Management, Training & Systems Strengthening
for
The General Organization For Greater
Cairo Water Supply

Black & Veatch International

Technical Support for Operation and Maintenance

Baseline Data Report

6 December 1994

Cairo Water II - Institutional Development Component
USAID Project No. 263-0193

In Association with:
Montgomery Watson - National Education International - Sabbour Associates

Black & Veatch International

Management, Training & Systems Strengthening (MTSS) Project

General Organization for Greater Cairo Water Supply

6 December , 1994

Eng. Afaf El Marakby
MTSS Project Manager
General Organization for Greater Cairo
Water Supply
42 Ramses Street
Cairo, A. R. E.

Subject: MTSS Contract No. 263-0193
TSOM Transmittal

Dear Eng. Afaf,

On behalf of Black & Veatch International (BVI) and our affiliated subcontractors, I am pleased to submit the following Report titled:

Technical Support for Operation and Maintenance
Baseline Data Report

This report has been prepared by the TSOM Program in accordance with the approved Management, Training & Systems Strengthening (MTSS) project work plan.

The professional efforts of Mr. Don Houser, the TSOM staff and the counterparts assigned to the TSOM program in collecting and analyzing data and compiling this report are acknowledged.

Your comments on this report are most welcome. Please feel free to contact Mr. Don Houser or myself about any matter related to this report.

Very truly yours,

Black & Veatch International

John C. Dalton
Team Leader

cc: Home Offices
USAID

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فكرة عامة:

تجرى الحكومة المصرية حاليا تنفيذ سياسة قومية جديدة تحل فيها مبادئ السوق والاعتبارات الاقتصادية محل سياسة الدعم. وستشجع الحكومة المركزية الهيئات الاقتصادية كالهيئة العامة لمرفق مياه القاهرة الكبرى لتعمل بأسلوب تجارى بمعنى أن المصروفات الجارية تغطى عن طريق ايرادات تعريفة المياه. كما أن التوسعات الرأسمالية المستقبلية يتم تحديدها وفقا لأسس اقتصادية. هذه الحالة تسمى بالحيوية المالية.

ولتحقيق استمرارية الحيوية المالية والعمل على أساس تجارى فان مجلس الادارة والادارة العليا للمرفق تحتاج الى منحها السلطات اللازمة لتتصرف باستقلالية فيما يخص الخطط والموازنات والتصرفات الفردية والشئون المالية وشراء المعدات والعديد من الأمور الأخرى. وهذه الحالة تسمى بالاستقلالية الادارية.

وللمساعدة على تحقيق العلاقة المتبادلة بين الحيوية المالية والاستقلالية الادارية، طلبت الهيئة العامة لمرفق مياه القاهرة الكبرى مساعدة وكالة التنمية الدولية الأمريكية بتوفير التمويل لمشروع مساندة تأسيسية باسم "مشروع دعم الادارة والتدريب والنظم". وهذا المشروع يعتبر الوسيلة التى تساعد الهيئة على أن تعمل كهيئة مستقلة اداريا وذات حيوية مالية بدءاً بالممارسة الفعلية تحت الشكل القانونى الحالى، ثم تحت شكل قانونى جديد اذا لزم. وقام اتحاد من عدة شركات أمريكية ومصرية برئاسة بلاك آند فيتش انترناشونال ليكون المقاول الذى يساعد الهيئة على تحقيق هذه الأهداف.

وتُنظم مشروع دعم الادارة والتدريب والنظم فى ستة برامج ترتبط باحكام بالتنظيم الداخلى للهيئة ومهيأة لتمكين الهيئة من تحقيق أهداف كل من الحيوية المالية والاستقلالية الادارية. وهذه البرامج الست هى:-

- رئيس الفريق
- الحيوية المالية
- التنمية الادارية
- الدعم الفنى للتشغيل والصيانة
- ادارة المواد والمشتريات
- ادارة المشروع وخدمته اداريا

إن إحدى المعتقدات الهامة لمشروع دعم الادارة والتدريب والنظم هى أن يقام الأساس للحيوية المالية والاستقلالية الادارية بواسطة ادارة الهيئة. فيقوم المقاول بالنصح والتدريب والمساعدة بينما يتولى مديرو الهيئة التنمية والاختيار والتنفيذ.

ويشكل برنامج الدعم الفنى للتشغيل والصيانة جزءا جوهريا بالمشروع ويهدف بنوع خاص الى تدعيم اجراءات التشغيل والصيانة التى اذا ارتبطت بالنواحى الأخرى للمشروع فى خطة شاملة ستمكن الهيئة من التقدم نحو الحيوية المالية والاستقلالية الادارية ويجب أن يبدأ قياس التحرك نحو الحيوية المالية بجمع وتفسير قاعدة البيانات لتحديد حالة الهيئة كما هى الآن. ومن ثم يجب استنباط طريقة قياس محسنة لتوفير الأساس لتحديد فعالية تحسينات التشغيل التى اقترحت للتنفيذ.

وقد تم وضع مؤشرات أداء كوسيلة لتقييم فعالية الهيئة فى تنفيذ التغيرات. وقد صادق السيد المهندس رئيس مجلس ادارة الهيئة على مؤشرات الأداء، وهذا يدل على الالتزام القوى للهيئة نحو أهداف المشروع. ومؤشرات الأداء هذه ستقيس كميا التحسينات فى كفاءة وفعالية العمل الذى قام به العاملون بالهيئة. كما توفر مؤشرات الأداء وسيلة لمقارنة كيفية اداء الهيئة عند مقارنتها بأفضل ممارسات تجارية للمرافق الناجحة على مستوى العالم.

تنظيم التقرير:

يحتوى هذا التقرير على ثروة من المعلومات الاحصائية تتمشى مع الغرض منها كتقرير قاعدة بيانات. ويحتوى كل من الأقسام الكبيرة على جداول وقوائم تبين مدى

العمل المؤدى بواسطة فريق مشروع دعم الادارة والتدريب والنظم لاعداد هذا التقرير. ويشمل النص تحليلا للبيانات وما تتضمنه من أداء محسن للهيئة.

ويوجد ثلاثة أقسام بالتقرير كما يلى:

القسم الأول: مقدمة – تحتوى على فكرة عامة عن الترتيبات الوظيفية والجغرافية للهيئة مع التركيز الأولى على النواحى الفنية بالمحطات والشبكات والمشروعات. ويحدد الشكل التنظيمى للهيئة (كهيئة اقتصادية كما جاء وصفها فى وضعها القانونى بقرار رئيس الجمهورية رقم ١٦٣٨ لسنة ١٩٦٨) كما يناقش العلاقة بين الهيئة والعديد من الأجهزة الخارجية التى تنظم أو تراقب أنشطتها.

القسم الثانى: جمع البيانات والتحليل – ويحتوى على سجل بالبيانات التى جمعت وحللت بواسطة فريق المشروع ولخصت وفقا لعلاقتها بالمحطات والشبكات والمشروعات. كما تحدد برنامج التوسع الرأسمالى المتوقع من وجهة نظر الهيئة.

القسم الثالث: النتائج والتوصيات – يخطط النتائج الأولية المستمدة من البيانات، ويعد كشفاً بالمجالات التى يلزم أن يقوم المشروع مع الهيئة بتقوية أدائها.

وفيما يلى بيان بهذه النتائج:

١- اعادة التأكيد على الأساس الاقتصادى للهيئة من خلال شكل قانونى جديد يتيح للسلطة المخولة لمجلس ادارة الهيئة بأن تضع معايير للخدمات الادارية والفنية.

٢- تركيز الموارد على كفاءة التشغيل والصيانة بشبكة توزيع المياه حتى يمكن تخفيض التسرب والفاقد، واستعادة تكامل الشبكة ككل مع استخدام التصميم الواعى بالتكلفة والمعايير الانشائية.

٣- اتباع سياسة قياس بالعدادات وبرنامج تنفيذ قياس كل من الانتاج والاستهلاك ويجب أن توفر عدادات الانتاج أساس دقيق لتحديد كمية المياه المنتجة فعلا فى كل من مراحل

التكرير. كما يجب أن يكون برنامج قياس الاستهلاك واقعيا وهادفا لمستهلكى الكميات الكبيرة كما يكون قابلا للتنفيذ عبر القيود على الموارد بالهيئة.

٤- وضع معايير للتشغيل والصيانة لجميع المحطات والشبكات والمعدات التى تمتلكها وتشغلها الهيئة وتأسيس نظام وضع قيمة للتشغيل والصيانة يستخدم بواسطة مديرى وموظفى الهيئة.

٥- وضع بطاقة تنظيم وهيكل تنظيمى داخلى يعكس الاختصاصات الوظيفية والجغرافية للهيئة ويسهل ادارة الموارد بفاعلية وكفاءة.

٦- تحسين مهارات القوة العاملة الموكول اليها أداء الأنشطة الفنية بالهيئة والتأكد من توازن توزيع الأفراد الفنيين بين ادارات الهيئة.

٧- تدعيم النظم والاجراءات الحالية وادخال التقنية الحديثة فى المهام الرئيسية بالعملية الادارية، لتحسين نظم حفظ السجلات ووضع التقارير، خاصة فى المتابعة المالية والتشغيل والصيانة.

ومن بين النتائج الأساسية أن الاستثمار الرأسمالى يجب أن يوجه الى تحسين شبكة توزيع المياه بدلا من انشاء محطات تكرير مياه اضافية والتوسع فى منطقة الخدمة. وهذه النتيجة لها مفاهيم ضمنية كبيرة على استراتيجية المستقبل والأساس القانونى وأسلوب تقديم الخدمة ومستويات الخدمة التى تقدمها الهيئة وكذلك لها آثار فورية على هيكل ونظم الهيئة وأيضا على المستويات والوضع النسبى للأفراد.

وقد قام الأفراد الفنيون بالهيئة بتقديم مساعدة كبيرة ومساهمة وتعاون مع برنامج الدعم الفنى للتشغيل والادارة. وغالبا ما كانت البيانات التى يطلبها المقاول صعبة فى معرفة مكانها وجمع بياناتها. ومع ذلك فقد كان الأفراد الفنيون والاداريون بالهيئة راغبين باستمرار فى تقديم المعاونة فى جمع البيانات، واننا لشاكرون جدا لمساعداتهم الجليلة.

Executive Summary

Overview

A new national policy is being implemented by the Egyptian government in which subsidies will be replaced by market principles and economic considerations. Economic organizations such as the GOGCWS will be encouraged by the central government to operate in a business-like manner so that recurring expenditures are covered by water tariff revenues and future capital expansion is determined on economic principles. This condition is termed "financial viability."

To achieve and sustain financial viability and operate on a commercial basis, the Board of Directors and top management of the GOGCWS will need the authority to act independently with respect to plans, budgets, personnel actions, financial affairs, equipment purchases and a host of other matters. This condition is termed "managerial autonomy."

To help it achieve these two interrelated conditions of financial viability and managerial autonomy, the GOGCWS requested assistance from the United States Agency for International Development (USAID) which provided funds for an institutional support project entitled, "Management, Training & Systems Strengthening" (MTSS). The MTSS project is a vehicle to help the GOGCWS operate as a managerially autonomous and financially viable organization, first in actual practice under its existing legal mandate and then under a new legal/institutional arrangement, if required. A consortium of American and Egyptian Companies, headed by Black and Veatch International, has been retained as the contractor to help the GOGCWS achieve these objectives.

The MTSS project is organized into six programs which are closely related to the internal organization of the GOGCWS and geared to enable the GOGCWS to achieve both the financial viability and managerial autonomy objectives. The six programs are:

- Team Leader (TL)
- Financial Viability (FV)
- Management Development (MD)
- Technical Support for Operation and Maintenance (TSOM)
- Materials Management & Procurement (MMP)
- Project Management & Administration (PM&A)

One of the basic tenets of the MTSS project is that the foundation for financial viability and managerial autonomy must be constructed by GOGCWS management. The contractors advise, train and assist; GOGCWS managers develop, adopt and implement.

The TSOM program is an integral part of the MTSS project. It is aimed specifically at strengthening the operation and maintenance (O&M) procedures which, when combined with the other aspects of the project into a comprehensive plan, will enable the organization to progress toward financial viability and managerial autonomy. Measurement of the movement toward financial viability must start with the collection and interpretation of baseline data to determine the condition of the organization as it now exists.

Subsequently, a method of measuring improvement must be devised to provide a basis for determining the effectiveness of the operational enhancements which are proposed for implementation.

Performance indicators have been developed as a means to evaluate the effectiveness of the organization in implementing change. The performance indicators have been endorsed by the Chairman of the GOGCWS, an indication of the strong commitment of the organization toward the project objectives. These performance indicators will quantitatively measure improvements in the efficiency and effectiveness of work done by GOGCWS staff. The performance indicators also provide a means of comparing how the GOGCWS performs when compared with the best commercial practice of successful utilities around the world.

Organization of the Report

This report contains a wealth of statistical information, consistent with its purpose as a Baseline "Data" Report. Each of the major sections contains tables and spreadsheets which indicate the extent of the work performed by the TSOM staff to prepare this report. An analysis of the data and its implications for improved GOGCWS performance is contained in the text.

There are three sections in the report. *Section 1: Introduction* contains an overview of the functional and geographical arrangement of the organization, concentrating primarily on the technical aspects of waterworks, networks and projects. The organizational form of the GOGCWS (i.e., an economic organization as described by its legal charter: Presidential Decree 1638 of 1968) is defined and the relationship of the GOGCWS to the numerous external agencies which regulate or control its activities is discussed. *Section 2: Data Collection and Analysis* contains the record of data collected and analyzed by the TSOM team summarized according to its relationship to waterworks, networks and projects. The anticipated capital expansion program, from the GOGCWS perspective, is also identified. The third section of the report, *Section 3: Conclusions and Recommended Actions*, lays out the preliminary conclusions drawn from the data and provides a list of areas where MTSS and GOGCWS action may be required to strengthen performance. These conclusions are listed below.

1. Reconfirm the "economic" basis of the organization through a new enabling act and capitalize fully on the existing authority of the GOGCWS Board of Directors to establish management and technical service standards.

2. Concentrate resources on the effective operation and maintenance of the distribution system in order to reduce leakage and waste and restore the integrity of the overall system. Employ cost-conscious design and construction standards.

3. Establish a metering policy and implementation program for both production and consumption meters. The production meters should provide an accurate basis for determining the amount of water actually produced at each stage of treatment. The consumption metering program should be realistic, targeted on high volume consumers and capable of being implemented within the resource constraints of the organization.

4. Develop standards for operation and maintenance of all facilities and equipment owned and operated by the GOGCWS. Institute an "O&M" value system for GOGCWS managers and employees.

5. Establish an organization form and an internal organizational structure which reflects the functional and geographical responsibilities of the GOGCWS and facilitates the effective and efficient management of resources.

6. Improve the skills of the GOGCWS work force assigned to technical activities and assure a balanced distribution of technical personnel among GOGCWS departments.

7. Strengthen existing systems and procedures and introduce technology at key points in the management process to improve record keeping and reporting, especially for both financial control and operations and maintenance.

Among these principal conclusions is that capital investment should be channeled to improving the existing distribution system rather than constructing additional treatment plants and expanding the service area. This finding has major implications for the future strategy, statutory foundation, service delivery approach and service standards of the GOGCWS and also has immediate impacts on the structure and systems of the organization as well on the levels and configuration of the staff.

The TSOM program was greatly assisted by the participation and cooperation of the technical staff of the GOGCWS. Data needed by the contractor was often difficult to locate and assemble. Nevertheless, the professional, technical and administrative personnel of the organization were always willing to assist in collecting available data and presenting it to us. We are most grateful for their assistance.

Section 1: Introduction

Background

The objective of the Management, Training and Systems Strengthening (MTSS) project is to promote financial viability and managerial autonomy of the GOGCWS. The project consists of six programs as follows:

- Team Leader (TL)
- Financial Viability (FV)
- Management Development (MD)
- Technical Support for Operation and Maintenance (TSOM)
- Materials Management & Procurement (MMP)
- Project Management & Administration (PM&A)

The purpose of the TSOM program is to assist the GOGCWS in achieving financial viability by improving the efficiency of operations and maintenance of water treatment and distribution facilities. Measurement of movement toward financial viability began with collection and interpretation of baseline data to determine the existing condition of the organization. Then a target or ideal was defined as the future condition to be achieved by the GOGCWS. Subsequently, a method of measuring improvement was devised to determine to what extent recommendations proposed by the TSOM program have contributed to the achievement of the identified target.

This baseline data report presents information about GOGCWS operations which are pertinent to the TSOM program and which will facilitate the "before and after" assessment of the program's effectiveness. To assist the GOGCWS make progress toward achieving its objectives, the TSOM program will develop, and assist in implementing, performance improvement activities, to reduce the amount of unaccounted for water by:

- Operating treatment facilities more effectively
- Maintaining facilities
- Metering water production
- Detecting and correcting leakage
- Conserving water

Cross cutting support to these five areas will be provided through training and technology.

In addition to these basic activities, the TSOM program will also investigate alternative water treatment technologies, such as ozonation, which minimize the formation of chlorine by-products, thought to have adverse long-term health effects. Pilot or bench scale studies will be conducted to determine the effectiveness of alternative treatment methods. Other special research projects will be conducted as needed. Modern utility management concepts such as best commercial practices, privatization and Build-Own-Operate-(Transfer) will be investigated to evaluate their applicability to GOGCWS.

Finally, the existing organizational structure, systems and staff capacity will be evaluated to determine how reorganization could enhance the O & M management capability of the GOGCWS. Recommendations will be made regarding necessary restructuring efforts.

Organization of The GOGCWS

The GOGCWS was established in 1968 under presidential Decree 1638 (PD1638/1968). It is a large utility with more than 12,500 employees. Most of these employees constitute a large day-labor work force responsible for operating, maintaining and repairing the water production and distribution system. Approximately 4500 employees work at the water treatment plants and well fields; about 3500 employees work at the network level. maintaining and repairing the water transmission and distribution infrastructure and an additional 170 employees are assigned to project design and construction supervision.

The Waterworks Central Department is responsible for operating and maintaining : a) the water production facilities (treatment plants and well fields), b) the water storage reservoirs, and c) the distribution system booster pumps. The Networks Central Department is responsible for a) the water distribution system pipelines and valves, b) customer meters, and c) service connections. The Projects Central Department administers foreign funded (grant or loan) projects, and supervisors a) installation of pipelines with diameters greater than 600 millimeters (mm), and b) other major design and construction projects.

Figure 1-1 for the Waterworks Central Department indicates that the managers of the larger water treatment plants are classified as General Directors who report directly to the Undersecretary of Waterworks. This is the official organizational structure approved by the CAOA. However, since the Ministry of Finance (MOF) has not approved funding for all of the positions required for the GOGCWS to operate in this manner, the GOGCWS has designated two intermediate managers to oversee the water production facilities, as follows:

- A General Director for North & East Water Works - Ameryia, Mostorod, Rod El Farag, and Shobra El Kheima.
- A General Director for South & West Waterworks - Embaba, Giza, Geziret El Dahab, Roda, Fostat, Maadi, Helwan, Kafr El Elw, Tebeen.

The well fields are under the control of designated water treatment plants, as specified below:

Well Field	**Water Treatment Plant**	**General Director**
Bahteem	Rod El Farag	North & East
El Marg	Mostorod	North & East
Jolie Ville	Geziret El Dahab	South & West
El Ramaria	Geziret El Dahab	South & West

The other two official organizational charts for the Networks Central Department (Figure 1-2) and the Projects Central Department (Figure 1-3) have been verified as accurate by the GOGCWS.

Figure 1.1 Waterworks Central Department Organization

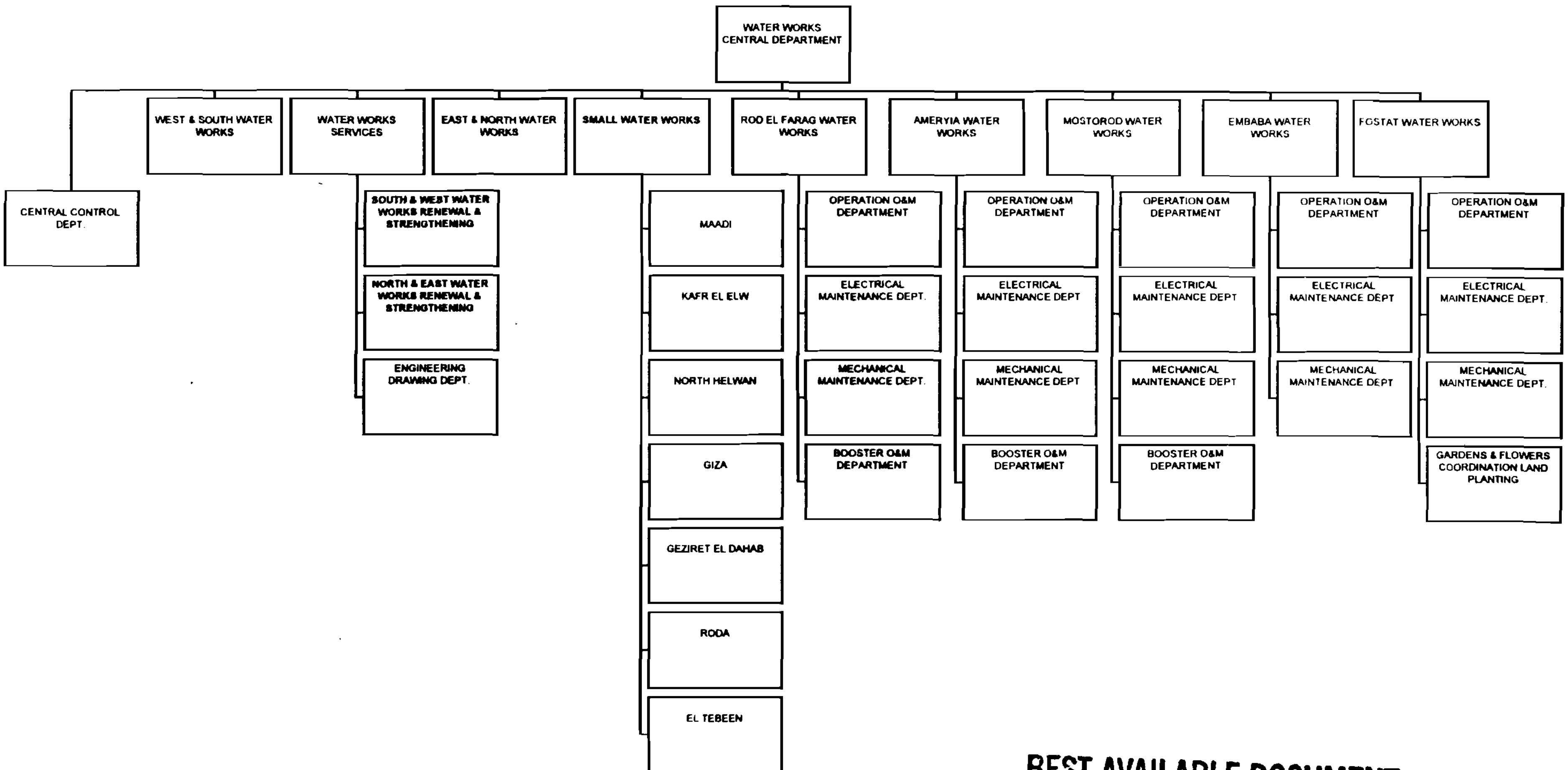


Figure 1.2 Networks Central Department Organization

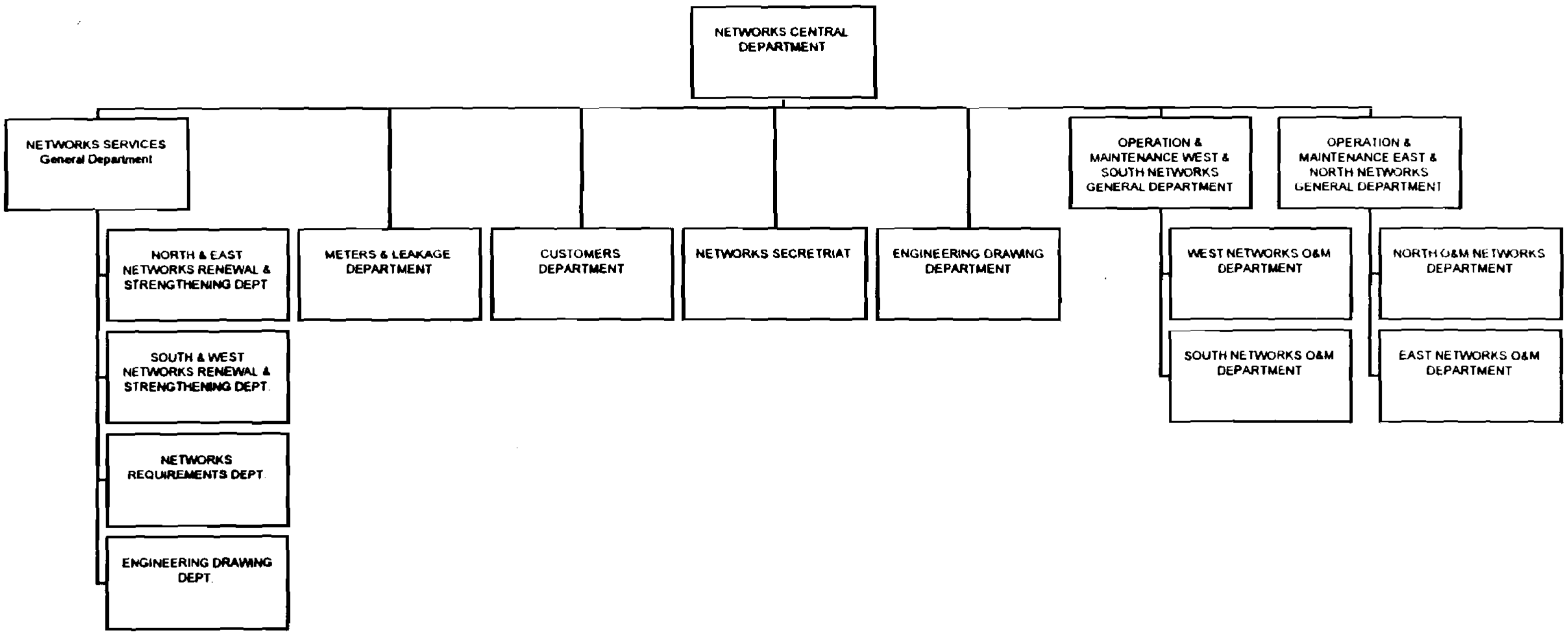
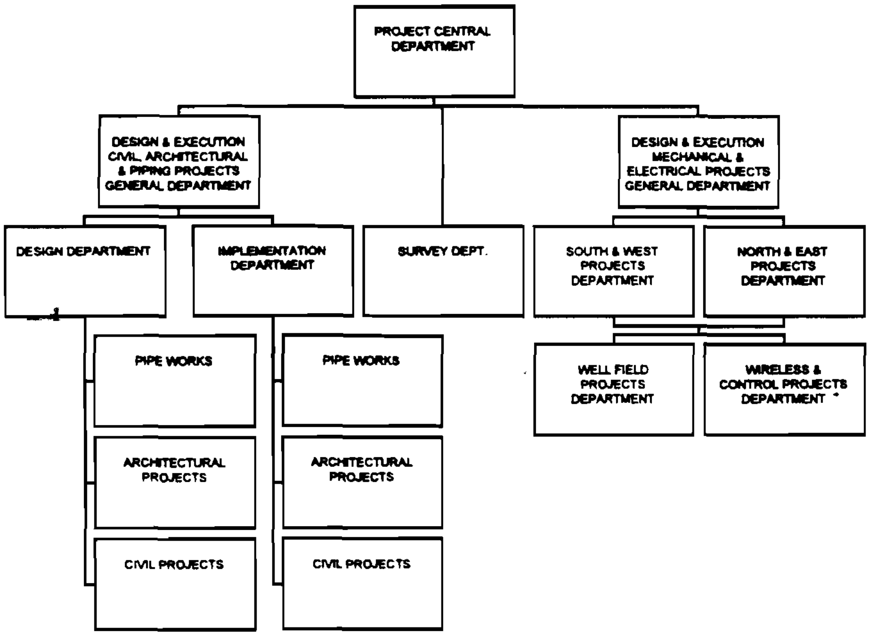


Figure 1.3 Projects Central Department Organization



Service Area

The area served by the GOGCWS includes the entire Governorate of Cairo and urban portions of the Giza and Qaliubia Governorates. It covers an area of approximately 911 square kilometers and provides water for a population estimated at between 10 and 14 million people. The service area, already extensive by comparison to other urban utilities in the world, has continued to expand to serve outlying developments around Cairo. The GOGCWS does not have the managerial autonomy to determine where and on what basis to authorize system expansion, and consequently, cannot control the size and extent of the service area. This lack of control over the development of the system makes it impossible for the GOGCWS to assure system integrity in terms of water quality, amount of water produced and size of work force necessary to operate and maintain the system. The unregulated growth of the system's service area also contributes to the financial losses incurred by the organization.

Water Resources

Egypt has an annual Nile River entitlement of 55 billion cubic meters. This is based on an agreement with the countries of Sudan, Ethiopia, Rwanda, Chad, Uganda, Niger, Zaire and Kenya, countries which share the waters of the Nile with Egypt. Egypt constructed the high Aswan dam in 1964 to impound Nile River water for its needs. The capacity of the reservoir is approximately 150 billion cubic meters which represents about a 3 year reserve supply for the entire country. The region drained by the Nile River recently experienced a prolonged drought with severe consequences on neighboring countries. The impact on Egypt was minimized due to the storage in Lake Nasser behind the high dam. Utilization of the Nile River entitlement within Egypt is not strictly adjudicated. The Ministry of Public Works and Water Resources controls the overall use.

The GOGCWS treats approximately 1.25 billion cubic meters for potable domestic use, excluding the amount of water which is lost during the treatment process. The total production of 1.25 billion cubic meters amounts to approximately 2.2 percent of the national entitlement of 55 billion cubic meters. The Nile River, or one of its canals, is the source of supply for 87% of GOGCWS potable water production.The source for the remaining 13% is municipal wells. Well water typically contains higher total dissolved solids compared with water from the Nile River and is therefore less desirable for potable purposes.

The implication is that Egypt has a firm water supply which needs little regulation based current demand for water. It appears there is no immediate need to limit consumption within the GOGCWS service area. However, water conservation may reduce demand for potable water and consequently, reduce the requirement for additional water treatment and distribution facilities. This could lower future investment expenses and indirectly support financial viability objectives. Accordingly, the TSOM program, will implement a limited water conservation plan, concentrating on community education and awareness.

External Agencies

The GOGCWS is subject to the rules and regulations of many Government of Egypt (GOE) agencies. For example, on administrative matters three agencies have oversight responsibility:

1) Central Agency for Organization and Administration (CAOA)- determines the GOGCWS official organization structure;

2) Ministry of Local Administration (MLA)- reviews the budget of all Governorates and their associated utilities,

3) Ministry of Finance (MOF)- approves GOGCWS revenue and expenditure estimates, including which staff positions should be funded.

Two other GOE agencies have technical impact on the GOGCWS:

The Ministry of Health (MH) sets and enforces the drinking water standards with which GOGCWS must comply. In addition, MH maintains laboratories in the Governorates to monitor drinking water quality. MH reports violations of drinking water standards to the GOGCWS.

The Ministry of Public Works and Water Resources (MPWWR) is responsible for assuring the availability of suitable water to municipalities, industries, and for irrigation. The major concern of MPWWR is on irrigation, the largest user of water in Egypt. MPWWR also sets discharge standards to the Nile with which GOGCWS Water Treatment Plants must comply. More importantly, MPWWR standards protect the GOGCWS primary water source.

Other agencies active in the Egyptian water and wastewater sector may also affect GOGCWS, particularly those concerned with protecting the Nile River from discharges of industrial and sanitary wastes. These include:

- National Organization for Potable Water And Sanitary Drainage. (NOPWASD) is responsible for planning, designing, and constructing municipal water treatment and distribution systems and municipal wastewater collection and treatment systems throughout Egypt except in the service areas of Cairo, Alexandria, and the Suez Canal Authority (SCA) which provides potable water to the cities of Port Said, Ismailia, and Suez.

- Egyptian Environmental Affairs Agency (EEAA) reviews and recommends environmental laws; collects environmental data; and disseminates information about environment protection. EEAA is organizing a data collection program for Nile River water quality analyses. Other agencies currently monitoring the Nile River include the Academy of Scientific Research and Technology (ASRT), the Ministry of Health, the Nile River Institute in the MPWWR, and several small water utilities.

- General Organization For Industry (GOFI) in the Ministry of Industry manages over 300 government owned industrial facilities and about 200 major private industries throughout Egypt. Unfortunately GOFI has no authority to require compliance with the Ministry of Industry decree requiring all industrial facilities to install and operate pollution control equipment for waste discharges to the Nile River, canals, drains, etc.

Section 2: Data Collection and Analysis

Approach

The TSOM program relied on the following three sources of data to complete the Baseline Data Collection tasks:

- Historical data - primarily reports by other consultants
- Site visits to each facility
- Counterpart meetings and interviews

Historical Data

The GOGCWS library contains many volumes of recent studies and consultant reports. These reports were reviewed to develop an understanding of the GOGCWS from the perspective of previous consultants. The following reports were reviewed :

- *Water Master Plan*, ES Parsons, 1979
- *Network Operational Improvements, Final Report Volume 5*, JMM Engineers, Febrary 1986
- *Pilot Metering Program Supplemental Report*, JMM Engineers, October 1986
- *Draft Report for Review of Master Plan Appendices*, Sanyu Consultants, February 1986
- *Draft Report for Review of Master Plan Executive Summary*, Sanyu Consultants, February 1986
- *Study of Water Supply for City of Giza, Final Report Volume 2*, GKW Consultants, June 1987
- *Ameryia Water Treatment Plant Upgrading*, JICA, 1994

Historical data and record information, collected from many sources within the GOGCWS, has been incorporated into the Baseline Data Report. Proper reference and credit is provided as appropriate.

Site Visits

The TSOM program visited each water treatment plant and major network center to collect data. Much of the information for this report was obtained from the site visits and discussions with operating personnel at these facilities. A great deal of time was spent reconciling discrepancies in data.

Counterpart Meetings

Many meetings were held with GOGCWS counterparts during Phase 1 (July 1993 - June 1994) of the MTSS project. Counterparts have subsequently verified the accuracy of data in this report. The TSOM program will continue utilizing the counterparts as advisors to develop specific recommendations for improving O&M.

Most of the data contained in this section of the report applies to the technical branches of the organization: Waterworks Central Department, Networks Central Department and Projects Central Department and the facilities they design, operate and maintain.

Waterworks Central Department

Facilities

The Waterworks Central Department is responsible for water production and storage facilities as well as booster pump stations. Production facilities consist of water treatment plants and well fields. Storage facilities include elevated and ground level reservoirs.

Water Production

The GOGCWS operates and maintains 12 water treatment plants (WTPs) as shown in Figure 2-1. These plants range in size from the smallest plant, Maadi, having a capacity of 70,000 m^3/day, to the largest plant, Mostorod, which has a capacity of 770,000 m^3/day (at the end of 1994, the capacity will be 820,000 m^3/day). The raw water source for all WTPs is the Nile River or the Ismailia Canal which is fed by the Nile. These plants treat raw water by prechlorination, coagulation with aluminum sulfate (Al_2SO_4), followed by filtration and final disinfection with chlorine (Cl_2) prior to distribution. The WTPs have a combined design capacity of 3.6 million m^3 per day. In addition there are five groundwater production facilities which provide an additional 265 thousand m^3 per day of disinfected groundwater for potable use.

In an attempt to mitigate system leakage, the GOGCWS operates the overall system at a level of pressure below that generally employed by most water utilities and below recommended health and sanitation guidelines. The reduced pressure at which the system operates significantly restricts actual water delivery capability. Ironically, it is doubtful that this practice provides any benefit in reducing leakage or breakage of transmission or distribution pipes.

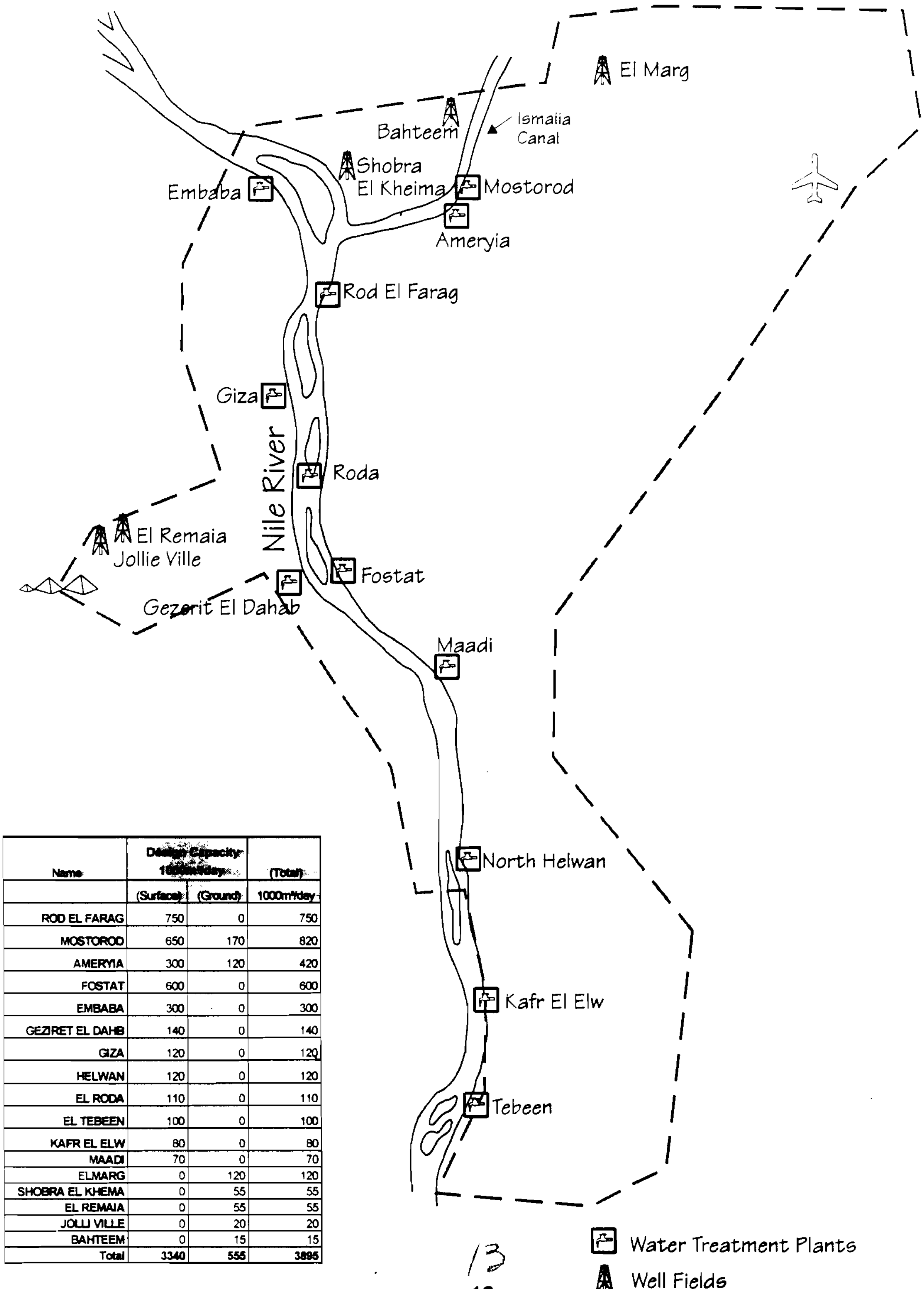
The WTPs and well fields are operated by a staff of 4324 personnel including 4266 who work on-site at the various plants to operate and maintain the facilities. The remainder are at GOGCWS Headquarters.

The absence of functioning meters for raw water requires operating personnel to use crude methods to estimate alum and prechlorination dosing. The alum dosage is determined by a daily jar test conducted in each WTP laboratory. Jar tests usually are more appropriate to verify the suitability of the chemical dosage, not to determine actual dosage amounts.

Although design capacity has been used as the basis for analysis in this report, a general deficiency in plant metering equipment exists at most of the WTPs. Roda WTP is the only plant with all meters in working order. The primary factors for this deficiency are poor preventive maintenance and a shortage of spare parts.

Preventive maintenance is generally deficient at the water treatment plants. There are two reasons for this: the absence of standard maintenance procedures and the lack of standardization of major equipment. The WTPs are very different in design due to the fact that they were generally constructed to meet the standards of foreign donors. Table 2-1 summarizes the country of origin for major equipment at GOGCWS WTPs. The size and age of these facilities vary considerably. Older treatment plants have obsolete equipment which is no longer manufactured and for which spare parts are no longer available. Much of the original equipment has been replaced with newer equipment, but of different design. This requires a large inventory of spare parts and space to warehouse them.

Figure 2.1
GOGCWS Water Production Facilities
1 March 1994



Name	Design Capacity 1000m³/day		(Total)
	(Surface)	(Ground)	1000m³/day
ROD EL FARAG	750	0	750
MOSTOROD	650	170	820
AMERYIA	300	120	420
FOSTAT	600	0	600
EMBABA	300	0	300
GEZIRET EL DAHB	140	0	140
GIZA	120	0	120
HELWAN	120	0	120
EL RODA	110	0	110
EL TEBEEN	100	0	100
KAFR EL ELW	80	0	80
MAADI	70	0	70
ELMARG	0	120	120
SHOBRA EL KHEMA	0	55	55
EL REMAIA	0	55	55
JOLLI VILLE	0	20	20
BAHTEEM	0	15	15
Total	3340	555	3895

Table 2.1: Country of Origin for Major Equipment

	Design Capacity 1000 m³/day	Source of Equipment								
Water Works		Czechoslovakia	Egypt	England	France	Germany	Japan	USA	other	Total
Toura El Asmant	not in service									
Shobra El Kheima	under construction				X					1
Maadi	70	X		X		X		X		4
Kafr El Elw	80			X	X					2
Helwan	120	X				X				2
Tebeen	100	X								1
El Giza	120		X	X		X	X			4
El Roda	110	X								1
Gezirhet El Dahab	215	X	X				X			3
Embaba	300				X				Austria	2
Ameryia	420	X	X				proposed		Austria	4
Fostat	600				X					1
Rod El Farag	750	X		X	X			X		4
Mostorod	835				X	X				2
Well Fields										
Bahteem	15					X		X		2
El Remaia	55					X		X		2
Jollie Ville	20					X		X		2
El Marg	120					X		X		2
Total	3930	7	3	4	6	8	3	6	2	

Water Storage
There are 51 reservoirs, both elevated and ground level, located throughout GOGCWS' service areas. The reservoirs range in size from 100 m^3 to 35,000 m^3 with a combined design capacity of 468,550 m^3. However, the effective storage capacity is less because many elevated reservoirs cannot be filled to their design capacity due to low system pressure. Current GOGCWS reservoir capacity represents about a three hour supply. Reservoir storage is deficient compared to recommended best practice of the water industry which prescribes a minimum six hours of balancing storage.

Operations
Each water treatment plant has a manager responsible for operation and maintenance. The plant manager is also responsible for the booster pumping stations and water storage reservoirs within the geographic area served by the plant. Each plant manager is on-site at the plant from 8 am until 3 pm Saturday through Thursday. After regular work hours, the plant is operated by senior employees on each shift. The plant manager is on call.

Each WTP manager is responsible for establishing plant-specific management procedures. As a result there is a wide variation in the operation and maintenance procedures used throughout the system. Each WTP manager reports to the Vice Chairman for Technical Affairs on a daily basis. Daily personal contact with such a large number of management personnel occupies a great deal of the Vice Chairman's time.

The WTPs operate continuously. Diesel power generators and reservoir storage maintain water service during short duration power outages.

Summary of Waterworks Data
Table 2-2, summarizes physical and operational data for each water production facility. The age of the plant and the nominal design capacity are included. Table 2.3 shows the status of effluent metering equipment. The meters are important because an accurate measurement of water production is required to determine appropriate chemical dosing. In-plant metering equipment at GOGCWS facilities is seriously deficient.

The GOGCWS service area is relatively flat with elevations ranging from 20 to 165 meters above sea level. Booster pumps provide service to the areas at the higher elevations Table 2-4 indicates the capacity of each booster pump station and the associated WTP which supplies it. The raw water booster pump stations are used for landscape irrigation and industrial water.

The GOGCWS contracts with Cairo Electric Distribution Center (CEDC) for electricity. The electric rate structure consists of a consumption charge, a power factor charge, and a reserve capacity charge. GOGCWS is paying a penalty for those facilities with a power factor less than 0.9 but could earn a bonus if the power factor is 0.95. The column titled capacitor KVAR lists the size needed to do this. Energy consumption has a major impact on operating cost. Restructuring the electric rate and optimizing the energy consumption at each facility are essential to economic operation. Low cost options to improve energy efficiency are being given top priority by the TSOM program. An example of a low cost option would be specifying high efficiency electric motors on future grant funded capital works projects.

Table 2.2 GOGCWS Water Production Facilities

WATERWORKS NAME	Governorate	Originally Built year	Upgrade / Expansion completed	Design Capacity $1000m^3$/day (Surfacewater)	Design Capacity $1000m^3$/day (Groundwater)	(Total) $1000m^3$/day	Water Production 1993 $1000m^3$/year	Number of Employees: Engineers	Number of Employees: Other	Primary Source of Equipment Country	Raw Water Pumps m^3 per hr	Influent Meters Number/Diameter	Sedimentation Tanks Number	Filters Number
ROD EL FARAG	Cairo	1903	1906, 1964 ,1987	750	0	750	284,136	25	775	USA	13@5000,3@6000	2@800,2@1000	16	110
MOSTOROD	Cairo	1977	1991, 1994	650	170	820	302,269	20	433	France	8@4320,4@4500, 2@6120	4@1200	16	60
AMERYIA	Cairo	1962		300	120	420	119,485	17	467	Czech	4@1980	2@1250	8	36
FOSTAT	Cairo	1989	note 1	600	0	600	135,418	14	392	France	8@5760	4@1600	12	72
EMBABA	Giza	1983	1986	300	0	300	114,560	11	228	France	8@5760	2@1200	8	36
GEZIRET EL DAHB	Giza	1973	1976	140	0	140	84,649	13	322	Czech	4@2160,4@990	2@1000	6	40
GIZA	Giza	1898	1939, 1952, 1959	120	0	120	48,193	12	289	England		3@800,1@1000	6	48
HELWAN	Cairo	1963		120	0	120	28,384	10	248	Czech- German	4@2160,4@990, 2@1080	none	7	34
EL RODA	Cairo	1968		110	0	110	51,187	10	323	Czech	4@3600,4@200	1@1000,1@800	3	20
EL TEBEEN	Cairo	1973		100	0	100	35,669	12	274	Czech-Japan	6@5760,1@5000	4@1200	8	12
KAFR EL ELW	Cairo	1923	1939, 1948,1967,1970	80	0	80	27,530	6	199	multiple	3@800,1@1500	1@600	6	24
MAADI	Cairo	1903	1955, 1960, 1966	70	0	70	28,793	4	162	English-Czech	2@2160,2@1440, 2@960	2@800,1@600	3	18
ELMARG	Cairo	1970	1982, 1988	0	120	120	16,986	1	73	Germany-USA	@216	none	none	none
SHOBRA EL KHEMA	Qalubiya	1972	note 2	0	55	55	2,687	none	102	Germany-USA	@216	none	none	none
EL REMAIA	Giza	1972		0	55	55	note 3	none	25	Germany-USA	@216	none	none	none
JOLLIE VILLE	Giza	1972	1993	0	20	20	note 3	none	15	Germany-USA	@216	none	none	none
BAHTEEM	Qalubiya	1989	1994	0	15	15	5,256	none	13	Germany-USA	@216	none	none	none

note 1: expansion to begin 1995

note 2: expansion began 1994 French supplied equipment

note 3: production figures included in Geziret El Dahab

BEST AVAILABLE DOCUMENT

Table 2.3: SUMMARY OF WATER TREATMENT PLANT PRODUCTION METERS

WATER WORKS FACILITY	1992 / 1993 (M m³/year)*	EFFLUENT METER present	EFFLUENT METER operational	SUBTOTAL (M m³/year)*	SUBTOTAL (Percent)
Rod El Farag	279	Y	Y		
Fostat	122	Y	Y		
Embaba	113	Y	Y		
El Marg	19	Y	Y	533	43%
Mostorod	278	Y	N		
Ameryia	118	Y	N		
Gezirhet El Dahab	104	Y	N		
Roda	53	Y	N		
Tebeen	35	Y	N	589	47%
Giza	49	N	N		
Helwan	29	N	N		
Kafr El Elw	28	N	N		
Maadi	21	N	N		
Shobra El Kheima	3	N	N		
Toura El Asmant (out of service)	0	N	N	129	10%
Total	1,251				

*millions m³ per year

Table 2.4: BOOSTER PUMP STATIONS

Sector	Water Treatment Plant	Booster Pump Station	Pumps	Capacity m³/hr	Head (meters)
NORTH & EAST	MOSTOROD	ZAYTOON	3	800	80
		NASR 1	5	540	100
		NASR 2	4	1080	100
		NASR 3	4	1080	100
		NASR 4	3	540	60
			3	540	100
		NASR 5	4	1440	90
	AMERYIA	WAFAA	2	216	80
		TAWFIK	2	216	80
		EL TOOB EL RAMLY	2	200	60
		ESTAD	4	270	45
		KATTAMIA	5	180	100
		TAGAMA	3	180	100
		EIN SHAMS	3	150	45
	ROD EL FARAG	AMN MARKAZI	1	180	100
		DARASSA	2	-270	45
			1	120	45
		TELAL ZEINHOM	2	150	70
			2	150	50
			1	120	45
		SAYEDA ZEINAB	3	858	42
		SAYEDA AISHA	3	1014	32
		EBAGAYIA	2	288	36
SOUTH & WEST	EL RODA	ABO EL SEOUD	4	900	50
		MADABEGH	4	500	60
			3	288	50
		AIN EL SERA	1	288	35
			2	212	30
		SALAH EL DIN	1	264	90
			1	288	75
		MOKATTAM	1	100	90
			1	200	90
			1	250	90
		ZABALEEN	2	120	63
		EL AMN EL MARKAZY	3	60	120
	MAADI	MWAZAFEEN 1	3	360	20
		MWAZAFEEN 2	2	54	28
	FOSTAT	ZAHRAA EL MAADI	8	2160	85
			4	1008	165
		ABO EWEKEL	5	2160	85
			2	1080	150

UNTREATED WATER PUMP STATIONS

NORTH & EAST	MOSTOROD	ALMAZA*	4		
	AMERIYA	KATTAMIA 1¹	3		
		KATTAMIA 2¹	3		
		TABBAT*	1		
		WAFAA 1*	na		
		WAFAA 2*	na		
SOUTH & WEST	MAADI	DIGLA*	na		
		ROAD 85*	na		
		Cairo American College*	na		

*landscape irrigation
1. industrial
na: not available

BEST AVAILABLE DOCUMENT

Table 2-5a and 2-5b list the kilowatts used by GOGCWS pump stations, well fields, and water treatment plants classified according to low voltage (380 volt) and high voltage (10.5, 6.6, and 3.3 kilovolt). Also listed is the power factor for each facility.

Table 2-6 summarizes pertinent data about each water reservoir. Total reservoir storage capacity is approximately 3 hours at average day demand, deficient when compared to an industry standard of 6 hours. In addition, elevated reservoirs cannot be filled to their design capacity due to low system pressure, further reducing storage capacity.

Table 2-7 summarizes the total water production for the previous three years. The production capability has been steadily expanded to keep pace with the increase in demand which is caused by both population growth and increased per capita consumption.

Table 2-8 provides a summary of operational statistics for each production facility, including the number of employees, water production, chemical usage and energy consumption. Reducing chemical consumption will lower the cost of water production. Use of Al_2SO_4 and Cl_2 can only be optimized by monitoring and adjusting the feed rate. Real time monitoring of the feed rate requires accurate metering of the plant flow. Many of the meters do not work and cannot be fixed due to a lack of spare parts. Standardization of metering equipment or local manufacture of spare parts might solve the problem, provided that in-house expertise can be developed to keep the metering equipment in working order.

Water Quality Standards
Drinking Water Standards (DWS) with which GOGCWS must comply were issued in January 1975 by the Ministry of Health (MH). The DWS list contains maximum upper limits for physical, inorganic, and radiological parameters, and defines bacteriological compliance standards as shown in Table 2-9.

GOGCWS routinely monitors water quality at its laboratories. Each WTP laboratory is equipped to perform bacteriological monitoring and wet chemical analysis. Some (e.g., Rod El Farag WTP) are equipped with an Atomic Absorption Spectrophotometer (AAS) for instrumental analyses of heavy metals. The new Central Laboratory at the Fostat WTP is equipped to perform instrumental analyses of metals and organics including pesticides, disinfection by-products (DBP) such as trihalomethanes (THM), and Volatile Organic Chemicals (VOC).

Water quality analyses are reported to the facility manager and to the GOGCWS' General Director for Laboratories and Research. Results are reviewed for compliance and summarized in monthly and annual reports. The MH also monitors compliance by collecting and analyzing samples in the GOGCWS service area. Non-compliance is also reported to the GOGCWS General Director for Laboratories and Research.

Figure 2.5a Low Voltage (380 v) Facilities

Location	Type	Kilowatts	Power Factor	Capacitor for PF=.95 [KVAR]
Abo El- Saoud	PS	382	0.86	95
Ain Esera	PS	68	0.89	12
Booster No.(4)	PS	520	0.86	140
El- Mowasafien El- Gedida Booster	PS	143	0.86	36
El- Sayeda Aisha	PS	218	0.91	21
El- Wafaa Wi El- Amal	PS	138	0.90	21
El- Zabaleen	PS	29	0.90	4
El-Amn Markazi	PS	69	0.86	17
El-Madabegh	PS	519	0.88	106
El-Mokattam	PS	77	0.85	23
Fom El- Khalig Plant	PS	80	0.79	35
Hunting Club	PS	372	0.83	130
Menshiet El- Bakry	PS	94	0.86	23
Menshiet El- Tawfik	PS	465	0.83	260
Salah El Din	PS	69	0.81	26
El- Marg El- Adeema	WF	69	0.84	21
El- Marg El- Gedida Well's (1)	WF	315	0.80	130
El- Marg El- Gedida Well's (2)	WF	109	0.73	59
El- Ramia Wells(El- Amirea)	WF	203	0.86	50
El-Jollie Ville	WF	130	0.82	48
Wash House Depot (Mostord)	WTP	274	0.85	71
(Rod El- Farag) Substation A	WTP	117	0.70	80
(Rod El- Farag) Substation C	WTP	282	0.80	113
Agriculture Transformer (Mostord)	WTP	390	0.80	155
Back Wash (North Helwan)	WTP	72	0.82	25
El- Bahr (North Helwan Raw Water)	WTP	163	0.83	55
El- Giza Plant	WTP	300	0.73	200
El- Maadi	WTP	55	0.66	45
El- Roda Plant	WTP	71	0.80	34
El- Tebeen	WTP	224	0.77	110
El-Diesel Transformer (Mostord)	WTP	364	0.83	120
Embaba	WTP	380	0.86	100
Geziret El-Dahab	WTP	765	0.80	300
Kafr El- Elw	WTP	84	0.80	35
Old Filtered Water (North Helwan)	WTP	61	0.84	17
Raw Water (Mostord)	WTP	615	0.80	250
Raw Water (Rod El- Farag)	WTP	426	0.82	156
Raw Water (Rod El- Farag)	WTP	424	0.82	156
REF North Plan Back Wash	WTP	205	0.85	57
Transformer No.(1)	WTP	237	0.82	95
Transformer No.(2)	WTP	not in service		
Transformer No.(3)(Mostord)	WTP	34	0.66	27
Transformer No.(4)(Mostord)	WTP	140	0.83	50
Transformer No.(5)(Mostord)	WTP	171	0.84	50

PS Pump Station
WF Well Field
WTP Water Treatment Plant

Table 2.5b (10.5, 6.6 & 3.3 kv) Facilities

Location	Type	Kilowatts	Power Factor	Capacitor for PF=.95 [KVAR]
15 - May	PS	1,440	0.85	420
Abo Awekail	PS	2,319	0.70	1,600
Abo El- Saoud	PS	648	0.78	300
El- Madabegh	PS	630	0.89	120
El- Warrak (Embaba)	PS	2,500	0.73	1,500
Nasr City (4)	PS	825	0.73	625
Nasr City Booster (1)	PS	1,802	0.67	850
Nasr City Booster (2)	PS	966	0.81	480
Nasr City Booster (3)	PS	960	0.80	400
Zahra El- Maadi	PS	1,582	0.85	500
El- Amiryia (North Cairo)	WTP	63,000	0.83	2,160
El- Giza	WTP	2,250	0.77	1,125
El- Maadi El- Gdida	WTP	1,260	0.64	1,100
El- Marg	WTP	720	0.76	380
El- Roda	WTP	4,096	0.85	1,200
El- Tebeen	WTP	5,914	0.80	2,500
El-Amiryia	WTP	1,120	0.74	650
El-Fostat	WTP	5,487	0.80	2,310
El-Fostat	WTP	2,100	0.78	1,000
Gezerit El-Dahab	WTP	2,880	0.80	1,200
Kafr El- Elw	WTP	1,980	0.81	780
Mostorad	WTP	7,296	0.85	2,120
Mostorad	WTP	4,560	0.81	1,920
North Helwan	WTP	2,275	0.83	780
Rod El- Farag	WTP	8,962	0.83	3,000

PS Pump Station
WTP Water Treatment Plant

TABLE 2.6 GOGCWS RESERVOIRS

Sector	Responsible for O&M	Name	Location	Capacity m³	Source of Water
North & East	Ameryia	Zaitoon*	Suez Road	1200	Ameryia
		Zaitoon*	Suez Road	1800	Ameryia
		Zaitoon*	Suez Road	2400	Ameryia
		Nasr City No. 1	Nasr City	15000	Ameryia, Mostorod
		Nasr City No. 2	Nasr City	5000	Mostorod
		Nasr City No. 3	Nasr City	15000	Mostorod
		Nasr City No. 4	9th District	5000	Mostorod, Fustat
		Nasr City No. 5	10th District	5000	Mostorod, Fustat
		Nasr City No. 6	11th District	5000	Mostorod, Fustat
	El Salam Network	El Salam City 1	Cairo North	5,000	Mostorod, El Marg
		El Salam City 2	Cairo North	5,000	Mostorod, El Marg
		El Salam City 3	Cairo North	5,000	Mostorod, El Marg
	Mostorod	New Almaza 5	Heliopolis	14,000	Ameryia, Mostorod
		Old Almaza 1	Heliopolis	300	Ameryia, Mostorod
		Old Almaza 2	Heliopolis	5,000	Ameryia, Mostorod
		Old Almaza 3	Heliopolis	10,000	Ameryia, Mostorod
		Old Almaza 4	Heliopolis	5,000	Ameryia, Mostorod
		Sheraton	Heliopolis	14,000	Mostorod
		Sheraton	Heliopolis	5,000	Mostorod
		Wadi Leblaba 1	Nasr City	2,000	Ameryia, Mostorod
		Wadi Leblaba 2	Nasr City	1,000	Ameryia, Mostorod
	Rod El Farag	Bahteem	Shoubra El Khema	5,000	Mostorod & Bahteem
		Darassa #1	Darassa	35,000	Rod El Farag
		Darassa #2	Darassa	35,000	Rod El Farag
		Darassa #3	Darassa	35,000	Rod El Farag
		Abassayia	Abassayia	35,000	Rod El Farag
		Gabal Ahmar*	Cairo Central	20,000	Rod El Farag, Ameryia, Fostat
		Kalaat El Kabsh	Cairo South	15,000	Rod El Farag
		Salah El Din	Cairo South	20,000	Rod El Farag
		Sayeda Zeinab	Cairo South	20,000	Rod El Farag
		Shoubra El Kheima*	Shoubra El Kheima	100	Shoubra El Kheima
		Telal Zeinhum*	Cairo South	250	Rod El Farag
South & West	Embaba	Boulak El-Dakrour*	Boulak	10,000	Embaba
		Embaba No.1	Embaba	1,000	Embaba
		Embaba No.2*	Kit Kat	10,000	Embaba
	Gezerit El Dahab	Pyramids No.1	Giza	5,000	Jollie Ville & El-Ramaia
		Pyramids No.2*	Giza	8,000	Jollie Ville & El-Ramaia
	Maadi	El Bassateen*		150	Maadi
		Maadi	Maadi WTP	700	Maadi
		New Maadi		15,000	Maadi
	North Helwan	Helwan 1	Helwan	750	Fostat, North Helwan
		Helwan 2	Helwan	2,700	Fostat, North Helwan
		Helwan 3	Helwan	4,200	Fostat, North Helwan
		Helwan 4	Helwan	4,200	Fostat, North Helwan
		Hadaek Helwan		10,000	Fostat, North Helwan
		Helwan New Community	Helwan	5,000	North Helwan
		Wadi Hof	Helwan	3,500	North Helwan
		Wadi Hof	Helwan	3,500	North Helwan
	Roda	Mokattam No.1	Cairo South	18,000	Roda
		Mokattam No.2	Cairo South	9,000	Roda
		Mokattam No.3	Cairo South	5,000	Roda
		Mokattam No.4*	Cairo South	500	Roda
		Mokattam No.5	Cairo South	10,000	Roda
	Tebeen	Military Factory	Helwan	700	Tebeen
TOTAL =	10	54		473,950	

* = not in service

data sources:

1/ "Network Operational Improvements Final Report", Volume 5
JMM, Assistance In Upgrading Services (USAID Project 263-0038) Feb. 1986

2/ "Rod El Farag Distribution System, East Bank Water System Master Plan Update", Volume 1
CH2M-Hill, (USAID Grant 263-0102), 1990

3/ site visits and interviews with WTP Managers

Table 2.7: GOGCWS Water Production for the Past Three Years (m^3)

WATER WORKS FACILITY	Design Capacity m^3 per day	1990/91 Total	1990/91 Average Daily Production	1991/92 Total	1991/92 Average Daily Production	1992/93 Total	1992/93 Average Daily Production
MOSTOROD	820,000	246,927,850	676,515	275,282,550	754,199	278,216,350	762,237
ROD EL FARAG	750,000	253,676,190	695,003	258,481,800	708,169	275,999,400	756,163
FOSTAT	600,000	62,536,840	171,334	86,842,880	237,926	121,561,100	333,044
AMERYIA	420,000	125,877,800	344,871	118,687,770	325,172	118,083,030	323,515
EMBABA	300,000	115,450,760	316,303	113,483,860	310,915	113,203,100	310,145
GEZIRET EL DAHAB	140,000	78,012,730	213,734	84,232,040	230,773	80,742,850	221,213
NORTH HELWAN	120,000	36,083,920	98,860	29,967,930	82,104	28,715,560	78,673
GIZA	120,000	43,890,520	120,248	45,684,130	125,162	48,782,600	133,651
EL MARG	120,000	23,038,610	63,119	15,850,840	43,427	19,000,700	52,057
RODA	110,000	63,899,420	175,067	60,827,370	166,650	52,930,830	145,016
TEBEEN	100,000	29,472,210	80,746	36,965,290	101,275	35,478,660	97,202
KAFR EL ELW	80,000	28,343,140	77,652	27,153,100	74,392	27,778,920	76,107
MAADI	70,000	15,464,500	42,368	20,867,600	57,172	20,867,000	57,170
SHOBRA EL KHEIMA	55,000	5,166,200	14,154	3,707,750	10,158	2,537,900	6,953
EL REMAIA	55,000	11,716,600	32,100	13,176,200	36,099	19,256,450	52,757
JOLLIE VILLE	20,000	5,123,630	14,037	3,966,150	10,866	4,354,500	11,930
BAHTEEM	15,000	3,499,000	9,586	3,498,800	9,586	3,490,000	9,562
TOURA EL ASMENT*	0	750,140	2,055	810,660	2,221	190,390	522
TOTAL	3,895,000	1,148,930,060	3,147,754	1,199,486,720	3,286,265	1,251,189,340	3,427,916
Average Daily Production (million m^3/day)	**3.90**		**3.15**		**3.29**		**3.43**

*Toura El Asment ceased production in 1993

Table 2.8: WATERWORKS 1992/1993 Statistics

Name	Number of Employees	Production m³/year	Production m³ / Employee	Energy kwh	CL2 1000 kg	AL2SO4 1000 kg	Energy kwh/1000m³	CL2 ppm	AL2SO4 ppm
Mostorod	453	278,216,350	1683	74,255,196	2,015	15,523	267	7	28
Rod El Farag	800	275,999,400	945	13,661,800	1,794	17,477	49	7	32
Fostat	406	121,561,100	820	62,526,770	825	9,559	514	7	39
Ameryia	484	118,083,030	668	22,776,450	773	6,509	193	7	28
Embaba	239	113,203,100	1298	27,854,209	723	7,250	246	6	32
Geziret El Dahab	335	80,742,850	660	20,692,192	570	4,904	256	7	30
North Helwan	258	28,715,560	305	37,806,395	314	1,312	1,317	11	23
Giza	301	48,782,600	444	8,657,158	563	4,418	177	12	45
El Marg	74	19,000,700	703	5,984,560	17	note 1	315	1	note 1
Roda	333	52,930,830	435	20,744,257	413	3,122	392	8	29
Tebeen	286	35,478,660	340	30,377,784	347	4,185	856	10	59
Kafr El Elw	205	27,778,920	371	12,948,252	167	1,810	466	6	33
Maadi	166	20,867,000	344	7,298,378	180	214	350	9	5
Shobra El Kheima	102	2,537,900	68	2,908,568	13	note 1	1,146	5	note 1
El Remaia	25	19,256,450	2110	3,212,800	18	note 1	167	1	note 1
Jolli Ville	15	4,354,500	795	1,005,730		note 1	231	0	note 1
Bahteem	15	3,490,000	637	1,168,200	21	note 1	335	6	note 1
TOTAL / AVERAGE	4,497	1,250,998,950	762	353,878,699	8,753	76,282	7,278		
*Toura El Asmant ceased operations		190,390							

note 1: no aluminum sulphate used at well fields

TABLE 2.9: GOVERNMENT OF EGYPT DRINKING WATER STANDARDS

(Issued by the Ministry of Health in January 1975)

	PARAMETER	SYMBOL	MAXIMUM UPPER LIMIT	UNITS
PHYSICAL QUALITY	Color (mg/L Platinum)		50	mg/L
	Turbidity		JTU = Jackson Turbidity Units	
	Surface Water		5	JTU
	Ground water		25	JTU
	Taste		Acceptable	
	Odour		Absent	
INORGANIC CHEMICAL QUALITY	Lead	Pb	0.1	mg/L
	Arsenic	As	0.05	mg/L
	Cyanide	CN	0.05	mg/L
	Fluoride	F	0.8	mg/L
	Nitrate	NO3	45	mg/L
	Total Dissolved Solids	TDS	1500	mg/L
	Iron	Fe	1	mg/L
	Manganese	Mn	0.5	mg/L
	Copper	Cu	1.5	mg/L
	Zinc	Zn	15	mg/L
	Magnesium	Mg	150	mg/L
	Calcium	Ca	200	mg/L
	Total hardness		500	mg/L
	Sulfates	SO4	400	mg/L
	Chlorides	Cl	600	mg/L
	Phenols		0.002	mg/L
	pH		6.2-9.0	
	Cadmium	Cd	0.01	mg/L
	Mercury	Hg	0.001	mg/L
	Selenium	Se	0.01	mg/L
RADIOLOGICAL QUALITY	Gross Alpha Activity		3	pico Curies/Liter
	Gross Beta Activity		30	pico Curies/Liter

Bacteriological compliance standards for treated surface water supplies & untreated groundwater supplies

1. No sample shall show more than 10 coliform organisms /100 ml.
2. 95% of all samples collected during the previous yearly period shall be free of total coliform organisms.
3. All samples collected shall be free of fecal coliform organisms.
4. Coliform organisms shall not be detectable in any two consecutive samples.

Networks Central Department

Facilities

The GOGCWS operates and maintains a water distribution system consisting of over 3,500 kilometers of pipe, 50,000 valves and 500,000 service connections.

Operations

The network is operated and maintained by the GOGCWS Network Central Department located in Ain El Sera and divided into three General Departments and four Departments:

General Departments:

- O & M South and West Network General Department
- O & M North and East Network General Department
- Network Services General Department

Departments:

- Meters and Leakage Department
- Customers Department
- Networks Secretariat Department
- Engineering Drawing Department

The network consists of 21 service areas covering an area of about 911km^2 as shown on Figure 2-2. Table 2-10 lists the number of pipe repair, valve turning, and meter repair crews for each service area.

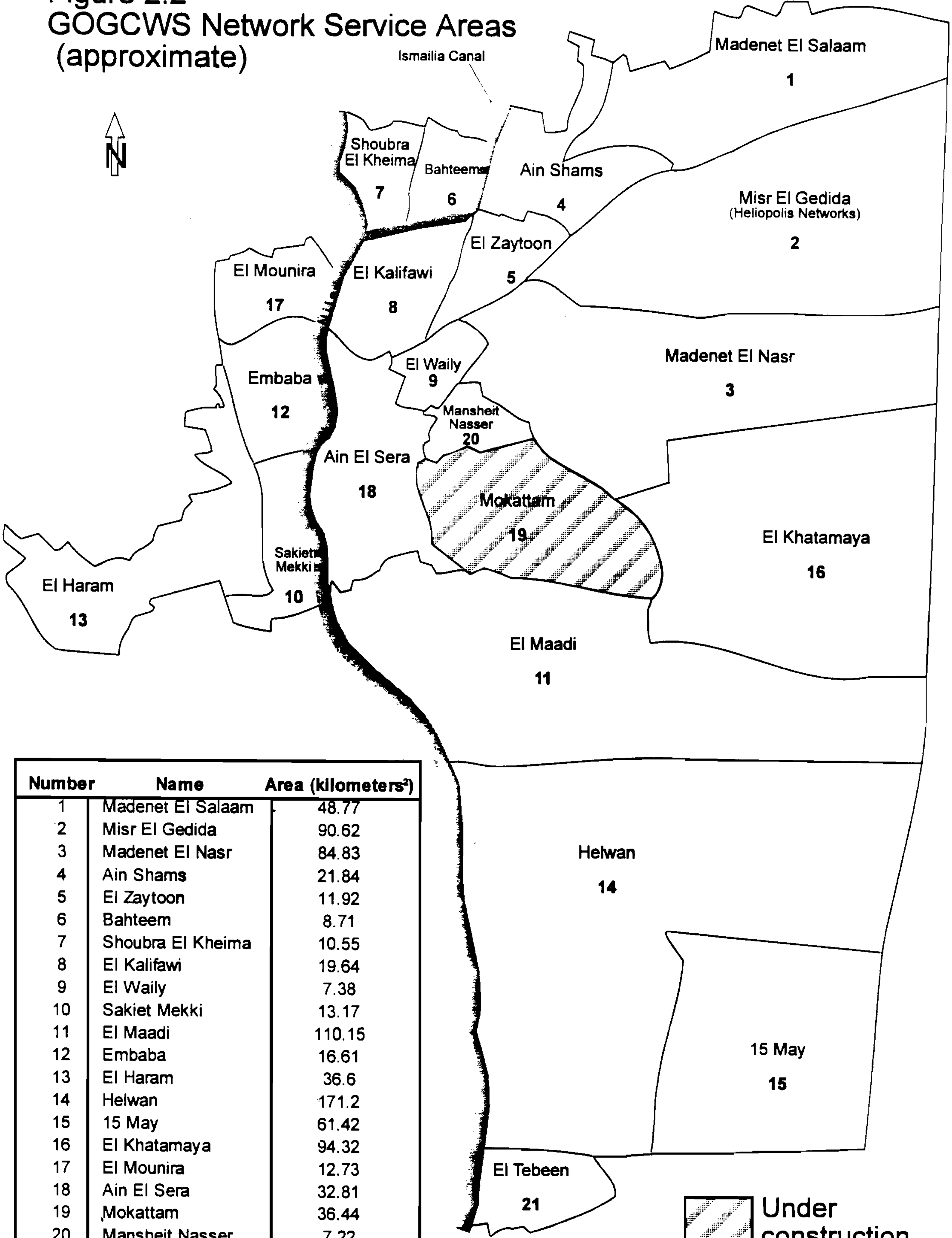
Twenty service areas are controlled by the O&M General Departments. The Misr El Gedida service area is controlled by the Heliopolis Networks General Department which is separate from the Networks Central Department. As the network is expanding, five new service areas will be organized and constructed as follows:

- Boulak Abou El Ela
- El Zawia El Hamra
- El Basateen
- El Marg
- Hadabat El Haram

Network operation and maintenance centers (MC) are located in each service area with the following exceptions:

- Ain Shams is located in Zaytoon
- El Kattamia is located in Helwan
- El Mounira is located in Embaba
- Mokattam is located in Ain El Sera

Figure 2.2
GOGCWS Network Service Areas
(approximate)



Number	Name	Area (kilometers²)
1	Madenet El Salaam	48.77
2	Misr El Gedida	90.62
3	Madenet El Nasr	84.83
4	Ain Shams	21.84
5	El Zaytoon	11.92
6	Bahteem	8.71
7	Shoubra El Kheima	10.55
8	El Kalifawi	19.64
9	El Waily	7.38
10	Sakiet Mekki	13.17
11	El Maadi	110.15
12	Embaba	16.61
13	El Haram	36.6
14	Helwan	171.2
15	15 May	61.42
16	El Khatamaya	94.32
17	El Mounira	12.73
18	Ain El Sera	32.81
19	Mokattam	36.44
20	Mansheit Nasser	7.22
21	El Tebeen	13.95

Total: 911km²

Table 2-10: GOGCWS Service Areas

Number	Service Area	Area (km²)	Pipe Repair Crews	Valve Turning Crews	Meter Repair Crews
1	Madenet El Salaam	48.77	5	4	
2	Misr El Gedida	90.62	not available	not available	
3	Madenet El Nasr	84.83	12	3	
4	Ain Shams	21.84	11	3	
5	El Zaytoon	11.92	12	3	2
6	Bahteem	8.71	7	3	
7	Shoubra El Kheima	10.55	9	3	2
8	El Kalifawi	19.64	43	6	2
9	El Waily	7.38	10	3	1
10	Sakiet Mekki	13.17	7	3	
11	El Maadi	110.15	10	3	
12	Embaba	16.61	20	3	2
13	El Haram	36.6	23	3	1
14	Helwan	171.2	20	3	
15	15 May	61.42	2	3	
16	El Khatamaya	94.32	1		
17	El Moneera	12.73	5		2
18	Ain El Sera	32.81	27	3	1
19	Mokattam*	36.44	note 1		
20	Mansheit Nasser	7.22	12	3	
21	El Tebeen	13.95	2	2	
	Totals	*910.88*	238	54	13

* under construction

note 1: Totals included in other maintenance centers

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The MCs operate 24 hours per day. After regular work hours (8:00 am to 2:00 pm), there is one valve crew and one pipe break crew per MC for emergency repairs. Each network operation and maintenance center has a drafting room where detailed maps are stored. These maps show:

- Street names
- Pipe materials, diameter, and joints
- Fire hydrant locations
- Valve types and sizes
- Domestic and commercial connections

There are limited working copies of these maps. Originals are not archived. All of the network maps require updating to show locations of new connections and the current status of valves. One important task identified by the TSOM program is the updating and preserving of information contained on these maps. GOGCWS needs a comprehensive program for maps and mapping. There are at least two mapping related efforts currently in progress, one by CH2M-Hill on the Incremental Pressure Increase Program (IPI) financed under the Cairo Water II project and the other by the Greater Cairo Utility Data Center (GCUDC).

The IPI program is a sub-task of the Cairo Water Supply II Construction Management Contract (USAID Grant No. 263-0193). The boundaries for the project area are restricted to the central 63M zone on the east bank of the Nile. IPI is assisting and training GOGCWS in developing an incremental pressure increase program with the related tasks of leak detection, pipeline repair, hydraulic analysis and mapping A special emphasis is placed on training the GOGCWS in the use of computers for mapping.

An important deliverable of the IPI project is 1000 scale A3 size maps showing valve and pipe locations with inventory tables containing valve type and status data. These maps will be used by GOGCWS to develop and improve valve and pipe inventory control and maintenance.

The Greater Cairo Utility Data Center (GCUDC) is a public institution within the Cairo Governorate. It was established in 1988 by a bilateral grant from Finland to provide accurate maps of installed underground utilities. The maps are available to anyone who requires information on the location of these facilities. The GOGCWS pays an annual fee of LE 200,000 for access to these maps. In addition, the GOGCWS provides information to the GCUDC on changes and additions to its underground installations.

Stores and Warehouses
Each network operation and maintenance center (MC) has its own store, except:

Ain Shams MC is served by El Zaytoon MC
15 May MC is served by Helwan MC
Mounira MC is served by Embaba MC
Mokattam MC is served by Ain El Sera MC

Networks stores are replenished from Kallett El Kabsh General Store. Tools and equipment are plumbing tools, electric welding machines, compressors, long bed trucks, excavators, and dump trucks.

Network Leakage

Network service crews respond to about 380 main breaks or other significant leaks per day. The GOGCWS deploys a full time work force of 3455 personnel dedicated to emergency repairs. There is minimal regularly scheduled maintenance.

Current GOGCWS policy is to repair any break on the service lateral up to the meter, which is generally located on private property of the consumer. The GOGCWS is authorized to collect fees for these repairs from consumers. Review of financial data indicates the cost of the repairs is not fully recovered by the GOGCWS.

Finally, the low pressure at which the system is operated may compromise the system integrity from a health standpoint. Low system pressures can potentially allow inflow and infiltration from contaminated sources such as domestic wells. The widespread practice of turning off the water in multi-story office buildings also represents a potential for serious adverse health effects. Ironically, this practice is followed at the GOGCWS Headquarters Building.

Summary of Networks Data

Table 2-11 summarizes the quantity of pipe in the GOGCWS network. The pipe is categorized by diameter as follows:

- Transmission- 1000 mm or greater
- Main- 400-900 mm
- Distribution- 100-300 mm

Current GOGCWS record information indicates that there are 3500 kilometers of pipe in the system. This amount of pipe represents a very large infrastructure by any world standard. However, a water master plan prepared by James M. Montgomery Consulting Engineers in 1986 reported 3800 km of pipe in the system.

This apparent discrepancy in the total length of pipe in the system illustrates one of the persistent problems of the organization, that of poor or inaccurate record information.The TSOM program has formulated plans to strengthen this particular aspect of GOGCWS record keeping. Accurate, maps are needed to form the basis for preventive maintenance programs such as gate valve exercise, water main flushing and water main dewatering.

Table 2-12 summarizes the main and service lateral breaks, meter washing, and valve repairs throughout the system for the fiscal year 1992-93. Figure 2-3 illustrates a typical service lateral connection and meter.

Table 2-13 represents the baseline condition of customer water meters. The GOGCWS has approximately 500,000 service connections. According to the Water Meter Department, 412,523 of these connections are metered but only 232,637, or approximately 56%, are in working order.

Table 2.10: GOGCWS Network Summary

Type	Diameter mm	Length km	Percent	Total Length per Type	Total % per Type
Transmission	1600	8	0.23%	165	4.7%
	1400	17	0.49%		
	1200	65	2%		
	1000	75	2%		
Main	900	20	1%	435	12.4%
	800	90	3%		
	700	70	2%		
	600	80	2%		
	500	90	3%		
	400	85	2%		
Distribution	300	300	9%	2900	82.9%
	250	150	4%		
	200	150	4%		
	150	800	23%		
	100	1500	43%		
	Total	3500			

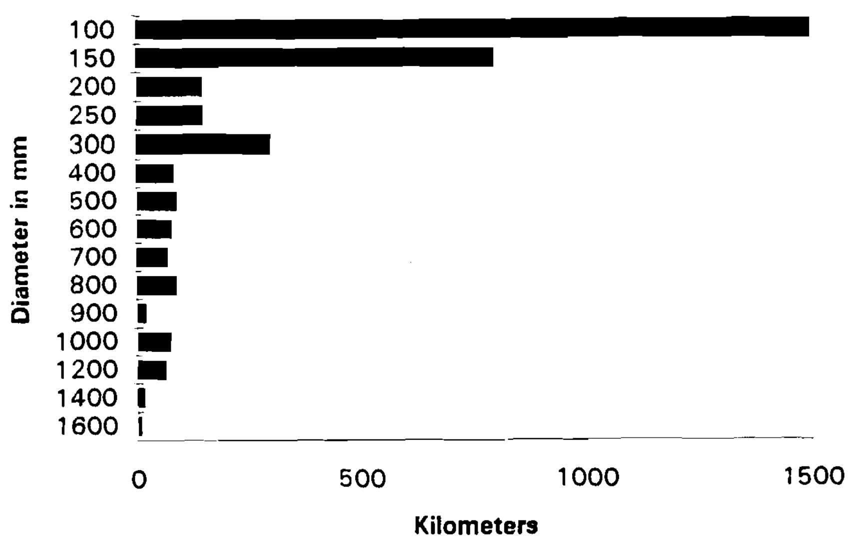


Table 2.12: Network Maintenance Activities FY 1992-93

Network Center	Meter Cleaning	Service Laterals	Repairs 100mm to 300mm (distribution pipe)	Repairs 400mm to 800mm (main pipe)	Repairs 1000mm and Above (transmission)	Valves Repaired	Total Repairs
AIN EL SERA	54	20,970	1,725	80	11	1,005	23,845
EL WAILY	210	7,208	1,407	326	0	297	9,448
EMBABA	39	7,238	1,344	42	0	3,897	12,560
EL HARAM	35	7,623	4,822	109	0	1,434	14,023
SAKIET MEKKI	209	1,691	691	4	0	1,211	3,806
EL MAADI	103	2,244	1,839	8	0	555	4,749
HELWAN	0	5,270	3,841	37	0	2,794	11,942
ZAITOON	2	5,305	1,464	17	2	519	7,309
EL SALAM	0	1,872	902	17	0	1,226	4,017
EL KHALAFAWI	32	14,174	6,948	510	90	2,387	24,141
NASR CITY	0	3,649	963	56	0	553	5,221
SHOBRA EL KHEMA	0	2,436	0	0	0	412	2,848
EL TEBEEN	1	741	542	30	0	236	1,550
BAHTEEM	1	606	655	9	0	311	1,582
AIN SHAMS	21	8,102	2,806	50	3	534	11,516
MANSHIET NASER	13	1,534	1,360	29	0	515	3,451
TOTAL/YEAR	720	90,663	31,309	1,324	106	17,886	142,008
*AVERAGE PER DAY**	2	248	86	4	<1	49	389

* 365 days

Figure 2.3
Typical GOGCWS Service Connection

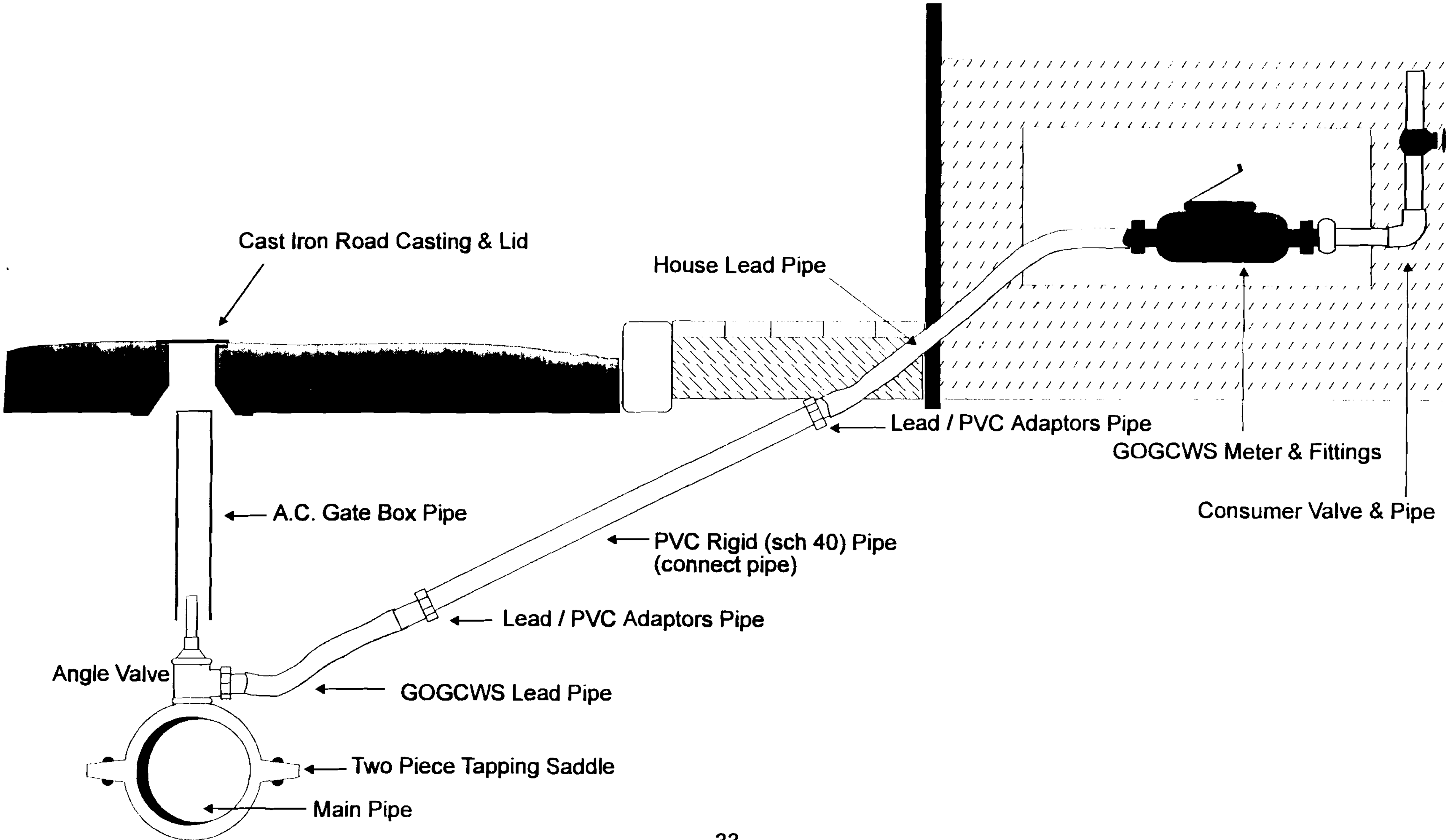
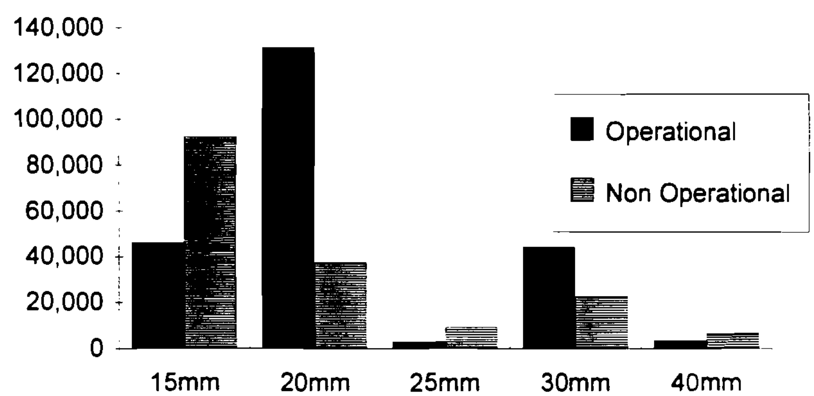
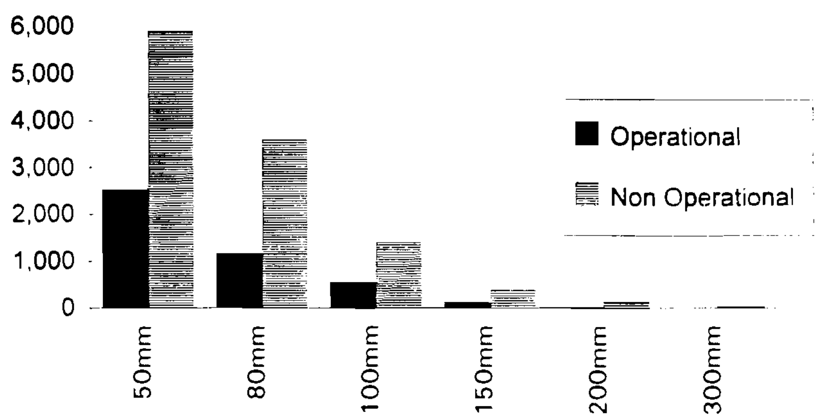


Table 2.13: Water Meter Status 1994

Diameter	Operational	Non Operational	Total	Percentage of Total
15mm	46,355	92,529	138,884	34%
20mm	131,281	37,511	168,792	41%
25mm	2,977	9,151	12,128	3%
30mm	44,139	22,562	66,701	16%
40mm	3,488	6,696	10,184	2%
50mm	2,538	5,901	8,439	2%
80mm	1,161	3,594	4,755	1%
100mm	559	1,410	1,969	0.48%
150mm	120	375	495	0.12%
200mm	18	127	145	0.04%
300mm	1	30	31	0.01%
Totals	232,637	179,886	412,523	100%





The meters do not work for a number of reasons. Some of them are old and worn to the point where they no longer register: some have been damaged by external forces; and some are clogged with debris from the water mains which are frequently broken and improperly repaired. Many meters are of inferior quality. Since there are no national or local standards. GOGCWS must set standards for meters and enforce them with meter testing prior to installation.

Over seventy percent of the meters for large customer do not work properly. These meters represent large volume commercial and industrial accounts. Top priority should be placed on the repair or replacement of these meters. Accurate metering of large accounts will provide information needed for equitable cost recovery.

Metering of all customer classes is not always necessary to equitably distribute the cost of service. For the smaller services, a flat monthly charge based on the size of the connection or estimated water consumption could be utilized. This method is simpler and less costly because there would be no capital or O&M expense for meters. Other methods can be utilized to apportion the costs in accordance with ability to pay. For example, a higher flat rate or higher metered rate could be applied to all businesses or to all buildings which have telephone service or high electricity consumption on the assumption that these customers can afford to pay higher rates.

Table 2-14 indicates that 2711 new metered connections, both domestic and commercial, were installed by GOGCWS during a recent four month period (January - April 1994). This represents a projected growth rate of more than 8100 new connections per year, or less than 2% based on the current number of services. The cost of a new service connection with meter, ranges from L.E.104 for a 15 mm meter to L.E.2056 for a 50 mm meter. The cost for larger service connections includes materials and labor.

There are a large number of illegal connections in the GOGCWS service area. Illegal connections add demand to the system without providing revenues. The magnitude of the problem cannot be quantified at this time, but some estimates are as high as 200,000 illegal or unregistered connections.

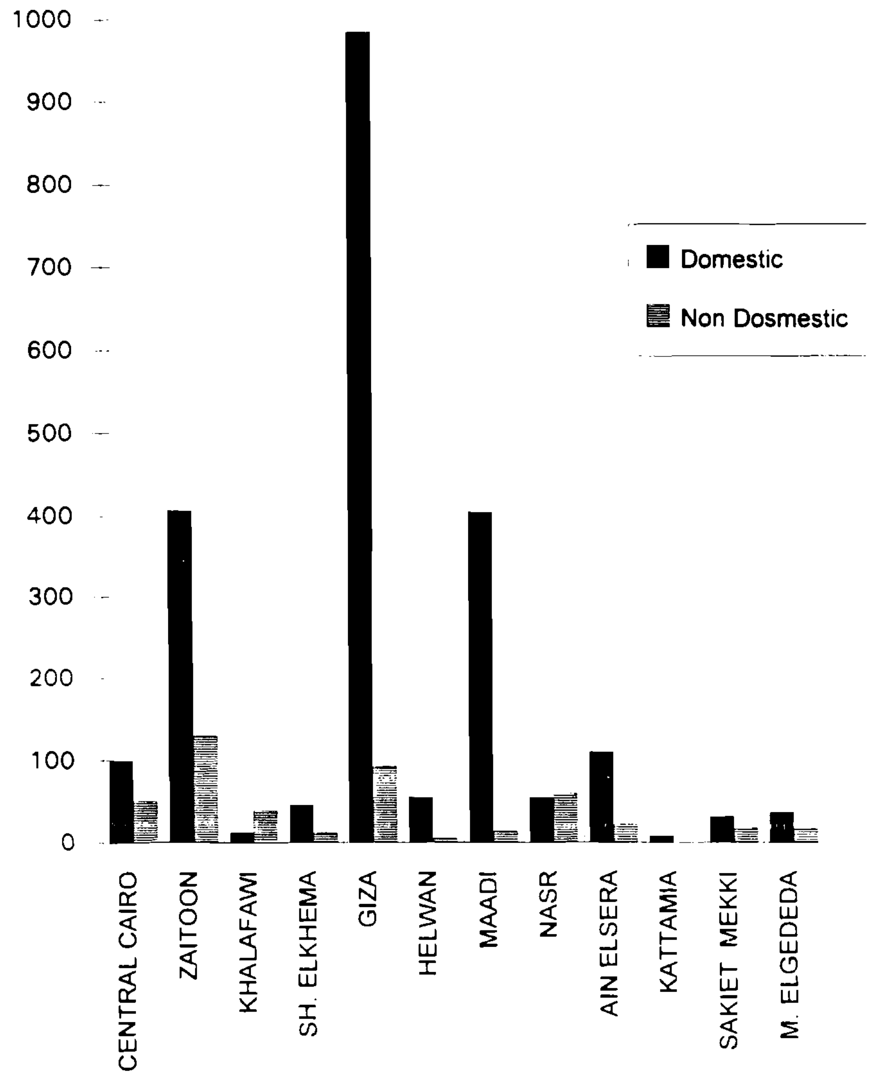
It is apparent from the information in Table 2-14 that the areas of highest growth are Giza, Zaytoon, and Maadi, and that the older parts of the network such as Khalafawi are relatively stable. This demonstrates that growth continues on the periphery of the system.

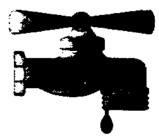
Table 2-15 lists by zone the number of public taps and water used. Public taps are installed at the request of the Government of Egypt District Chief. The Networks Central Department is responsible for inspection and maintenance. These taps have no meters and no lock so the water used is estimated.

On 22 February 1994, GOGCWS Chairman Saad El Deeb issued decree number 25 creating the GOGCWS Networks Valve Renovation and Maintenance work section and assigning four engineers to locate, inspect exercise and document valves greater than 400mm on transmission and main pipelines. These engineers, assisted by a crew of six people, began work in Kalifawi, El Waily and El Zaytoon service areas. Future plans are to expand this work unit to provide coverage to the entire GOGCWS network system.

Table 2.14: NEW CONNECTIONS 1/1/94-30/4/94

District	Domestic	Non Domestic	Total
CENTRAL CAIRO	99	51	150
ZAITOON	407	130	537
KHALAFAWI	12	39	51
SH. ELKHEMA	46	12	58
GIZA	985	92	1077
HELWAN	55	5	60
MAADI	405	14	419
NASR	55	60	115
AIN ELSERA	110	22	132
KATTAMIA	8	0	8
SAKIET MEKKI	32	18	50
M. ELGEDEDA	37	17	54
TOTAL	2251	460	2711





Governorate	Zone Name	Number of Taps	Water Used m³
Qalubaya	Shoubra El Kheima	24	15,600
	Bahteem	15	3,000
Giza	Geziret El Dahab	10	118,700
	Nazlet El Sammam (El Haram)	12	8,400
	Dokki, Agouza	35	29,600
	Embaba	19	7,000
	Mounira	6	2,180
Cairo	Maadi & Old Cairo	64	22,939
	Boulaq & Sabtia	28	66,400
	Abdeen	21	18,600
	Abbassayia	41	47,841
	Waily	25	24,100
	Manshiet Nasser	50	48,105
	Kobba	8	6,500
	Sharabia	33	9,332
	Nasr City	7	6,900
	Rod El Farag	6	8,467
	El Sayeda Zeinab	76	72,178
Totals		480	515,842

Table 2.15 GOGCWS Public Water Taps

Projects Central Department

The GOGCWS Projects Central Department is responsible for design and construction management of a) all capital works projects which involve pipelines of 600 mm diameter or greater and b) all new WTP projects.

The capital works budget for 1992-93 of L.E.105,563,000 ($31,417,560) was managed by the Projects Central Department. This work is funded by the State budget through the Ministry of Planning. Specific capital works projects are funded by foreign grants such as those administered by the United States Agency for International Development (USAID) and similar agencies from other nations. Table 2-16 lists proposed water treatment improvements for which the GOGCWS will seek foreign funding and Table 2-17 lists major projects funded by foreign donors.

Most of the capital works for the GOGCWS is paid for by foreign grants and as a result, high profile projects receive the most attention and the most money. The infrastructure, including the water distribution system, is largely neglected due to a lack of capital needed to replace much of the old and dilapidated pipe throughout the system. This type of capital investment must be championed by some part of the GOGCWS. This would appear to be the role of the Projects Central Department and organizational support will be needed to promote this concept.

The Projects Central Department has a total of 166 employees. This includes 77 engineers, 48 technicians, 15 draftsman, 14 clerks and 12 drivers.

Table 2-16: Proposed Water Treatment Plant Expansions & Constructions
(Funding source to be determined)

Water Treatment Plant	Proposed	Size (1000 m^3/d)
Rod El Farag	Partial Rehabilitation	200
Tebeen	Expansion	200
Embaba	Expansion	200
Kafr El Elw	Expansion	400
El Khosos	Construct	800
Zahraa El Maadi	Construct	900
Shobra El Kheima	Expansion	400
Ameryia	Expansion	200

Table 2-17: Foreign Funded Projects for GOGCWS
(in progress or planned 1992-1997)

No	Source of Funds	Project	Sum	Type	Description
1	France	Expansion of Fostat WTP	FF90 million	Loan	Supply and installation of mechanical and electrical equipment for 300,000 m^3/d
2	France	Construction of Shobra El Kheima WTP	NA	NA	Phase 1-200,000 m^3/d WTP treating Nile River Water
3	France	Expansion of Mostorod WTP	US$10 million	Loan	Supply and installation of mechanical and electrical equipment for 200,000 m^3/d
4	France	South Giza WTP Expansion	FF70 million	Loan	Supply and installation of mechanical and electrical equipment for a 200,000 m^3/d
5	France	Leak Detection	FF5 million	Grant	Pilot project to test French leak detection equipment
6	France	Expansion of Embaba WTP	FF100 million	Loan	Supply and installation of mechanical and electrical equipment for 400,000 m^3/d
7	Italy	Information (SCADA) Monitoring Center	14,800 million Lira	Grant	Installation of a SCADA system (Second Phase)
8	Japan	South Giza WTP Expansion (note 1)	2.3 billion yen	Grant	Increase WTP by 35,000 m^3/d and distribution piping
9	Japan	Rehabilitation and upgrading of Ameryia WTP	NA	Grant	Civil works, mechanical and electrical equipment for 375,000 m3/d
10	USAID	Distribution System Upgrade	US$110 million	Grant	Improvement of the distribution piping and construction of distribution reservoirs in the Rod El Farag service area.
11	USAID	Institutional Development	US$35 million	Grant	Financial viability and managerial autonomy for the GOGCWS
12	USAID	Central Water Quality Laboratory	US$65 million	Grant	Construction of a Water Quality Laboratory, and supplying equipment, chemicals and training.

NA = Not Available.
Note1: This project is for the Giza Governorate, totals 5.8 billion yen, and includes a sewage treatment plant.

Section 3: Recommended Actions

The GOGCWS is a very large public utility which, over the past 26 years, has successfully responded to the potable water needs of an exploding urban population and also has satisfied the growth and development needs of business and government. In mid 1994, its annual water production level of 1.25 billion m^3 placed the GOGCWS among the largest developing country water utilities in the world.

However, over the past 26 years, the rate of urban population growth in Greater Cairo and the demands upon government for service expansion, typically on the periphery of the system and under frequently uneconomic arrangements, has jeopardized both the technical integrity of the overall system and its financial viability (i.e., its capacity to cover operations and maintenance expenses from current revenue). Lacking the statutory authority or managerial autonomy to either regulate or direct growth and being unable to deny service provision to outlying areas, the GOGCWS has reached a critical point in its own organizational development. Under current financial conditions (i.e., without an increase in the tariff for water consumption), the organization will require an operating subsidy of LE 279 million ($ 82.54 million) in FY 1996-1997. The weight of this financial burden, coupled with a centralized organizational structure, an informal management style, and the absence of appropriate or functional modern technology could contribute to a major breakdown in service delivery and undermine the professional reputation of the organization.

Since past growth trends and development patterns are likely to persist, the GOGCWS must adapt its organization structure and management style to address these requirements. Among the possible actions which the GOGCWS may consider and implement, with the assistance of the MTSS project are:

1. Reconfirm the "economic" basis of the organization through a new enabling act and capitalize fully on the existing authority of the GOGCWS Board of Directors to establish management and technical service standards.

Since its establishment as an economic organization in 1968, the authority of the organization has been diminished as a result of; a) changes in the legal framework within which the organization operates (e.g., Law 43 of 1979 which gave Governorate Popular Councils the right to approve tariff increases) and b) adoption by the Board of Directors of restrictions which have eroded the independent authority contained in the Presidential Decree. In addition, there were no written policies, service standards or management guidelines which can define the organization's priorities and values.

Several interrelated actions could be initiated by the GOGCWS to strengthen the current statutory/legal foundation of the GOGCWS. The following are courses of action which are considered to be priority items at this time.

- Establish a stronger statutory foundation (i.e., a new or revised Presidential Decree) to enable the GOGCWS to prepare plans and budgets and then finance, manage and monitor their implementation, in a professional, business-like manner without undue influence or interference from other institutions or individuals. The new statutory foundation should specifically authorize the GOGCWS to decide how, when, where and on what financial basis to offer services.

- Implement a comprehensive policy framework so that the GOGCWS' technical services and standards can be properly defined and communicated to regulating agencies, consumers and to all GOGCWS managers and employees.

- Negotiate specific, quantitative performance objectives for the GOGCWS with national and Governorate agencies in order to limit the ad hoc, political influence on GOGCWS' service provision.

These actions will assist the GOGCWS to establish the statutory/legal foundation needed to pursue a technical mission within the organization's financial limitations.

2. **Concentrate resources on the effective operation and maintenance of the distribution system in order to reduce leakage and waste and restore the integrity of the overall system. Employ cost-conscious design and construction standards.**

The GOGCWS has an extensive water distribution network which, as a consequence of age and poor maintenance, is now the major service delivery problem confronting the organization. Because of the poor condition of the distribution system, almost all of the time allocated to network operation and maintenance is spent on emergency repairs. In addition, improper installation procedures also contribute to the diminished capacity of the network.

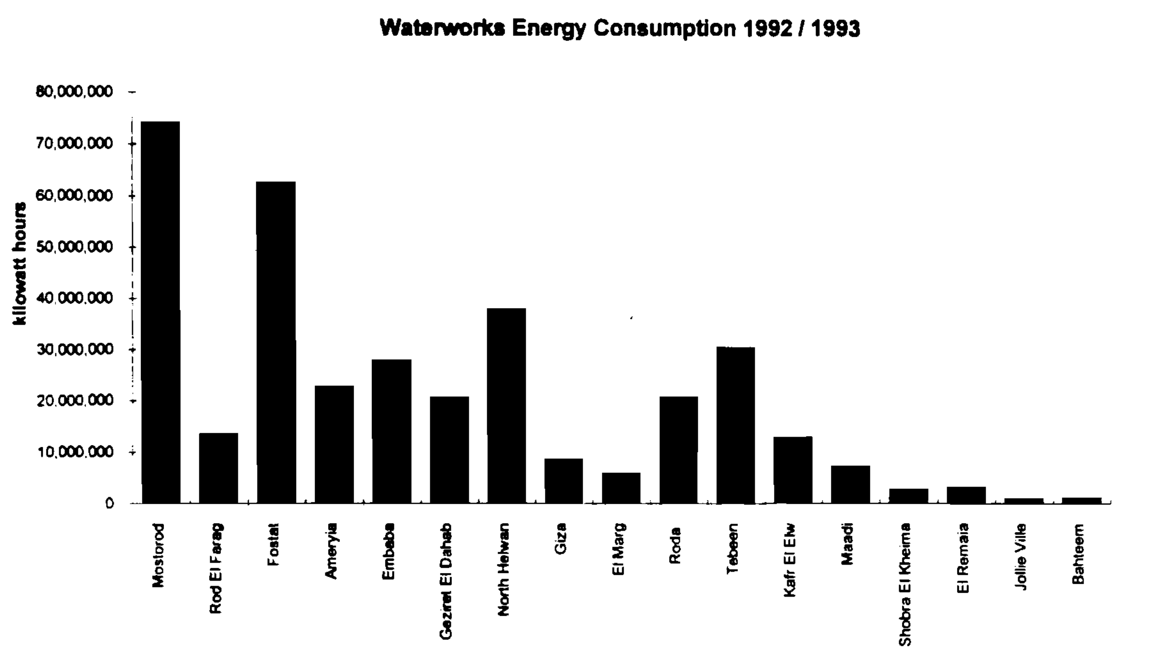
Proposed capital projects should be evaluated from a long term running cost perspective, especially with respect to electricity costs. The wide variation in energy consumption/m^3 water produced (see Figure 3.1) is attributable to the lack of electric efficiency standards (either for the equipment itself or its operating costs) for capital project approval.

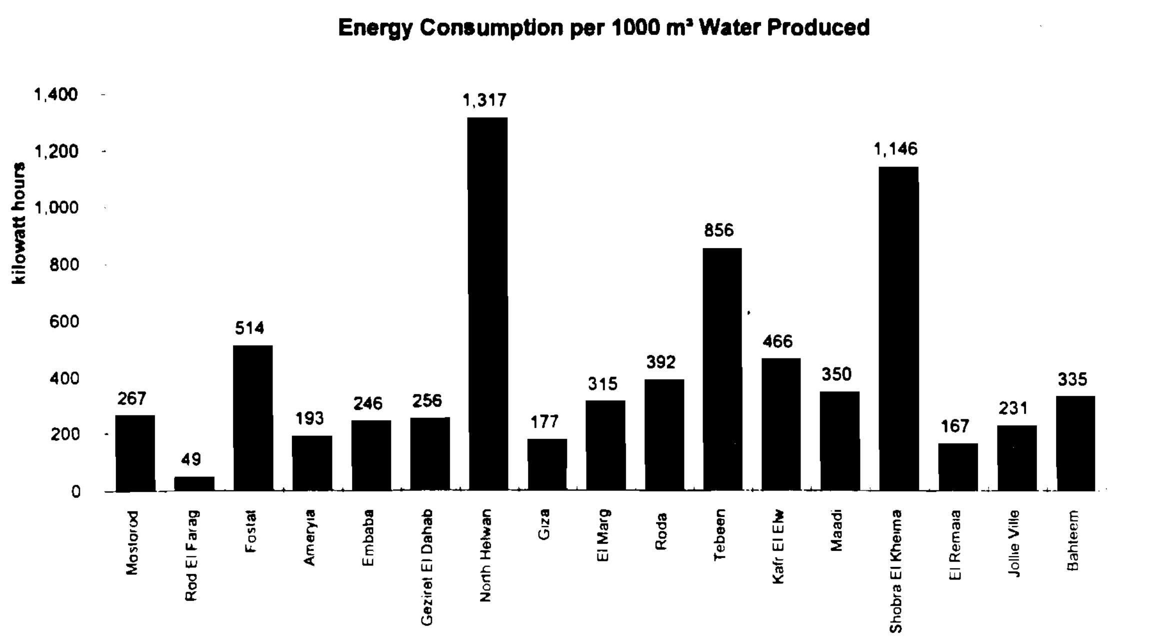
Among the actions which the GOGCWS could take to address this situation are the following:

- Establish a capital investment and equipment procurement priority ranking procedure which accords a higher rating for network projects, especially for older sections of the water distribution system. The priority for network investments also implies that no new treatment capacity will be added until the associated water distribution network can support the added pressure.

- Introduce best industry practices for design, construction, repair and maintenance of the water distribution network and train key GOGCWS managers on appropriate planning and implementation activities which comply with these service standards.

Figure 3.1 Energy Consumption





- Establish and sustain an effective preventive maintenance program, including the mapping and record keeping systems which are needed to document the location and cost of preventive maintenance activities. An effective preventive maintenance program may involve capital investments by the GOGCWS to acquire the necessary tools and equipment.

3. **Establish a metering policy and implementation program for both production and consumption. The production meters should provide an accurate basis for determining the amount of water actually produced at each stage of treatment. The consumption metering program should be realistic, targeted on high volume consumers and capable of being implemented within the resource constraints of the organization.**

The GOGCWS cannot define accurately the amount of water actually produced by the 12 water treatment plants (WTPs) and 5 wells which it operates. Consequently, it is difficult to establish accurate performance targets and or cost recovery goals. Without accurate meters the extent of improved performance cannot be accurately determined.

Within the GOGCWS there is a great divergence of opinion about the need for consumption meters and/or the benefits which would accrue to the organization. The lack of a clear policy regarding consumption metering was a major impediment to the development and implementation of a program to improve performance.

The following specific actions are recommended for the GOGCWS, to be implemented with the advice and assistance of the TSOM program.

- Repair and calibrate existing operable meters and/or obtain and install new meters at the 17 water production facilities operated by the GOGCWS

- Establish a production meter O&M program, including specifically a maintenance management and reporting system to record both scheduled and emergency maintenance activities.

- Adopt a realistic, phased metering policy which has the following characteristics:

  1. Provides an immediate, positive financial return to the organization (i.e., the documented financial benefits exceed the costs of implementation).

  2. Concentrates initially on commercial, industrial, governmental and other high volume, non-domestic consumers.

  3. Provides incentives for voluntary compliance among the target population for metering.

  4. Is capable of being implemented within the financial and non-financial resource constraints of the GOGCWS.

5. Promotes water conservation.
6. Penalizes tampering with the operation of the meter.

- Concentrate on private sector sources for both production and consumption meters, with higher technological options (including remote sensing through the existing SCADA system for large volume users such as hotels and government-owned industrial sites)

These action steps are designed to promote greater reliability in the GOGCWS' water management data base and to overcome the inertia concerning a metering policy for the GOGCWS.. Now that USAID grant funds are available for meter acquisition, and in conjunction with Phase 2 of the SCADA installation at the Rod El Farag WTP location, specific action is a necessity.

4. **Develop standards for operation and maintenance of all facilities and equipment owned and operated by the GOGCWS. Institute an "O&M" value system for GOGCWS managers and employees.**

Although pumps and motors are usually in good working order, much of the equipment at the WTPs not considered critical to water production is poorly maintained (e.g., chlorinators, electric controls, sludge valves, backwash valves, remote sensing switch gear). Consequently, not only is a considerable amount of water lost during the treatment process, but also significant inefficiencies occur in the use of electricity, in dosing levels for chemicals (see Figure 3.2 and 3.3) and for deployment of manpower.

In addition to lack of O&M at the WTPs, other GOGCWS buildings and grounds also are poorly maintained, demonstrating a lack of pride in the organization. The absence of clear standards, and the lack of a strong, positive relationship between the average employee and the GOGCWS organization itself contributes to an overall lack of quality in O&M.

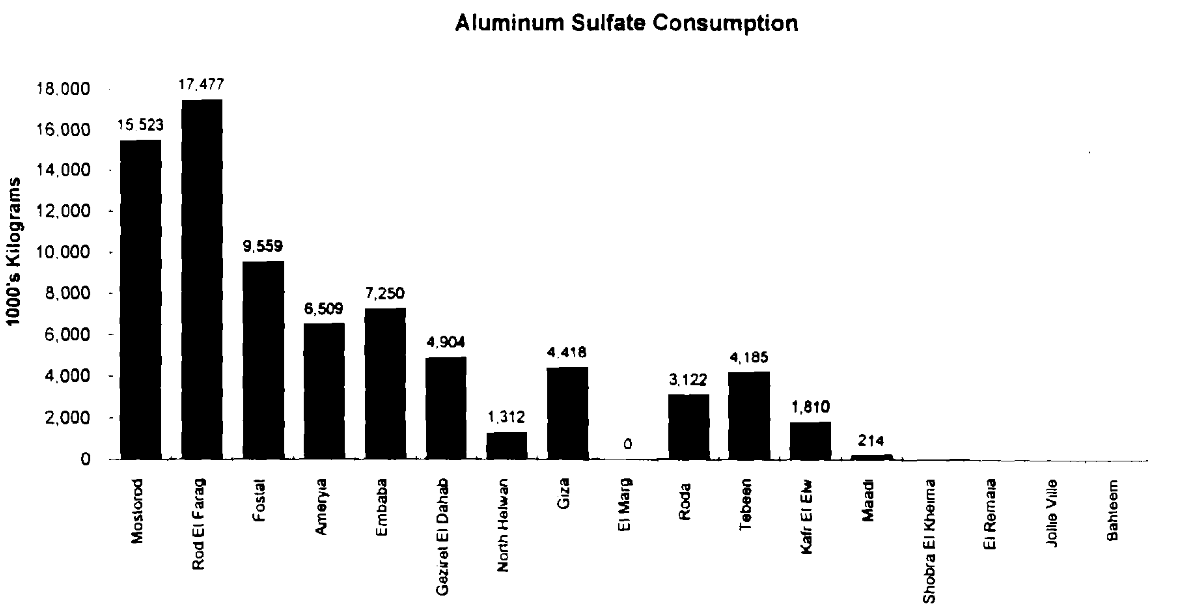
To address this issue, the following actions are recommended:

- Endorse a comprehensive O&M policy and establish a multi-faceted O&M promotion and management program which reaches all levels of the organization. Inspections and monitoring visits, as well as incentives and rewards for exceptional performance, should be instituted. Training on proper O&M procedures and the preparation and distribution of O&M manuals is required.

- Develop O&M skills among a core group of GOGCWS personnel through recruitment, by training existing personnel as well as by contract with private sector maintenance specialists.

- Introduce O&M performance indicators (e.g., time in service for equipment, use of chemicals and other supplies/water produced, overall cleanliness of managed facilities) at the management level of the GOGCWS and use actual performance as the basis for promotion, payment of incentives, overseas travel and other discretionary benefits conferred by the GOGCWS.

Figure 3.2 Aluminum Sulfate Usage



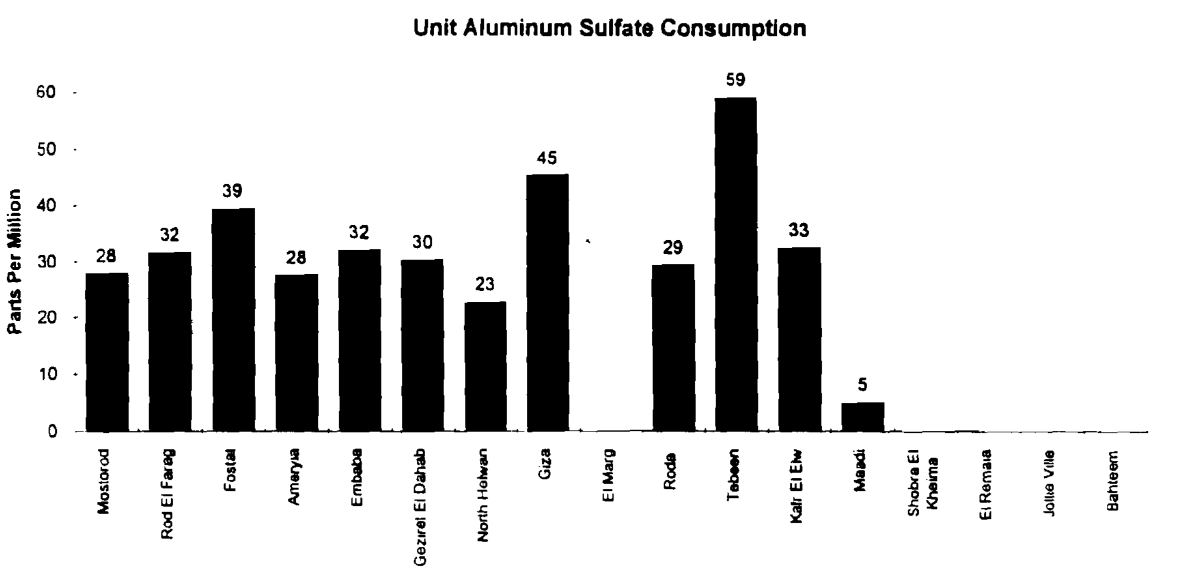
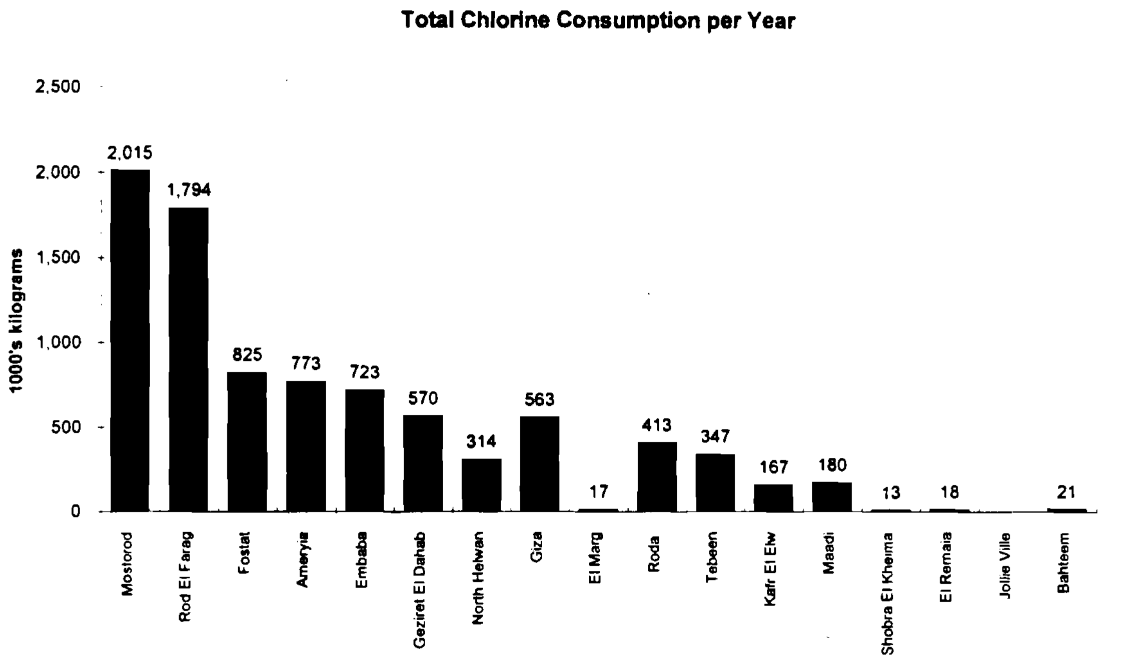
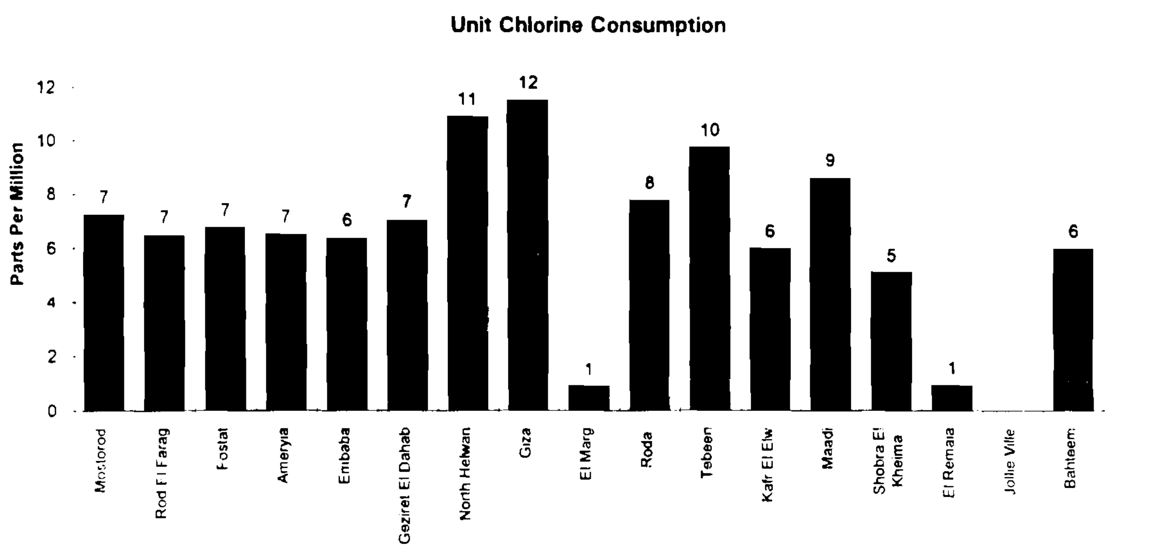


Figure 3.3 Chlorine Usage





Although the GOGCWS operates and maintains much of its equipment and facilities better than many developing country utilities, there is still much room for improvement, especially at the policy and management level where sustainability is created.

5. **Establish an organization form and an internal organizational structure which reflects the functional and geographical responsibilities of the GOGCWS and facilitates the effective and efficient management of resources.**

In 1968, when the GOGCWS was established by Presidential Decree as an "economic organization", the population within its service area was approximately 6 million people, mostly concentrated in the built up areas of central Cairo Governorate. Extraordinary changes have occurred within the Greater Cairo service area over the past 26 years, and the pace of change is exponential.

The GOGCWS has successfully performed the technical mission it was originally authorized to undertake, but the vast service area (911 km^2), cost of service expansion and intra-Governorate water price disparities (i.e., consumers outside the GOGCWS service area within Giza and Qaloubiya Governorates pay more for water than GOGCWS consumers) suggest the need for a reassessment of a centrally managed, regional organization like the GOGCWS.

In response to these organizational concerns, the following actions should be undertaken:

- Prepare a new decree for a smaller, more compact GOGCWS after first having defined the preferred option for decentralizing duties and responsibilities to the individual Governorates or to operating units with authority to charge consumers for the cost of treating and distributing water.

- Decentralize management functions for technical aspects of the GOGCWS (e.g., waterworks, networks and projects)to lower levels in the organization (e.g., Grade 1, at a minimum) and delegate authority and responsibility to managers to overcome the negative effects of overly centralized decision making and administration.

- Redefine the mandate and mission of the technical departments of the GOGCWS in order to improve coordination, communication and resource sharing.

These action steps will need to be coordinated with other activities of the MTSS project since structural reform also is being considered from perspectives other than technical.

6. **Improve the skills of the GOGCWS work force assigned to technical activities and assure a balanced distribution of technical personnel among GOGCWS departments.**

The 3 technical sections of the GOGCWS constitute approximately 7950 employees of which 271 are classified as engineers. Most of the engineers are assigned to the waterworks and projects departments - the networks department has a small number of engineers (38) relative to the management, operation and maintenance needs of that department. In addition, many

In addition, many of the mid-level engineers have not had any exposure to management through either education or training. Other skill deficiencies include a lack of awareness of water treatment processes and technologies.

The staff of the Projects Central Department will review and approve numerous high value waterworks and networks projects over the next decade. In light of the financial constraints affecting the GOGCWS, strict financial and economic feasibility criteria should be applied to all investment decisions. Training in these skills will be needed.

In addition to balancing the distribution of trained resources, the actual number of personnel (technical, administrative, clerical and general labor) required for each function needs to be determined and a "right-sizing" plan and implementation approach is needed. For example, based on data collected for all WTPs, there is no clear correlation between the number of personnel assigned to each plant and the amount of water actually produced. (see Figure 3.4)

The following action steps should be taken to address these concerns:

- Implement a comprehensive management training program for senior-level and mid-level technical personnel which concentrates on developing skills in areas such as budgeting, personnel administration, performance improvement, financial reporting, maintenance management, technology, materials management and cost reduction.

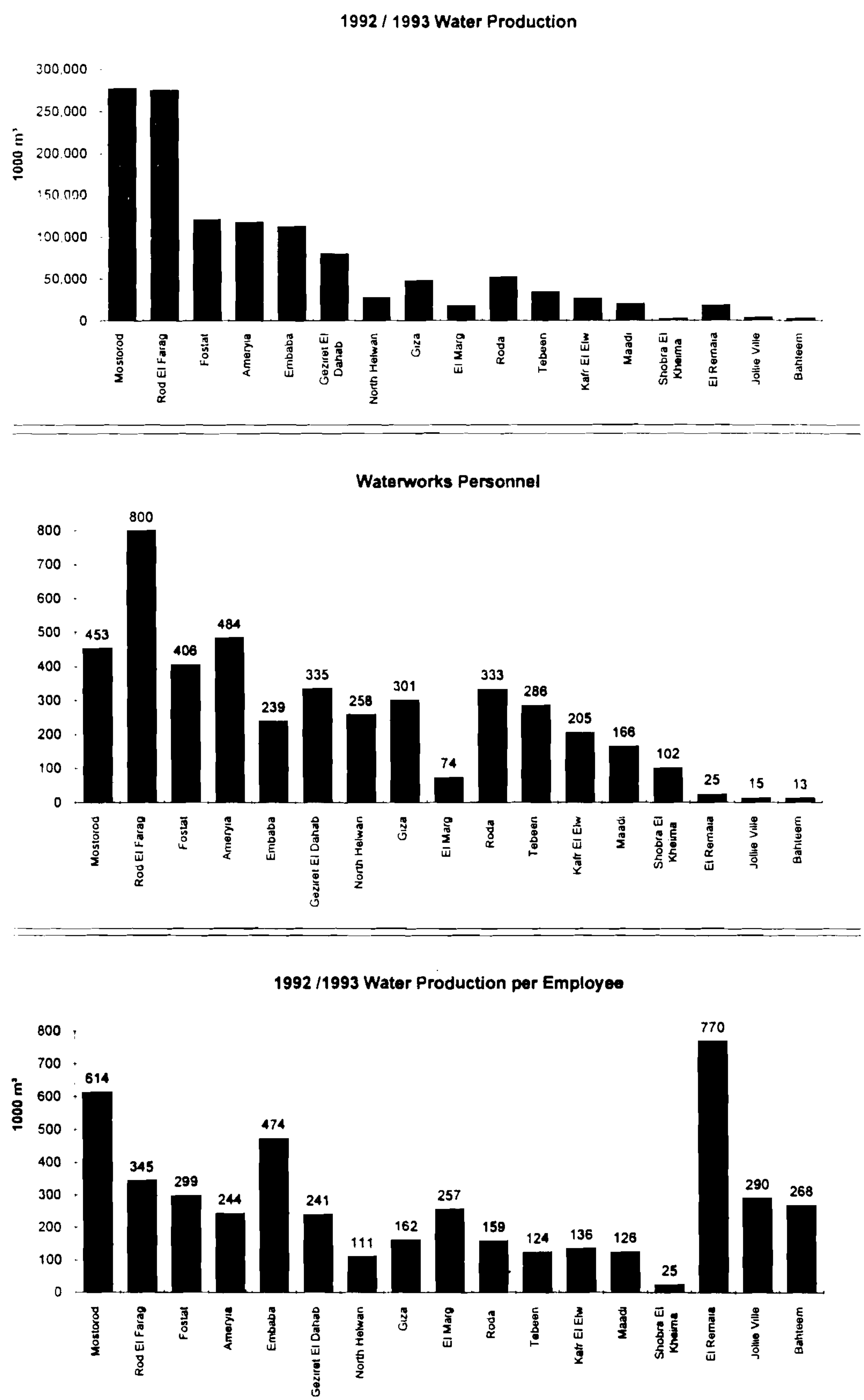
- Continue to implement the new GOGCWS policy of increasing the number of competent engineers assigned to the Networks Central Department and create a separate career path for networks engineers to promote continuity and commitment.

- Provide training to mid-level engineers in the Projects Central Department with not less than 15 years of remaining service in economic and financial analysis, technology cost-conscious project design, construction management and project monitoring. Overseas training may be necessary in order to obtain the resources required for skill development in these areas.

- Define the actual staff complement required for optimal operation of each WTP and implement a re-training and reassignment program to redeploy excess personnel.

Developing the human resources of the technical departments in the GOGCWS is a high priority for the organization. It is important to emphasize, however, that only 2 of the 24 top mangers in GOGCWS are less than 50 years of age and 12 of the 24 are within 30 months of retirement. Carefully targeted training is therefore a key consideration for any action steps in this area. The manpower planning activity being carried out under other MTSS programs will assist the technical departments to develop a clear picture of the management training required for the next generation of GOGCWS leaders.

Figure 3.4



1992 / 1993 Water Production
1000 m³
300,000
250,000
200,000
150,000
100,000
50,000
0
Mostorod
Rod El Farag
Fostat
Ameryia
Embaba
Gezriet El Dahab
North Helwan
Giza
El Marg
Roda
Tebeen
Kafr El Elw
Maadi
Shobra El Kheima
El Remaia
Jollie Ville
Bahteem
Waterworks Personnel
800
700
600
500
400
300
200
100
0
453
800
406
484
239
335
258
301
74
333
286
205
166
102
25
15
13
Mostorod
Rod El Farag
Fostat
Ameryia
Embaba
Gezriet El Dahab
North Helwan
Giza
El Marg
Roda
Tebeen
Kafr El Elw
Maadi
Shobra El Kheima
El Remaia
Jollie Ville
Bahteem
1992 /1993 Water Production per Employee
1000 m³
800
700
600
500
400
300
200
100
0
614
345
299
244
474
241
111
162
257
159
124
136
126
25
770
290
268
Mostorod
Rod El Farag
Fostat
Ameryia
Embaba
Gezriet El Dahab
North Helwan
Giza
El Marg
Roda
Tebeen
Kafr El Elw
Maadi
Shobra El Kheima
El Remaia
Jollie Ville
Bahteem

7. Strengthen existing systems and procedures and introduce technology at key points in the management process to improve record keeping and reporting, especially for both financial control and operations and maintenance.

Many of the systems used by effective utilities in both developed and developing countries are not yet fully used by the GOGCWS. In other cases the systems which are available are inefficient due to lack of management experience and/or the absence of appropriate technology. In general, there is no information management plan for the GOGCWS, including its technical functions.

The following action steps are suggested as means to upgrade and improve the availability, quality and reliability of GOGCWS systems.

- Inventory and evaluate existing systems and develop a program for upgrading and strengthening them through better coordination among departments, more effective management and introduction and use of appropriate technology.

- Identify system deficiencies, based on sound utility practices, and develop an information management systems plan. Especially relevant are systems for planning, control, mapping, water quality monitoring and other technical support areas.

- Develop the criteria and standards for computerization of systems, recognizing the current limited capability of the GOGCWS.

These systems planning actions will provide the GOGCWS with the basis for designing and implementing effective systems.

Appendices

Appendix I

List of Abbreviations

Al_2SO_4	Aluminum Sulfate (Alum)
Cl_2	Chlorine
d	day = 24 hours
EEAA	Egyptian Environmental Affairs Agency
GOE	Government of Egypt
GOGCWS	General Organization for Greater Cairo Water Supply
h	hour =60 minutes
ha	hectare =10,000 square meters
hp	horsepower
kg	kilogram = 1000 grams
km	kilometer = 1000 meters
km^2	square kilometer = 100 hectares
kwh	kilowatt hour
L	liter = 1000 milliliters
LE	Egyptian Pound = 100 piasters
m	meter =100 centimeters =1000 millimeters
m^2	square meter
m^3	cubic meter = 1000 liters =266 gallons
mm	millimeter
MOF	Ministry of Finance
MH	Ministry of Health
MPWWR	Ministry of Public Works and Water Resources
MTSS	Management, Training and Systems Strengthening
NOPWASD	National Organization for Potable Water and Sanitary Drainage
O & M	Operation and Maintenance
TSOM	Technical Support for Operation and Maintenance
USAID	United States Agency for International Development
WHO	World Health Organization
WTP	Water Treatment Plant

Appendix II: WATER TREATMENT PLANT PROFILES

Baseline data collection included assembling information about each of the major GOGCWS water treatment and production facilities. Data from the 1979 ES-Parsons report was updated through site visits, review of facility drawings, and interviews with GOGCWS Waterworks Department Staff. Each WTP profile consists of:

1. General Descriptions
2. Intake and Raw Water Pumping
3. Chemical Dosing
4. Flocculation & Clarification
5. Filtration
6. Water Storage
7. Chlorination
8. Treated Water Pumping Station
9. Power Supply and Utilizations
10. Standby Power Generation

1. ROD EL FARAG WATERWORKS

1.1 General Description

This plant started operation in 1903 producing groundwater from a series of wells. Construction started in 1906 on a filtration plant for treatment of Nile River water. Between 1906 and 1964 the plant was expanded several times, each enlargement involving equipment from different countries. This has resulted in a plant with dissimilar facilities and varied equipment.

The present rated capacity of the plant is 750,000 m^3/d of potable water. The northern portion of the plant has a capacity 200,000 m^3/d and the new southern portion, built in 1987 with USAID financing, has a capacity of 450,000 m^3/day. In addition there are three old filter buildings within the southern portion with total capacity of 100,000 m^3/day.

Except for the inter-ties between the delivery lines from pump stations, the northern section and the southern of this plant are completely independent of each other with respect to operation of the process units, so each will be discussed separately. Both plants operates on a 24 hour basis with three shifts.

1.2 Intake and Raw Water Pumping

Separate intake and raw water pumping facilities exist for both the northern and southern portions of the plant.

1.2.1 Intake and Raw Water Pumping for the Northern Section

Two intake structures draw water from the Nile River for delivery to the plant for treatment. The older intake, located above the water level and about 40 m off shore can draw water from either an upper or a lower level inlet and feeds into four suction lines. Two of these are 1000 mm in diameter, one is 1,100 mm and one 1,400 mm. Six raw water pumps located in the old pump station receive the water from these lines.

The newer intake structure, built in 1964, is located about 200 m downstream from the older one and is only 5 m off shore. Two 1000 mm diameter pipes extend into the Nile River and serve as intakes. Three electrically operated pumps and one diesel unit pump water from the new station through two 1,200 mm discharge lines which are interconnected with the older station, permitting flow of raw water to the plant treatment facilities from either raw water pumping station.

In the older station, three pumps are horizontal centrifugal units driven by diesel engines, and three pumps are vertical centrifugal units driven by electric motors. All must be primed upon start-up.

In the newer station there are three vertical centrifugal pumps driven by electric motors and one horizontal centrifugal pump driven by a diesel engine. All are above the Nile Water level and must be primed upon start-up.

The low lift pumps installed in the old raw water pumping station are as follows:

Three horizontal centrifugal pumps, two with a capacity of 6100 m^3/h, against 14 meters head and one 6120 m^3/h against 12 meters head, two of these units are driven by diesel engines of 578 HP and one by an 410 HP diesel.

Three vertical centrifugal pumps each with a capacity of 5000 m^3/h, 12 meters head. Each of these unit is driven by a 3-phase induction motor 3.3 KV, with capacity of 306 HP.

The low lift pumps installed in the newer raw water pumping station are as follows:

Three vertical centrifugal pumps each with a capacity of 5040 m^3/h against 12 meters head, electrically driven by 3 phase induction motor 3.3 KV, 315 HP

One horizontal centrifugal pump with a capacity of 600 m^3/h against 12 meters head driven by diesel engine 435 HP.

1.2.2 Intake and Raw Water Pumping for the Southern Section

The raw water intake system for the Southern (newer) section of the plant operates independently of the Northern Plant raw water intake facilities.

The raw water intake structure is located in the Nile River at a distance of 175 meters from the east bank and consists of two 96 inch diameter (2400 mm) pipes each branching out into two 72 inch (1800 mm) lines. Adjacent to the slide gates at the raw water pump sump the four 72 inch pipes are consolidated into two 96 inch pipes.

At the Raw Water Pump Station, an open air installation, there are three travelling screens at the raw water sump. The six raw water pumps are vertical, single stage, mixed flow type pumps; each with a capacity of 130,000 m^3/d or 5416 m^3/h. One of the pumps is on standby status.

The pumps are electrically driven by 3-phase induction motors 380 V, 400 HP each.

1.3 Chemical Dosing

The new chemical building at the southern section has facilities for administering alum and polymer. Presently only alum is used for coagulation. A 10% solution is prepared either by dissolving solid alum or by diluting liquid alum. There are six dissolving tanks three available for dissolving or diluting and three with the alum solution to supply for alum metering pumps.

Eight chemical feed pump stations each with four discharge points provide 32 outlets to feed alum to the ten South Plant clarifiers and the six North Plant clarifiers. Operationally four pumps are required allowing the remaining four to be on standby.

1.4 Flocculation and Clarification

1.4.1 North Section

In the north portion of the plant, chemically dosed raw water is conveyed to two Patterson flocculator and clarifier units and to four Degremont units. The Patterson units (built in 1945) each rated at 1500 m^3/h, have flocculators separated from the clarifiers. Each flocculator has three mechanical agitators to provide the mixing energy for floc formation. The flocculated water enters the circular clarifier through a slot about mid-depth in the basin. It is directed to flow tangentially around most of the circumference of the basin. Each clarifier has a rotating bridge with a framework for attachment of scraper blades to sweep the floor of the basin. The floor is conical to facilitate movement of the sludge toward the sludge pit in the center, from which it flows by gravity to discharge into the Nile River. The discharge point is about 60 m downstream from the new raw water intake structure.

Three of the Degremont units are "accelerators" (built in 1947), one rated at 1200 m^3/h and each of the other two at 1500 m^3/h. These are solids-contact type units with sludge recirculation. Raw water enters the center well [the flocculator section, ie the reaction zone] of the unit where it is mixed with recirculated sludge and where alum is added. The flocculated water enters the annular outer space [the clarifier section] near the bottom but above the sludge layer, and gradually rises to overflow as clarified water in the combination of radial and circular collection launders in these units. As the level of settled sludge builds up in the bottom of the "accelerators", part of it is collected and concentrated into two sludge pockets on opposite sides of the floor of each basin. These serve as the source of sludge used for recirculation. The "accelerators" have no mechanical sludge scrapers. This sludge, as that from the other process units, flows by gravity for disposal into the Nile River.

The fourth Degremont unit (built in 1952) is rated at 1800 m^3/h. Unlike the "accelerators", this unit has no radial launders, just a circular launder for collection of the clarified water which rises upward from the lower portion of the basin, and this unit has a rotary scraper which moves the settled sludge along the conical bottom and into two sludge pockets on opposite sides of the circular path followed by the inner edge of the innermost scraper. The sludge is discharged by gravity flow into the Nile River.

1.4.2 Southern Section

The clarifier system consists of solids-contact type units [upflow clarifiers] which use a sludge blanket for recirculation and mixing. This type of clarifier includes a separate basin where raw water, sludge, and chemicals are brought together to initiate new floc formation. The combined mixture is then transferred to the flocculation zone within the basin where new floc is formed. The floc formation is driven by hydraulic currents created by the inflow to the flocculation zone. Water and floc then pass to the clarification zone for separation of the floc from the clarified water. The floc is collected as a slurry or sludge and a portion is conveyed to the external mixing basin for recycling through the process. The clarified water rises vertically to the effluent launders, where it is collected and transferred to the filters through a transfer channel. Waste sludge is moved to a collection sump by the traveling scrapers.

There are ten clarifiers, each a concrete tank 35 meters by 35 meters equipped with a solids-contact unit and with a capacity of 65,000 m^3/d. A saw-toothed weir is located on the overflow launder to ensure uniform overflow of the clarified water. There are two of these weirs, one located at the center and one at the periphery of the clarifier.

Clarified water is distributed to the various filtration facilities for filtering. The older Patterson (English) and Czechoslovakian filters are supplied by the three easternmost clarifiers (numbered as 8, 9, and 10). A splitter box distributes the flow to these filters by gravity. The newer filters are supplied by the remaining seven clarifiers.

1.5 Filtration

1.5.1 Northern Section

The clarified water from all six clarifiers in the northern portion of the plant flows to 36 Patterson filters (12 each constructed in 1945, 1947 and 1952) and 12 Degremont filters (built in 1950). The underdrain system for the Patterson units consists of perforated PVC laterals. A 30 cm deep layer of graded gravel rests on the bottom of the filter and over the PVC laterals. On top of the gravel is a 60 cm layer of 0.5 to 1.25 mm sand.

All 12 Degremont filters originally contained an underdrain system with slotted nozzles and a 90 cm depth of 0.8 to 1.25 mm sand as the filter medium. On the basis that the PVC lateral system as used in the Patterson filters was found to be more satisfactory than the nozzle system in the Degremont units, three of the twelve Degremont filters have been converted to correspond with the Patterson units; that is, the nozzles and the 90 cm of 0.8 to 1.25 mm sand were replaced by perforated PVC laterals, 30 cm of graded gravel and 60 cm of 0.50 to 1.35 mm sand.

The backwash is a two-step operation consisting of air followed by water. Two backwash water pumps are available, each rated at 850 m^3/h at a head of 13 meters. Normally, only one is used during backwash with the other a standby unit. The used backwash water is discharged into the Nile along with sludge from the clarifiers.

1.5.2 Southern Section

Water from the transfer channel through the filter is controlled by an inlet weir. The flow goes over the weir into the gullet through the backwash troughs into the filter. The water flows through the filter medium to the underdrain and out of the effluent line to the clearwell storage passing through an effluent control valve. A total of fourteen filters form the filtration system. Each filter has two bays with a gullet between bays. After the filtered water enters the underdrains, it is collected and transferred to storage located underneath the filters.

The filters are of the rapid sand filter type using sand as the single media. Each of the new filters consists of two bays, 7.5 meters by 12 meters each, with a gullet between bays. The 14 filters together provide an average nominal inlet flow of 455,000 m^3/d.

Backwash is performed for one filter at a time. Air, at about 60 $m^3/m^2/h$ and water at about 12 $m^3/m^2/h$ are introduced to the filter underdrain system. The air agitates the sand media and dislodges the filtered impurities from the media, while the water flushes those impurities out of the filter bed. After the impurities have been dislodged and flushed from the bed into the water above the bed, the air wash is discontinued and the water backwash increased to 20 to 30 $m^3/m^2/h$. This displaces the impurity bearing water upwards until it flows into the backwash troughs, which are spaced at about two meters apart, and from the troughs the backwash is drained to waste.

The Backwash Pump Station contains five two-stage, mixed flow, vertical backwash pumps and three air blowers. Three of the backwash pumps are high rate: each having the capacity of 750 l/s (2700 m^3/h). Two of the pumps are low rate; each having the capacity 600 l/s (2160 m^3/h). The air blowers are equipped with silencers and each is capable of delivering 3380 cfm.

During the filtration cycle the backwash uses two air blowers and one low rate pump for the air agitation cycle. Subsequently, two high rate pumps are used to displace the impurity bearing water into the backwash troughs.

1.6 Water Storage

Three underground water storage facilities for the southern section are provided:

- the clearwell (23,500 m^3) below the filters and the Backwash Pump Station;
- the treated water reservoir (11,500 m^3) extending southward from the treated water pump station;
- the treated Water Storage (13,400 m^3) located on the east side of the plant area.

Piping interconnections are provided to transfer the water from the clearwell and treated Water Storage to the treated Water Reservoir.

Two other storage facilities are:

Treated Water reservoir - 4200 m^3 beneath Czechoslovakian filters
Treated water reservoir - 1500 m^3 beneath Patterson filters

1.7 Chlorination

Pre-chlorination enhances algae removal and controls biological growth on the filters. Post-chlorination disinfects filtered water. Process equipment for chlorination is located in the chlorine buildings and consists of:

Liquid chlorine feed system
Evaporators
Chlorinators
Chlorine detectors
Caustic soda neutralization system

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The chlorination system is comprised of seven evaporators and nineteen chlorinators connected to two sets of 14 one ton cylinders of which one cylinder of each set is mounted on a cylinder scale. Liquid chlorine is fed to the evaporators, where it is heated and converted into gas for metering and control by the chlorinators. The status of each evaporator is monitored for water level, gas temperature, gas pressure and water temperature. Nineteen chlorinators are installed to service the new plant and the North plant. They are used for pre-chlorination and post-chlorination with the following distribution:

3 - Pre-chlorination - Raw Water Pump Station
2 - Pre-filtration - Patterson Filters
2 - Post-filtration - Patterson Filters
2 - Pre-filtration - New Filters
2 - Post-filtration - New Filters
2 - Post-chlorination - Finished Water Reservoir
2 - Pre-chlorination - North Plant Raw Water Pump
2 - Pre-filtration - North Plant filters
2 - Post-chlorination - North Plant Finished Water Storage

Each chlorinator is provided with a remote injector (eductor) for mixing the metered chlorine gas with water in preparation for piping it to the points of application. The chlorine injectors have an adjustable throat to obtain desired vacuum. Two chlorine analyzers are located at the Finished Water Pump Station to monitor the residual chlorine in the finished water. One of the analyzers is a standby unit.

1.8 Treated Water Pumping Stations

There are three treated water pumping stations, two are old and one is new. The ages of the pump stations are not known. One of the old pumping stations consists of electrically powered pumps and one contains diesel drive pumping equipment. The new pumping station contains electrically driven pumps. The pumping units installed in each pumping station are as follows:

The old electrically driven pumping station houses five vertical centrifugal pumps with a capacity of 2090 m^3/h, against 55 meter head. The pumps are driven by 3-phase induction motors 3.3 KV, 650 and 560 HP

The old diesel driven pumping station houses five pumping units consisting of horizontal centrifugal pumps with diesel drive in the following configuration:

4725 m^3/h against 51m, driven by 1400 HP diesel engine
4725 m^3/h against 51m, driven by 1400 HP diesel engine
2520 m^3/h against 56m, driven by 800 HP diesel engine
4500 m^3/h against 55m, driven by 1250 HP diesel engine
4500 m^3/h against 55m, driven by 1250 HP diesel engine

The new electrically driven pumping station houses eight vertical turbine, two stage pumps. Each pump has a capacity of 7000 m^3/h against 60 meters head. The pumps are driven by 3-phase induction motors 10.5 KV, 1750 HP each.

The treated water is pumped directly to the network through 9 trunk mains with different diameters ranging from 800 mm to 1500 mm. A venturi meter is installed in each discharge line. Four of the venturi meters are relatively new but are not working satisfactorily. The other five meters have been abandoned.

1.9 Power Supply and Utilization

The Cairo Electric Distribution Center (CEDC) located a 66 KV substation on the plant site and provides 10.5 KV power through four feeders to the main receiving substation. Two identical 10.5 KV feeders from the main receiving substation supply power to each of the four secondary substations each of which contains two transformers for stepping down 10.5 KV to 380/220 volts.

The 10.5 KV main receiving substation is located adjacent to the treated water pump station because it is at the approximate center of the plant and near the major electrical load created by the finished water pumps.

The secondary 380/220 volt substations are designated alphabetically as substations "A", "B", "C" and "D". They are located near the areas of demand for their service. Each substation contains a step-down transformer 10.5/0.38 KV, with capacity of 1500 KVA for substations A and D, and 1000 KVA for substations B and C. Switchgear for receiving and distributing the electrical power is also contained within each substation.

In addition there are two old substations, one is located on the Corniche and connected directly to the 10.5 KV distribution system of the electrical authority and contains two step down transformers, one is 1000 KVA, 10.5/3.3 KV and the other one is 500 KVA, 10.5/0.38 KV, with the necessary HT and LT switchgears to meet requirements. The HT switchgear is energized by two main feeders.

The second substation is incorporated with the old electrical pumping station and contains three step down transformers; 1500 KVA 10.5/3.3 KV, and two 500 KVA 10.5/0.38 KV, with the necessary HT and LT switchgears to meet requirements. The HT switchgear is energized by two main feeders connected to the new substation 66/10.5 KV built on-site by the electrical distribution authority.

1.10 Standby Power Generation

Two diesel generating sets are housed in a generating building. Each set consists of one diesel engine 1350 HP directly coupled to a three-phase alternator 10.5 KV with a capacity of 1100 KVA, complete with a HT switch gear. The station is out of service at present.

Another generating unit is located in a building incorporated with the diesel pumping station. This unit is used to power auxiliaries and consists of a diesel engine 720 HP with an alternator 529 KW, 380 volt.

2. MOSTOROD WATERWORKS

2.1 General Description

Mostorod waterworks is located on the Ismailia Canal about 4.5 km east of Ameryia WTP. The plant was put in service in 1977 with design capacity of 450,000 m^3/d, and consists of an intake pump station, filters, treated water pump station, sludge pump station and power generating station.

The low lift pumping station supplies raw water to two distribution shafts, one for each stream of clarifiers which distribute the water on 10 pulsator type, clarifiers. The clarified water is connected by the clarified water channels before flowing by gravity to 40 rapid sand filters. Beneath the filters there is a large reservoir with a total storage capacity of about 20,000 m^3. The plant is operated on a 24 hour basis.

2.2 Intake and Raw Water Pumping Station

Four 1200 mm intake pipelines are available to draw water from the Ismailia Canal for delivery to the plant for treatment. The raw water passes through mechanical screens before continuing to suction sumps at the raw water pump station which consists of 8 centrifugal pumps, vertical split casing, dry pit type. Each pump has a capacity of 1200 l/s (4320 m^3/h) against 12m head. The pumps are electrically driven by 3-phase induction motors 3.15 KV each with a nominal power of 200 KW.

The water delivered from the raw water pumps passes through two 1200 mm diameter pipelines to the two distribution shafts. Venturi meters are installed within each pipeline but are not working.

2.3 Chemical Dosing

The Chemical facility contains equipment for administering the following coagulation chemicals:

Aluminum sulfate (Alum) as main coagulant
Calcium hydroxide (lime)
Activated carbon
Polyelectrolyte

Only aluminum sulfate is currently being used for coagulation. Alum dosing is accomplished using an alum solution of 10% concentration prepared by dissolving solid alum or diluting liquid alum, in three tanks each with a capacity of 50 m^3. Each tank is equipped with an electrically operated mechanical mixer. Six dosing pumps are available to pump alum solution to the points of application.

2.4 Flocculation and Clarification

The ten clarification basins are constructed with five on either side of the filter house. The clarification basins receive chemically dosed raw water from two distribution shafts.

The clarifiers are of the sludge blanket type, vertical flow with pulse action, designed by Degremont Company of France as "pulsator clarifiers". The pulsator has no separate flocculator and clarifier sections and no mechanical mixing equipment.

A portion of raw water (with added chemicals) is drawn up by vacuum into a chamber at the center of the pulsator. When that water reaches a level of about 0.6 meters above the water level in the pulsator basin, the vacuum is relieved and the water surges from the center chamber into the basin in about 8 seconds. This surging water is discharged through perforated laterals near the bottom of the basin in order to effect uniform distribution over the entire area.

With each surge, some sludge from the blanket overflows into the sidewall of the sludge concentration hoppers from which sludge is extracted periodically for disposal.

2.5 Filtration

The clarified water from pulsators flows towards the filters which are of the Degremont Aquazer T type. Forty of these units are constructed in one filter house building. Each filter has two bays, one on each side of the center gullet. The clarified water enters each filter bay through two weir slots provided with check valves. During filtration these valves are opened and the incoming water flows horizontally across the surface of the water in the filters. The surface area of each filter is 80 m^2 and the rated flow is 450 m^3/h resulting in a filtration rate of 5.6 m/h. The filter underdrain consists of long stem nozzles screwed onto prefabricated concrete slabs. The filtering material has one layer of sieved sand.

The filters are washed by simultaneous return of air and filtered water. Back wash is initiated manually and takes place is three steps: (1) air, (2) air with water, and (3) water only. Three backwash water pumps are available, each rated at 1600 m^3/h. Under normal conditions two pumps will be in use, one for each of the two rows of 20 filters, and the third will serve as a standby unit.

2.6 Treated Water Reservoirs

Beneath the filters is a filtered water storage reservoir made up of five interconnected sections, each with a volume of about 4000 m^3. Total storage is about 20,000 m^3.

2.7 Chlorination

The chlorination facility contains equipment for applying pre-chlorination and post chlorination and space for storage of chlorine drums. The pre-chlorinaton dose is applied in the raw water pipeline just ahead of the distribution structure. A post chlorination dose is added to the filtered water entering the underground reservoir.

The available chlorinators for pre-chlorination are four units each 150 kg/h capacity. Two chlorinators are always in service and two are used for standby. Two chlorinators, each with a capacity of 40 kg/h, are used for post chlorination, one in service and the other on standby.

2.8 Treated Water Pumping Station

Twelve horizontal split case centrifugal pumps are available for pumping treated water. Six of the pumps are 2160 m^3/h against 100 m head, and six are 3600 m^3/h against 60 m head. The pumping units are installed in two lines in the clear water pumping station, and are electrically driven by 3-phase induction motors 10.5 KV, with nominai power of 830 KW for 2160 m^3/h pumps and 845 KW for 3600 m^3/h pumps.

2.9 Power Supply and Utilization

The electrical power is supplied from the electric distribution authority network by main feeder of 10.5 KV and two step down transformers having capacities of 2000 KAVA, 10.5/3.15 KV and two step down transformers with capacities of 1000 KAVA, 10.5/0.38 KV. A number of high, medium, and low tension switchgears are available to supply electric power to different buildings.

2.10 Standby Power Generation

Four diesel generation units are available each composed of a 1575 KAVA alternator directly coupled with an 1800 HP diesel engine. The capacity of this generating station can maintain 50% of the rated capacity of the plant in case of electric power failure.

2.11 Ground Water Production

There are 32 wells available to produce about 170,000 m^3/day. Each well is equipped with a submerged vertical pump producing about 5000 m^3/day, electrically driven by 3 phase inductor motor 380 V 90 KW installed over ground level. Ground water quality varies and wells are taken out of service when iron or manganese concentrations increase. Ground water is blended with treated water upstream of the treated water pumping station.

2.12 Plant Extensions

The plant has been extended in two stages for a capacity of 200,000 m^3/day for each stage. The first stage began service in 1991, while the second stage began service with 50% of its capacity at the beginning of 1994. The construction work is going forward for completion of the remaining 50% of the second phase extension and is planned to be completed before the end of 1994. The main extension units are as follows:

2.12.1 Intake and Raw Water Pumping Station

Two 2000 mm diameter pipelines are available to draw water from the Ismailia Canal to the raw water pumping station, where six vertical submerged pumps are installed, four units with capacity of 4500 m^3/h against 14 meter and two with capacity of 6120 m^3/h at 14 meters head. The pumps are driven by 3 - phase induction motor, 380 volts with capacity of 220 KW for the pump 4500 m^3/h and 315 KW for the pumps 6120 m^3/h.

2.12.2 Clarification and Filtration

The 2 stages of extension consist of 8 clarification basins of Degremont pulsator type and a filter house with 20 filters. 15 of these filters are already in service.

2.12.3 Treated Water Pumping Station

Five units with capacity of 3600 m^3/h against 60 meter head and five units with capacity of 2700 m^3/h against 100 meter head are available to deliver clear water to the high pressure and medium pressure network. The pumps are vertical submerged type driven by 3-phase induction motors, 10.5 KV with capacity of 810 KW for 3600 m^3/h pumps and 980 KW for 2700 m^3/h pumps.

3. AMERYIA WATERWORKS

3.1 General Description

Ameryia waterworks consists of a production facility that started service in 1962. Raw water is received from the Ismailia Canal. The site layout consists of two chemical buildings, eight clari-flocculators and one filter house which contains 36 filters located in four rows.

Filtered water flows by gravity from filters to two main collecting channels before continuing to two treated water reservoirs each 4500 m^3 capacity where the post chlorination dose is added at the inlet of these reservoirs.

The rated capacity of the plant is 300,000 m^3/d. A clear water pumping station delivers the treated water directly to the network by seven main pipelines, two 90 m head lines (800 mm diameter and 900 mm diameter) and five 60 m head lines (800 mm, 900 mm, 1000 mm, 1200 mm and 1400 mm diameter). The plant operates on a 24 hour basis.

3.2 Intake and Raw Water Pumping

Ismailia Canal water passes through a bar rack intake structure to two mechanical screens located adjacent to the raw water pump station, through four, 1100 mm diameter pipelines. The pump station contains eight vertical centrifugal pumps which deliver raw water to two distribution shafts.

The raw water pumping station contains the following low lift pumping equipment:

Four pumps @ 3960 m^3/hr capacity against 12 m head, electrically driven by 3 phase induction motors of 3.15 KV, 213 KW.

Four pumps @ 1980 m^3/hr capacity against 12 m head, electrically driven by 3 phase induction motors of 3.15 KV, 100 KW.

Two 1250 mm diameter pipelines direct flow to one distribution structure on the east side and one on the west side of the plant. Each of the two 1250 mm diameter pipelines splits into two 1000 mm diameter lines prior to reaching the distributor. These smaller pipelines pass through the chemical buildings where the chemicals are added.

3.3 Chemical Dosing

The two chemical houses have facilities for administering the following coagulation chemicals:

Aluminum sulfate (alum) as the main coagulant
Calcium hydroxide (lime) as a coagulant aid
Activated carbon

At present only alum is in use as a coagulant.

3.3.1 Alum Dosing

Alum solution, with a 10% concentration, is prepared by dissolving solid alum or diluting liquid alum. In each chemical house there are 3 concrete mixing basins with a capacity of 50 m^3 each. Motorized mixers are used for stirring and alum dosing is administered by 3 metering pumps available in each chemical house.

3.4 Flocculation and Clarification

The chemically dosed water is routed through two distributors each serving 4 circular clair-flocculators. Flash mixing chambers on the clair-flocculators provide mixing at the entrance of each structure. The water flows through a center shaft to a circular flocculator.

Flocculated water enters the clarifier section from the bottom of the flocculator and moves upward and radially over circular weirs into a main clarified water channel. Each clarifier has a diameter of 40 meters and a depth of 5 meters. The units are Dorr-Oliver type. The sludge is extracted by a slow speed rotating scraper which scrapes the sludge to a sludge hopper from which it flows by gravity for disposal into the Ismailia Canal. Sludge pumps are also available.

3.5 Filtration

Settled water flows by gravity to one filter building, housing 36 filters of Czechoslovakian design. Each filter is divided into 2 bays by a horizontal center gullet. The underdrain system consists of long stem nozzles with strainers made of plastic screwed onto concrete filter slabs. The filter media is one layer consisting of 90 cm of sieved sand size from 0.8 to 1.25 mm. The filter piping was designed so that each filter bay is backwashed individually. The backwash is a three-step operation consisting of air alone, air plus water, and water alone. Three backwash pumps are available each rated at 1250 m^3/hr against 12 m head. Normally one pump is used for each double row of 18 filters, and the third is a standby unit. For a nit rated capacity of 10,000 m^3/d the filtration rate is 4.2 $m^3/m^2/hr$.

3.6 Disinfection

Chlorine is used for disinfection. The chlorine dose is injected at the inlet of the two underground storage reservoirs.

3.7 Clearwell Storage

Two clearwell reservoirs have a total storage capacity of 9000 m^3. No reservoirs are available under the filters. The water flows from these reservoirs to two suction pumps inside the treated water pumping station.

3.8 Filtered Water Pumping

Ten pumps, located in one station, deliver the treated water directly to medium and high pressure trunk mains. The pumping station contains the following equipment:

> Six main pumps @ 3960 m^3/hr, 60 m head, dry pit vertical split case type centrifugal pumps

> Four booster pumps @ 1440 m^3/hr, 30 m head, dry pit vertical split case centrifugal pumps

The 30 m head pumps (high pressure) take suction from the 60 m head (medium pressure) pump header and thus deliver at a 90 m head. The pumps are electrically driven by 3 phase induction motors 3.15 KV with a capacity of 900 KW for the main pumps and 160 KW for the booster pumps.

3.9 Power Supply and Utilization

All the mechanical units are driven by electric motors. The power is supplied from the electric distribution authority network by three main feeders to the main high tension switchgear located in the treated water pumping station.

Three, 10.5/3.15 KV 4000 KAVA step down transformers are located in transformer rooms incorporated into the treated water pump house. Two stepdown transformers 3.15/0.38 KV 500 KAVA are available for feeding the low tension units.

3.10 Standby Power Generation

Four 1210 KAVA diesel generating units are available consisting of a 1320 HP diesel engine direct coupled with a 3 phase 1210 KAVA alternator.

4. EMBABA WATERWORKS

4. General Description

Embaba water treatment plant is located on the western bank of the Nile River at Warrak El Arab to the extreme north of Embaba. It is basically designed for a capacity of 300,000 m^3/day of treated water. Fifty percent of plant capacity began service in 1983 and the other 50% began service in 1986. The intake and raw water pumping station are designed and constructed for an output of at least 600,000 m^3/day of treated water.

An extension of 400,000 m^3/day is now under construction including chemical dosing, clarification basins, filtration and treated water pumping facilities. Predicted completion date is the end of June 1996. The project is financed by a French loan. The total output of the plant after completion of the extension will be 700,000 m^3/day.

The low lift pumping station supplies raw water to two open distribution channels which distribute the water onto the clarifiers by two inlet weirs for each clarifier, where the chemicals for coagulation are added.

The clarified water channel of each clarifier is connected to a main clarified water channel before continuing by gravity to 36 filter units divided into two batteries of 18 rapid sand filters. Each filter is 77 m^2 split into two bays by a central wash-out channel.

Two 4,000 m^3 reservoirs constructed under the filter house, receive water for a contact period of about 40 minutes for post chlorination before continuing to two treated water sumps located on either side of the treated water pumping station. Treated water pumps deliver water directly to the trunk mains of the network. The plant is operated on a 24 hour basis.

4.2 Intake and Raw Water Pumping Station

The intake consists of four submerged 1,600 mm diameter steel pipe lines, each 170 meters in length extending approximately 50 meters from the bank into the river. The raw water is taken by these pipelines to the main sumps passing through four mechanical weed screens. A number of isolating gates are installed for maintenance purposes, so that half of the intake sump can be isolated.

The raw water pumping station consists of eight vertical split case, centrifugal pumps, dry pit type, each 1,600 L/s (5760 m^3/h) capacity with 14 m total head at duty point.

The pumps are electrically driven by three phase induction motors of 3.15 KV, nominal power 315 KW. Four transformers each 1500 KAVA, 10.5/3.15 KV are installed in four transformer rooms incorporated with the raw water pumping station.

The switchgear consists of 10.5 KV, 3.15 KV and 380 V equipment for receiving electrical power from the main switchgear installed in the engine room incorporated with the filter house.

The water delivered from the raw water pumps passes through two 1200 mm diameter main pipelines to the two distribution shafts. Venturi meters are installed within each

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pipeline. The rate of flow and pressure readings are transmitted to the low tension board in the raw water pump house. The meters were not working at the time of the initial inspection but have since been repaired.

4.3 Chemical Dosing

The chemical facility contains equipment for administering the following coagulation chemicals:

Aluminum sulfate (Alum) as main coagulant
Calcium hydroxide (lime)
Activated carbon
Polyelectrolyte

Aluminum sulfate is the only chemical currently being used.

Alum dosing is accomplished using an alum solution of 10% concentration prepared by dissolving solid alum or diluting liquid alum in three mixing concrete basins (50 cubic meters each). Compressed air is used for stirring the solution. It is delivered from two electrically driven air blowers each with a capacity of 250 m^3/h, by passing through a perforated PVC pipe located at the bottom of each basin.

For alum solution metering two piston pumps are used, each with a capacity of 5430 L/h at 2 bar pressure. One of the pumps is used to pump the alum solution to two constant head distributors located at either side of the clarification basins, which then distribute the alum solution by gravity to each clarifier at the inlet shafts.

4.4 Flocculation & Clarification

Eight clarification basins provide for an output of 300,000 m^3/day of treated water. Raw water flows to two open distribution channels which distribute the water between four rectangular clarifiers by means of partition weirs on the inlet of each.

The clarifiers are of the sludge blanket type, vertical flow with pulse action designed by Degremont Company of France, with the register name of "Pulsator Clarifier".

The approximate internal dimensions of the pulsator units are 28.5 m length x 20 m width x 4.5 m depth of water. The overall surface area is approximately 570 m^2.

The rated output of each pulsator clarifier is 40,000 m^3/day of clarified water, and the hydraulics are designed for an exceptional overload of 25% over the nominal flow. The retention period at nominal capacity is 1.5 hrs and the surface loading is 2.9 m/h.

The pulse action is obtained by operating a high pressure centrifugal fan and an air relief valve sequentially by a float switch. the water level is alternately raised and lowered on a 30-40 second cycle. The cyclic action described maintains suspension of a sludge blanket so that the unit acts as an accelerator clarifier and has a relatively high surface loading.

The sludge is automatically extracted as a timer periodically opens each blow-off pipe for a short extraction period (adjustable from 0 to 45 sec.) and closes for a settling time up to 30 minutes.

4.5 Filtration

For an output of 300,000 m^3/day of treated water, there are two batteries of rapid sand filters, each with 18 filters, of the Accuser V type. Each filter consists of two identical cells, with a length of 12.8 m and 6 m width resulting in a total surface area of 77 m^2 for each filter at the nominal output of 10,000 m^3/day. The nominal filtration rate is 5.4 m/h.

The filter floor consists of prefabricated concrete slabs each of which contains 63 long stem nozzles. The filter material consists of one layer 85 cm deep of a sieved sand with a nominal effective size of 0.95 mm and a maximum uniformity coefficient of 1.6. This filtering layer is supported by a 5 cm deep layer of gravel with a grain size between 4-8 mm.

Each filter is equipped with a flow rate control system to maintain a constant output during the entire filtration cycle. The system of control is a Degremont standard design with an upstream control device operating on the siphon principle.

The filters are washed by simultaneous return of air and filtered water. The washing process is further improved by cross washing of the surface with clarified water, which is admitted into the filter during the washing cycle. All the valves are pneumatically operated and of the butterfly type. An engine room incorporated with the filter building houses the washing equipment which consists of the following:

> Six vertically mounted centrifugal pumps, electrically driven, three for each battery of 18 filters (two on duty and one stand by). Each pump has a capacity of 577.5 m^3/h at 6.55 m delivery head.
>
> Four motor driven scour air blowers, two for each battery of eighteen filters (one in service, the other stand-by. Each blower is capable of delivering 4235 m^3/h at 250 millibar delivery head.
>
> Four motor driven compressors and two air vessels for operating the pneumatic control valves of the filters.

4.6 Treated Water Reservoirs

Two identical reservoirs, each with a capacity of 4,000 m^3, are located under the filters. The reservoirs receive filtered water from the filters through the main filtered water channels where a post chlorination dose is added. The treated water flows out of the two reservoirs through butterfly valve outlets, 1200 mm diam, to two treated water sumps.

4.7 Chlorination

The chlorination facility contains equipment for applying pre-chlorination, intermediate and sterilization chlorination. There is also space for storage and chlorine leakage detection equipment and a caustic soda spray tower for neutralization of chlorine in an emergency.

For pre-chlorination, the installation consists of the following equipment:

Two rows of six 800 kg chlorine tanks connected to the liquid phase and equilibrated by the gaseous phase

One change-over panel, automatic operation type

Two evaporators, each with a maximum capacity of 200 kg/h (one in service, the other stand-by)

Four 113 kg/h each maximum capacity vacuum type chlorinators (two in service, two on stand-by) complete with ejectors

Two electrically driven booster pumps

For sterilization chlorination, the installation consists of the following equipment:

Two rows of seven 800 kg chlorine tanks connected in the gaseous phase
One change-over panel, automatic operation type
Four 38 kg/h maximum capacity vacuum type chlorinators (two in service, two on stand-by) complete with ejectors
Two electrically driven booster pumps

Chlorine leakage protection is based on neutralizing the leaking chlorine by caustic soda solution. The chlorine house contains the following equipment for chlorine protection:

Two extraction fans with motor drive
PVC rectangular ducting between fans and chlorine room
Two caustic soda pumping units
One caustic soda dissolving tank
One neutralization tower
Complete piping system

4.8 Treated Water Pumping Station

For an output of 300,000 m^3/day of treated water, six horizontal split casing centrifugal pumps, each 1000 L/s (3600 m^3/h) against 60 meter manometric head at duty point, are installed in two lines in the clear water pumping house.

The pumps are electrically driven by 3-phase induction motor 10.5 KV nominal power 900 KW. 10.5 KV switchgear is installed to receive the power by two main feeders from the main switchgear. A 380 V switchboard is installed for operating the auxiliary units.

4.9 Power Supply and Utilization

The power is supplied from a main substation, belonging to the electrical distribution authority, which is adjacent to the plant. Power is supplied by two main feeders, each with a capacity of 6 MVA, connected to a main switchgear located in the engine room, from which electricity is connected to switchgear located in other buildings. In each building there is a suitable LT switchboard for operating the auxiliary units, lighting, etc. The H & MT switchgear is designed for 500 MVA breaking capacity with a 1250 AMP current rating.

5. EL FOSTAT WATERWORKS

5.1 General Description

El Fostat waterworks is located about three kilometers to the east of the Nile River. The plant is identical in process and layout to Embaba waterworks, but with double the capacity. The design capacity of the plant is 600,000 m^3/day, and it began service at 50% capacity in 1989 and the rest in 1990.

The intake and raw water pumping station is constructed on the Nile River east bank. The low lift pumping station supplies raw water to four open distribution channels, one for each stream of clarifiers, which distribute the pre-chlorinated water into the clarifiers by two inlet weirs where chemicals for coagulation are added.

The clarified water from each clarifier flows through channels to a main clarified water channel before continuing by gravity to 72 rapid sand filter units, each divided into four groups of 18. Each filter is 77 m^2 split into two bays by a central wash out channel. Two groups of filters (36 filters) are housed in one filter building. Two 5000 m^3 treated water reservoirs are constructed under each of the two filter houses. The treated water reservoir receives chlorinated water and provides a contact period of about 40 minutes. The treated water is pumped from sumps directly to the distribution network.

The plant is operated on a 24 hour basis by three shifts.

5.2 Intake and Raw Water Pumping Station

The intake consists of four submerged 1,600 mm diameter steel pipelines, each 32 meters in length, extending into the Nile River. The raw water is taken by these pipelines to main sumps passing through four mechanical weed screens. A number of isolating gates are installed for maintenance purposes.

The raw water pumping station consists of eight vertical split casing, centrifugal pumps, dry pit type, each with capacity of 1600 L/s (5760 m^3/h) against 20 m total head at duty point. The pumps are electrically driven by three phase induction motors of 10.5 KV with nominal power 485 KW.

The water delivered from the raw water pumps passes through three 1600 mm diameter pipelines connected together at the treatment plant by a main header from which four pipelines 1200 mm diameter are taken. Each pipeline feeds a distribution channel which distributes the water into three clarifiers (total of 12). A 1200 mm venturi meter is installed in each pipeline (4 total) but none are in service.

5.3 Chemical Dosing

There are two chemical facilities each containing equipment for administering the following coagulation chemicals:

Aluminum sulfate (alum) as main coagulant
Calcium hydroxide (lime) or activated carbon
Polylectrolyte

Only alum is being used at present. Alum dosing is accomplished using a solution of 10% concentration prepared by dissolving solid alum, or diluting liquid alum in six mixing tanks, three in each chemical house. Each tank is 5 m^3 in size. Compressed air passing through a perforated PVC pipe located at the bottom of the basins is used for stirring the alum. Compressed air is delivered from two electrically driven air blowers, each with a capacity of about 250 m^3/h.

For alum solution metering, four piston pumps installed in each chemical building with a capacity of 10,000 l/h, are used to pump the alum solution to two constant head distributers located at either side of the clarification basins, which then distribute the alum solution by gravity to each clarifier at the inlet shaft.

5.4 Flocculation and Clarification
For an output of 600,000 m^3/day of treated water, twelve clarification basins have been constructed, three on each side of each of the two filter buildings forming a treatment unit of 300,000 m^3/day. Raw water flows to two open distribution channels in both treatment units which distribute the water between three rectangular clarifiers by means of partition weirs at the inlet of each clarifier.

The clarifiers are of the sludge blanket type, vertical flow with pulse action. The approximate internal dimensions of each pulsator clarifier are 33.3 m length x 22.9 m width and 4.5 m depth. The rated output of each clarifier is 50,000 m^3/day of clarified water, the retention period at nominal capacity is 1.65 hrs, and the surface loading is 2.9 m/h. The pulse action and the sludge extraction is operated in the same way as the Embaba waterworks with similar equipment.

5.5 Filtration
For an output of 600,000 m^3/day of treated water the filtration facilities are composed of two filter buildings each containing two groups each of 18 rapid sand filters. Each filter is 77 m^2 in area and has a nominal output of 10,000 m^3/day with a filtration rate of 5.4 m/h.

The filter floor consists of prefabricated concrete slabs containing long stem nozzles. The filtering material has one layer 80 cm deep of a sieved sand 0.9 mm to 1.25 mm in size. This filtering layer is supported by 5 cm deep layer of gravel with a grain size of between 4-8 mm. All the filters are equipped with a flow rate control syphon of Degremont standard design with an upstream control device using the syphon principle.

The filters are backwashed by simultaneous return of air and filtered water similar to Embaba. There are twelve vertical mounted centrifugal pumps, electrically driven, three for each battery of 18 filters. Each pump has a capacity of 580 m^3/h against 11 m head.

Eight electrically driven scour air blowers, two for each group of 18 filters each having a capacity of 4235 m^3/h at 325 m bar delivery head are installed for backwashing. The filter valves are of the pneumatic system operated by compressed air from the compressors with electric drive.

5.6 Treated Water Reservoirs
Two identical treated water reservoirs with a maximum capacity of 5000 m^3 are located

under each of the two filter buildings.

The reservoirs receive filtered water from filters through the main filtered water channel, where the post-chlorination dose is added, the treated water flows out of the reservoirs through two 1200 mm diameter pipelines to the treated water sumps of each treated water pumping station.

5.7 Chlorination
The chlorination facilities contain equipment for applying pre-chlorination, intermediate, and post-chlorination. There is also space for storage, chlorine leak detection, and a caustic soda spray tower for neutralization of chlorine in case of emergency.

The available chlorinators for each of the two chlorination units are:

Four 83 kg/h capacity, vacuum type chlorinators (two in service and two on standby) complete with ejectors are used for pre-chlorination & intermediate chlorination.

Four 38 kg/h capacity, vacuum type chlorinators (two in service and two on standby) complete with ejectors are used for post-chlorination.

The method of protection from chlorine leakage is similar to that of Embaba. There are two facilities, each for one half of the plant, that neutralize the leaking chlorine gas by caustic soda solution. Each facility contains the following equipment:

Two extraction fans with motor drive units
Two caustic soda pumping units
One caustic soda dissolving tank
One neutralization tower
Complete piping system

5.8 Treated Water Pumping Stations
For an output of 600,000 m^3/day of treated water, there are two pumping stations, each for one half of the plant. Each pumping station contains six horizontal split case centrifugal pumps each 1000 l/s (3600 m^3/h) against 75 m head. The pumps are electrically driven by 3 phase induction motors 10.5 KV with capacity of 1080 KW.

Every three pumps (12 total) deliver water to one of four main 1200 mm diameter delivery pipes which are collected together by a main 1200 mm diameter header to which four trunk mains are connected with 1000 mm, 1200 mm, 1400 mm and 1600 mm diameter pipes. A connection for another trunk main of 1200 mm diameter is also possible.

Each trunk main is equipped with a venturi meter (4 total). All of the venturi meters are presently out of service.

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5.9 Power Supply and Utilization

Electric power is provided by the Cairo electric distribution center (CEDC) network to the treatment plant and to the raw water pumping station.

Two main 10.5 KV feeders, each consisting of two cables, feed a main 10.5 KV switchgear located at the diesel generating station, which distributes electric power to the two treated water pumping stations, by two feeders for each, and to the two filtration units each by two feeders through four step down transformers, each with a capacity of 1500 KAVA. 10.5/0.38 KV

Two main 10.5 KV feeders are feeding a main 10.5 KV switchgear located at the raw water pumping station, where two step down transformers each 250 KAVA, 10.5/0.38 KV are installed, with a 380 V switchgear for auxiliary.

In each building there is a suitable 380 V switch board for operating the auxiliaries. All switchgear has incoming feeders and a number of outgoing lines to meet requirements.

5.10 Sludge Pumping Station

The sludge from clarifiers and filter backwash is collected by gravity to two sludge pumping facilities, one for each side of the treatment plant. Each facility consists of a sludge collecting tank and three pumps with capacity of 918 m^3/h at 11 meters head. The pumps deliver sludge to two 600 mm diameter pipelines (one for each side), which are connected to one 1000 mm diameter pipeline which delivers the sludge to the Nile River downstream of the intake. The pumps are electrically driven by 3 phase induction motor 380 volt, 45 KW.

5.11 Standby Power Generating

There is a standby power generating building containing four diesel generating units, each with a capacity of 2000 KAVA. Each unit is composed of one diesel engine, 2350 HP directly coupled to a 10.5 KV, 2000 KAVA alternator. The generating station is complete with high tension switchgear and all the required accessories.

6. GIZA WATERWORKS

6.1 General Description

Giza waterworks is one of the oldest water treatment plants in Cairo. It was first constructed in 1898 with expansions in 1934, 1951, 1959 and 1970. The plant is located in a central area of Dokki and Giza on the west bank of the Nile River, and is separated by a major road with clarifiers and raw water intake on the east side and filters and post chlorination on the west.

The rated capacity of the plant is 120,000 m^3/day of treated water. In addition some raw water is pumped directly to non-potable network for landscape irrigation. The low lift pumps supply water from two intakes through several pipes to the clarification basins. These were constructed as four units in subsequent stages; Unit 1- Patterson (British), Unit 2- Permutit (British), Unit 3- Bamag (German) and Unit 4- (similar to Bamag - Czechoslovakian).

The clarified water flows by gravity from clarifiers to the corresponding filtration facilities and the treated water flows by gravity from the underground reservoirs beneath each filter building to two sumps through a loop of 800 mm diameter pipeline. Two treated water reservoirs are connected to the loop where water is stored at night by special pumps and flows by gravity through an outlet adjusting valve before continuing to the loop and the treated water sumps.

A clear water pumping station delivers the treated water directly into the network by two main 800 mm diameter pipe lines connected to different distribution pipeworks outside the plant area. The plant is operated on a 24 hour basis.

6.2 Intake and Raw Water Pumping Stations :

There are two separate intake structures on the west bank of the Nile River. The older intake consists of five submerged steel pipelines extending about 15 meters into the river from the shore, however only two 1000 mm diameter intake lines are still in service. Each pipe line feeds two raw water pumps.

The older pumping station, located within the plant site, contains the following equipment:

Two pumps @ 3960 m^3/h against 18 m head, electrically driven one by 3 phase induction motor, 525 V, nominal power 270 KW, the other by 3 phase induction motor, 3.15 KV, nominal power 270 KW.

Two pumps @ 3060 m^3/h against 15 m head, electrically driven by 3 phase induction motors, 3.15 KV, nominal power 170 KW. All of the units are of horizontal split case centrifugal pumps located on a low level floor. Two pumps each are connected from the suction side directly to one of the two 1000 mm diameter pipelines. These deliver raw water to the main 600 mm diameter headers branched outside the pumphouse for feeding five clarifiers on the same site. Three venturi meters are installed with each pipeline feeding clarification units. These venturi meters and the related measuring instruments have been abandoned.

The newer intake structure is constructed at the edge of the Nile river, approximately 30 meters upstream from the old intake. It is constructed to house eight pumping units, five low lift pumps and three higher lift pumps for irrigation purposes. Three of the low lift pumps have been dismantled and taken to another plant. Only two pumps are still in use which have a capacity of 1980 m^3/h against 15m head. The pumps are electrically driven by a 3 phase induction motor, 3.15 KV, with nominal power of 112 KW.

From the new intake the low lift pumps deliver raw water to two main 1000 mm diameter pipelines connected to the main header of the old pumping station. A 800 mm diameter pipeline branches from one of the 1000 mm diameter pipelines to feed the clarification basin located on the other side of the plant. Venturi meters have been abandoned and measuring of raw water is not possible.

6.3 Chemical Dosing

The chemical dosing facility is contained in a building equipped for dosing alum as the main coagulant. Equipment for dosing lime or activated carbon has been abandoned. Alum dosing is accomplished using an alum solution of 10% concentration is prepared by dissolving solid alum or diluting liquid alum in three mixing concrete basins (35 cubic meters each) located on the ground floor. Compressed air passing through a perforated PVC pipe located at the bottom of the tanks is used for stirring.

Two alum metering piston pumps are used to pump the alum solution to the Patterson, Permutit and Czechoslovakian clarifiers. One of these two pumps is in operation and the other is on standby. The alum dose is injected into the raw water pipes feeding the clarifiers.

For adding the alum solution to Bamag clarifiers, the alum solution is pumped from the dissolving tanks to two storage tanks (50 cubic meters each) located on the third floor of the building. The alum solution then flows by gravity from the storage tanks to the two clarifiers through a flow metering device composed of a constant head tank with orifice flow meters.

6.4 Flocculation and Clarification

For a rated output of 120,000 m^3/day of treated water, four clarification units of different types are available consisting of the following equipment:

6.4.1 Patterson (U.K) Clarifier Unit

The Patterson clarifier is a square settling tank about 30 x 30 m equipped with mechanical scraper and constructed in 1934. A separate rectangular flocculator was added later that year. There is an adjacent structure for alum mixing which has been abandoned. The flocculator is equipped with three vertical turbine mixers, operated by an electric motor and gear box.

The chemically dosed raw water, with no adequate mixing enters the flocculator from one side and leaves it from the other side into the clarifier inlet which is formed by a partition wall across the entire width beginning half way below the surface of the water. Clarified water flows over an outlet weir across the entire width on the opposite side from the influent then continues through a 600 mm diameter pipe line to the corresponding filter house located at the western half of the plant.

The rated output of this clarifier is 24,000 m^3/day with a surface loading of 1.1 m/h and retention period of 3.6 hrs which are within normal practices.

6.4.2 Permutit Clarifier Unit

The Permutit clarifiers were constructed in 1951 and consist of two identical circular clair-flocculators each with an output of 18,000 m^3/day of clarified water, the chemically dosed raw water enters each basin by a 600 mm pipeline to a flash mixing chamber at the edge of the clarifier and is carried by a pipe which dips under the basin and rises in the central shaft before continuing through the openings near the top to the flocculation zone, the flocculation zone is formed by cylindrical steel partition wall supported by the scraper structure and completely opened near the floor, the water flows from the bottom of the flocculator to the surrounding settling tank. The clarified water is then collected by a circular weir to a clarified water channel before continuing through a 600 mm pipe line to the corresponding filter house in the western half of the plant.

The surface loading of these clarifiers is 1.2 m/h and the retention period is 3.2 hours which are within normal practices. The approximate internal dimensions of each clair-flocculator is 28m diameter by 4m deep for the settling tank and 12m diameter by 4m depth for the flocculators.

The sludge is extracted by a mechanical scraper, which rotates very slowly scraping the sludge on a conical bottom ta a central access from which sludge flows by gravity back to the Nile River about 30m downstream of the old intake.

6.4.3 Bamag Clarifier Unit

The Bamag clair-flocculators were constructed in 1959, consisting of two identical circular clair-flocculators, each with a rated output of 24000 m^3/day of clarified water. These units are similar in operation to the Permutit clair-flocculators.

The approximate internal dimensions of each clair-flocculator are 32m diameter by 4 meter depth for the settling tank and 12m diameter by 4 meter depth for the flocculator. The surface loading of these units is 1.4 m/h and the retention period is 2.8 hrs which are within normal practices.

6.4.4 Czechoslovakian Clarifier Unit

This unit was constructed in 1970 and is located in the western portion of the plant near the corresponding filter house. It consists of one circular clair-flocculator with an output of 40,000 m^3/day. The clarifier is identical to the clarifiers at Roda Treatment Plant which are similar in operation to Permutit clair-flocculators.The approximate internal dimensions of this clarifier are 43 m diameter, 5 m depth for the settling tank and 20 m diameter and 6 m depth for the flocculating zone. The surface loading is 1.1 m/h and the retention period about 4 hrs which are within the normal practices.

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6.5 Filtration

The filters are housed in four buildings located on the western part of the plant. Each unit receives clarified water from the corresponding clarification facility.

6.5.1Patterson Filter House

Constructed in 1934, it consists of 16 rapid sand filter units each 25 m^2 in area in two rows on either side of the building. The filtration rate is 4 m/h at the normal unit output of 2400 m^3/day. The total output of the filters would be about 35,000 m^3/day of filtered water for optimum performance.

The filter under drain system has a layer of perforated pipes, over which lies a 50 cm high gravel supporting bed. There are four equal layers of gravel ranging in size from 32 mm to 3m. The filter medium which is 60 cm deep of sieved sand reported as ranging in size from 0.8 to 1.25 mm, lies on top of the gravel layer.

The clarified water flows by gravity from the Patterson clarifier at a rate of 1000 m^3/h added to 500 m^3/h from Bamag clarifiers to two main distribution channels before continuing to filter inlets. The flow rate of each filter is controlled at a constant rate with the downstream system by float valve devices. All the valves for the filter operation are manually operated.

The filters are washed by simultaneous return of air followed by filter water. Two backwash pumping units with motor drive, each with a capacity of 400 m^3/h against 15m delivery head and two motor driven air blowers are available for backwashing.

6.5.2 Permutit filter house

Constructed in 1951, this unit is essentially identical to the Patterson filter house with respect to total output, number and size of filters, the underdrain system, gravel supporting bed, filter medium, filtration rate, flow control device, backwash equipment and conditions. The unit receives clarified water from the corresponding Permutit clair-flocculators at a rate of about 1500 m^3/h.

6.5.3 Bamag filter

Constructed in 1959, it consists of 12 enclosed rapid sand filter units each with an area of 95 m^2 laid in two rows one either side of the building. The filtration rate is 4.3 m/h at the normal unit output of 3600 m^3/day. The total output is about 35,000 m^3/day of filtered water. These filters are similar to Patterson and Permutit filters except the filter medium consists of 180 cm layer of 0.8 - 1.25 mm sieved sand supported on a layer of gravel of 4-8 mm grain size just covering the perforated pipes.

The flow rate of each filter is controlled at a constant rate by a Bamag controller, based on an upstream control system. The filter operating valves are hydraulic sluice valves operated from a desk for each filter located at the main operating hall of the filter house. The filters are washed by the simultaneous return of air and filtered water in a two-stage cycle of air and filtered water. Two back wash motor driven pumps with 720 m^3/h and 10 m head and two motor driven air blowers, with a capacity of 2650 m^3.h and 10 m head are installed in the treated water pumping station.

6.5.4 Czechoslovakian filter house

Constructed in 1970, it consists of four rapid sand filter units each 100 m^2 in area. At the nominal rated unit output of 12,500 m^3/d, the filtration rate is 5.2 m/h, the total output is approximately 36,000 m^3/d of filtered water. These filters are essentially the same as Bamag filters with respect to the underdrain system gravel supporting bed, filter medium and backwash conditions.

Each filter is split into two bays by a central channel used for clarified water entrance and back wash water outgoing to waste. Each bay is back washed separately.

Two back wash motor driven pumps with a capacity of about 720 m^3/h and 10 m head, and two motor driven air blowers with a capacity of 2,650 m^3/h and 10 m head are available. The back wash flow rate of air is 1.7 m/min. which is acceptable, however the back wash flow rate for water is 15 m/h which is less than the minimum recommended figure of 19 m/h.

Backwash water from each filter house flows to a separate sump, from which wastewater is pumped to the Nile River by two motor driven pumping units for each filtration facility.

6.6 Treated Water Reservoirs

Four treated reservoirs are located under each filtration unit. Three of them have a capacity of 1800 m^3 each and one which is under the Bamag filter has a capacity of 1600 m^3. In addition there are two main reservoirs each with a capacity of 6000 m^3. These two reservoirs are filled by pumping. The total storage capacity is 18,200 m^3.

6.7 Chlorination

A chlorine building which was previously used for alum storage, is situated at the eastern edge of the plant. Four vacuum type chlorinators, each with a capacity of 40 kg/h, are used without standby units for injecting chlorine solution into the raw water pipe lines feeding the clarifiers on the east side of the plant. For the Czechoslovakian clarifier another 20 kg/h chlorinator is available.

At the time of the TSOM field survey no post chlorination was used for any of the filtration facilities. A chlorine residual was achieved by adding high doses of pre-chlorination. This practice is not normal, requires higher amounts of chlorine, and could produce higher levels of chlorine disinfection by-products. Post chlorination is only used for night time filling of the two large reservoirs. Two small chlorinators are used for this purpose. The chlorination facility at Giza Water Treatment Plant is inadequate and has the potential for failure with adverse health effects.

6.8 Treated Water Pumping Station

The treated water pumping station is situated on the western side of the site and consists of six horizontal split case centrifugal pumps, two with a capacity of 800 l/s (2880 m^3/h) and four with a capacity of 400 l/s (1440 m^3/h) against 50 meters total manometric head. Suction is taken from two sumps, one on either side of the pump station.

The pumps are electrically driven by a 3 phase induction motor 3.15 KV with nominal output of 340 KW for the 400 l/s pumps and 660 KW for the 800 l/s pumps.

6.9 Power supply and utilization
The electrical power is supplied from the electric distribution authority network by two main 10.5 KV feeders connected to main H switchgear. from which electricity is connected to switchgear located in another building.

6.10 Standby Power Generation
Three diesel generation units are available. Two diesel generation units are located on the higher floor of the treated water of these pumphouses. Each of these units has a 1013 KAVA, 3 phase, 10.5 KV alternator directly coupled to a 1200 HP diesel engine.

One diesel generating unit is located at an old generating house. This unit has a 435 KAVA, 3 phase, 525 V alternator directly coupled to a 600 HP diesel engine. This unit is extremely old.

7. GEZIRET EL DAHAB WATERWORKS

7.1 General Description

The WTP is located on the western bank of the Nile, just upstream from Roda WTP. This waterworks was constructed in two stages. The first stage, with a rated capacity of 70,000 m^3/d, began service in 1973 and the second stage with the same rated capacity began service in 1976. The plant consists of one intake, one raw water pumping station, six clarification basins, two filtration facilities and one treated water pumping station. Two chemical houses are used for mixing and dosing alum together with chlorination facilities.

The low lift pumps supply raw water from the intake through a group of pipes with different diameters to two distribution shafts before continuing by gravity to the clarifiers. Clarified water from the outlet of the clarifiers flows to two filter houses. Each filter house contains twenty rapid sand filters and each filter has a surface area of 42 m^2.

Two treated water reservoirs, each with a volume of 6000 m^3, are located under the filter houses. These receive the sterilized water for a contact period of about two hours at the rated output.

A clear water pumping station delivers the treated water directly to the network by two main pipelines with diameters of 800 mm and 1000 mm respectively. The plant is operated on 24 hour basis.

7.2 Intake and Raw Water Pumping Station

The intake structure is located adjacent to the main channel of the Nile. There are four submerged intake pipes, each with a diameter of 1000 mm, which extend 150 meters into the Nile River. The four intake pipes are connected in pairs, to two circular suction intake connections into the pump house.

The low lift pumping units at the raw water pump station consists of eight pre-primed for starting, horizontal split case centrifugal pumps. Four have a capacity of 275 L/s (990 m^3/h) and the other four have a capacity of 600 L/s (2160 m^3/h) against 14 meters delivery head. The pumps are electrically driven by 3 - phase induction motors of 380 volts receiving electrical power from three step down transformers 650 KAVA, 10.5/0.38 KV. The nominal output of the motors as 75 KW for the pumps 275 L/s, and 130 KW for the pumps 600 L/s. The low lift pumps deliver raw water to two distribution shafts where chemicals are added through two 1200 mm diameter pipelines. There are no venturi meters or other means for raw water flow measurement.

7.3 Chemical Dosing

Two buildings for chemical facilities are located at the two distributors which contain equipment for administering the following chemical:

- Aluminum sulfate (alum) as main coagulant
- Coagulant aid

Alum dosing utilizes an alum solution of 10% concentration which is prepared by dissolving solid alum or diluting liquid alum in three 6.4 m^3 concrete tanks at each

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distributor. Motorized mechanical mixers are used for stirring. The alum solution is fed into the raw water in the distributer by gravity through flow meters with a constant head tank.

7.4 Flocculation and Clarification

Three clarification basins are available. Each basin consists of two adjacent rectangular clair-flocculators, each settling basin being 6.7 m wide by 49 m length and approximately 4.3 m deep. The dimensions of the clarifiers at the rated design capacity of 140,000 m^3/day would give 2.9 hours retention time and a surface loading of 1.4 m/h which should be considered acceptable loading for good clarification.

The chemically dosed raw water enters the flocculator at the receiving end of the basin and flows through baffle walls where flocculation occurs. A slotted wall at the end of each flocculator distributes the flocculated water uniformly across the width and depth of each clarifier basin.

The bottom portion of the basin has slopes to six points from which the sludge is withdrawn through 200 mm pipes to 300 mm pipelines before joining the waste of backwash water to be carried away by 500 mm pipelines back to the River Nile, about 150 meters downstream from the intake.

The clarified water flows from clarifier outlets to a main collecting channel before continuing to the filter houses, by a main 1200 mm pipeline laid on the top of the central gallery of each filter house.

7.5 Filtration

Two filter houses have been constructed each with 20 rapid sand filter units, each unit is 42 m^2 in area, divided into two bays by a central distribution and backwash channel. At a rated output of 140,000 m^3/day, the filtration rate will be 3.86 m/h which is lower than the recommended waterworks standard rate of 5 m/h - 6 m/h. At a surface loading of 5 m/h and two filters on standby in each filter house a production of 180,000 m^3/day can be achieved.

The filter under drain system has slotted long-stem plastic nozzles screwed on pre-fabricated reinforced concrete slabs. The filter medium is one layer 90 cm deep of a sieved sand of 0.8 to 1.25 mm grain size.

The 20 filters of each filter house are located in two rows. Each row of 10 lies on either side of a control gallery. The flow rate of each filter is controlled at a constant rate by a controller based on an upstream control system. The filter valves are hydraulically operated from the operating desk for each filter located at the main operating hall of each filter house. The filters are washed by the simultaneous return of air and filtered water in a three stage cycle of air, air and filtered water, and filtered water only.

There are three motor driven back wash pumping units each with a capacity of 810 m^3/h at 10 m head and three motor-driven air blowers each with 2,375 m^3/h capacity at 16 m delivery head.

7.6 Treated Water Reservoir

Two identical reservoirs with a total capacity of 12,000 m^3 provides about two hours storage at the rated capacity. The reservoirs, which are located under the filters, receive filtered water through two collecting channels. The water then continues to the inlet of the reservoirs where a post-chlorination dose is added.

7.7 Chlorination

Two facilities for chlorination are available, one for pre-chlorination and the other for disinfection prior to distribution. The pre-chlorination facility consists of three 40 kg/h maximum capacity vacuum type chlorinators and three 20 kg/h maximum capacity vacuum type chlorinators. The chlorinators are put into service in accordance with the raw water flow and the dose. For post-chlorination there are two 20 kg/h capacity chlorinators available.

7.8 Treated Water Pumping Station

Eight pre-primed for starting, horizontal split casing centrifugal pumps listed as follows:

Four units with a capacity of 720 m^3/h against 60 m head
Two units with a capacity of 2160 m^3/h against 60 m head
Two units with a capacity of 2628 m^3/h against 60 m head

The pumps are electrically driven by 3-phase induction motors, 3.15 KV receiving electric power from 3 main step down transformers, 1,250 KAVA, 10.5 / 3.15 KV. The nominal output of the motors are 240 KW for the pumps 720 m^3/h, 550 KW for the pumps 2160 m^3/h and 630 KW for the pumps 2628 m^3/h. The treated water pumps deliver water directly to the distribution network through two main pipelines with 800 mm diameter, which increase to 1000 mm outside the pump house.

The delivered water is measured by a 800 mm diameter venturi meter installed with each pipeline. The readings for indicating, recording and integrating the flow rate were intended to be transmitted to wall mounted instruments installed in the pump house. However, these instruments are not working.

7.9 Power Supply and Utilization

The electrical power is supplied from the electric distribution authority network by two main feeders of 10.5 KV through reactors to main H switchgear from which electricity is connected to switchgear located in different buildings.

7.10 Standby Power Generation

Two diesel generating units are available each composed of 1000 KAVA, 3-phase 10.5 KV alternator directly coupled with a 1200 HP diesel engine.

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8. RODA WATERWORKS

8.1 General Description

This waterworks is located at the southern end of Roda Island and is constructed to a Czechoslovakian design. The plant has been in continuous operation since 1968 and has a design capacity of 110,000 m^3/day. The low lift pumps supply raw water from the Nile River through two 800 mm diameter pipelines to the distribution shaft which distributes the water to three circular clair-flocculator units. The clarified water flows by gravity from the outlet of each clarifier to the filter house. The filter house contains 20 filter units, each 60 m^2, divided into two bays by a central channel.

Two treated water reservoirs with a total capacity 6,300 m^3 located under the filters receive water for a contact period of about 55 minutes. A clear water pumping station delivers the treated water directly to the network by two main pipelines, one with 1000 mm diam. the other with 800 mm diameter. The plant is operated on a 24 hour basis.

8.2 Intake and Raw Water Pumping Station

The intake structure is located adjacent to the main channel of the River Nile. Water flows through a short tunnel buried in the river bank to two inlet chambers with isolating gates and passes through two mechanical screens before continuing to a sectionalized suction pump.

The raw water low lift pumps are of vertical split casing, centrifugal dry pit type and consist of :

Four units @ 3600 m^3/h against 15 m head, electrically driven by 3 phase induction motor 204 kw, 3.15 KV.

Four units @ 200 m^3/h against 15 m head, electrically driven by 3 phase induction motor 380 V, nominal power 40 kw.

The switchgear consists of 3.15 KV and 380 V equipment for receiving electric power from the main switchgear and operating the different units.

The water delivered from the raw water pumps passes through a 1000 mm diameter eader with a sectioning valve, branched outside the pump house to two 800 mm diameter pipelines. These pipes pass beneath the chemical building to a distribution shaft. Venturi meters are installed with each pipe line and the flow rate readings are transmitted to a separate panel which has flow rate recording and integrating instruments situated in the pump house. The flow rate meter is in operation.

8.3 Chemical dosing

The chemical house has facilities for administering the following chemicals :

Aluminum sulfate (alum)
Calcium hydroxide (lime)
Activated carbon

At present only alum is in use as a coagulant. The alum dosing consists of preparing an alum solution of 10% concentration by dissolving solid alum or diluting liquid alum in three mixing concrete basins (50 cubic meters each). Motorized mixers are used for stirring the solution. Three alum metering pumps, each with 540 m^3/h capacity, are used for injecting the alum dose into the main raw water pipelines.

8.4 Flocculation and Clarification

Three circular Dorr-Oliver clair-flocculators of Czechoslovakian design have been constructed in line, each with a designed output of 40,000 m^3/d of clarified water. The approximate internal dimensions of each clair-flocculator are 43 m diameter by 5 m depth for the settling tank and 20 m diameter and 6 m depth for the flocculating zone. The flocculator consists of a set of vertical mechanical paddle mixers which rotate at a variable speed driven by an electric motor and gear box unit.

The sludge extraction basins have conical bottoms with a sludge hopper in the center and mechanical scraper pivoted at the center, rotating at about 40 minutes per revolution. The sludge is extracted by gravity from the center hopper and returned to the Nile River about 135 m downstream from the intake.

The surface loading is 1.1 m/h at the designed flow rates and the retention period is about 4 hrs which is within normal practice.

8.5 Filtration

There is one filter house constructed for a designed output of 110,000 m^3/d of treated water. It consists of 20 rapid sand filters of Czechoslovakian manufacture. Each filter unit is 60 m^2 in area, split into two bays by a central channel.

At the unit rated designed output of 6,000 m^3/d, the filtration rate is 4.1 m/h. The filter underdrain system has long stem plastic nozzles with slotted brass circular cylinders screwed on fabricated reinforced concrete slabs. The filter material is one layer, 100 cm thick, of a sieved sand of 0.8 to 1.25 mm grain size. Each filter is equipped with a flow rate controller of Bamag type to maintain constant output during the entire filtration cycle.

The filters are washed by the simultaneous return of air and filtered water, backwash is a three-step process, air, air and filtered water, and with filtered water only. Two back wash pumping units with motor drive, each with a capacity of 1,260 m^3/h against 10 m delivery head, and two motor drive scour-air blowers each with 2,500 m^3/h at 10 m head, are located in the treated water pumping station. The valves of the filters are hydraulic type operated by pressurized water.

8.6 Treated Water Reservoirs

Two reservoirs with a total capacity of 6,300 m^3 are located under the filters. This represents about one hour storage at operating capacity. The treated water flows from the two reservoirs through a diameter 1000 mm outlet valve to a sectionalized treated water sump along two diameter 1000 mm pipelines.

8.7 Chlorination

There are two facilities for chlorination. The pre-chlorination facility is incorporated into the chemical building which contains the chlorine storage and has a capacity of 10 drums

(800 - 1000 kg each). The chlorine apparatus room contains four vacuum type chlorinators with a capacity of 40 kg/h. The chlorine solution is fed by pressurized water through ejectors to the main raw water pipelines passing under the chemical house.

The disinfection (post-chlorination) equipment is located in a separate room at the back of the filter house. It contains 4 chlorine drums (800 - 1000 kg), two in operation and two standby. The chlorine apparatus room contains four vacuum type chlorinators with a capacity of 40 kg/h. The chlorine solution is fed by ejector to the filtered water just before it enters the two underground reservoirs.

8.8 Treated Water Pumping Station
The treated water pumps consist of four pumps @ 3200 m^3/h against 60 m head, electrically driven by 3 phase induction motors 3.15 kv with nominal power 670 kw, the pumps are of vertical split casing, centrifugal dry pit type. The pumps deliver the treated water directly to the distribution network through two main pipe lines of 1000 mm and 800 mm diameter.

The flow rate and pressure are measured by two venturi meters and the readings are transmitted to a hydraulic panel containing flow rate indicating, recording and integrating instruments for each pipeline.

8.9 Power Supply and Utilization
All the mechanical units are driven by electric motors. The power is supplied from the electric distribution authority network by two main feeders, 10.5 kv to main high tension (H) switchgear located in the switchgear and transformer room incorporated into the treated water pump house from which electricity is connected to three step-down transformers, 10.5/3.15 kv 200 KAVA, then to medium tension (MT) switch gear for treated water and raw water pumping units, the low tension (LT) is obtained by two step-down transformers 500 KAVA 3.15/0.38 KV. All the switchgear is of Czechoslovakian manufacture.

The switchgear in different buildings is as follows:

- Main H switchgear, located in a switchgear room composed of 13 panels, 10.KV
- Main MT switchgear, located in a switchgear room composed of 13 panels, 3.15 KV
- MT switchgear for RW pumps, located in the RW pump house, composed of 12 panels, 3.15 KV
- MT switchgear for TW pumps, located in a switchgear room, composed of 12 panels, 3.15 KV
- Main LT switchgear, located in a switchgear room composed of 8 panels.
- Auxiliary LT Switchboards

In each building there is a suitable LT board for operating the auxiliary units. Each board is complete with incoming feeder and a number of outgoing ones to meet requirements.

8.10 Standby Power Generation
One 1000 KAVA diesel generating unit is available, consisting of a 1200 HP diesel

engine. a 3 phase 380 V alternator and a 1000 KAVA step up transformer 10.5/0.38 KV. The unit can operate raw water and treated water pumps for about 20% of the normal plant capacity.

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9. MAADI WATERWORKS

9.1 General Description

Maadi Water Treatment Plant was originally started in 1903 as a raw water intake and non-potable irrigation system. Subsequently, the first filtration plant was installed in 1955 the second in 1960 and the third and largest unit in 1966. The plant actually consists of three facilities each with a chemical mixing building, flocculator, clarifier, and filter unit. All of these units are connected to three under ground treated water storage reservoirs and one treated water pumping station.

The rated capacity of the entire plant is 70,000 m^3/day and it is operated on a 24 hour basis with 3 shifts.

9.2 Intake and Raw Water Pumping Station

The intake of Maadi waterworks is located on the River Nile shore consisting of four pipe lines, 1000 mm diameter extending about 25 meters into the Nile.

The low lift raw water pumping units consist of 6 horizontal centrifugal pumps as follows:

two pumps @ 2160 m^3/h against 14 m head
two pumps @ 1440 m^3/h against 16 m head
two pumps @ 990 m^3/h against 14 m head
two pumps @ 990 m^3/h against 14 m head for irrigation

The low lift pumps deliver raw water to the treatment plant by two 800 mm diameter pipelines. There are no venturi meters installed for flow measurement of the raw water delivered to the clarification basins. The pumps are electrically driven by 3 phase induction motors 3.3 KV with capacity of 130 KW for the 2160 m^3/h pumps, 100 KW for the 1400 m^3/h pumps, and 0.38 KV, 65 KW for the 990 m^3/h pump.

9.3 Chemical Dosing

Only alum is used as the main coagulant. A 10% concentration alum solution is prepared by dissolving solid alum or diluting liquid alum in dissolving tanks. The dose is injected into the raw water by dosing units at different points of application.

9.4 Flocculation and Clarification

The clarification facilities consist of the following equipment :

One Dorr-Oliver clarifier with a capacity of 50,000 m^3/day
One Old Bamag clarifier with a capacity of 800 m^3/day
One New Bamag clarifier with a capacity of 12,000 m^3/day
One Patterson clarifier with a capacity of 4,800 m^3/day

All the clarifiers receive chemically dosed raw water from a distribution shaft and deliver it to the corresponding filters. In addition there is one experimental clarifier used for clarification trials but it is not in service.

9.5 Filtration

Four filtration facilities receive clarified water from the corresponding clarification basin. The filtration facilities include the following :

twelve Czechoslovakian filters, unit capacity of 2880 m^3/day each
two Old Bamag filters, unit capacity of 2160 m^3/ day each
four new Bamag filters, unit capacity of 2880 m^3/day each
two Patterson filters, unit capacity of 2040 m^3/day each
three experimental filters, unit capacity of 5040 m^3/day each

All the filters are of the rapid sand configuration. The filtration rate is about 5 m/h. Five backwash pumps are available for filter backwashing in addition to air blowers.

9.6 Treated Water Reservoirs

Three separate treated water reservoirs are constructed with a capacity of 7500 m^3, 1500 m^3 and 750 m^3. All the reservoirs are connected together and receive filtered and chlorinated water for the contact period of chlorine with water.

9.7 Chlorination

There are two facilities for chlorination, one for pre-chlorination and the other for post-chlorination. These include :

one 40-kg/h chlorinator apparatus, one 20 kg/h chlorinator and two 10 kg/h chlorinator for pre-chlorination including standby .

one 10 kg/h chlorinator is available for post-chlorination.

9.8 Treated Water Pumping Station

One new treated water pumping station is in service containing five horizontal centrifugal pumps with capacity of 300 L/s (1080 m^3/h) against 75 meters total manometric head. The pumps are electrically driven by 3 phase 3.3 KV induction motors with a capacity of 335 KW. The treated water is pumped to the network through two 800 mm diameter pipelines and one 600 mm diameter pipeline. Each is equipped with venturi meters which are currently inoperable.

9.9 Power Supply and Utilization

The power is supplied from the electric distribution authority network by two main 105 KV feeders to main H switchgear from which the electricity is distributed to different units at the appropriate operating voltage. There is a suitable LT board complete with incoming feeder and a number of outgoing ones to meet requirements in each building. There are 2 stepdown transformers 200 KAVA, 10.5/3.3 KV, and two 500 KAVA, 10.5/0.38 KV, used for electric power utilization.

9.10 Standby Power Generation

Three diesel generating units with a capacities of 700 KW, 440 KW and 220 KW respectively are available, all generating electric power with 3.3 KV.

10. NORTH HELWAN WATER TREATMENT PLANT

10.1 General description

North Helwan waterworks began its service in 1963, with a capacity of 50,000 m^3/day. The plant was expanded in 1978 to a total capacity of 120,000 m^3/day.

Raw water is pumped directly from an intake and pumping station on the bank of the Nile River. Water is piped directly to the two distributors that serve the clair-flocculators. By gravity flow, clarified water moves to rapid sand filters, (contained in two filter buildings), reservoir storage, and to two effluent pump stations for distribution.

The facility is operated on a 24-hour basis in 3 shifts. The facility also contains workshops, storage, administration offices and laboratory.

Non potable water for irrigation is available by 2 pumping units at the raw water pumping station.

10.2 Intake and Raw Water Pumping

The intake structure is located on the bank of the River Nile. Water flows through six 1000 mm pipelines which extend 50 meters into the Nile River. There are three raw water sumps, from which raw water is pumped by the low lift pumping units. The raw water pumping facility contains the following equipment:

Four pumps with a capacity of 2160 m^3/h against 14 m head, electrically driven by 3 phase induction motors 6.6 KV, 112 KW for two units from Japan and 160 KW for two Czechoslovakian units .

Four units 990 m^3/h against 14 m head, electrically driven by 3 phase induction motors 0.38 KV, 75 KW.

The pumps deliver water to two distribution shafts before continuing to clarification basins.

10.3 Chemical Dosing

The chemical house has facilities for administering alum as the main coagulant, and for pre-chlorination. Only alum is used for coagulation at present. Alum dosing is accomplished using a 10% solution prepared by dissolving solid alum or diluting liquid alum in three tanks each 2.4 x 1.9 x 1.9 m in size. One electric mixer is provided in each tank. Metering pumps are available for dosing.

10.4 Flocculation and Clarification

The chemically dosed water is routed to the distributors and then to four Pintsch-Bamag circular clair-flocculators from one distributor and to two adjacent rectangular clair-flocculators from the second distributor.

A 500 mm pipe delivers the overflow from the weir in the distributor structure to the bottom of the flocculator section for the Bamag clair-flocculators. The water moves upward through the mixing zone and overflows into a ring section formed by a cylinder, with an open top and bottom surrounding the flocculator section with a space about 0.5 m between them.

The flocculated water moves downward through that annular space and enters the clarifier section near the bottom, over the layer of settled sludge on the conical floor of the clarifier. The water then flows upward and radially toward the circular weir collecting the clarified water.

A rotary scraper is operated for one hour during each shift to move the sludge toward the sludge discharge opening in the floor of the clarifier, from which point it flows by gravity to the sludge receiving basin about 15 m westerly from the clarifiers. From that basin it can flow by gravity or be pumped, to a discharge point about 700 m upstream from the plant intake.

The clarified water collected in the peripheral launder flows into a 500 mm pipe which combines with three lines delivering water to the filters.

For the rectangular clair-flocculators, the chemically dosed raw water enters the flocculator at the receiving end of the basin and flows through baffle walls where flocculation occurs.

A slotted wall at the end of each flocculator distributes the flocculated water uniformly across the width and depth of each clarifier basin. Upon leaving the basin, the clarified water flows over a weir extending across the width of the basin. For sludge extraction, the bottom portion of the basin has slopes to some points from which the sludge is withdrawn through two 300 mm pipes before joining the waste of backwash water to be carried by 600 mm pipeline and flow by gravity or be pumped upstream from the plant intake.

10.5 Filtration

Two filter buildings have been constructed. One filter building that consists of 14 filters receives clarified water from the Bamag clair-flocculators and the other building consisting of 20 filters receives water from the adjacent longitudinal clair-flocculators.

The 14 filters are constructed with a central gullet dividing the filter longitudinally into two bays. Two backwash water troughs span the width of each bay and are connected to the gullet. As the lips of the troughs and the gullets are at the same elevation, they all serve to collect the backwash water during the backwash cycle. The backwash water drains into the central gullet and thence to the disposal line to the Nile. With the gullet gate closed, the gullet and troughs serve to distribute the incoming clarified water during filtration.

The underdrain system in the Pintsch-Bamag filter differs from the nozzles or perforated laterals used at the other water treatment plants of GOGCWS. The underdrains are precast concrete sections in the general shape of an open-ended inverted trough with the upper edges beveled. The sections are 50 cm long, 15 cm wide, and 12.5 cm high. The cutout or inner section of the trough is 10 cm by 10 cm. Five 2.5 cm holes evenly spaced along each of the two sides of the section permit water to flow from the outside into the center during filtration, and thence via a series of gullets in the filter floor to the filter effluent conduit and pipeline. The underdrain sections are set on the filter floor and aligned so as to cover the entire floor and straddle the underlying inflow-outflow gullets. Over the underdrains are placed 60 cm of graded gravel ranging in size from 5 cm at the bottom of the layer to 1.25 cm at the top. A 1.0 m deep layer of 0.5 to 1.8 mm sand covers the gravel.

The twenty filters receive water from the adjacent longitudinal clair-flocculator. Each filter unit is split into two bays by a central channel. The filter underdrain system has long stem plastic nozzles screwed on fabricated reinforced concrete slabs. The filter material is one layer of sieved sand 0.8 to 1.2 mm grain size. All the filters in the two filter houses are washed by the simultaneous return of air and filter water, back wash is in three-steps process air, air and water together and finally water only. Electrically driven wash water pumps and blowers are available for the backwashing of the filters at the two filter houses.

10.6 Treated Water Reservoir

Filtered water is collected in two underground reservoirs each with a capacity of 3250 m^3 .

10.7 Chlorination

There are two facilities for chlorination: one with capacity of 40 kg/h for pre-chlorination and the other for post-chlorination which consists of two chlorinators each of capacity 20 kg/h. Three chlorinators with a capacity of 40 kg/h, and three chlorinators with a capacity of 20 kg/h to be used for pre- and post-chlorination are under construction.

10.8 Treated Water Pumping Station

There are two treated water pumping stations. The old pumping house contains three pumps, one with a capacity of 1080 m^3/h and two with a capacity 540 m^3/h, all against 100 m head. All the units are horizontal centrifugal pumps, driven by 3 phase induction motors 6.6 KV with capacity of 500 KW for the 1080 m^3/h pump and 250 KW for 540 m^3/h pumps.

The newer pumping house contains seven pumps with capacity of 1080 m^3/h against 100 m head. The pumps are horizontal centrifugal units, driven by 3-phase induction motors 6.6 KV,465 KW. All the pumps in the two buildings deliver treated water to two main 800 pipelines through two non operational 800 mm venturi meters.

10.9 Power Supply and Utilization

The power is supplied from the electric distribution authority network by two main feeders 6.6 KV to main H switchgear from which electricity is connected to different units either directly with 6.6 KV or through stepdown transformers 6.6/0.38 KV for auxiliaries. Each building contains a suitable LT board complete with an incoming feeder and a number of outgoing load lines to meet requirements.

10.10 Standby Power Generation

One 1100 KAVA diesel generating unit is available consisting of 1320 HP diesel engine directly coupled to 1100 KAVA alternator. The unit is currently under construction.

11. KAFR EL ELW WATERWORKS

11.1 General Description

In 1923, this plant was put into service with two slow sand filters. A clair-flocculator unit rated at 600 m^3/h and six rapid sand filters were constructed in 1939. A second clair-flocculator unit rated at 150 m^3/h and two rapid sand filters were added in 1948. In 1967, the slow sand filters were remodeled to form two longitudinal flocculation-sedimentation basins, each rated at 600 m^3/h. Two longitudinal flocculation-sedimentation basins, each rated at 800 m^3/h, were completed in 1970 to increase the rated capacity of the plant to 80,000 m^3/d of filtered water. Presently two intake pump stations, a chemical mixing facility, clair-flocculators, filters, storage tanks and a filtered water pump station exist at the site.

The plant is operated on a 24-hour basis through 3 shifts. The facility also contains storerooms, workshops, laboratory, power generation facility and administration offices.

11.2 Intake and Raw Water Pumping

Two intake structures are in use at the plant. The older one has a 600 mm pipe which extends about 30 m offshore into the Nile River. The newer one, about 35 m downstream from the old has four 1400 mm pipelines extending about 536 m offshore, however only one pipeline is in operation at present.

Each intake system has a separate raw water pump station. The old intake has one 1500 m^3/h pump, at 18 meters head while the new intake has four units, two 800 m^3/h against 25 meter head, one 800 m^3/h against 20 meter head and one 1500 m^3/h against 18 meters head.

All units are horizontal centrifugal type requiring priming upon start up and are electrically operated by 3 phase induction 3.3 KV and capacity of 125 KW for 1500 m^3/h pumps and 1.00 KW for 800 m^3/h.

11.3 Chemical Dosing

Chemicals are added at various points throughout the plant from a central chemical facility, at present only alum is used for coagulation, prepared at a 10% concentration by dissolving solid alum or diluting liquid alum. in alum dissolving tanks equipped with mechanical mixers. The alum dose is applied by gravity to different clarification basins.

11.4 Flocculation and Clarification

The flocculator clarifier built in 1939 is a solids-contact unit of Italian design with a circular center well serving as the flocculator section and the surrounding annular ring as the clarifier section. The clarified water flows over a circular weir into a circular collection launder and thence to the six filters built to operate in conjunction with this pretreatment unit. A slow moving rotary scraper sweeps the sludge along the conical bottom of the clarifier toward a sump in the center from which it flows by gravity to a discharge point in an adjacent canal which enters the Nile River about 200 m downstream of the plant intakes.

The clair-flocculator unit built in 1948 is also a circular solids-contact type quite similar to the 1939 unit but smaller and of French design. In operation it is comparable to the 1939 unit. The clarified water flows toward two rapid sand filters built to accommodate the flows from it. The sludge is discharged into the sludge line leading from the 1939 unit.

In 1967 the slow sand filters which had gone into service in 1923 were remodeled to form two long in-line flocculation and sedimentation basins. One was designed with a baffle-type flocculator section at one end adjoining a long sedimentation basin. In cross-section, the floor of the sedimentation basin slopes so that the side wall depth is greater on one side of the basin than on the other. This facilitates manual movement of sludge into four sludge pockets on the lower side of the basin when it is taken out of service for cleaning. Ahead of the flocculator section is a separate flash mixing structure where the alum is added for chemical treatment. From the sedimentation basin, the clarified water flows over a weir spanning the width of the basin and thence to the 16 larger and newer filter units completed in 1970.

The other flocculation and sedimentation facility is actually two end connected mirror-image units. A single flash mixing structure feeds two adjoining flocculators equipped with mechanical mixers. Two long sedimentation basins, one to the north and one to the south of the two flocculators, receive flocculated water from the flocculation basins. The clarified water is collected at the far end of each sedimentation basin and directed toward the 16 new filters. The floor of these sedimentation tanks is flat and each has a sludge collection trough in the floor and across the width of the basin at the end adjoining the flocculator. A single travelling bridge spans the width of the basin and travels the full length of each in turn, sweeping the sludge along the bottom and into the respective sludge collection troughs. From each of these, the sludge is carried by a pipe which combines with the sludge from the two solids-contact units or flows to two other sludge discharge points, one at the El Khshab Canal located beneath the Corniche El Nil and the other to a point located between the two intake structures.

In 1970, two new in-line flocculation and sedimentation basins were constructed. Each sedimentation basin is preceded by a flash mixing box where alum is added, and twin flocculation basins designed for baffle type mixing. The clarified water flows over a weir across the end of the basin and thence to the 16 new filters. A transverse section of the basin consists of a double V bottom producing two long hopper-shaped troughs running the length of each basin. Four cross-troughs in each basin facilitate sludge accumulation for removal when the basins are drained for cleaning. The sludge is discharged through the same discharge lines mentioned above.

11.5 Filtration

The clarified water from all the basins is pre-chlorinated before entering the filters. All filters have essentially the same basic features. The underdrains are small plastic nozzles with about 0.25 mm wide slits. The spacing between the nozzles is about 10 cm. No gravel is used under the 100 cm depth of 0.8 to 1.25 mm sand. The filtration rate is about 5.4 m/h. The backwash is a three-step operation consisting of air, air and water together, and water alone.

Two horizontal centrifugal backwash pumps are available each with a capacity of 800 m^3/h against 10 meters head. One pump is used for backwash and the other is on stand-by.

Air compressors provided the air needed for backwashing.

11.6 Treated Water Storage Reservoirs
Two underground storage reservoirs are in use. The storage below the filters has a capacity of 1,050 m^3 and the second, separate reservoir just east of the filters has a capacity of 200 m^3.

11.7 Chlorination
There are two facilities for chlorination. The pre-chlorination facility consists of two 40 kg/h chlorinators which inject chlorine prior to flocculation. Post-chlorination is applied after filtration and consists of two 20 kg/h chlorinators at various locations.

11.8 Treated Water Pumping Station
The treated water pumps are contained in two buildings. One building contains 3 pumps with capacities of 1000 m^3/h against 100 m head. The other older building contains 3 pumps with capacities 1000 m^3/h, two with capacities of 500 m^3/h and two pumps with capacities of 400 m^3/h. All of the pumps operate at 100 m head.

The pumps are driven by 3 phase induction motors 6.6 KV, with capacity of 500 KW for units 1000 m^3/h pumps at new pumping station and 3.3 KV, 358 KW for 1000 m^3/h pumps, and 3.3 KV, 200 KW for the other units. The pumps deliver the treated water directly to the distribution network through four pipe lines, one 600 mm diameter, two with 400 mm diameter and one with 300 mm diameter. Venturi meters exists in each pipeline but they are out of operation.

11.9 Power Supply and Utilization
The electric power is supplied by main 6.6 KV feeder from the electrical distribution network to switchgear located in different buildings which distributes the electric power for pumping purposes and for auxiliary equipment. The switchgear is comprised of two incoming feeders, which supply a number of outgoing load lines to meet the requirements.

11.10 Stand-by Power Generation
Two 650 KW diesel generating units are available consisting of 1150 Hp diesel engine coupled with a 3.3 KV, 650 KW alternator.

12. TEBEEN WATERWORKS

12.1 General Description

This plant is the southernmost facility in the GOGCWS system and began operation in 1977. It consists of a raw water intake screen and pump, chemical mixing station, clair-flocculators, filters, storage tanks, and effluent pump stations. It primarily produces industrial water for delivery to an adjacent iron and coke plants. Four pipelines exit the plant, three delivering industrial water and one delivering potable water.

The total rated capacity of the plant is 340,000 m^3/d. The effluent from the clarifiers is delivered directly to two large settled water reservoirs on the plant site. Approximately 100,000 m^3/d is delivered to the potable water system and is pre- chlorinated, clarified, filtered and post-chlorinated. The coke factory receives about 25,000 m^3/d of pre-chlorinated, clarified and filtered but not post-chlorinated water. The iron factory receives about 200,000 m^3/day.

The facility is operated on a 24 hour basis through 3 shifts. The facility also contains storehouses, workshops, sludge pumping stations, a laboratory and administration offices.

12.2 Intake and Raw Water Pumping

Four submerged 1600 mm intake lines draw water about 60 m from the shore of the Nile River and convey it to a mechanical travelling screen and the raw water pumping station. The screens have openings of 2 cm and remove materials picked up by the intake pipeline. A total of 7 pumps are located within the pump station, six of which have a capacity of 5760 m^3/h against 17 m head electrically driven by 3 phase induction motor 66 kv, 380 KW. The other pump has a capacity of 5000 m^3/h against 17 m head driven by diesel engine 1200 HP. All pumps are of the vertical turbine type.

These pumps deliver water to the treatment plant directly across the Cornishe El Nil through four 1,200 mm pipelines. Two of these pipelines discharge at a distribution structure to serve four clarifiers on the north side and the south side of the plant. Four 1200 mm diameter venturi meters are installed, one in each 1200 mm raw water pipeline, but they are not in operation.

12.3 Chemical Application

Chemicals are mixed and controlled at one central facility near the center of the plant. Alum at 10 % concentration is prepared by dissolving solid alum or diluting liquid alum in 3 mixing tanks, each with an electrically driven mixer. The solution is then pumped by four metering pumps to application points at the distribution structures into the incoming raw water. A flash mixer operates to mix the water with the alum solution. The chemical building also has facilities to mix and deliver polymer and activated carbon, however at present neither is being used.

12.4 Flocculation & Clarification

Flocculation is accomplished at the center of 8 combination clair-flocculator units of Czechoslovakian design. Raw water with the alum solution is introduced at the center where the mixture rises and flows after flocculation to the clarifier section.

The outer ring of the circular units is used for clarification where the floc settles to the bottom as sludge. A slowly moving sludge and scum scraper transports the sludge to the center of the tank where the sludge is extracted and discharged to the Nile River about 160 m downstream of the intake. Each clarifier, rated at about 4000 m^3/d, is 42 m in diameter.and the effluent discharge is over a concrete circular weir.

12.5 Filtration

The settled water from the clarifier flows by gravity to 12 rapid sand filters. Each filter is 10 m by 7.2 m with a sand media 90 cm deep and is rated at 8,330 m^3/d. The underdrains are plastic slitted nozzles. Filter media is sand of 0.8 to 1.25mm gradation.

Clarified water enters each bay individually through a weir slot at one end of the bay and wash water is discharged to central and side gullets. Backwash is a three step operation consisting of air alone, followed by air and water and finally water alone. Three electrically driven horizontal centrifugal pumps each of 418 m^3/h capacity against 12 m head are installed for backwashing. Two of these pumps are used for backwash leaving one pump for standby and three electrically driven air blowers are also available for backwashing, two in service and one on standby.

12.6 Clearwell Storage

Settled water for industrial use is stored in two large reservoirs each with 18,000 m^3 capacity filtered water is stored beneath the filters in two reservoirs each of about 5000 m^3 capacity.

12.7 Chlorination

The chlorination facility contains equipment for applying pre-chlorination through four chlorinators each with a capacity of 75 kg/h and two on standby with capacity of 40 kg/h.

Post-chlorination is applied to that portion of the water used for domestic consumption. Four chlorinators are available each with a capacity of 20 kg/h. One is in service and three are on standby.

12.8 Pumping Station to Network

Only fully treated water is pumped into the Networks. Industrial water is discharged from this plant to the adjacent iron and coke facilities.

12.8.1 Filtered and Treated Water Pumping

Filtered water without post-chlorination is pumped by two pumps each with a capacity of 720 m^3/h against 60 m head. These pumps deliver water to a coke factory for industrial use. Treated water for domestic use is pumped by 4 pumps each with capacity of 1440 m^3/h and two pumps with a capacity of 720 m^3/h against 75 m head. The pumps are primed by a vacuum system and receive water from the storage reservoirs beneath the filters and deliver it into two transmission pipelines. The pumps are of horizontal centrifugal type driven by 6.6 KV induction motors with capacity

- 220 KW for the 1440 m^3/h, 60 m head units
- 250 KW for the 720 m^3/h, 75 m head units
- 450 KW for the 720 m^3/h, 60 m head units.

12.8.2 Settled Water Pumps

Settled water is pumped by eight pumps six of which are of 3600 m^3/h capacity against 50 m head with electric drive and two pumps are 3600 m^3/h against 45 m head with diesel engine drive. All of the pumps deliver settled water to the iron and steel factory for industrial use. Suction is taken from the two large reservoirs on the site.

The pumps are of the horizontal centrifugal type. The electrically driven units are driven by three phase induction motors 6.6 KV with the capacity of 610 KW where the diesel driven units are driven directly by 1050 HP diesel engines.

12.9 Power Supply & Utilization

The electric power is supplied by two main feeders 6.6 KV from the electrical distribution authority in addition to one feeder from the iron and steel factory. Switchgear is located in different buildings distributing the power to different units for pumping purposes and for auxiliary equipment. Each switchgear installation is composed of 2 incoming feeders and a number of outgoing load lines to meet requirements.

12.10 Standby Power Generation

No standby power generation is available at this plant. Only some pumps in the raw water and settled water pumping stations are driven by diesel units for securing settled water supply to the iron and steel factory.

13. GROUND WATER PRODUCTION FACILITIES

13.1 General Description

There are seven currently operational well fields supplying water to some areas in Greater Cairo. The average daily production of these well fields is as follows:

Mostorod Water Works	170,000 m^3/day
Ameryia Water Works	120,000 m^3/day
El Marg well field	120,000 m^3/day
Shobra El Kheima well field	55,000 m^3/day
El Remaya well field	55,000 m^3/day
Jolli Ville well field	20,000 m^3/day
Bahteem	15,000 m^3/day
Total daily average	**555,000 m^3/day**

This amount represents about 15 percent of the daily potable water production of GOGCWS water works. The well fields are generally located along the Nile or the Ismailia Canal because the aquifer recharge rate is usually better in these areas. The ground water levels in the Cairo area should remain relatively stable because of this groundwater recharge. A brief description of each well field follows:

13.2 Mostorod Well Field

The Mostorod well field is operating in conjunction with the surface water treatment plant, and has the highest production of the GOGCWS well fields. Specific technical data is as follows:

Drilled depth	70 m - 91 m
Perforated internal	19 m - 30 m
Casing diameter	400 mm

13.3 Ameriya Well Field

The Ameriya well field also operates in conjunction with the surface water treatment plant and has a significant daily production. Specific technical data is as follows:

Drilled depth	75 m - 110 m
Perforated internal	30 m - 35 m
Casing diameter	400 mm

13.4 El Marg Well Field

There are two well fields , the newer constructed in 1970. The age of the older facility is unknown. The chemical analysis of ground water in the El Marg area indicates that iron and manganese levels exceed the allowable limits of the GOE standard for potable water. Facilities for removal of iron and manganese have been installed to remove these constituents by aeration and filtration. Water from this well field must be blended with treated Nile River water in order to achieve the GOE standard for drinking water.

Drilled depth	95 m for all wells
Perforated internal	30 m for all wells

Casing diameter	400 mm

13.5 Shobra El Kheima Well Field

The wells in this field are constructed in an area which belongs to the Qaliubeya Governorate, where a new water treatment plan is under construction for surface water treatment.

Drilled depth	85 m - 90 m
Perforated internal	30 m - 35 m
Casing diameter	400 mm

13.6 El Remaya and Jolli Ville Well Fields

These well fields are located in the El Ahram area of Giza Governorate. These wells deliver water mainly to El Haram street, Remaya Military Club and the area at the beginning of the Alexandria and El Fayoum desert roads.

Drilled depth	67 m - 72 m
Perforated internal	30 m for all wells
Casing diameter	400 mm

13.7 Bahteem Well Field

This well field is located in the Bahteem area of Qaliubeya Governorate.

13.8 Fields Operating

The groundwater is taken from all wells by submerged, vertical turbine, multi stage borehole pumps which deliver it directly to the distribution network where it is mixed with the surface water from the water treatment plants.

All of the well field pumps have a capacity of 60 L/s (216 m^3/h) against 60 m delivery head except for those at Mostorod and Ameriya where some of the pumps operate against 60 m and others operate at 90 m head. The pumps are driven by 3 phase induction motors 380 volts with a capacity of 75 HP for 60 m pumps and 125 HP for 90 m pumps.

13.9 Power Supply and Utilization

All the well fields receive power from the electric distribution network which belongs to electric authority, by two main 10.5 KV feeders. The voltage is stepped down to 380 volts by 10.5/0.38 KV stepdown transformers with suitable capacities for each site. Proper voltage is supplied by 10.5 KV and 380 volt switchgear which contains incoming feeders and outgoing panels to meet the requirements.