462	4040	3580	3078	2531	1935	1295	577
P.A.I.D LOAN				1560	4800	5381	5058	4709	4332	3925	3485
O.D.F. LOAN					520	2100	17670	20654	19672	18630	17526
INTERNATIONAL BANK					2100	11230	45880	58333	57193	55939	54559
GOVERNMENT LOAN					1150	4380	23140	40179	39306	38354	37217
NET LONG-TERM DEBT	5530	5204	4849	6022	12610	26671	94826	126406	122438	118133	113364
CURRENT LIABILITIES											
ACCOUNTS PAYABLE	2860	3033	4149	6063	7087	6931	6445	7307	9056	9893	11492
CURRENT MATURITIES OF LONG-TERM DEBT	299	326	355	387	422	759	825	3660	3968	4305	4978
OTHERS	572	607	830	1213	1361	1008	1191	1364	1713	1861	2201
TOTAL CURRENT LIABILITIES	3731	3966	5334	7663	8670	8698	8461	12331	14737	16079	18671
TOTAL LIABILITIES	9261	9170	10183	13685	21480	35369	103287	138737	137175	134212	132035
TOTAL EQUITY AND LIABILITIES	82118	85511	87826	91047	98286	115371	195912	245883	248315	250069	256052
AVERAGE NET FIXED ASSETS IN OPERATION											
HISTORICAL COST	68346	70316	72738	73601	73596	74644	79105	91420	139472	202334	225323
REVALUED BASIS	76548	85082	98555	111348	124710	139591	158011	184547	249208	334496	387589

Annex 7
Table A7.5

PCWSC FINANCING PLAN 1983-1986

PCWSC FINANCING PLAN

	1983	1984	1985	1986	1987	TOTAL 1983-1986
IMMEDIATE IMPROVEMENT PROGRAM						
P.A.I.D LOAN	3240	880				4120
INTERNALLY GENERATED FUND	1240	1000				2240
GOVERNMENT GRANT	560	1200				1760
TOTAL	5040	3080				8120
MAJOR PROJECT						
ODF LOAN	520	1580	15570	3900		21570
INTERNATIONAL BANK LOAN	2100	9130	34650	13490		59370
GOVERNMENT LOAN	1150	3230	18760	17840		40980
INTERNALLY GENERATED FUND	1065	3911	15300	17400		37676
TOTAL	4835	17851	84280	52630		159596

LOANS REPAYMENTS SCHEDULE

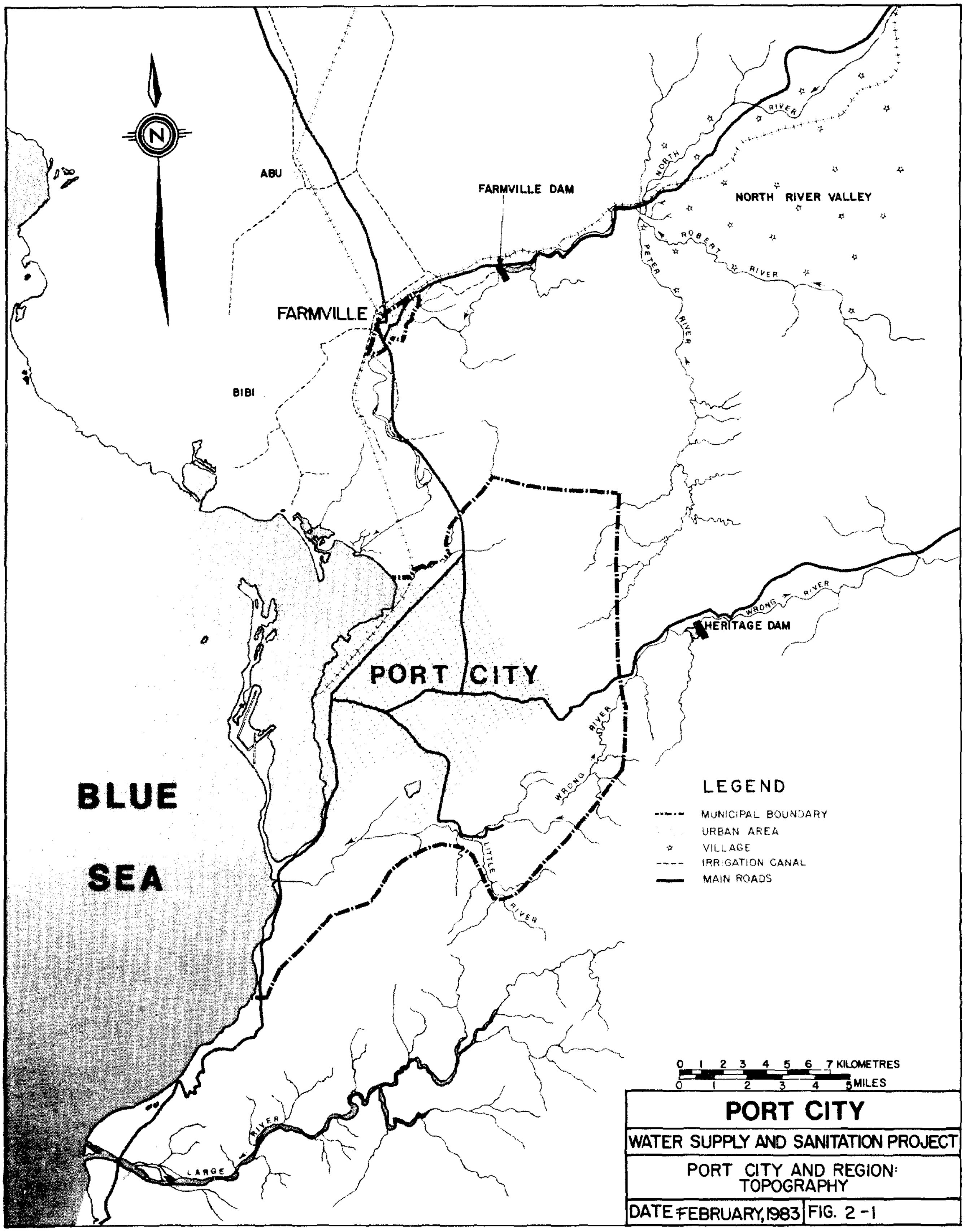
	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	TOTAL
CURRENT- INTEREST EXPENSE	497	473	446	417	385	350	312	270	225	176	122	3673
AMORTIZATION	275	299	326	355	387	422	460	502	547	596	650	4819
P.A.I.D- CAPITALIZED INTEREST				60	240	380						680
INTEREST EXPENSE							454	430	405	377	347	2013
AMORTIZATION							299	323	349	377	407	1755
ODF- CAPITALIZED INTEREST					30	80	570	1100				1780
INTEREST EXPENSE									1294	1239	1179	3712
AMORTIZATION									926	982	1042	2950
I.B- CAPITALIZED INTEREST					100	630	2650	4690				8070
INTEREST EXPENSE									5937	5833	5719	17489
AMORTIZATION									1037	1140	1254	3431
GOVT LOAN-CAPITALIZED INTEREST					50	230	1160	2640				4080
INTEREST EXPENSE									3688	3616	3538	10842
AMORTIZATION									801	873	952	2626
TOTAL- CAPITALIZED INTEREST				60	420	1320	4380	8430				14610
INTEREST EXPENSE	497	473	446	417	385	350	766	700	11549	11241	10905	37729
AMORTIZATION	275	299	326	355	387	422	759	825	3660	3968	4305	15581
DEBT SERVICE	772	772	772	772	772	772	1525	1525	15209	15209	15210	53310

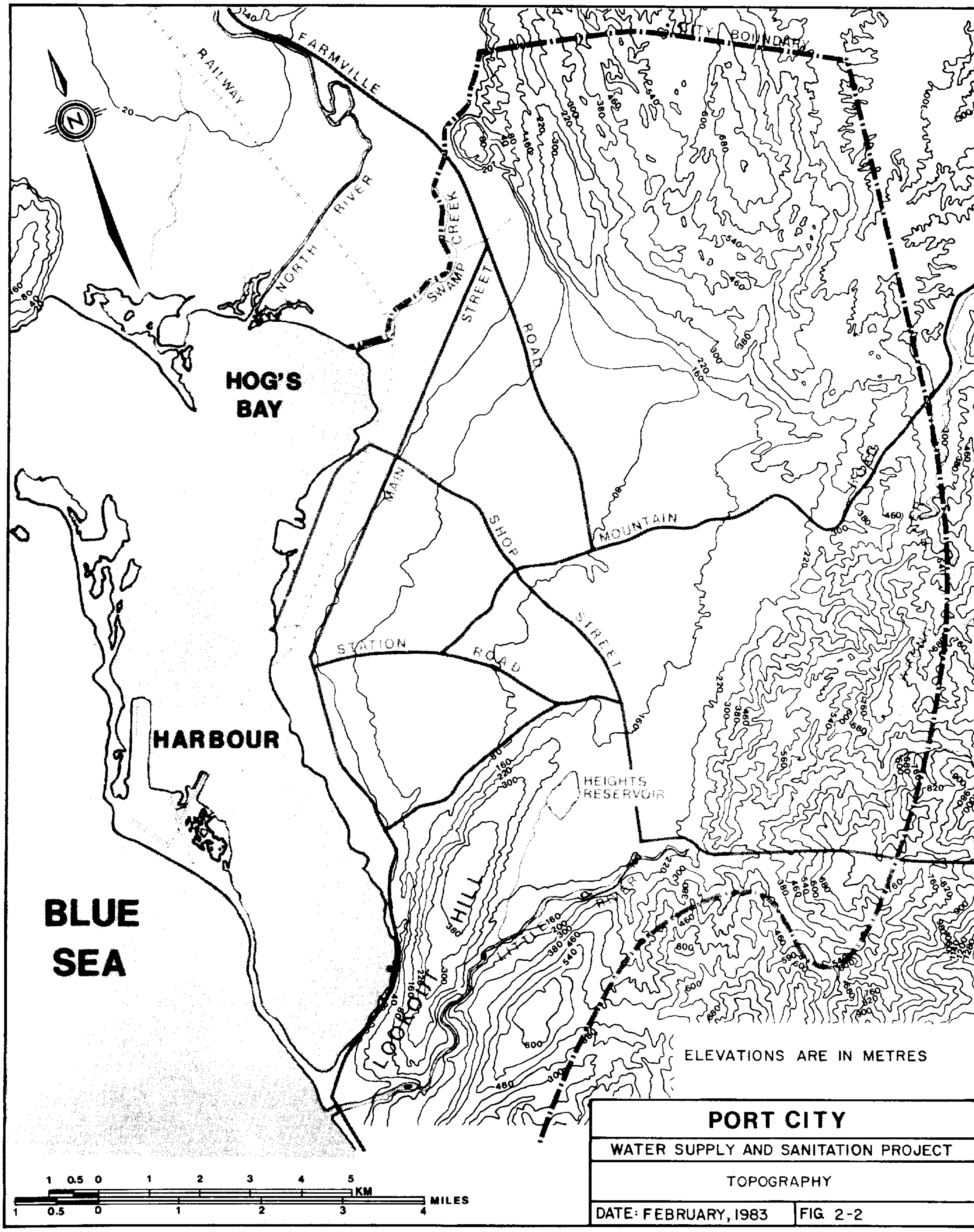
Annex 7
Table A7.6

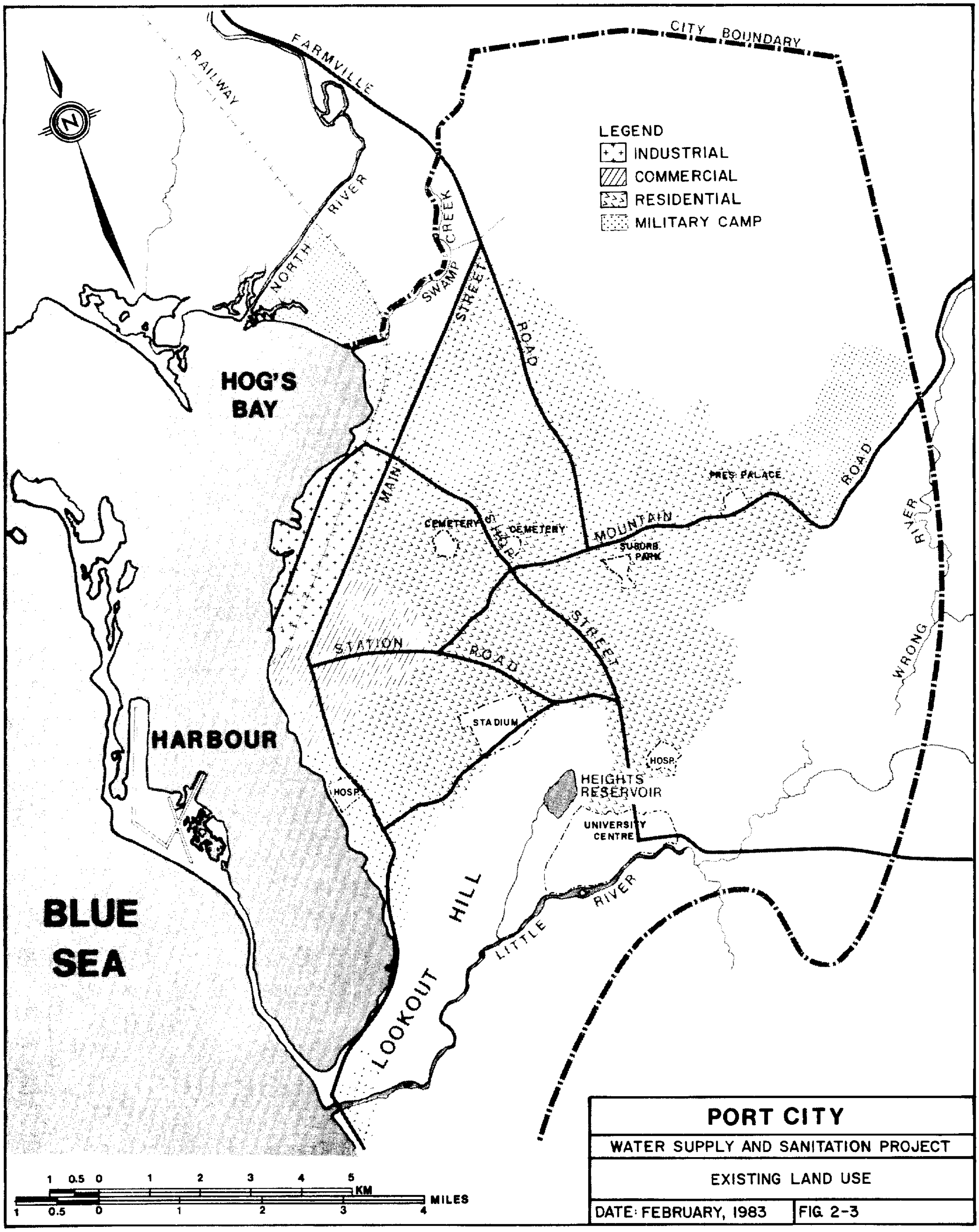
Consumer Loan Repayments Schedule

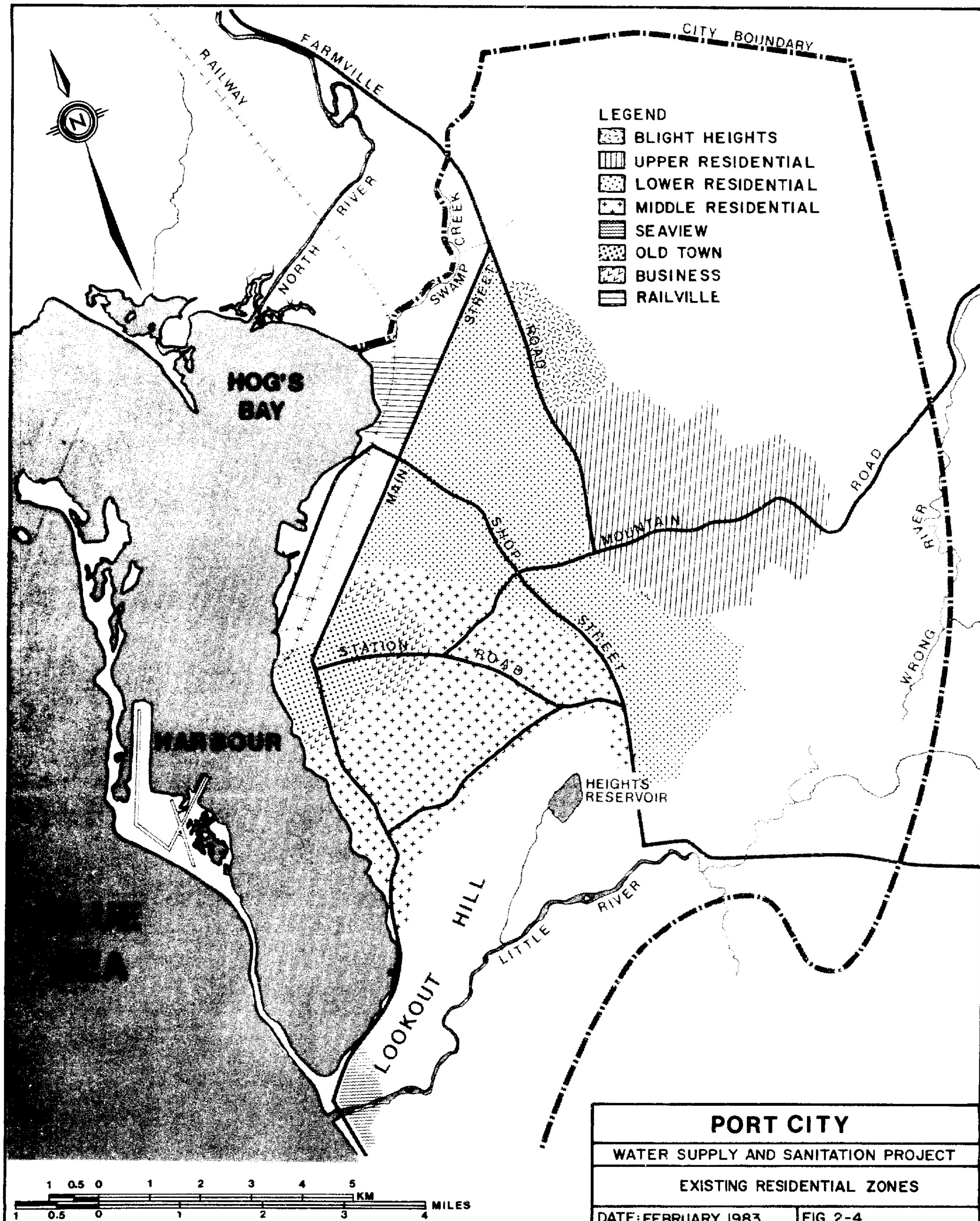
	1984	1985	1986	1987	1988	1989	Total
I. Conventional Sewers							
Total cost @ Z 300	8,490	9,750	11,550	13,170	13,530	13,860	70,350
10% of consumers paid-in	949	975	1,155	1,317	1,353	1,386	7,035
90% of consumers will take loans	7,641	8,775	10,395	11,853	12,177	12,474	63,315
Loan repayments (8% interest, 12 yrs)		939	2,017	3,294	4,750	6,246	17,246
II. Small Bore Sewers							
Total cost @ Z 200		400	1,760	1,820	2,100	2,240	8,500
10% of consumers paid-in		40	176	182	210	224	850
90% of consumers will take loans		360	1,584	1,638	1,890	2,178	7,650
Loan repayments (8% interest, 12 yrs)			44	239	440	672	1,395

FIGURES


ABU
BIBI
FARMVILLE
FARMVILLE DAM
NORTH RIVER VALLEY
NORTH RIVER
ROBERT RIVER
PETER RIVER
PORT CITY
WRONG RIVER
HERITAGE DAM
LITTLE RIVER
LARGE RIVER
BLUE SEA
LEGEND
MUNICIPAL BOUNDARY
URBAN AREA
VILLAGE
IRRIGATION CANAL
MAIN ROADS
0 1 2 3 4 5 6 7 KILOMETRES
0 1 2 3 4 5 MILES
PORT CITY
WATER SUPPLY AND SANITATION PROJECT
PORT CITY AND REGION: TOPOGRAPHY
DATE FEBRUARY, 1983
FIG. 2-1


FARMVILLE
RAILWAY
NORTH RIVER
SWAMP CREEK
CITY BOUNDARY
STREET
ROAD
HOG'S BAY
MAIN
SHOP
MOUNTAIN
ROAD
STREET
STATION
ROAD
HARBOUR
HEIGHTS RESERVOIR
LOOKOUT
HILL
LITTLE RIVER
BLUE SEA
ELEVATIONS ARE IN METRES
KM
MILES
PORT CITY
WATER SUPPLY AND SANITATION PROJECT
TOPOGRAPHY
DATE: FEBRUARY, 1983
FIG. 2-2


CITY BOUNDARY
FARMVILLE
RAILWAY
LEGEND
INDUSTRIAL
COMMERCIAL
RESIDENTIAL
MILITARY CAMP
NORTH RIVER
SWAMP CREEK
STREET
ROAD
HOG'S BAY
MAIN
SHOP
STREET
CEMETERY
CEMETERY
MOUNTAIN
ROAD
PRES. PALACE
SUBURB PARK
RIVER
WRONG
STATION
ROAD
STADIUM
HARBOUR
HOSP.
HOSP.
HEIGHTS RESERVOIR
UNIVERSITY CENTRE
HILL
LITTLE RIVER
LOOKOUT
BLUE SEA
1 0.5 0 1 2 3 4 5 KM
1 0.5 0 1 2 3 4 MILES
PORT CITY
WATER SUPPLY AND SANITATION PROJECT
EXISTING LAND USE
DATE: FEBRUARY, 1983
FIG. 2-3

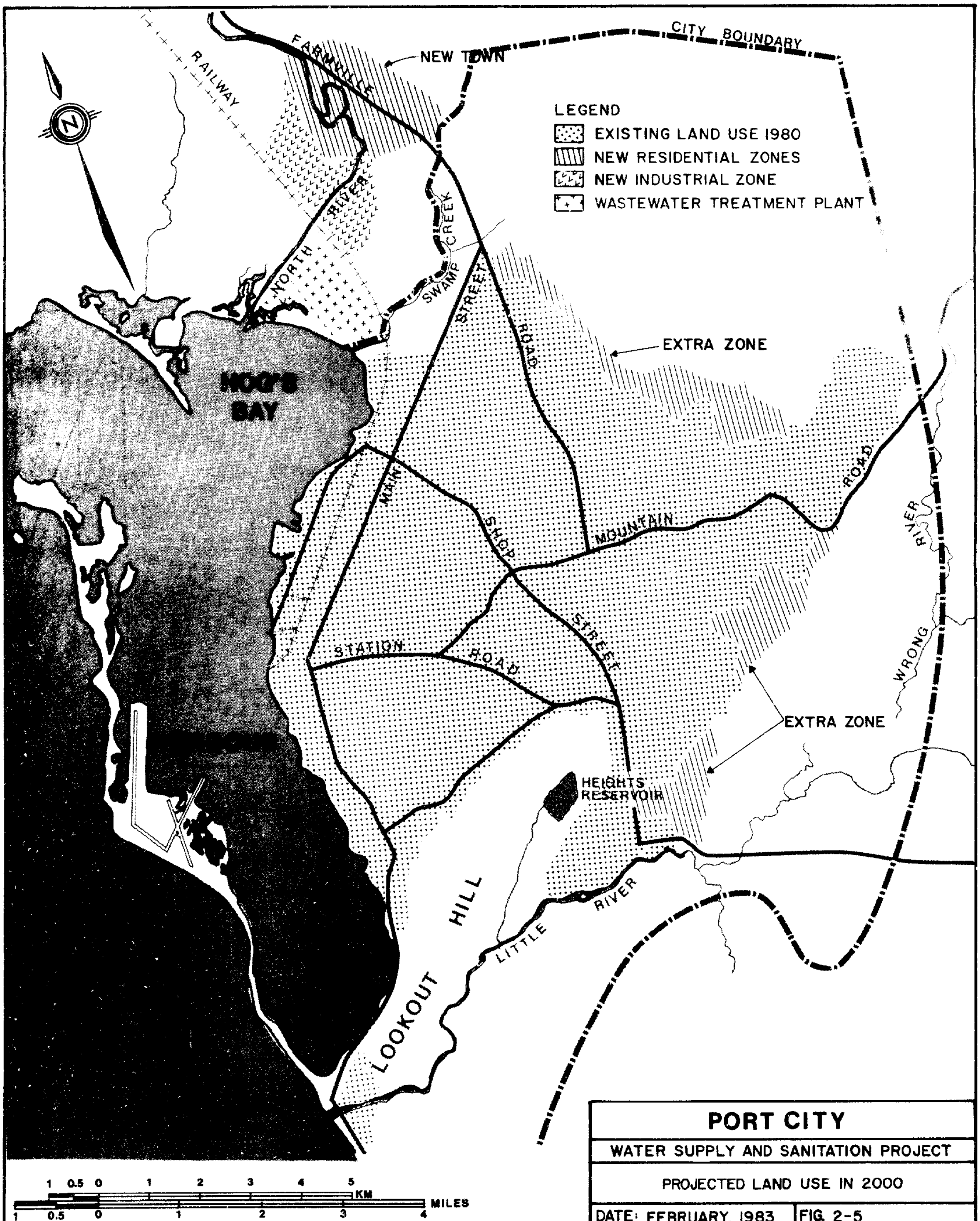


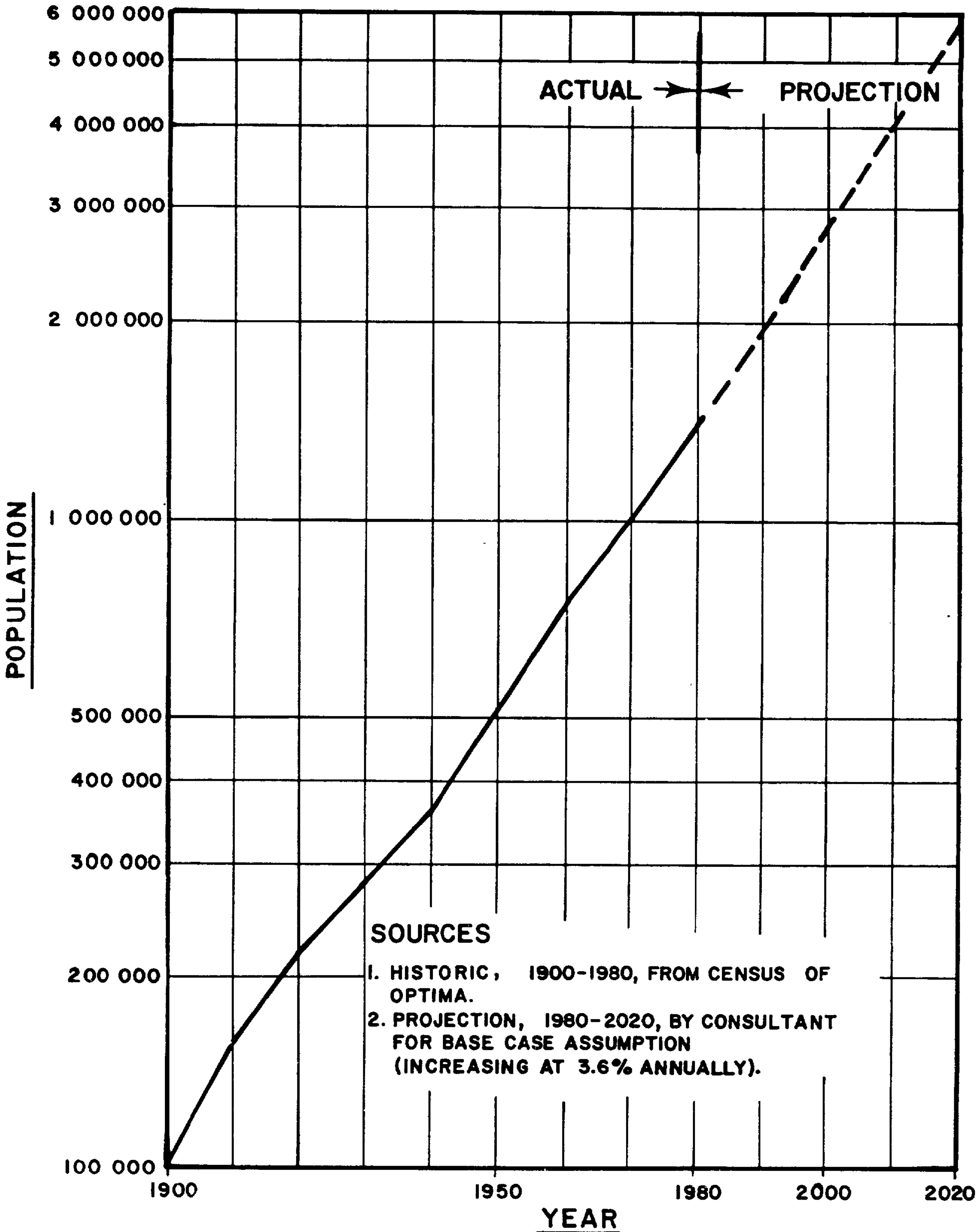
PORT CITY

WATER SUPPLY AND SANITATION PROJECT

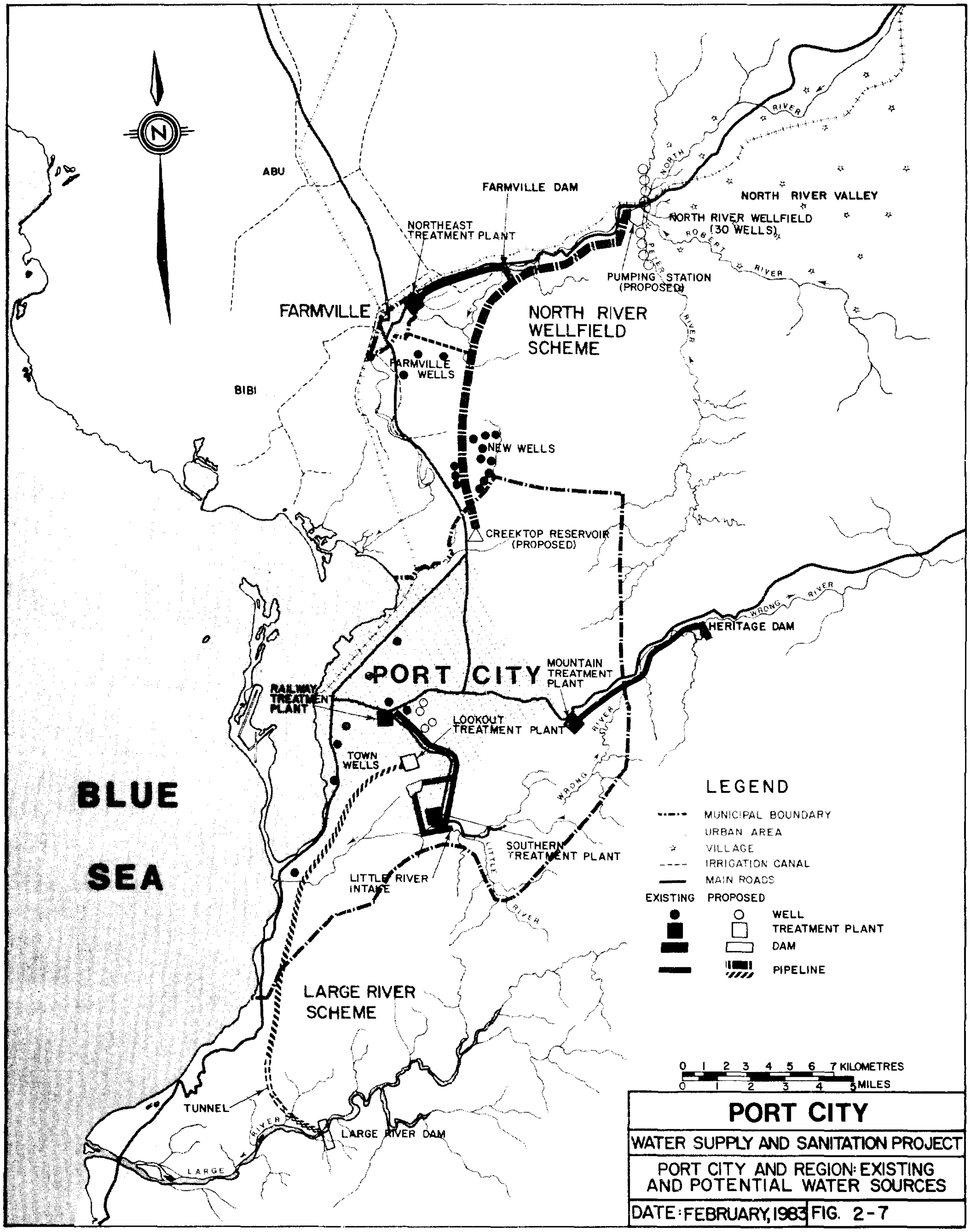
EXISTING RESIDENTIAL ZONES

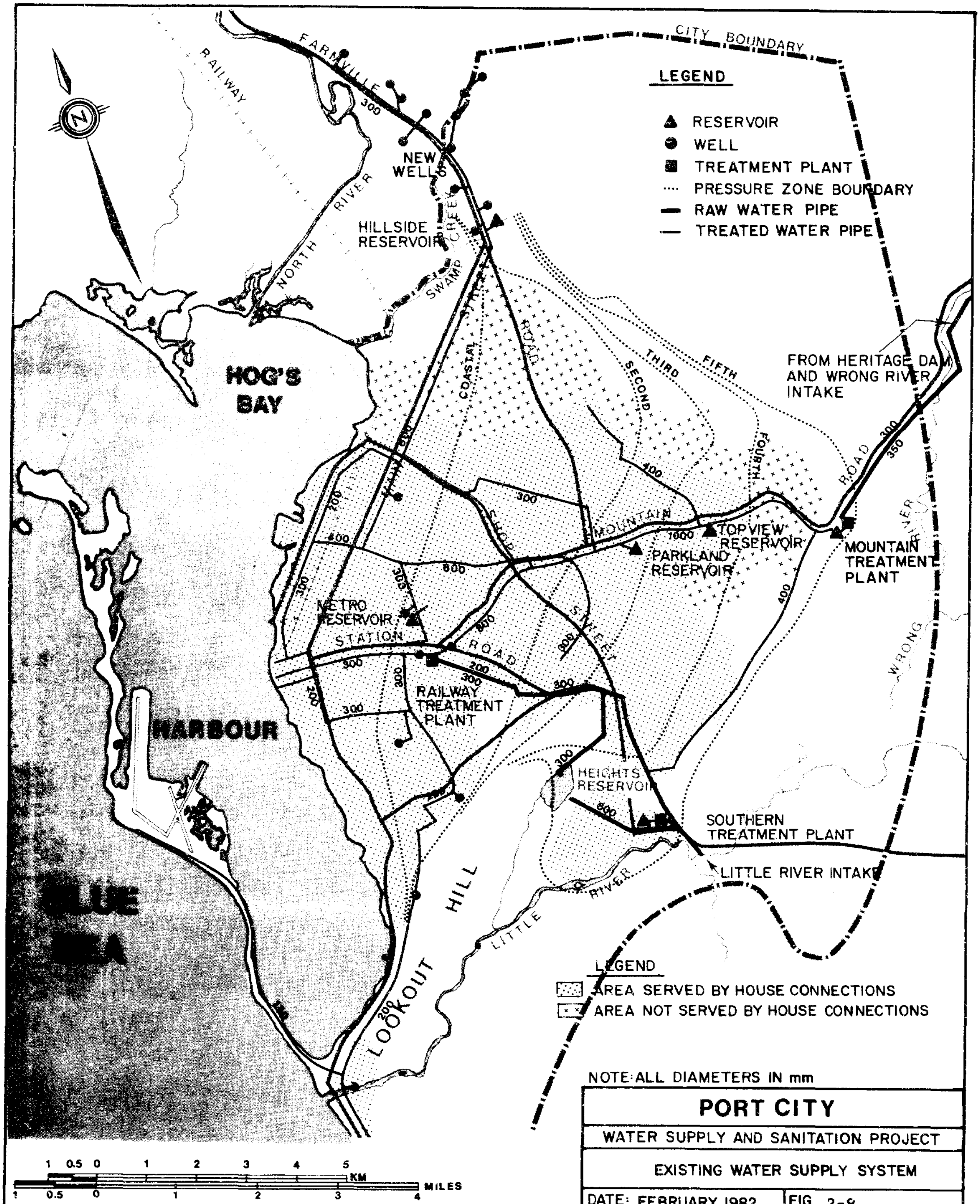
DATE: FEBRUARY, 1983 | FIG. 2-4


CITY BOUNDARY
NEW TOWN
FARMVILLE
RAILWAY
LEGEND
EXISTING LAND USE 1980
NEW RESIDENTIAL ZONES
NEW INDUSTRIAL ZONE
WASTEWATER TREATMENT PLANT
NORTH RIVER
SWAMP CREEK
STREET
ROAD
EXTRA ZONE
HOG'S BAY
MAIN
SHOP
MOUNTAIN
ROAD
RIVER
WRONG
STATION
ROAD
STREET
EXTRA ZONE
HEIGHTS RESERVOIR
LOOKOUT HILL
LITTLE RIVER
1 0.5 0 1 2 3 4 5 KM
1 0.5 0 1 2 3 4 MILES
PORT CITY
WATER SUPPLY AND SANITATION PROJECT
PROJECTED LAND USE IN 2000
DATE: FEBRUARY, 1983
FIG. 2-5



PORT CITY	
POPULATION—ACTUAL AND PROJECTED, 1900-2020	
DATE: FEBRUARY, 1983	FIG. 2-6


N
ABU
BIBI
FARMVILLE DAM
NORTHEAST TREATMENT PLANT
FARMVILLE
FARMVILLE WELLS
NORTH RIVER VALLEY
NORTH RIVER WELLFIELD (30 WELLS)
PUMPING STATION (PROPOSED)
NORTH RIVER WELLFIELD SCHEME
NEW WELLS
CREEKTOP RESERVOIR (PROPOSED)
HERITAGE DAM
WRONG RIVER
PORT CITY
MOUNTAIN TREATMENT PLANT
RAILWAY TREATMENT PLANT
LOOKOUT TREATMENT PLANT
TOWN WELLS
BLUE
SEA
SOUTHERN TREATMENT PLANT
LITTLE RIVER INTAKE
LITTLE RIVER
LARGE RIVER SCHEME
TUNNEL
LARGE RIVER DAM
LARGE RIVER
LEGEND
MUNICIPAL BOUNDARY
URBAN AREA
VILLAGE
IRRIGATION CANAL
MAIN ROADS
EXISTING
PROPOSED
WELL
TREATMENT PLANT
DAM
PIPELINE
0 1 2 3 4 5 6 7 KILOMETRES
0 1 2 3 4 5 MILES
PORT CITY
WATER SUPPLY AND SANITATION PROJECT
PORT CITY AND REGION: EXISTING AND POTENTIAL WATER SOURCES
DATE: FEBRUARY, 1983
FIG. 2-7

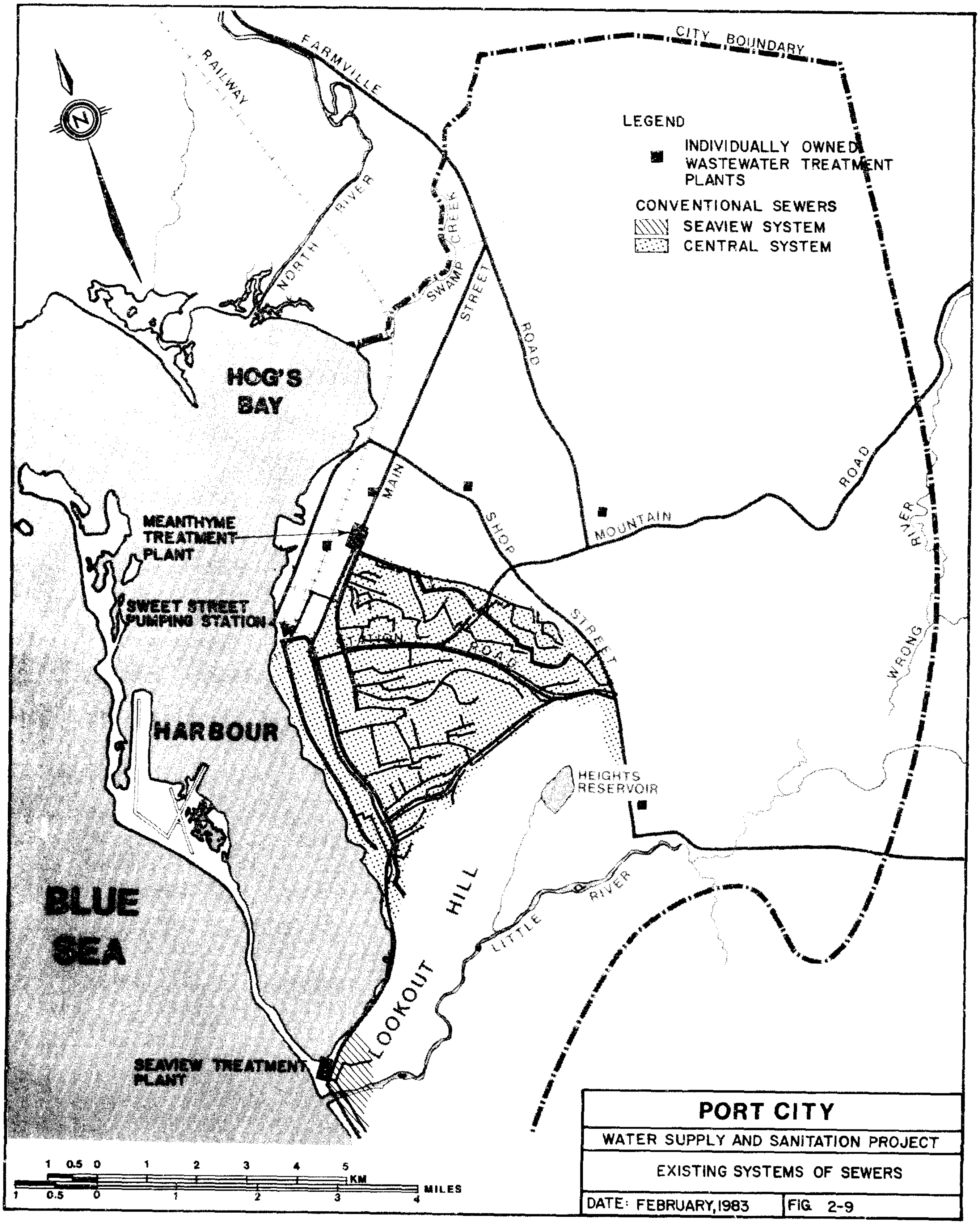


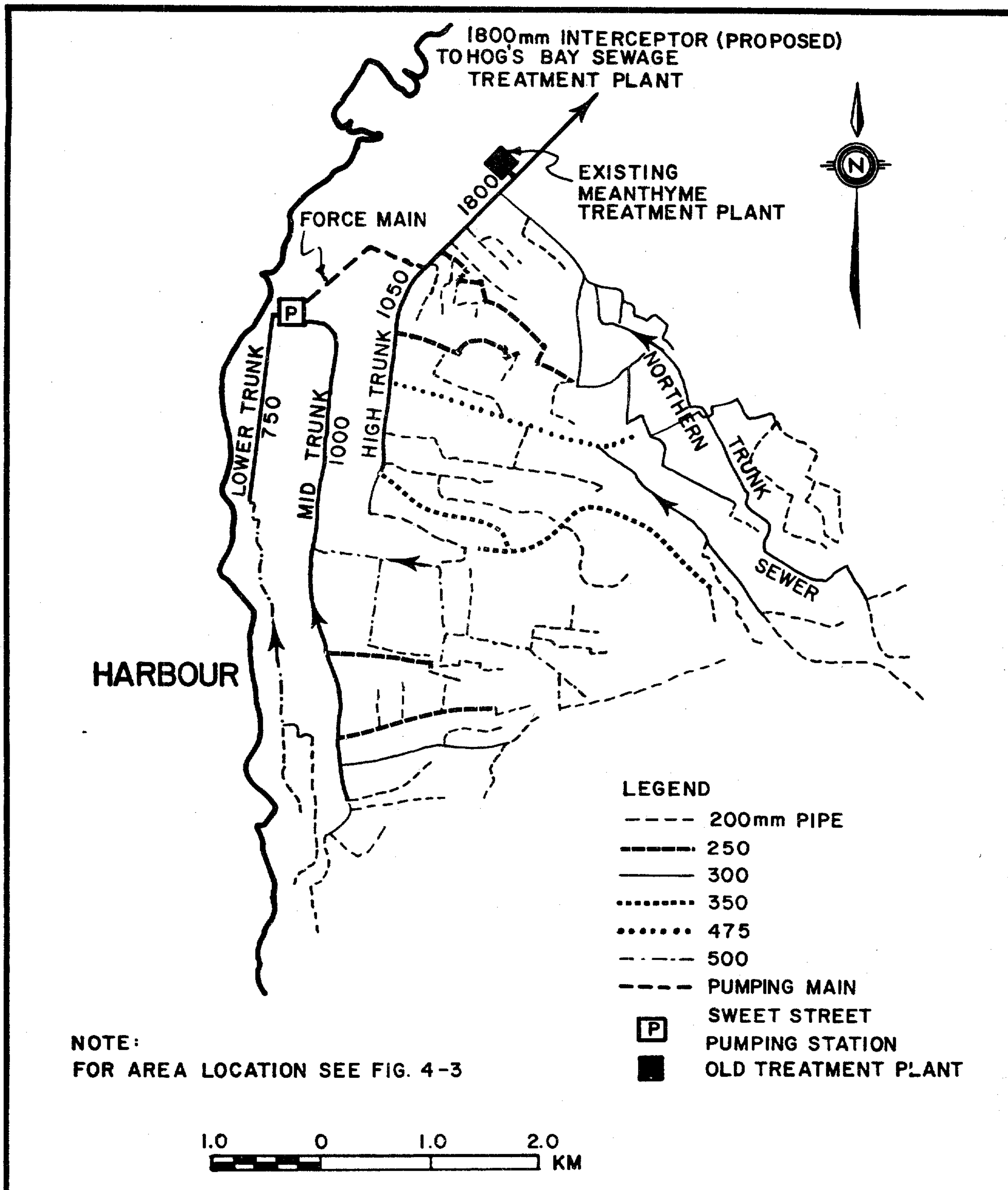
PORT CITY

WATER SUPPLY AND SANITATION PROJECT

EXISTING WATER SUPPLY SYSTEM

DATE: FEBRUARY, 1982 | FIG. 2-8


CITY BOUNDARY
FARMVILLE
RAILWAY
LEGEND
INDIVIDUALLY OWNED WASTEWATER TREATMENT PLANTS
CONVENTIONAL SEWERS
SEAVIEW SYSTEM
CENTRAL SYSTEM
NORTH RIVER
SWAMP CREEK
STREET
ROAD
HOG'S BAY
MAIN
SHOP
MOUNTAIN
ROAD
RIVER
MEANTHYME TREATMENT PLANT
SWEET STREET PUMPING STATION
STATION ROAD
STREET
WRONG
HARBOUR
HEIGHTS RESERVOIR
BLUE SEA
LOOKOUT HILL
LITTLE RIVER
SEAVIEW TREATMENT PLANT
KM
MILES
PORT CITY
WATER SUPPLY AND SANITATION PROJECT
EXISTING SYSTEMS OF SEWERS
DATE: FEBRUARY,1983
FIG. 2-9

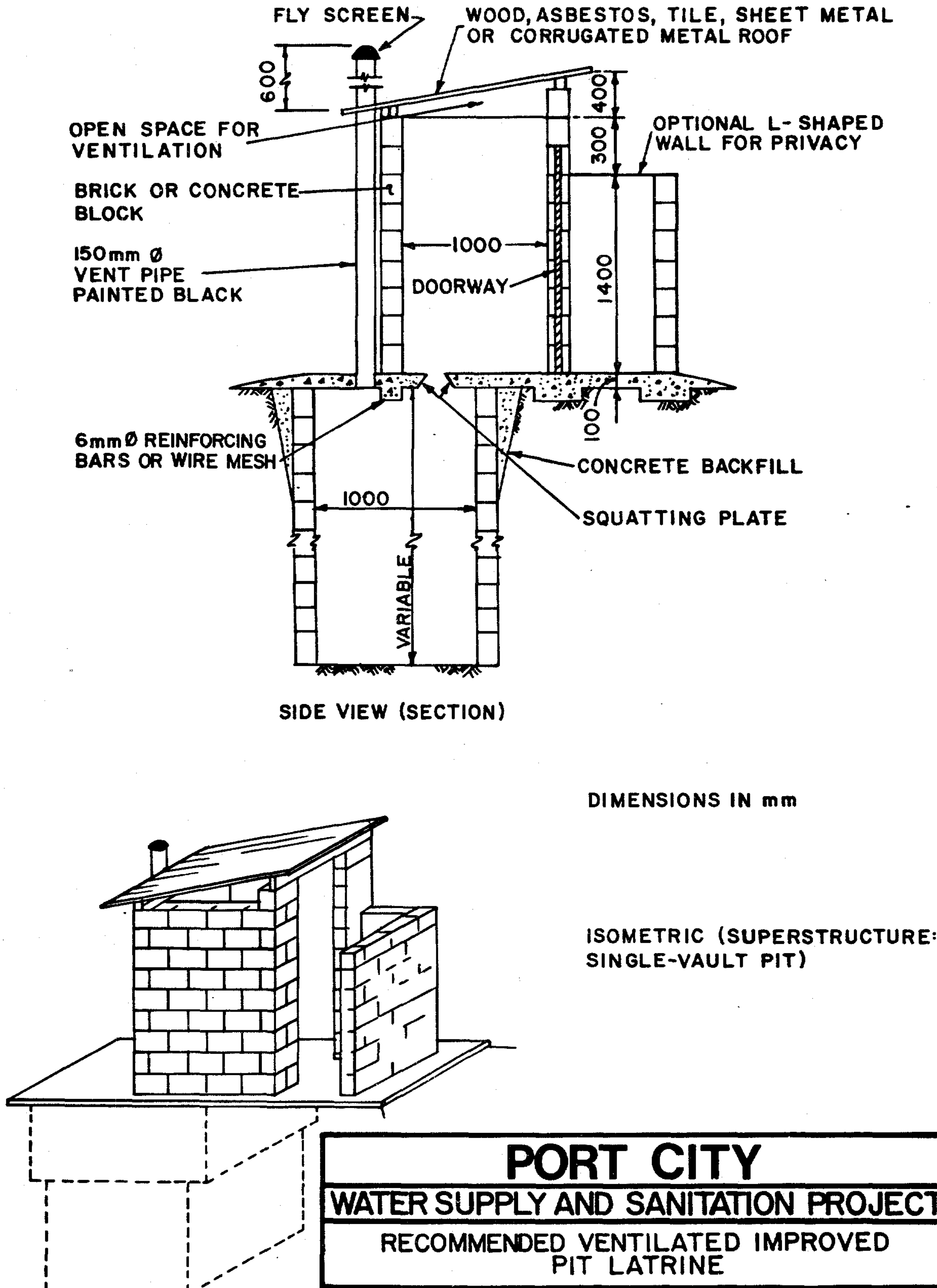


PORT CITY

WATER SUPPLY AND SANITATION PROJECT

CENTRAL SYSTEM OF
CONVENTIONAL SEWERS

DATE: FEBRUARY, 1983	FIG. 2-10

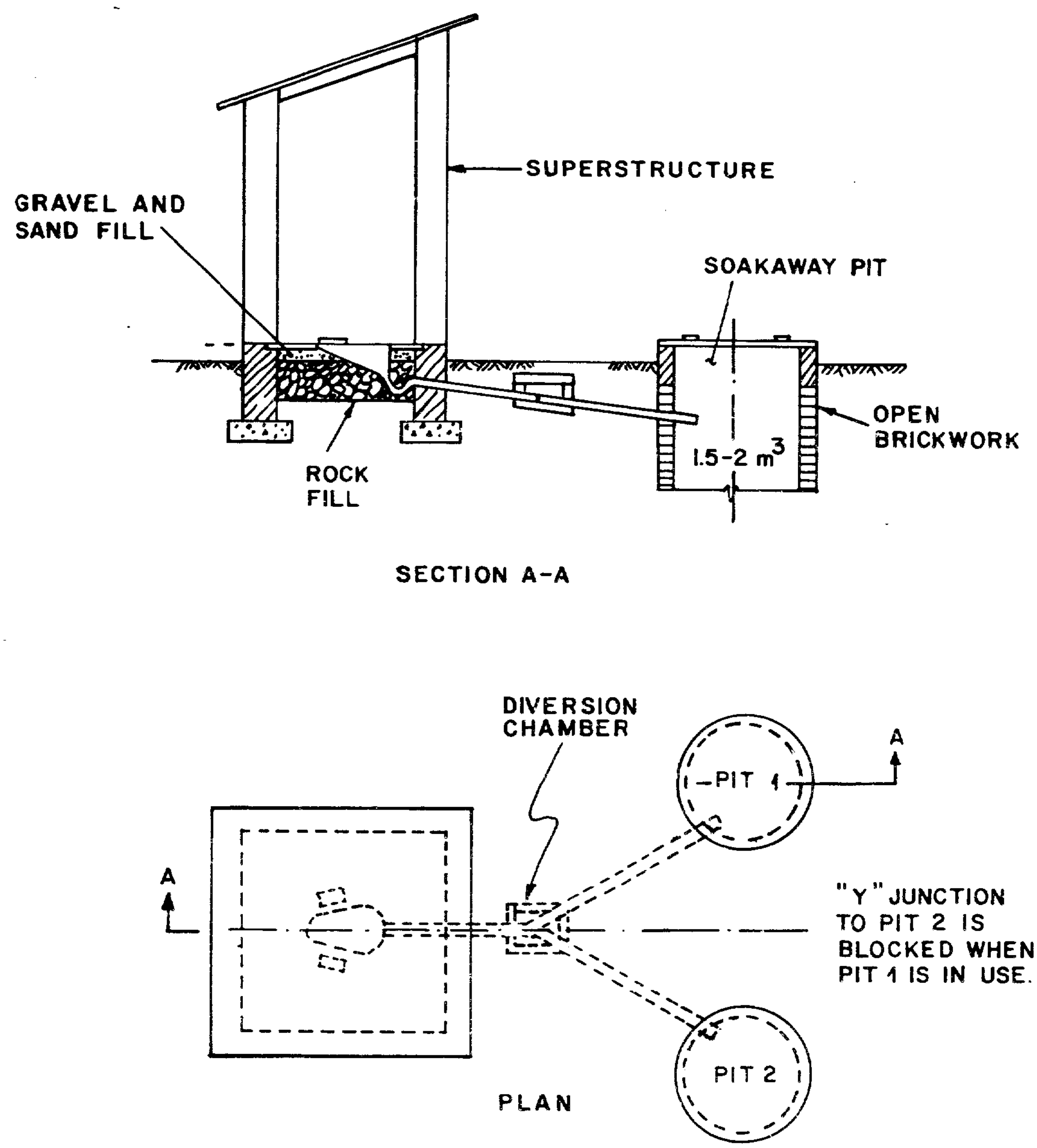


PORT CITY

WATER SUPPLY AND SANITATION PROJECT

RECOMMENDED VENTILATED IMPROVED PIT LATRINE

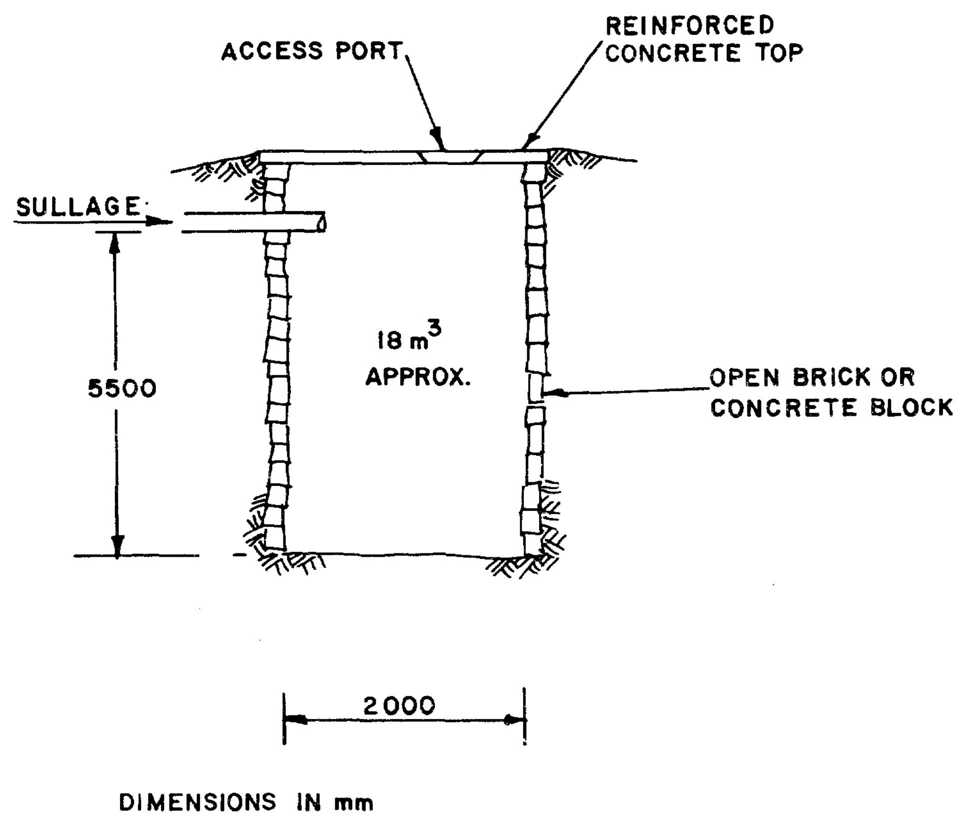
DATE: FEBRUARY, 1983	FIG. 3-1



NOTE:

The squat plate for the pour-flush toilet can be located inside the house if desired. The diversion chamber and pits would then be located outside the wall closest to the squat plate.

PORT CITY
WATER SUPPLY AND SANITATION PROJECT
RECOMMENDED POUR-FLUSH TOILET
DATE: FEBRUARY, 1983 — FIG. 3-2

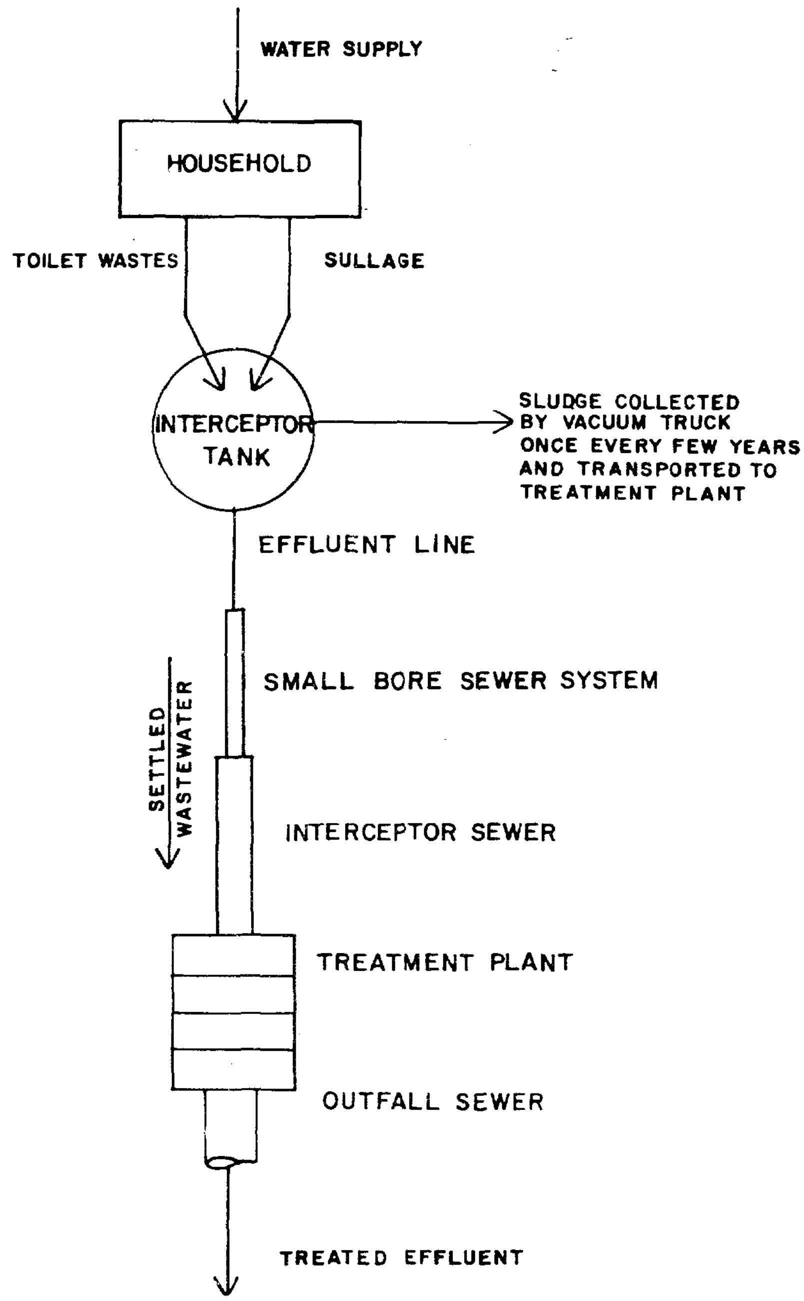


PORT CITY

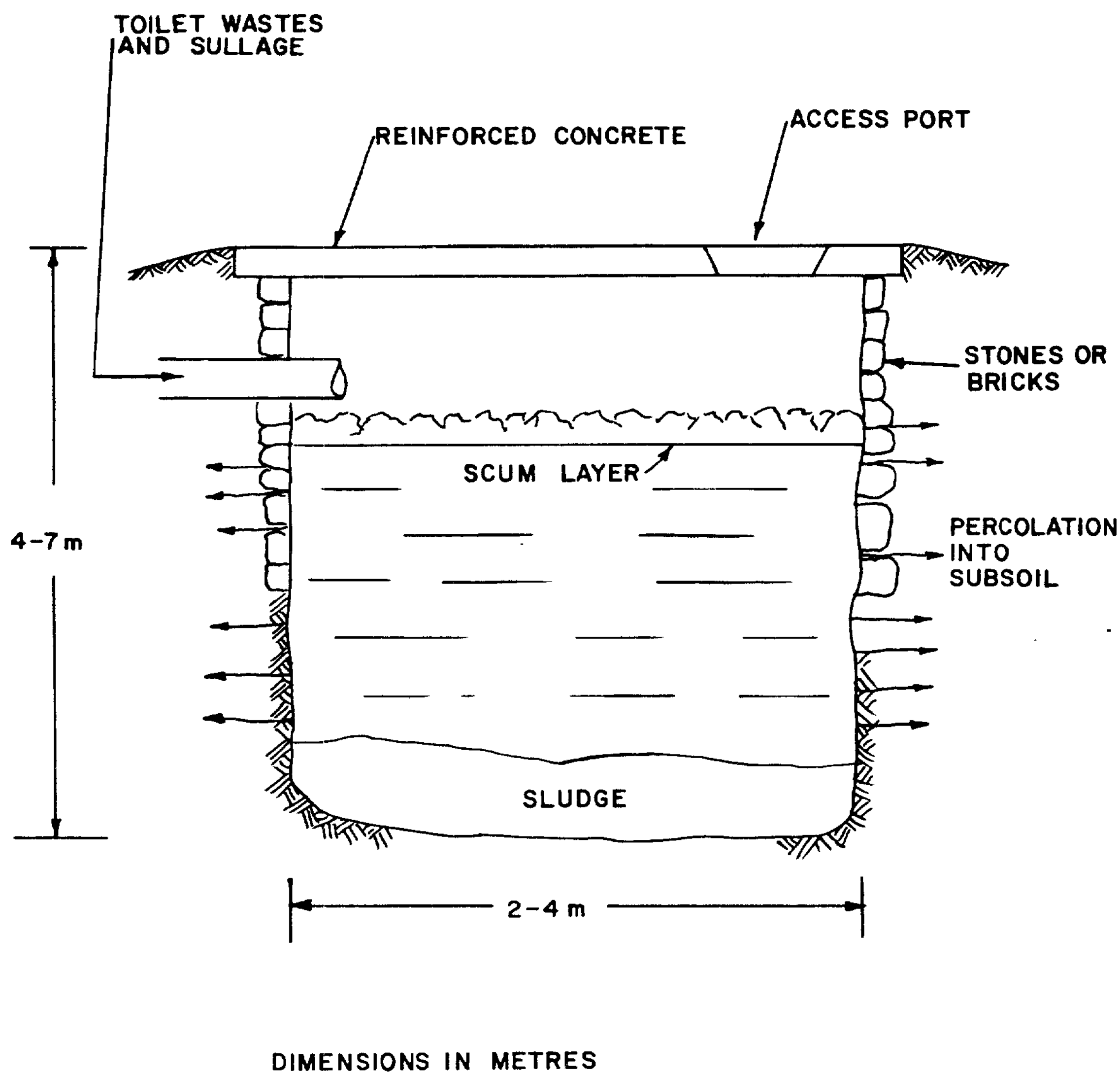
WATER SUPPLY AND SANITATION PROJECT

RECOMMENDED SULLAGE SOAKAWAY

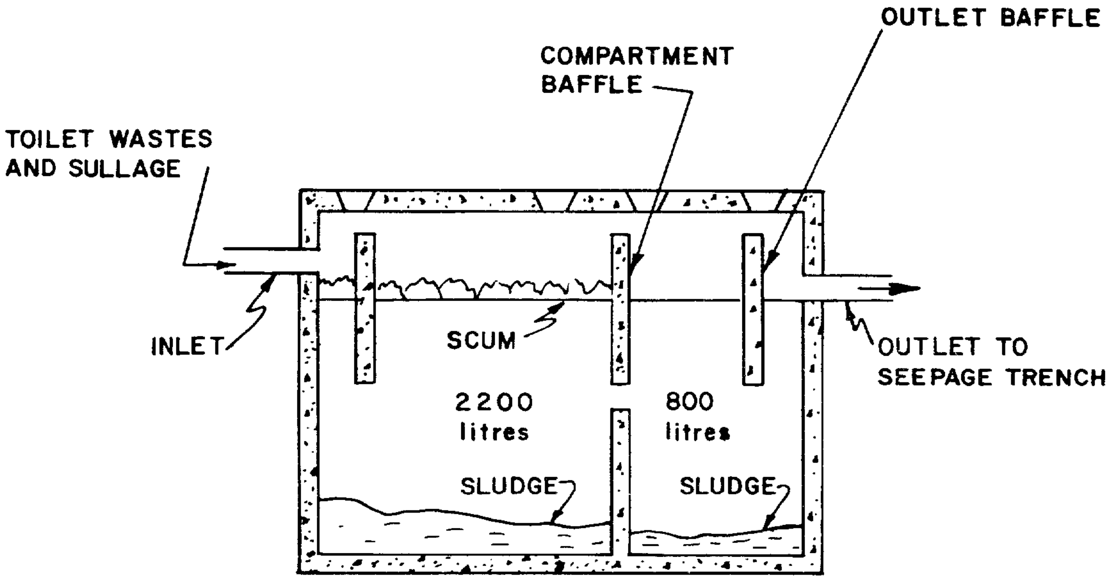
DATE: FEBRUARY, 1983 | FIG. 3-3



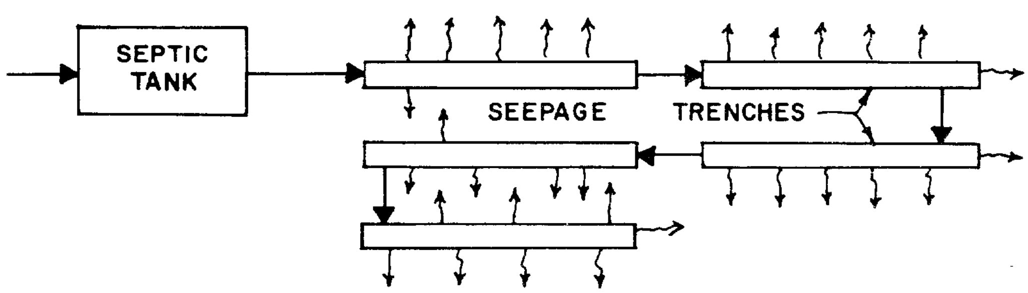
PORT CITY
WATER SUPPLY AND SANITATION PROJECT
RECOMMENDED SMALL BORE SEWER SYSTEM: SCHEMATIC DIAGRAM
DATE: FEBRUARY, 1983 | FIG. 3-4



PORT CITY
WATER SUPPLY AND SANITATION PROJECT
TYPICAL CESSPIT
DATE: FEBRUARY, 1983 — FIG. 3-5



SEPTIC TANK
SECTIONAL VIEW



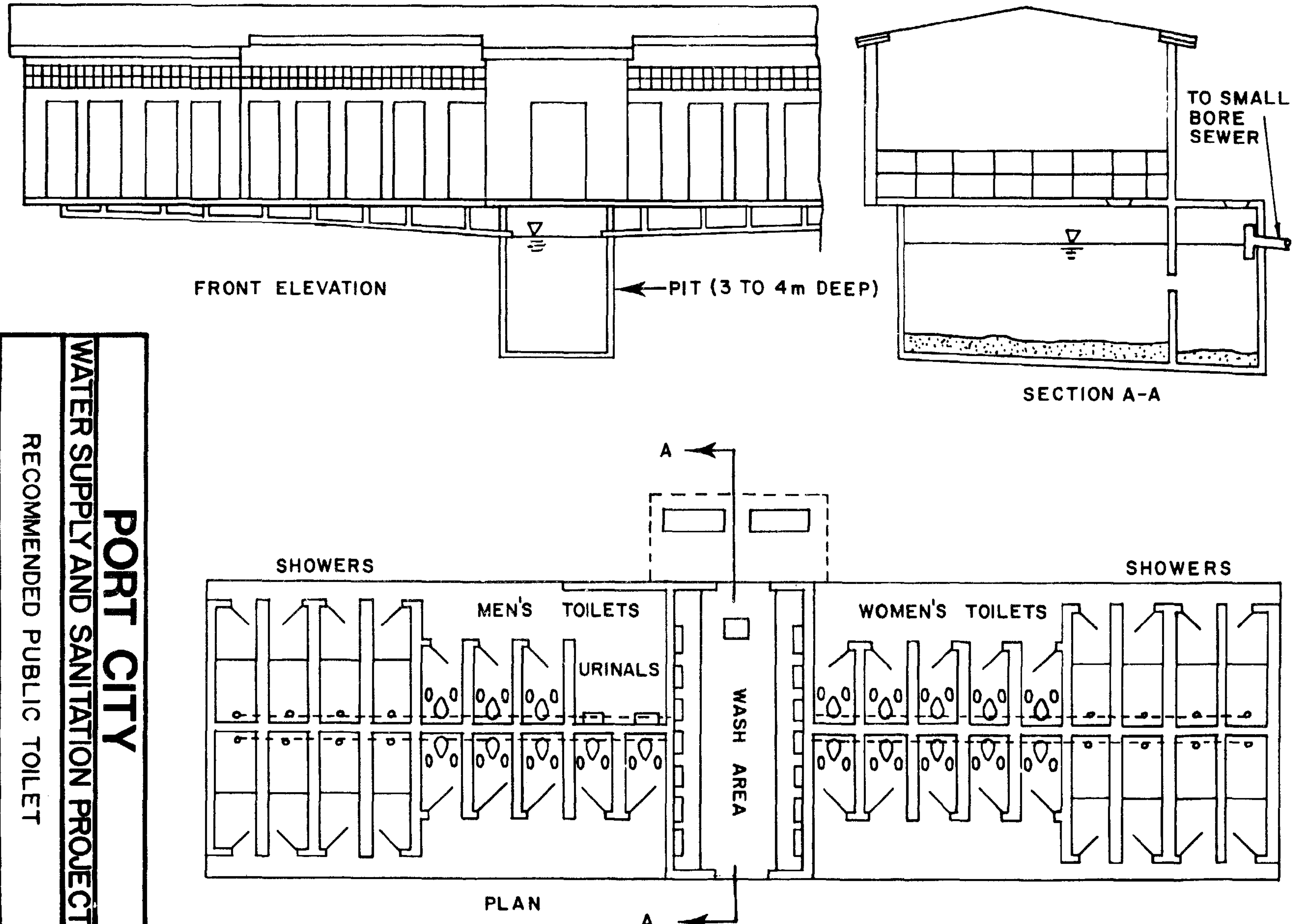
SEEPAGE TRENCH CONFIGURATION
PLAN VIEW

PORT CITY

WATER SUPPLY AND SANITATION PROJECT

TYPICAL SEPTIC TANK

DATE: FEBRUARY, 1983 | FIG. 3-6

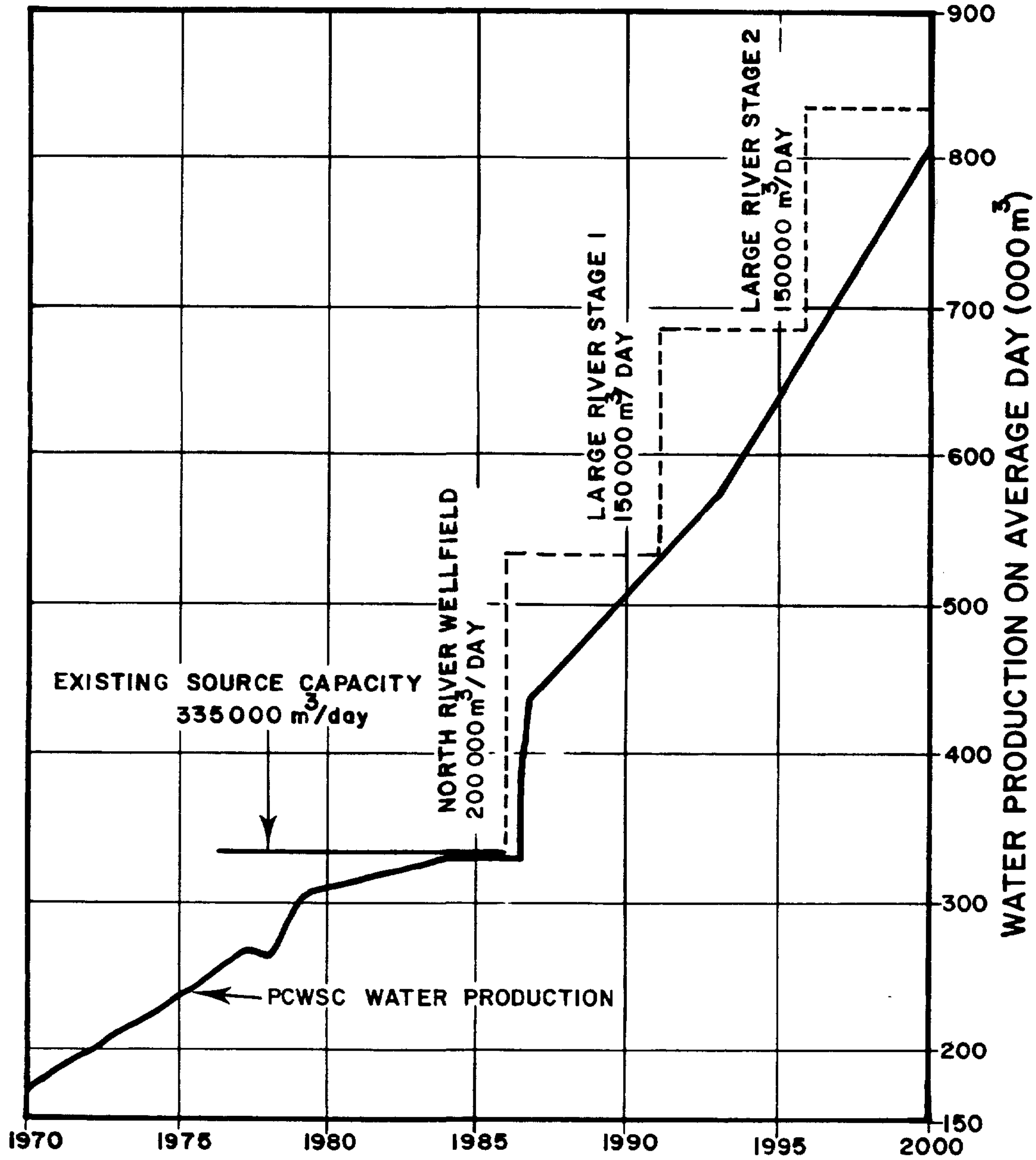


PORT CITY
WATER SUPPLY AND SANITATION PROJECT

RECOMMENDED PUBLIC TOILET

DATE: FEBRUARY, 1983

FIG. 3-7



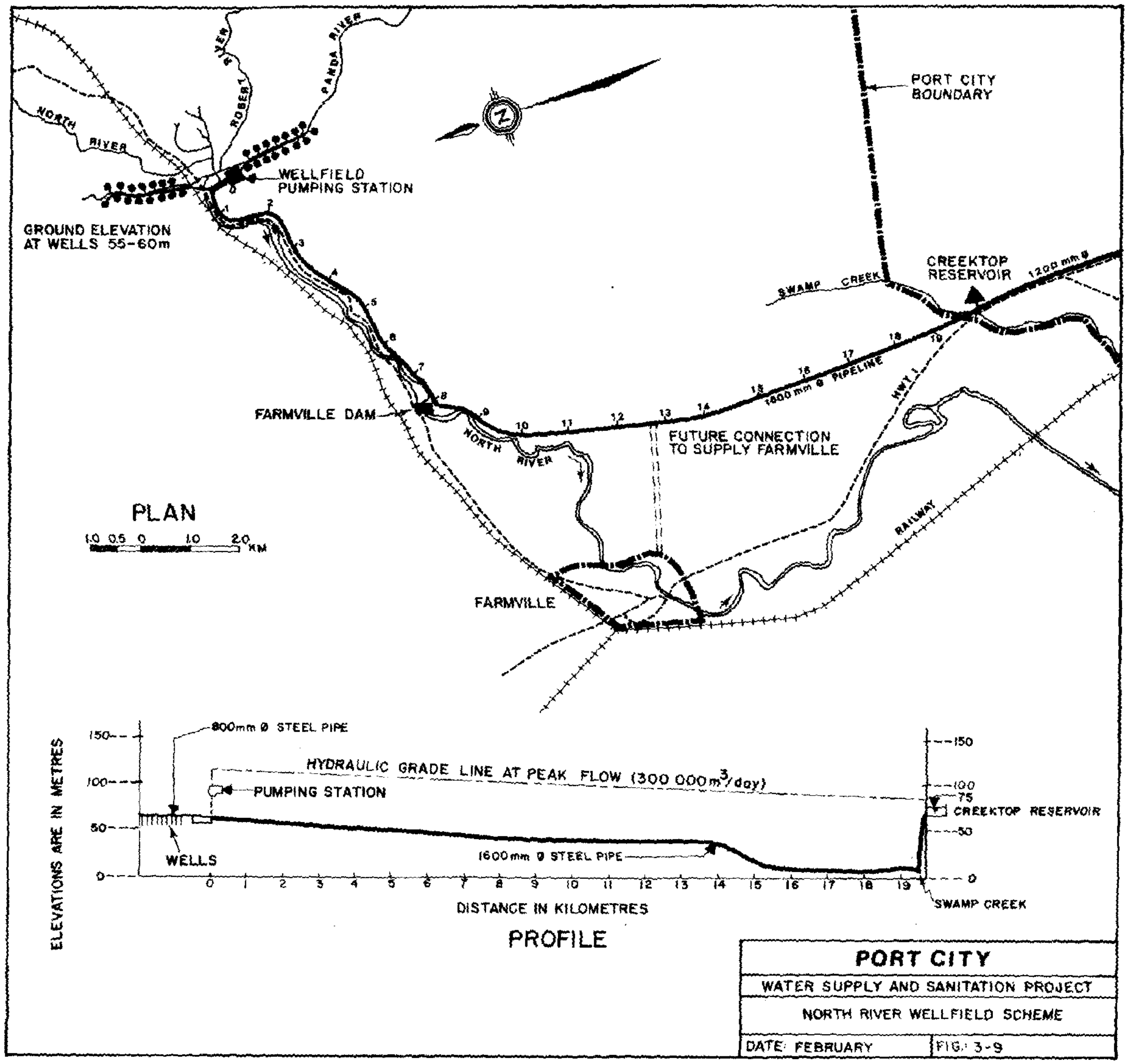
ACTUAL DATA TO 1982
PROJECTION FROM 1983

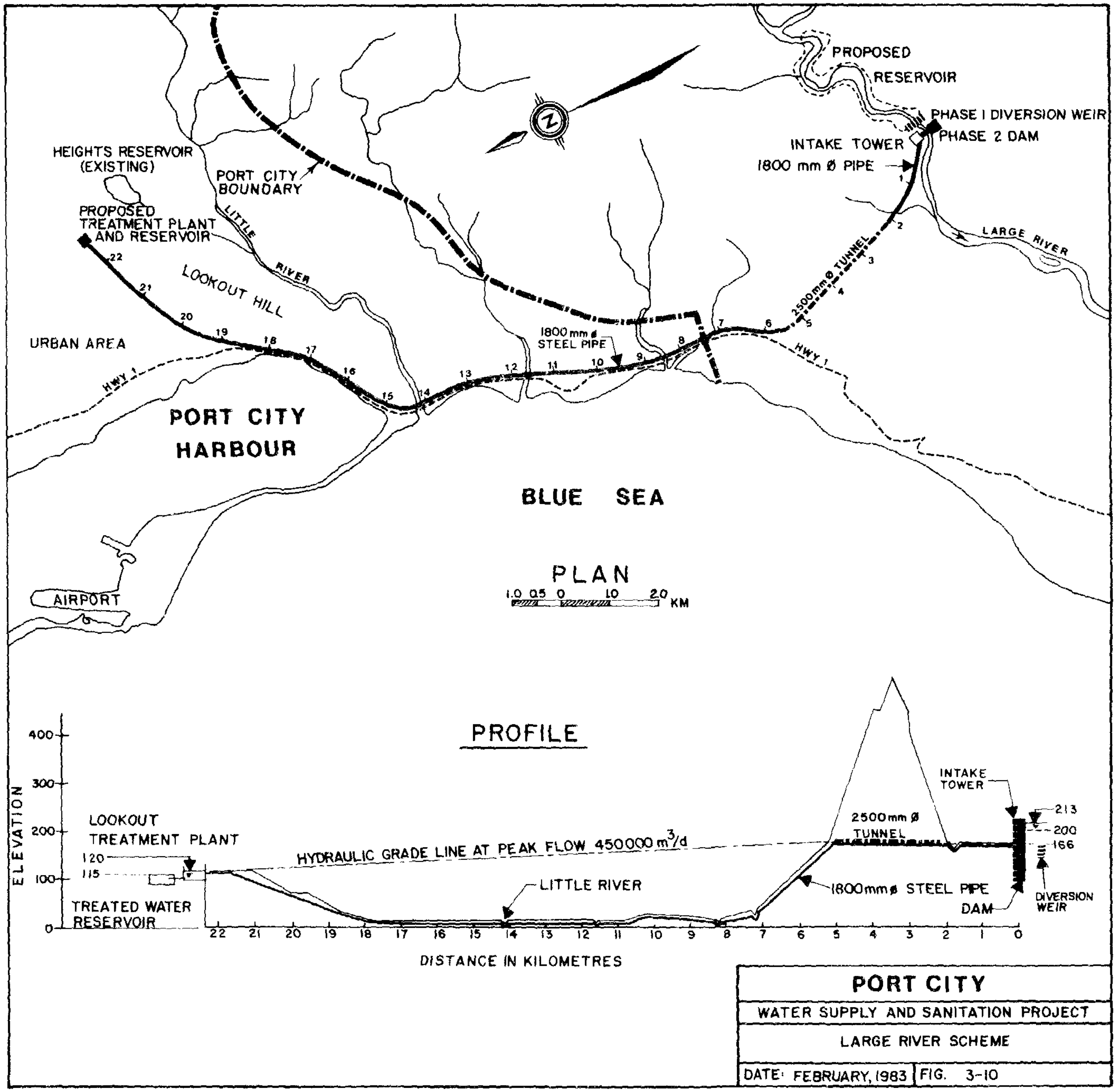
PORT CITY

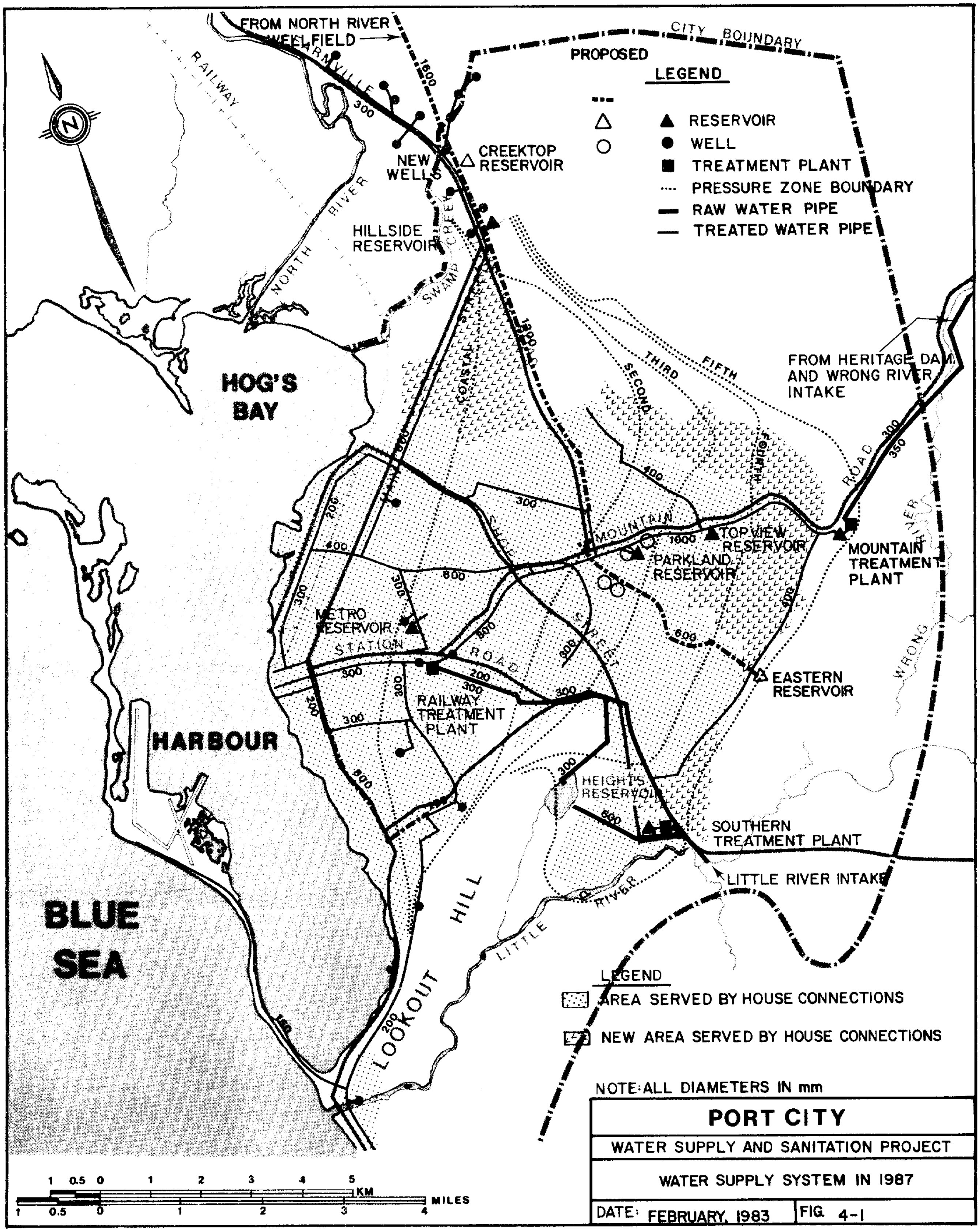
WATER SUPPLY AND SANITATION PROJECT

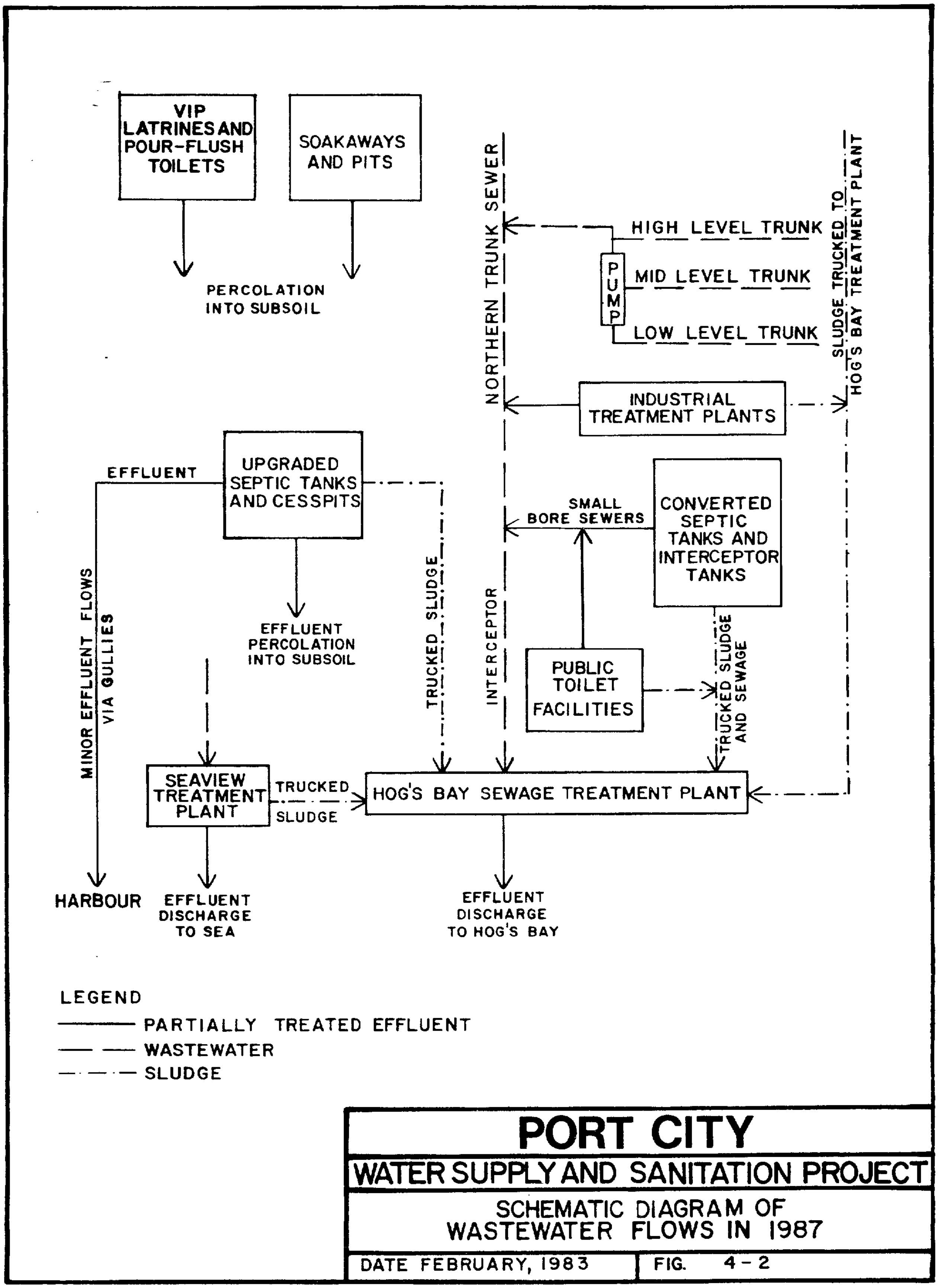
PCWSC WATER PRODUCTION AND
PROPOSED SOURCE DEVELOPMENTS

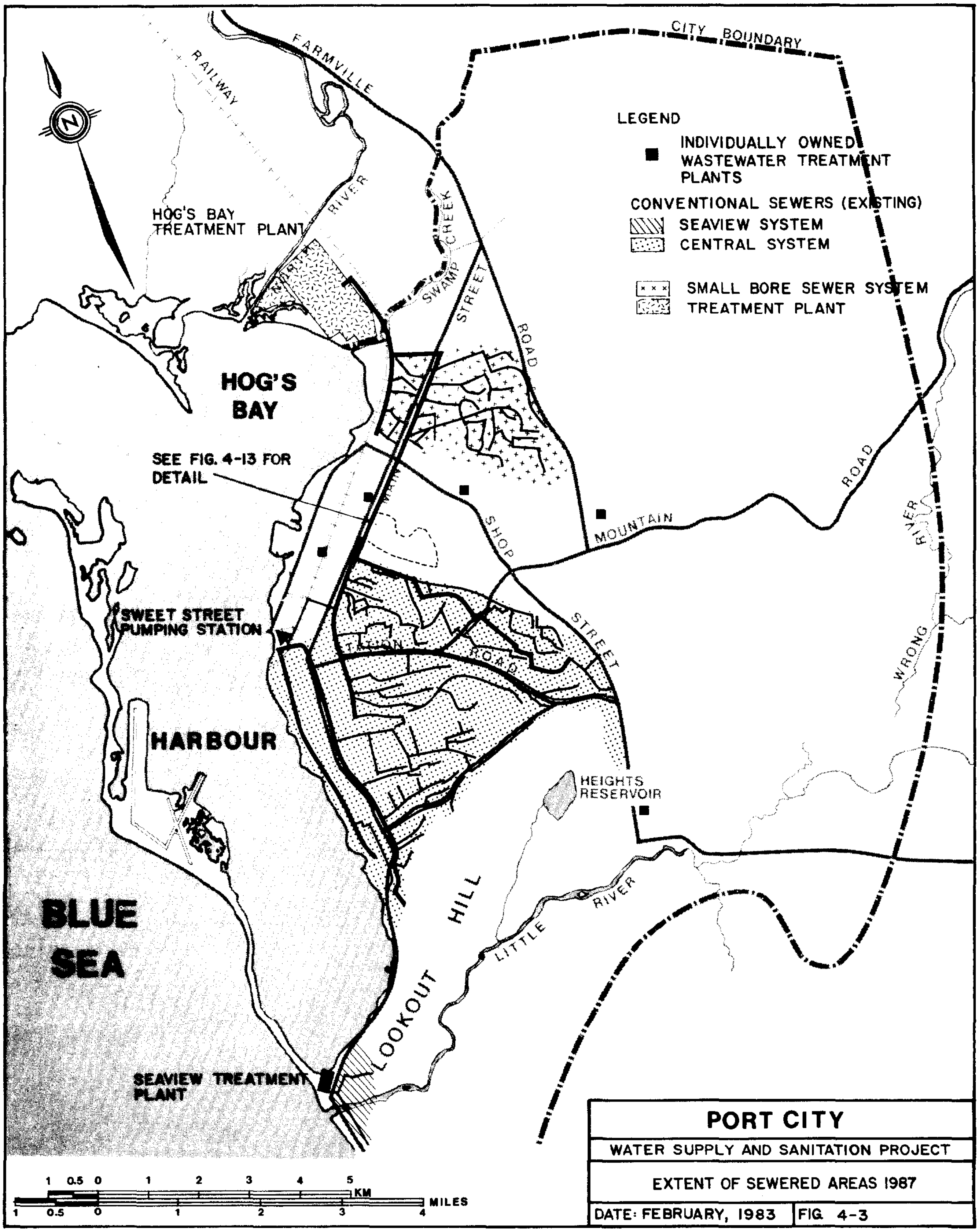
DATE: FEBRUARY, 1983 | FIG. 3-8

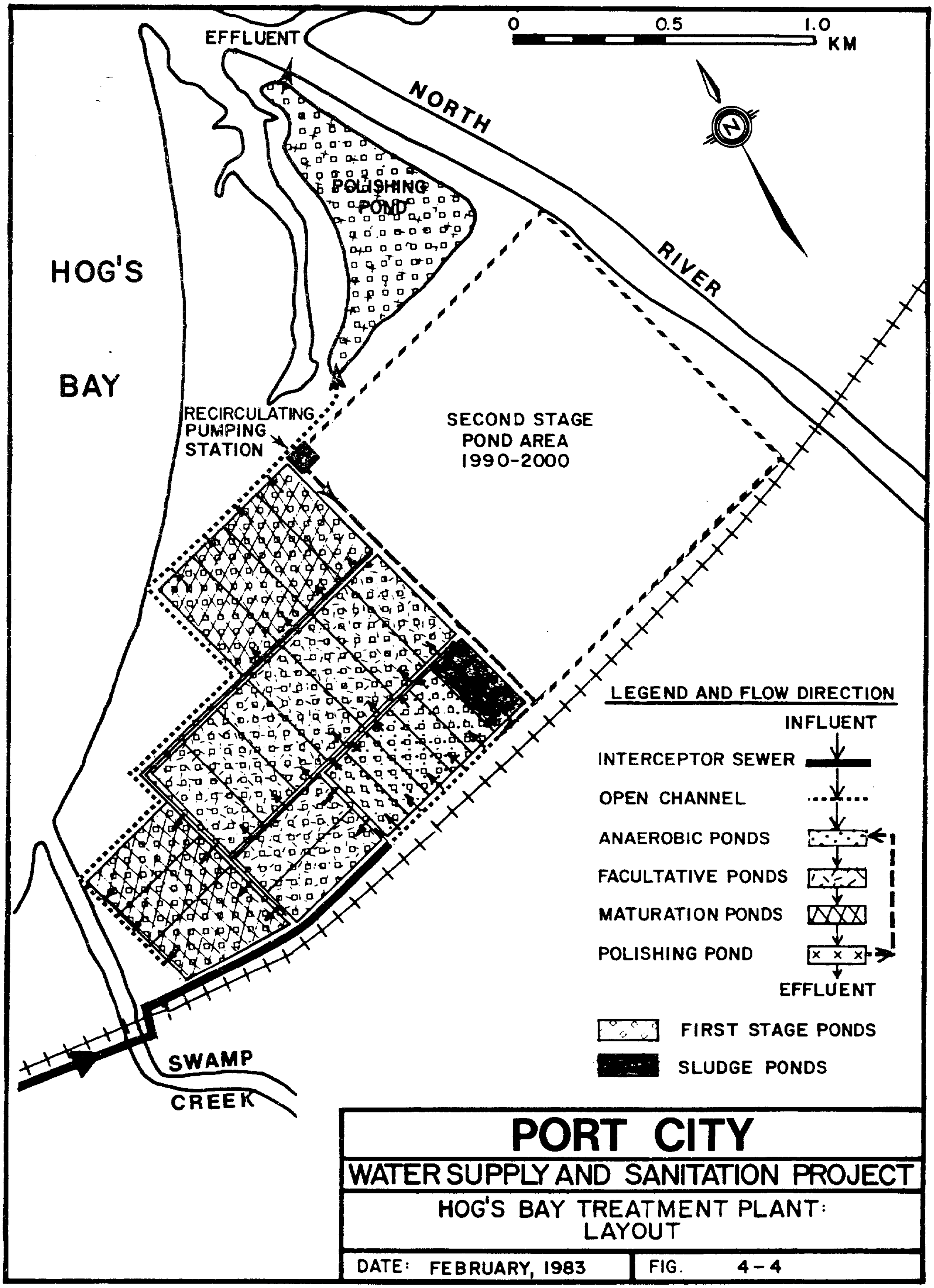

PORT CITY BOUNDARY
NORTH RIVER
ROBERT RIVER
PANDA RIVER
WELLFIELD PUMPING STATION
GROUND ELEVATION AT WELLS 55-60m
CREEKTOP RESERVOIR
1200 mm Ø
SWAMP CREEK
1600 mm Ø PIPELINE
HWY 1
FARMVILLE DAM
FUTURE CONNECTION TO SUPPLY FARMVILLE
NORTH RIVER
PLAN
1.0 0.5 0 1.0 2.0 KM
RAILWAY
FARMVILLE
ELEVATIONS ARE IN METRES
800mm Ø STEEL PIPE
HYDRAULIC GRADE LINE AT PEAK FLOW (300 000m³/day)
PUMPING STATION
WELLS
1600mm Ø STEEL PIPE
CREEKTOP RESERVOIR
SWAMP CREEK
DISTANCE IN KILOMETRES
PROFILE
PORT CITY
WATER SUPPLY AND SANITATION PROJECT
NORTH RIVER WELLFIELD SCHEME
DATE: FEBRUARY
FIG. 3-9

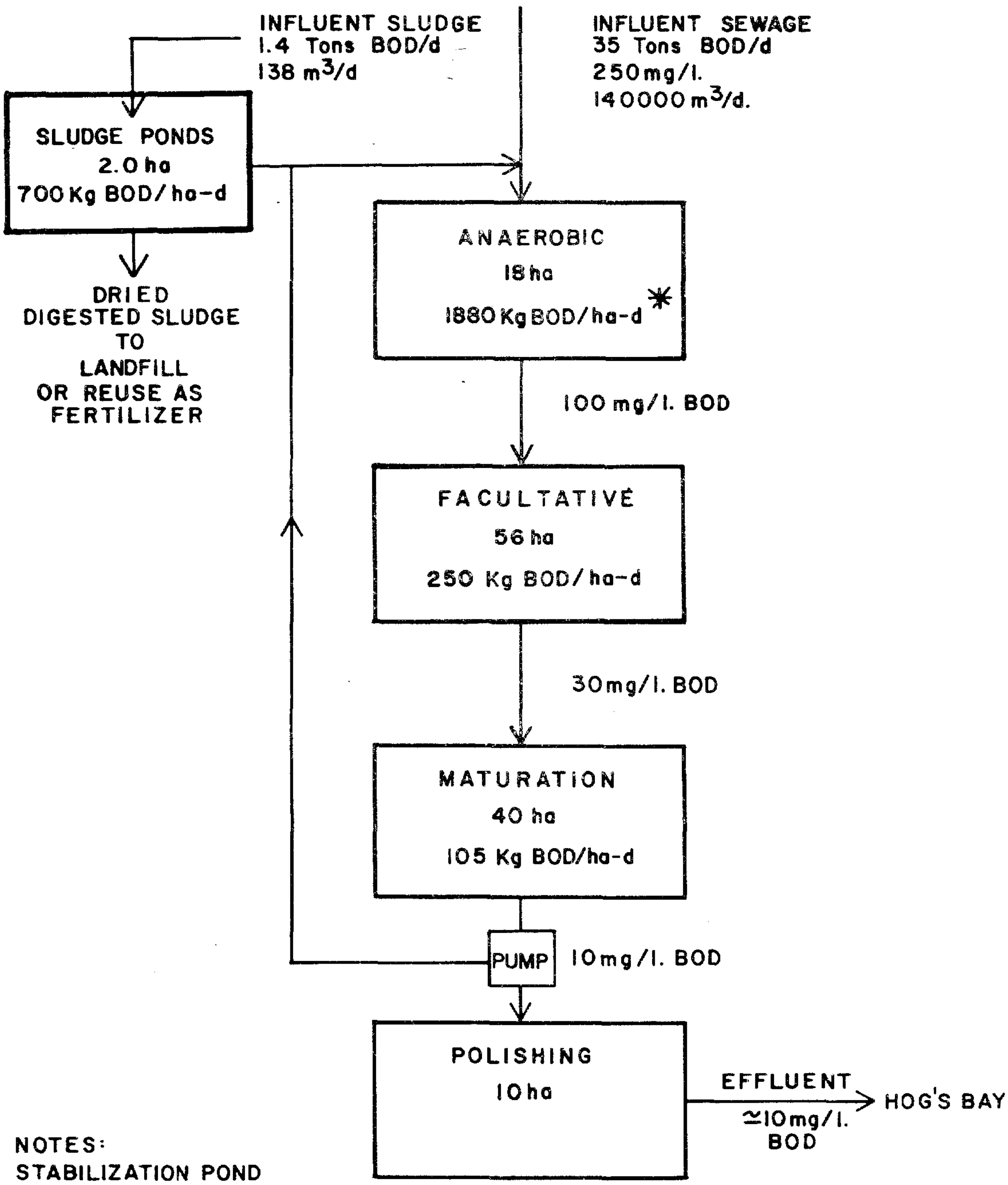

PROPOSED
RESERVOIR
PHASE I DIVERSION WEIR
PHASE 2 DAM
INTAKE TOWER
1800 mm Ø PIPE
HEIGHTS RESERVOIR
(EXISTING)
PORT CITY
BOUNDARY
PROPOSED
TREATMENT PLANT
AND RESERVOIR
LITTLE
RIVER
LOOKOUT HILL
LARGE RIVER
2500mm Ø TUNNEL
URBAN AREA
1800mm Ø
STEEL PIPE
HWY 1
PORT CITY
HARBOUR
BLUE SEA
AIRPORT
PLAN
1.0 0.5 0 1.0 2.0 KM
PROFILE
ELEVATION
LOOKOUT
TREATMENT PLANT
HYDRAULIC GRADE LINE AT PEAK FLOW 450000 m³/d
LITTLE RIVER
TREATED WATER
RESERVOIR
2500mm Ø
TUNNEL
1800mm Ø STEEL PIPE
INTAKE
TOWER
DAM
DIVERSION
WEIR
DISTANCE IN KILOMETRES
PORT CITY
WATER SUPPLY AND SANITATION PROJECT
LARGE RIVER SCHEME
DATE: FEBRUARY, 1983
FIG. 3-10


FROM NORTH RIVER WELLFIELD
CITY BOUNDARY
PROPOSED
LEGEND
RESERVOIR
WELL
TREATMENT PLANT
PRESSURE ZONE BOUNDARY
RAW WATER PIPE
TREATED WATER PIPE
CREEKTOP RESERVOIR
NEW WELLS
HILLSIDE RESERVOIR
HOG'S BAY
FROM HERITAGE DAM AND WRONG RIVER INTAKE
TOPVIEW RESERVOIR
PARKLAND RESERVOIR
MOUNTAIN TREATMENT PLANT
METRO RESERVOIR
EASTERN RESERVOIR
RAILWAY TREATMENT PLANT
HARBOUR
HEIGHTS RESERVOIR
SOUTHERN TREATMENT PLANT
LITTLE RIVER INTAKE
BLUE SEA
LOOKOUT HILL
LEGEND
AREA SERVED BY HOUSE CONNECTIONS
NEW AREA SERVED BY HOUSE CONNECTIONS
NOTE: ALL DIAMETERS IN mm
KM
MILES
PORT CITY
WATER SUPPLY AND SANITATION PROJECT
WATER SUPPLY SYSTEM IN 1987
DATE: FEBRUARY, 1983
FIG. 4-1


VIP LATRINES AND POUR-FLUSH TOILETS
SOAKAWAYS AND PITS
PERCOLATION INTO SUBSOIL
NORTHERN TRUNK SEWER
HIGH LEVEL TRUNK
PUMP
MID LEVEL TRUNK
LOW LEVEL TRUNK
SLUDGE TRUCKED TO HOG'S BAY TREATMENT PLANT
INDUSTRIAL TREATMENT PLANTS
EFFLUENT
UPGRADED SEPTIC TANKS AND CESSPITS
SMALL BORE SEWERS
CONVERTED SEPTIC TANKS AND INTERCEPTOR TANKS
MINOR EFFLUENT FLOWS VIA GULLIES
EFFLUENT PERCOLATION INTO SUBSOIL
TRUCKED SLUDGE
INTERCEPTOR
PUBLIC TOILET FACILITIES
TRUCKED SLUDGE AND SEWAGE
SEAVIEW TREATMENT PLANT
TRUCKED SLUDGE
HOG'S BAY SEWAGE TREATMENT PLANT
HARBOUR
EFFLUENT DISCHARGE TO SEA
EFFLUENT DISCHARGE TO HOG'S BAY
LEGEND
PARTIALLY TREATED EFFLUENT
WASTEWATER
SLUDGE
PORT CITY
WATER SUPPLY AND SANITATION PROJECT
SCHEMATIC DIAGRAM OF WASTEWATER FLOWS IN 1987
DATE FEBRUARY, 1983
FIG. 4-2


CITY BOUNDARY
FARMVILLE
RAILWAY
LEGEND
INDIVIDUALLY OWNED WASTEWATER TREATMENT PLANTS
CONVENTIONAL SEWERS (EXISTING)
SEAVIEW SYSTEM
CENTRAL SYSTEM
SMALL BORE SEWER SYSTEM
TREATMENT PLANT
HOG'S BAY TREATMENT PLANT
RIVER
SWAMP CREEK
STREET
ROAD
HOG'S BAY
SEE FIG. 4-13 FOR DETAIL
MAIN
SHOP
MOUNTAIN
ROAD
RIVER
WRONG
SWEET STREET PUMPING STATION
ROAD
STREET
HARBOUR
HEIGHTS RESERVOIR
HILL
LITTLE
RIVER
LOOKOUT
BLUE SEA
SEAVIEW TREATMENT PLANT
KM
MILES
PORT CITY
WATER SUPPLY AND SANITATION PROJECT
EXTENT OF SEWERED AREAS 1987
DATE: FEBRUARY, 1983
FIG. 4-3

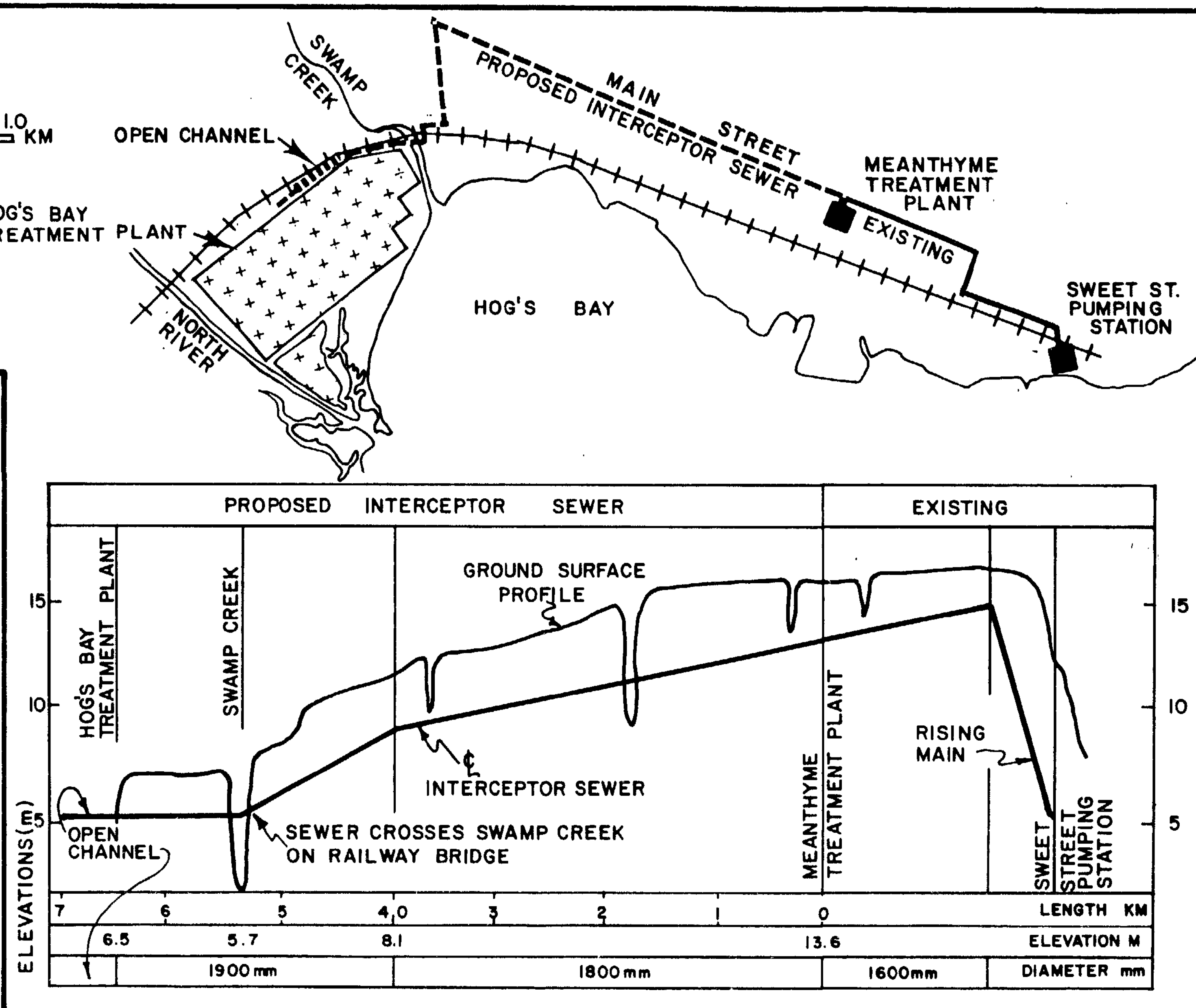

EFFLUENT
0
0.5
1.0
KM
NORTH
RIVER
N
POLISHING POND
HOG'S
BAY
RECIRCULATING PUMPING STATION
SECOND STAGE POND AREA 1990-2000
LEGEND AND FLOW DIRECTION
INFLUENT
INTERCEPTOR SEWER
OPEN CHANNEL
ANAEROBIC PONDS
FACULTATIVE PONDS
MATURATION PONDS
POLISHING POND
EFFLUENT
FIRST STAGE PONDS
SLUDGE PONDS
SWAMP
CREEK
PORT CITY
WATER SUPPLY AND SANITATION PROJECT
HOG'S BAY TREATMENT PLANT: LAYOUT
DATE: FEBRUARY, 1983
FIG. 4-4



NOTES:
STABILIZATION POND SYSTEM DESIGNED FOR LOADS AND FLOWS OF 1990

*KILOGRAMS OF BIOCHEMICAL OXYGEN DEMAND PER POND SURFACE AREA (hectares)/DAY

PORT CITY	
WATER SUPPLY AND SANITATION PROJECT	
HOG'S BAY TREATMENT PLANT: PROCESS DIAGRAM AND PARAMETERS	
DATE: FEBRUARY, 1983	FIG. 4-5



PORT CITY

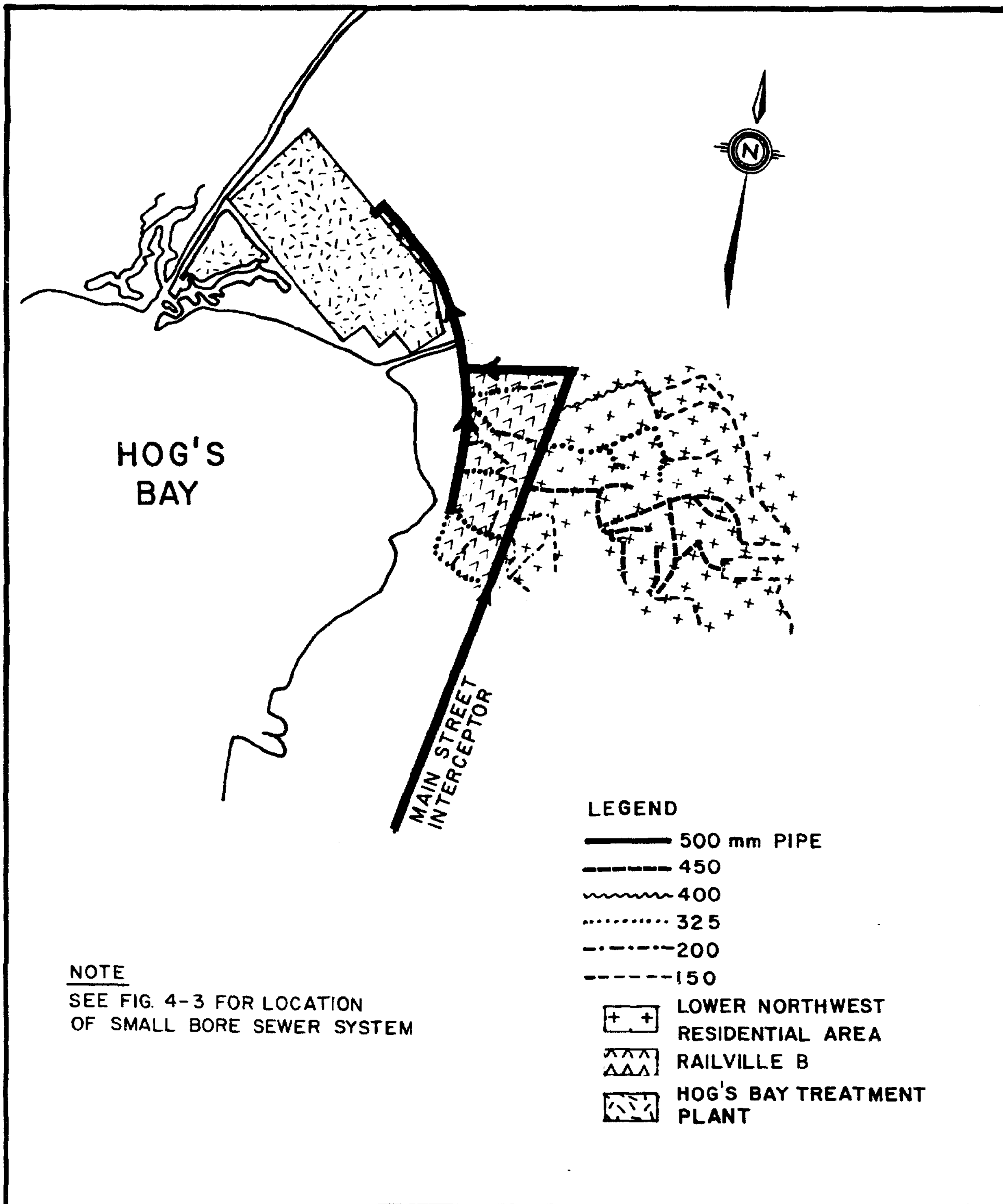
WATER SUPPLY AND SANITATION PROJECT

MAIN STREET INTERCEPTOR SEWER

DATE: FEBRUARY, 1983

FIG. 4 - 6

- 276 -

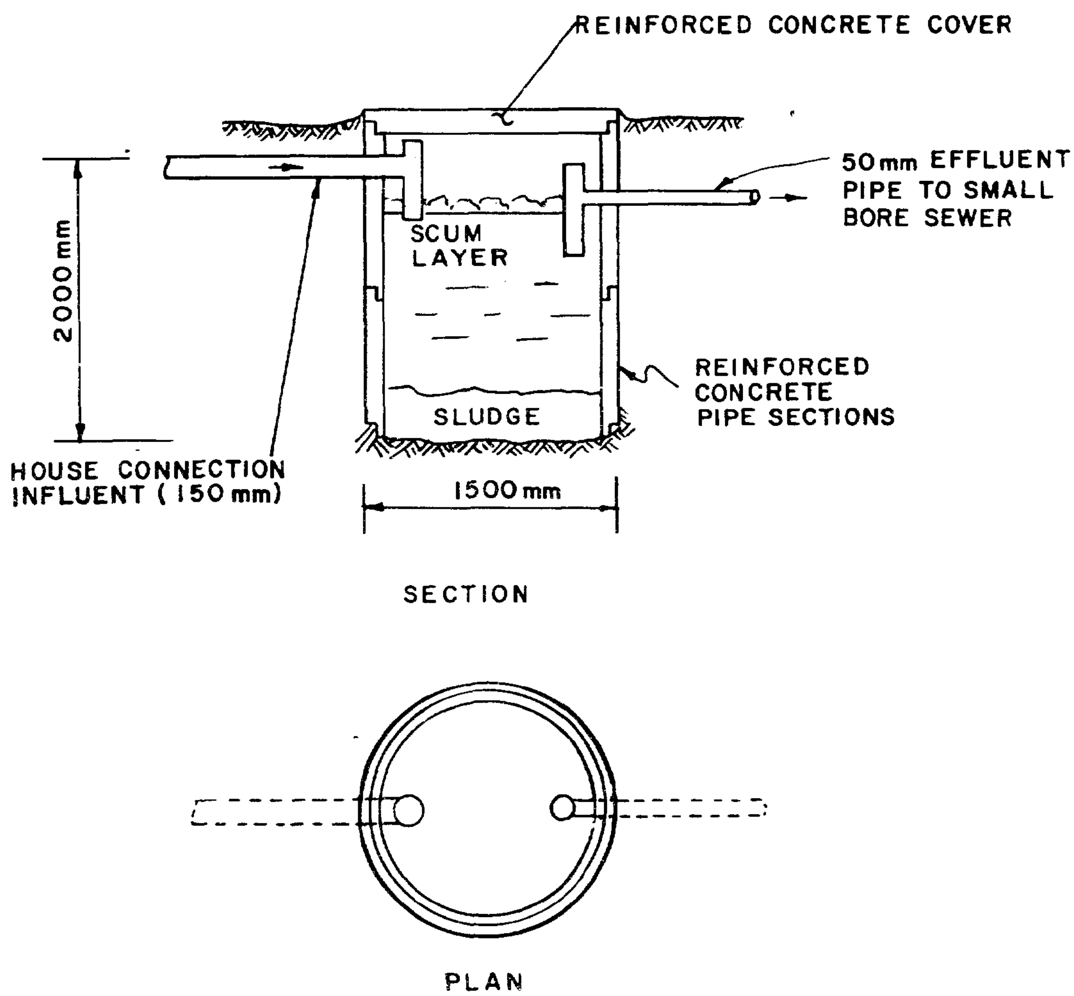


PORT CITY

WATER SUPPLY AND SANITATION PROJECT

PROPOSED SMALL BORE SEWER SYSTEM, 1987

DATE: FEBRUARY, 1983 | FIG. 4-7

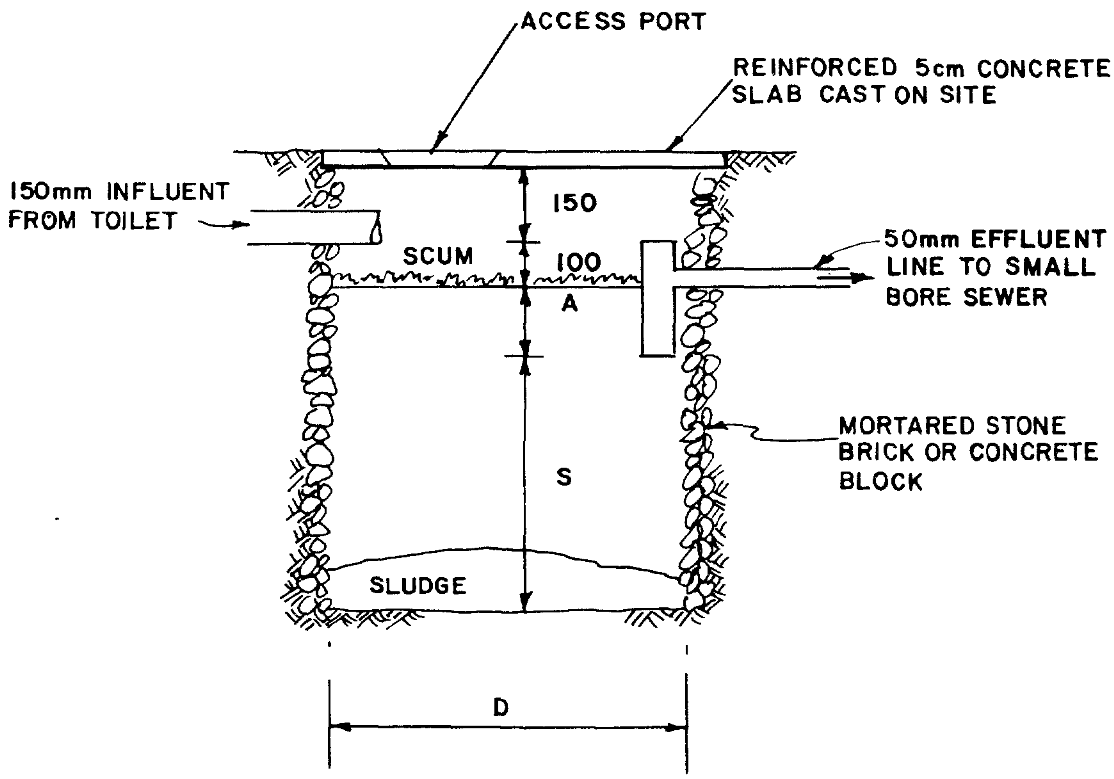


PORT CITY

WATER SUPPLY AND SANITATION PROJECT

RECOMMENDED INTERCEPTOR TANK FOR SINGLE FAMILY RESIDENCE

DATE: FEBRUARY. 1983 | FIG. 4-8



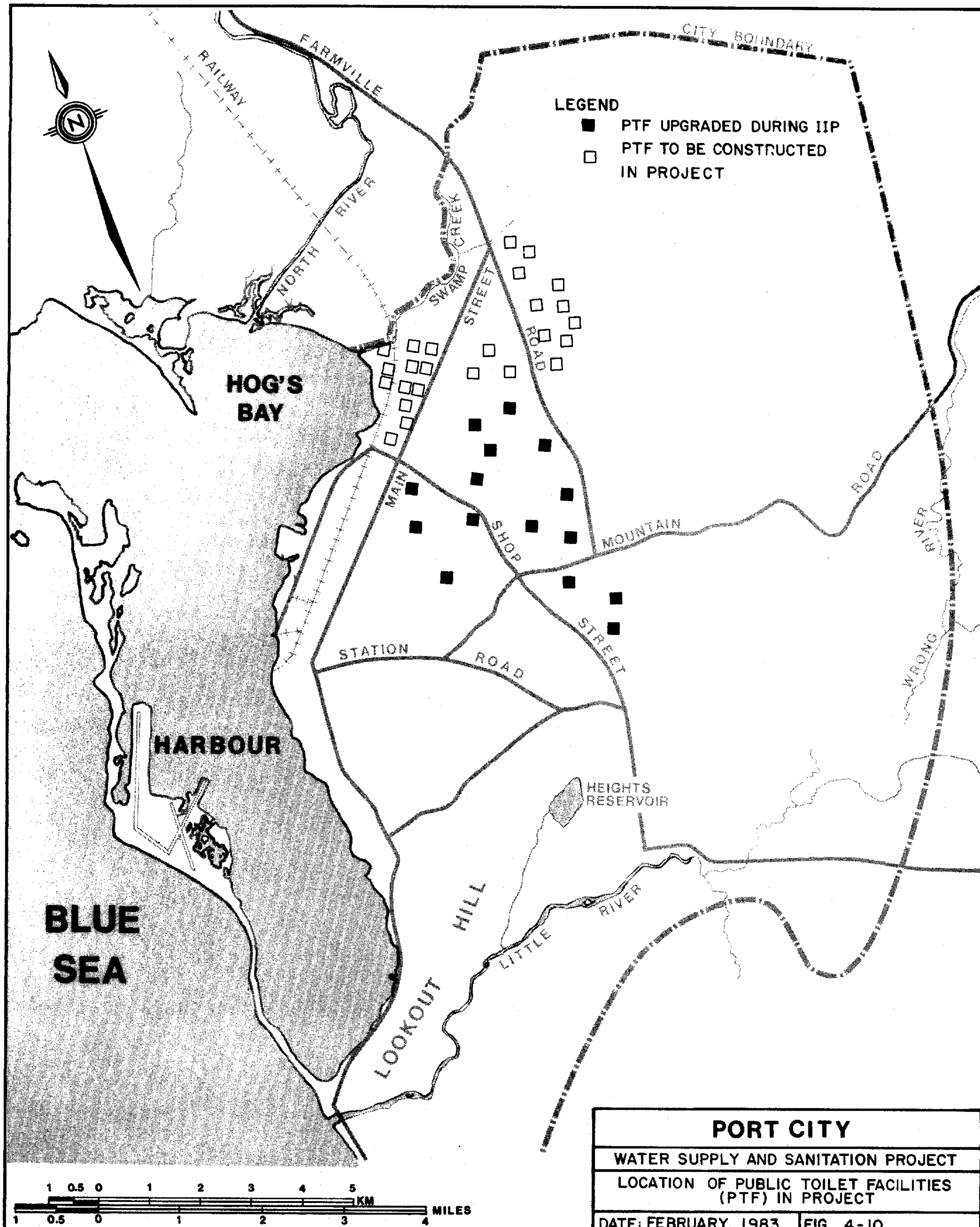
POPULATION SERVED	DIMENSION mm		
	D	S	A
10	1500	1000	400
20	2000	800	600
30	2000	1100	1000
40	2000	1500	1300

PORT CITY

WATER SUPPLY AND SANITATION PROJECT

INTERCEPTOR TANK FOR MULTI-FAMILY RESIDENCES

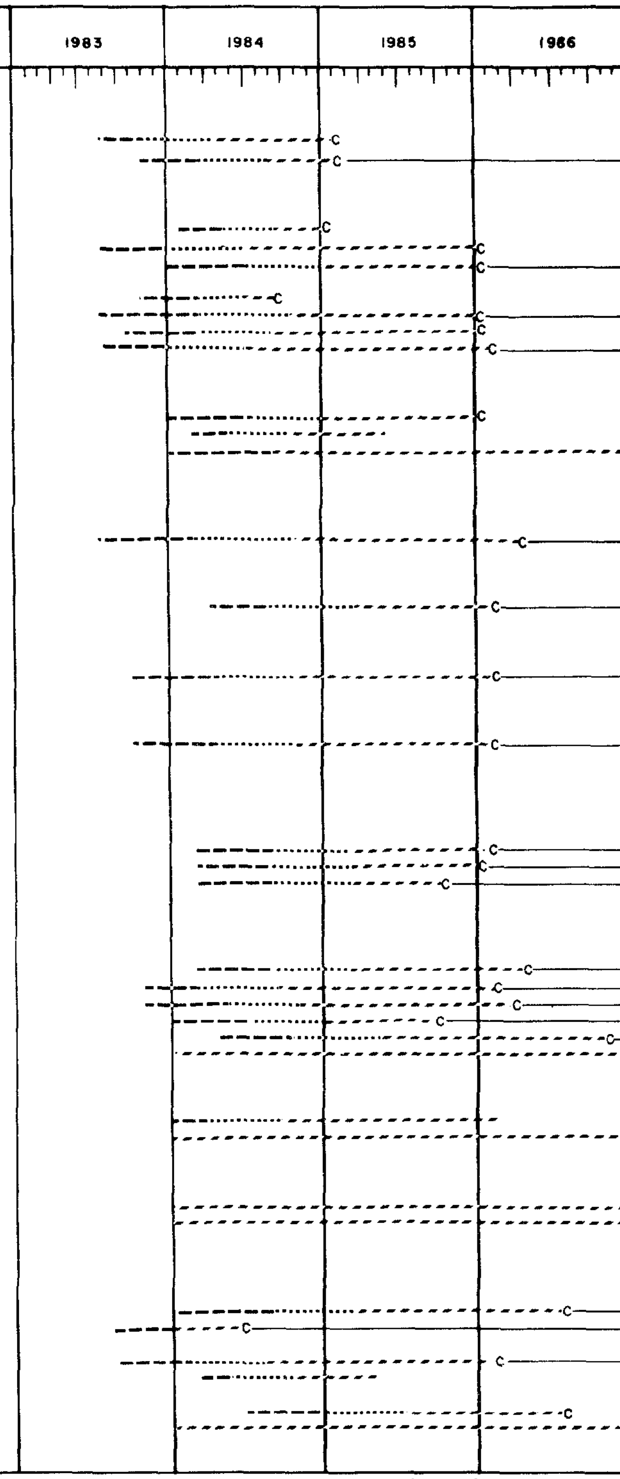
DATE: FEBRUARY, 1983 | FIG. 4-9



PORT CITY	
WATER SUPPLY AND SANITATION PROJECT	
LOCATION OF PUBLIC TOILET FACILITIES (PTF) IN PROJECT	
DATE: FEBRUARY, 1983	FIG. 4-10

CONSTRUCTION SCHEDULE FOR WATER SUPPLY COMPONENTS

CONTRACT NO.	ITEM
	CITY WELLS
W1	SUPPLY PUMPS AND MOTORS
W2	WELL DRILLING AND PUMP INSTALLATION
	NORTH RIVER WELLFIELD
W3	SITE PREPARATION (ACCESS, FENCING, ETC)
W4	SUPPLY PUMPS AND MOTORS
W5	WELL DRILLING AND PUMP INSTALLATION
W6	ELECTRICITY SUPPLY TO WELLFIELD AND PUMP STATION (BY OPTIMA POWER COMPANY)
W7	SUPPLY AND INSTALL COLLECTOR PIPELINE
W8	CIVIL WORKS FOR PUMP STATION
W9	SUPPLY AND INSTALL PUMP STATION EQUIPMENT
	VILLAGE WATER SUPPLY AND SANITATION
W10	WELL DRILLING (PROBABLY UNDER CONTRACT W5)
W11	SUPPLY HANDPUMPS
W12	HEALTH EDUCATION INCLUDING WELL COMPLETION AND LATRINE CONSTRUCTION (BY MINISTRY OF HEALTH)
	PIPELINE FROM NORTH RIVER WELLFIELD TO PORT CITY
W13	SUPPLY AND INSTALL PIPELINE
	COMMUNICATIONS AND CONTROL FOR WELLFIELD SYSTEM
W14	SUPPLY AND INSTALL EQUIPMENT
	CREEKTOP RESERVOIR
W15	CIVIL WORKS AND EQUIPMENT
	EASTERN RESERVOIR
W16	CIVIL WORKS AND EQUIPMENT
	TRANSMISSION PIPELINES WITHIN PORT CITY
	SUPPLY AND INSTALL PIPELINES:
W17	a) CREEKTOP RESERVOIR - FARMVILLE ROAD - SHOP STREET - RAILWAY - MAIN STREET
W18	b) EASTERN RESERVOIR - MOUNTAIN ROAD
W19	c) LOOKOUT HILL - CITY SOUTH
	DISTRIBUTION NETWORK EXTENSIONS
	SUPPLY AND INSTALL PIPELINES AND CONNECTIONS:
W20	UPPER RESIDENTIAL ZONE
W21	LOWER RESIDENTIAL ZONE
W22	RAILVILLE
W23	BLIGHT HEIGHTS
W24	EXTRA ZONES
W25	MISCELLANEOUS MINOR EXTENSIONS (PCWSC STAFF)
	NEW CONNECTIONS AND CONSUMER METERS
W26	PURCHASE OF METERS
W27	INSTALLATION OF NEW CONNECTIONS (PCWSC STAFF)
	RATIONALIZATION OF EXISTING NETWORK
W28	MATERIALS AND EQUIPMENT SUPPLY
W29	EQUIPMENT INSTALLATION (PCWSC STAFF)
	O & M FACILITIES AND EQUIPMENT
W30	RAILROAD PLANT: HEADQUARTERS EXTENSIONS AND OPERATIONS CONTROL CENTER
W31	NORTHERN REGIONAL OFFICE CONVERSIONS (PCWSC STAFF)
W32	METER AND REPAIR WORKSHOPS AND EQUIPMENT AT MEANTHYME SITE
W33	SUPPLY OF TRUCKS
W34	SUPPLY OF COMMUNICATIONS EQUIPMENT FOR OPERATIONS CONTROL CENTER
W35	SUPPLY OF MISCELLANEOUS OFFICE AND WORKSHOP EQUIPMENT



LEGEND

- ——— DETAIL DESIGN AND TENDER DOCUMENTS
- ········ PROCUREMENT (INCLUDING APPROVALS)
- - - - - SUPPLY/CONSTRUCT
- C COMMISSION NEW FACILITY
- ——— NORMAL OPERATION

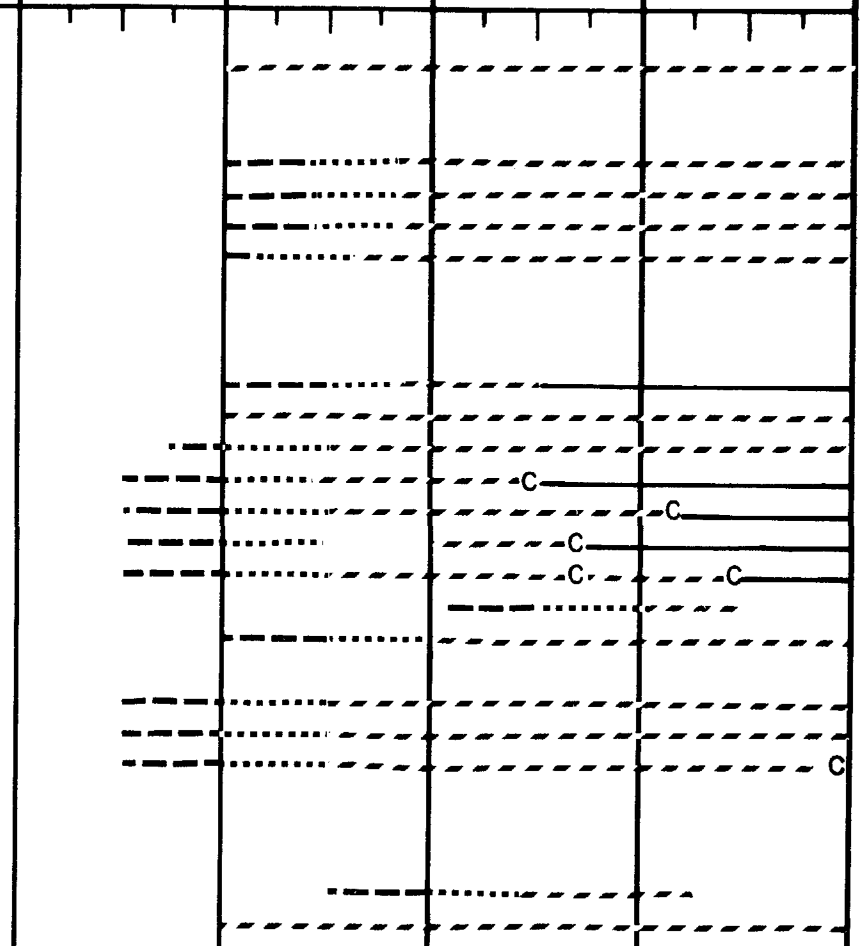
PORT CITY

WATER SUPPLY AND SANITATION PROJECT

CONSTRUCTION SCHEDULE FOR WATER SUPPLY COMPONENTS

DATE: FEBRUARY, 1983 | FIG.: 4-11

CONTRACT NO.	ITEM	1983	1984	1985	1986
	ON-SITE SANITATION SYSTEMS				
S1	SUPPORT ACTIVITIES (ISD)				
	CONSTRUCTION OF BELOW GROUND FACILITIES:				
S2	BLIGHT HEIGHTS				
S3	RAILVILLE A				
S4	EXTRA ZONES				
S5	UPGRADING OF EXISTING SEPTIC TANKS AND CESSPITS				
	OFF-SITE SANITATION SYSTEMS				
S6	REHABILITATION OF PACKAGE TREATMENT PLANTS				
S7	SUPPORT ACTIVITIES (ISD)				
S8	CONNECTIONS TO CONVENTIONAL SEWERS				
S9	EXTENSIONS TO CONVENTIONAL SEWERS				
S10A	INTERCEPTOR SEWER (MAIN STREET)				
S10B	INTERCEPTOR SEWER (RAILVILLE)				
S11	HOG'S BAY TREATMENT PLANT				
S12	DISMANTLE MEANTHYME TREATMENT PLANT				
S13	COMMUNAL LATRINES				
	SMALL BORE SEWER SYSTEMS:				
S14	UPGRADING OF EXISTING SEPTIC TANKS AND CESSPITS				
S15	CONSTRUCTION OF INTERCEPTOR TANKS				
S16	CONSTRUCTION OF SMALL BORE SEWERS				
	O & M FACILITIES AND EQUIPMENT				
S17	WORKSHOP AND STORE AT MEANTHYME PLANT				
S18	PURCHASE OF MISCELLANEOUS EQUIPMENT				



LEGEND

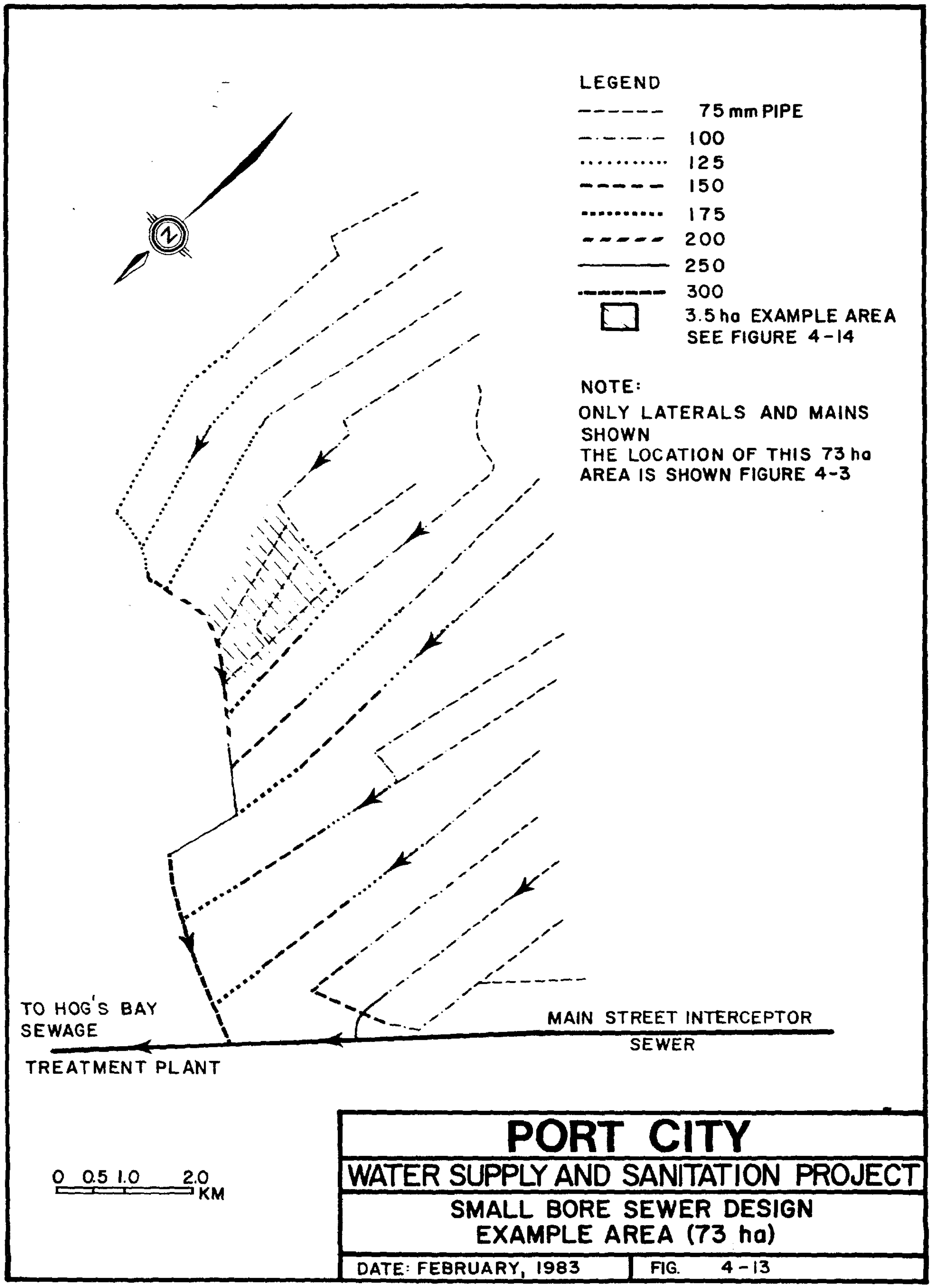
- DETAIL DESIGN AND TENDER DOCUMENTS
- PROCUREMENT (INCLUDING CONTRACT APPROVAL)
- SUPPLY/CONSTRUCT
- C COMMISSION NEW FACILITY
- NORMAL OPERATION

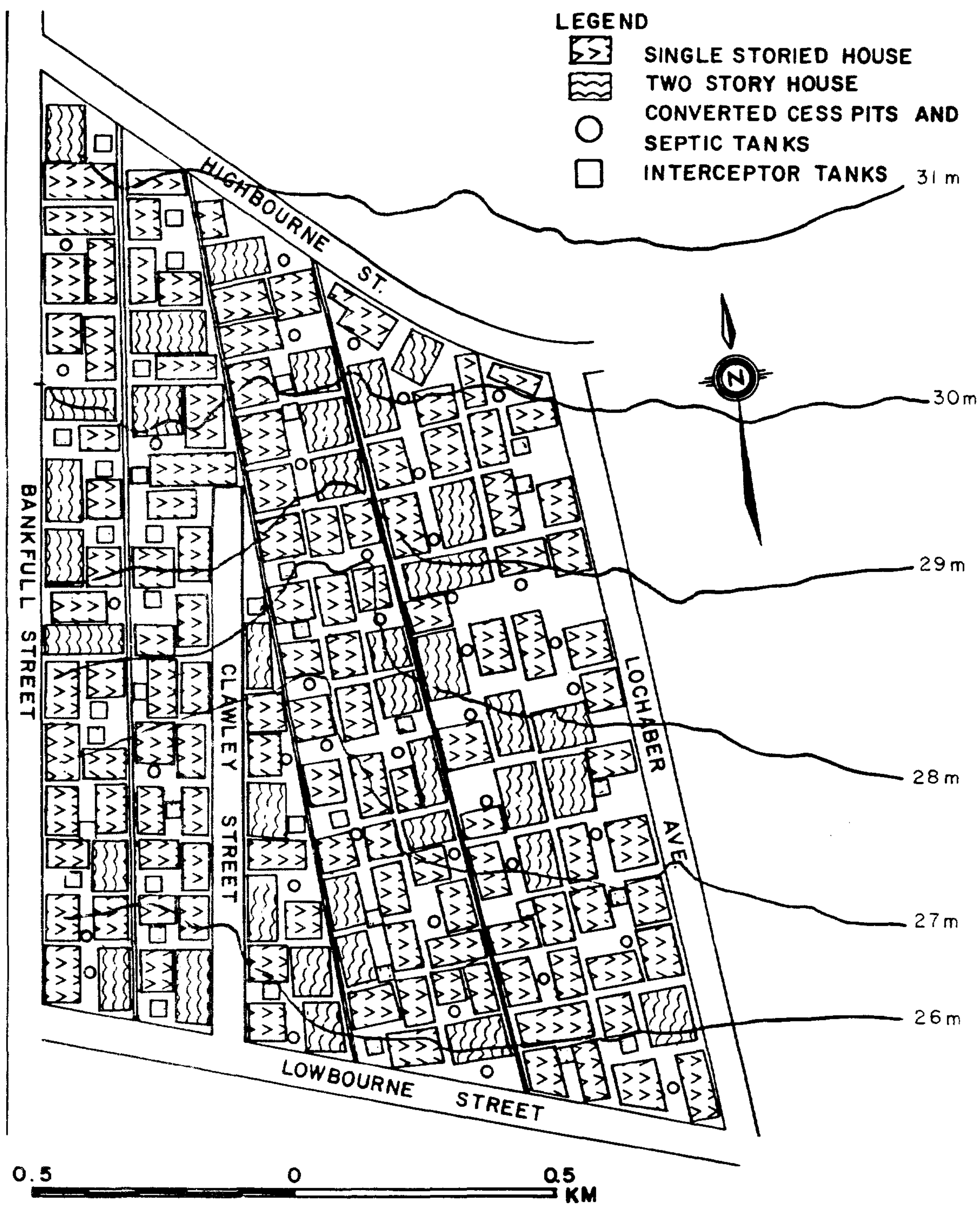
PORT CITY

WATER SUPPLY AND SANITATION PROJECT

CONSTRUCTION SCHEDULE FOR SANITATION COMPONENTS

DATE: FEBRUARY, 1983 | FIG. 4-12


LEGEND
75 mm PIPE
100
125
150
175
200
250
300
3.5 ha EXAMPLE AREA
SEE FIGURE 4-14
NOTE:
ONLY LATERALS AND MAINS SHOWN
THE LOCATION OF THIS 73 ha AREA IS SHOWN FIGURE 4-3
TO HOG'S BAY SEWAGE TREATMENT PLANT
MAIN STREET INTERCEPTOR SEWER
0 0.5 1.0 2.0 KM
PORT CITY
WATER SUPPLY AND SANITATION PROJECT
SMALL BORE SEWER DESIGN
EXAMPLE AREA (73 ha)
DATE: FEBRUARY, 1983
FIG. 4-13



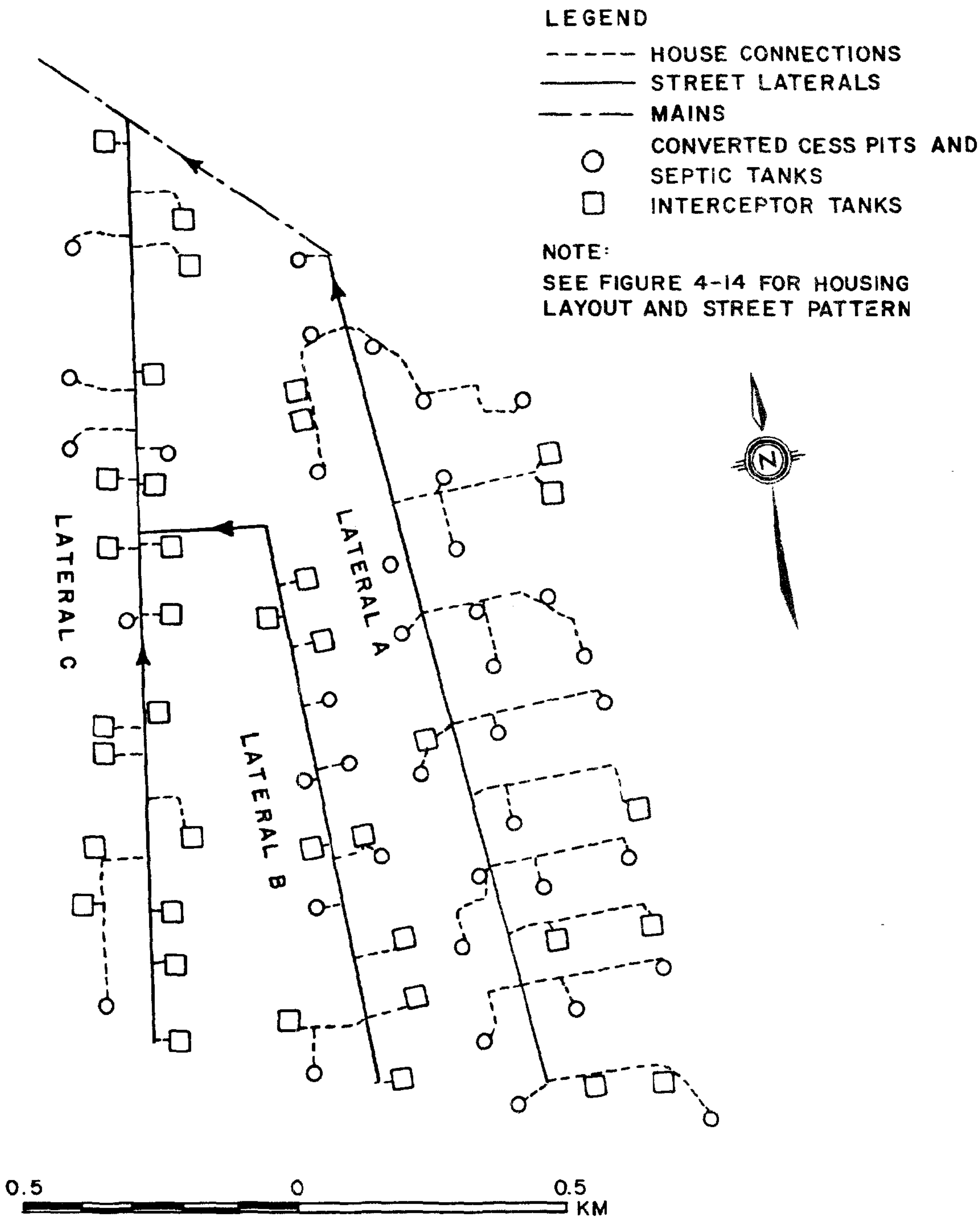
NOTE:
SEE FIGURE 4-13 FOR LOCATION MAP

PORT CITY

WATER SUPPLY AND SANITATION PROJECT

SMALL BORE SEWER DESIGN EXAMPLE (3.5 ha)

DATE: FEBRUARY, 1983 | FIG. 4-14

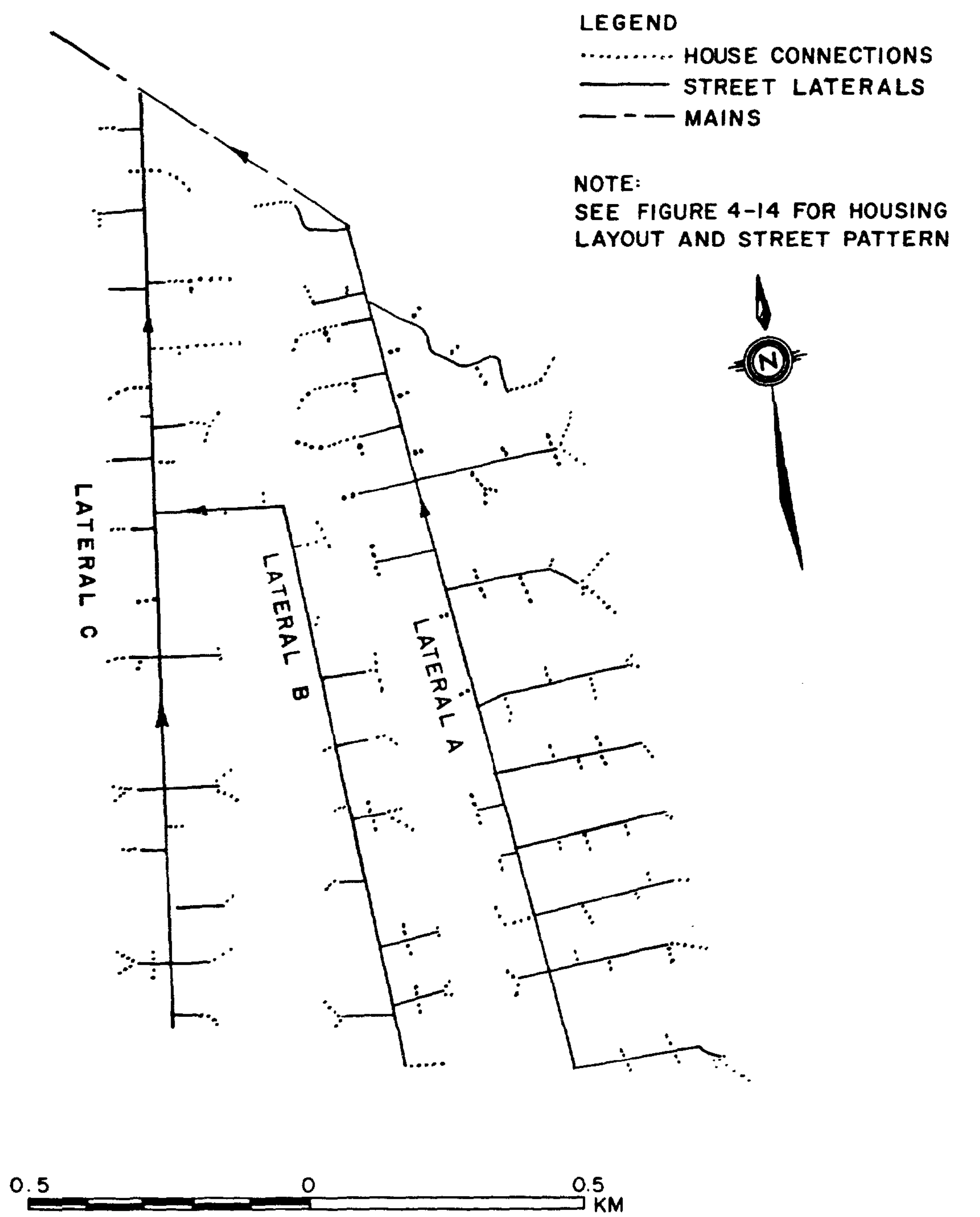


PORT CITY

WATER SUPPLY AND SANITATION PROJECT

LAYOUT OF SMALL BORE SEWERS
(3.5 ha EXAMPLE AREA)

DATE: FEBRUARY, 1983	FIG. 4-15

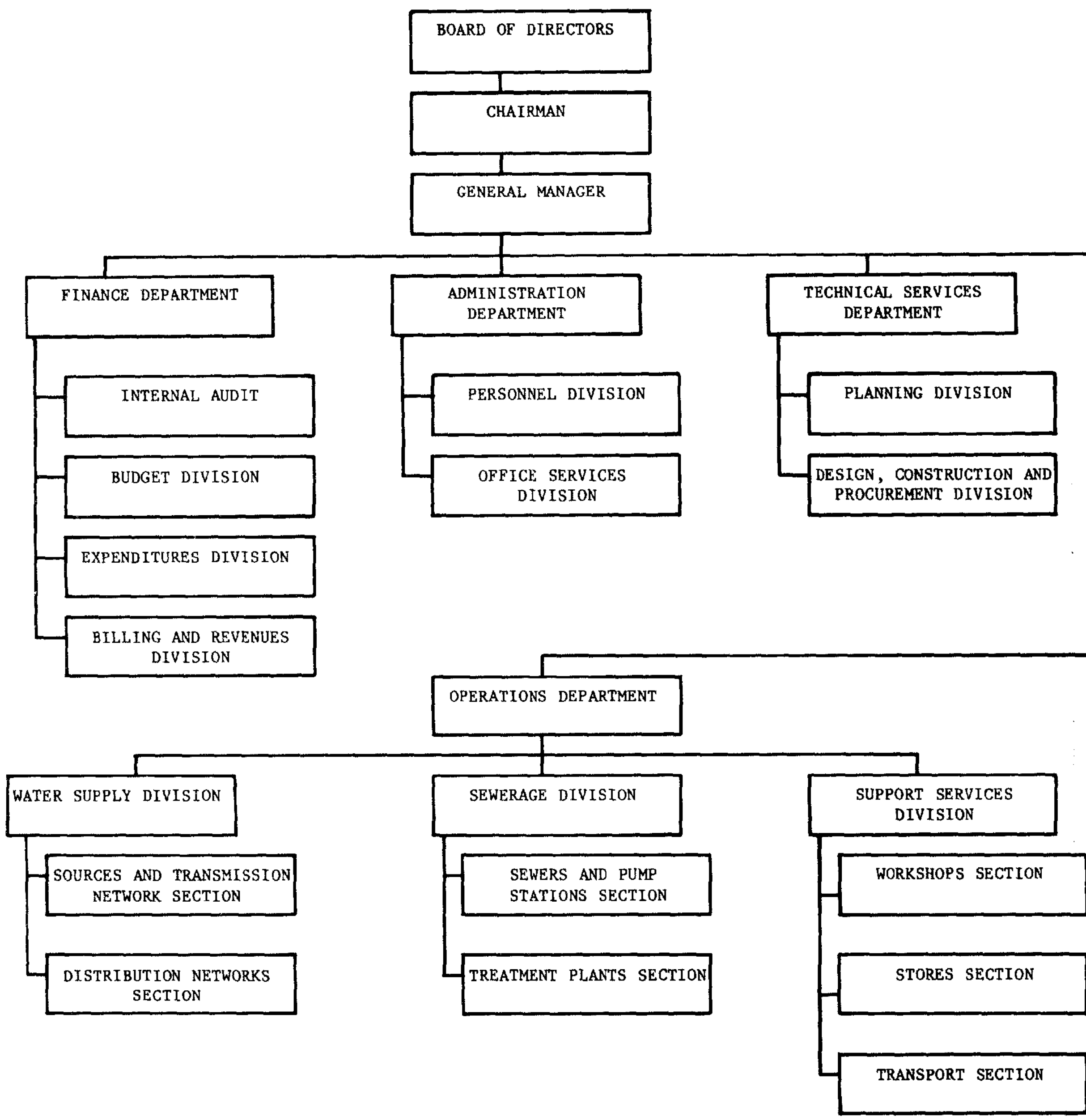


PORT CITY

WATER SUPPLY AND SANITATION PROJECT

LAYOUT OF CONVENTIONAL SEWERS
(3.5 ha EXAMPLE AREA)

DATE: FEBRUARY, 1983 | FIG. 4-16

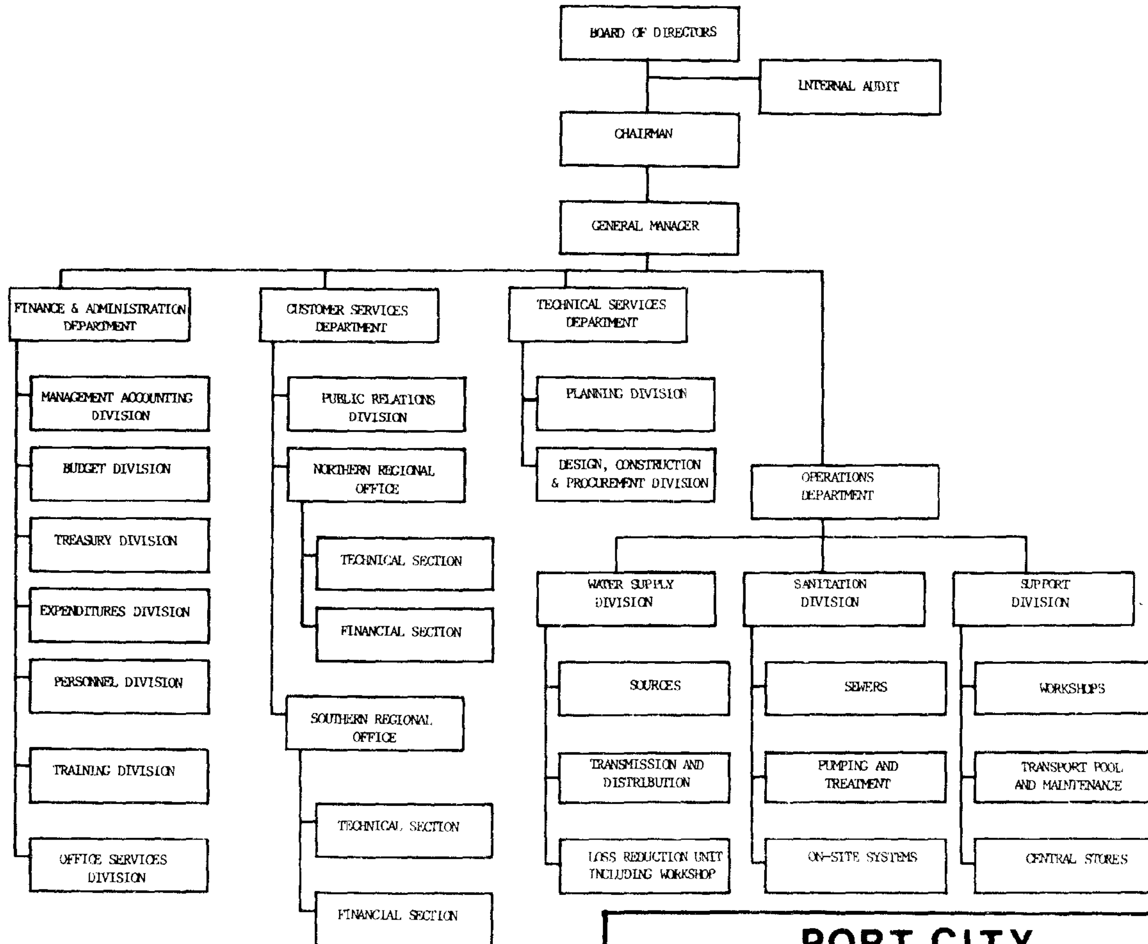


PORT CITY

WATER SUPPLY AND SANITATION PROJECT

EXISTING PCWSC ORGANIZATION CHART

DATE: FEBRUARY, 1983 | FIG.: 5-1



PORT CITY

WATER SUPPLY AND SANITATION PROJECT

PROPOSED PCWSC ORGANIZATION CHART

DATE: FEBRUARY, 1983 | FIG.: 5-2

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