Conference Papers

4TH Asia Pacific Regional Water Supply Conference & Exhibition

Jakarta, Indonesia

5-11 November 1983

KD 8017

Exhibition Guidebook

TIRTA DHARMA

4TH Asia Pacific Regional Water Supply Conference & Exhibition

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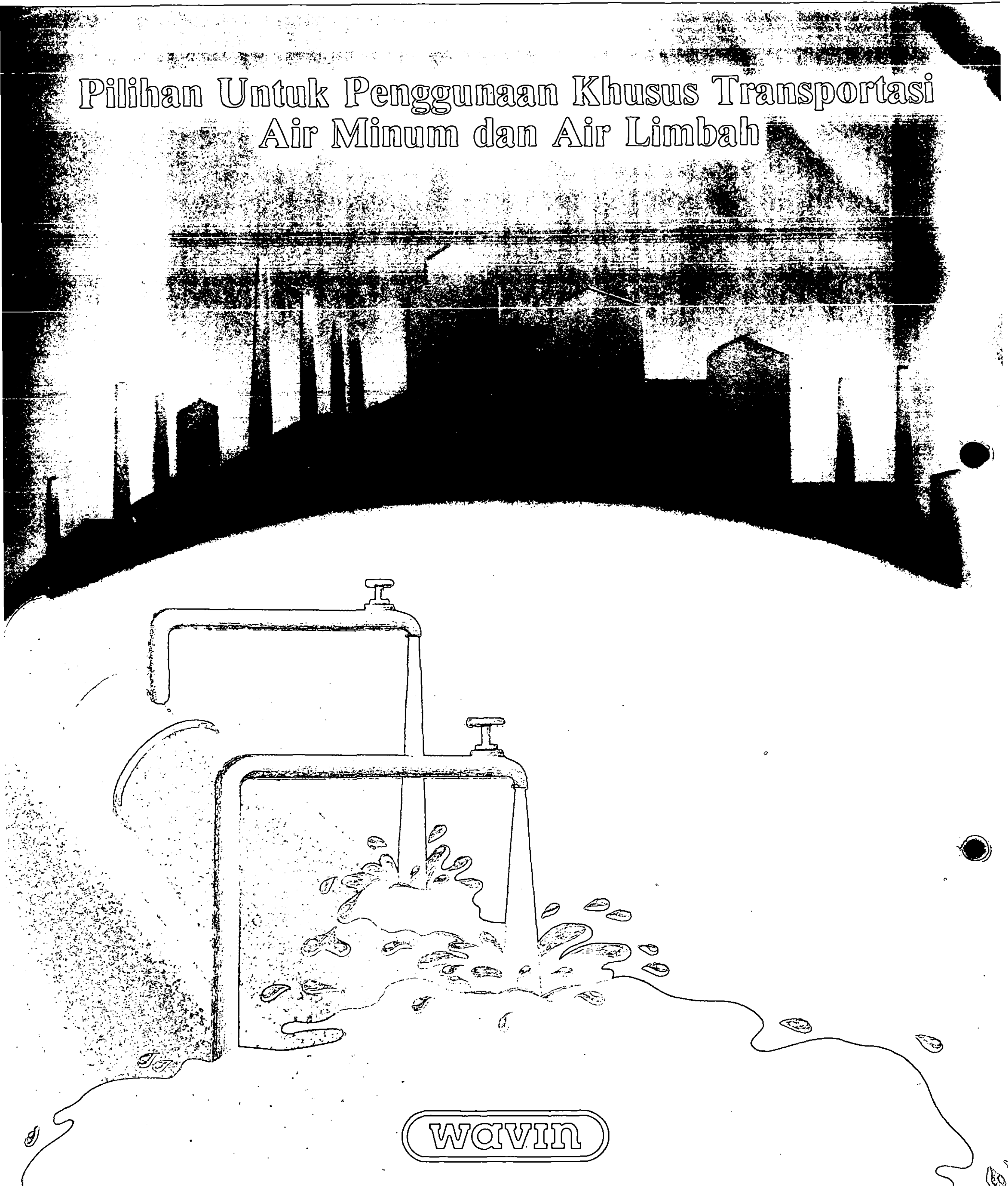
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TIRTA DHARMA

INTRODUCTORY REMARKS BY THE CHAIRMAN OF THE ORGANIZING COMMITTEE 4th ASPAC – RWSC & EXHIBITION.

Statistical records with respect to the actual conditions as to the water supply industry in Indonesia-although still in-complete have already shown that the position of the existing facilities is lacking when compared with the ever growing demand. In spite of ambitiously set-up national programmes for improving the water supply industry that since long ago have been launched into operation, many of the obstacles and difficulties could not be significantly overcome due recurring unfavourable factors.

Scarcity of water resources, particularly in the urban areas of which most are densely populated and often surrounded by industrial estates, is assumed to be the main cause of the fact that requirements have not as yet been statisfactorily met. Besides that, in-adequacy of the available distribution networks as well as underertilization of their production capacities have also confronted all efforts for arriving at a better situation.

Other reasons such as in-effective and deficient legislation that should have supported the development of the water supply and distribution systems; lack of coordination amongst and between the Government agencies that are to take care of the industry as a whole; (inadequacy of established) information methods that should control the data processing for thoroughly assessing the state of things and preventing any possible affliction; lack of effective communication systems to supervise the widely spread project location all of these adversities add up to the difficulties frustrating opposing all attempts to improve circumtances As the situation is now-there is admittedly much to prevail over. Whereas presently about 40% of Indonesia's population is living in urban and or sub urban areas with relatively the best water supply facilities, distributing comparatively low cost and sufficient clean water, the bulk of the population or approximately 60%, occupy the rural areas. The latter are to satisfy their water needs with the resources available to them-from rivers, water wells, groundwater holes, even swamps, ect.

The national objectives that have been plotted for the decade is to gradually provide 85 Ltr drinking water at the average per capita per day for 75% of the citywellers; for the rural groups the related figures are about 60% of the population for having access to a sound but moderate 60 Ltr per capita per day which in fact is assumed to be the basic human need.

In relation to the above-the "4th Aspac Exhibition 1983", organized in conjunction with the 4th ASPAC RWSC & EXHIBITION may be considered of great potential, since it is in some way related to the overall effort to accelerate and escalate the pursuit for mass provision of clean, fresh drinking water. It may simultaneously open the door to many opportunities for technology transfers in the field of the water supply and distribution industry. Besides this Exhibition-in all modesty though with pride dedicated to the distinguished visitor or other interested-groups may in the long run even contribute to Indonesia's ability to full-fill her national ambitions, particularly those aimed to attaining and maintaining the people's welfare and prosperity-generation after generation.

In conclusion , the Organizing Committee of the 4th ASPAC RWSC & EXHIBITION would like to take this opportunity to extend their sincerest gratitude and appreciation to the numerous Government officials, to the participants and all of those involved in the strenous exertion needed in order to make this exhibition a successful event, for their highly esteemed advice, cooperation and valuable assistance. On the other hand a cordial and hearty welcome is also conveyed to the overseas participant and visitor. Selamat datang.

OC 4th ASPAC – RWSC & EXHIBITION

A Razak Manan

IR. H. A. RAZAK MANAN
CHAIRMAN

MENTERI DALAM NEGERI
REPUBLIK INDONESIA

MINISTER FOR HOME AFFAIRS
REPUBLIC OF INDONESIA

REMARKS FROM THE MINISTER FOR HOME AFFAIRS

First of all, I wish, on behalf of the Indonesian Government, to congratulate the organisers of the 4th ASPAC Exhibition 1983, and to extend a cordial welcome to all participants, in particular those from abroad.

Since this is an international exhibition in which some of the partisipants come from countries that have advanced water-supply industries, we will have valuable opportunities to learn things to our advantage. We should be able to learn about the high technologies that participants display and to see what can be adapted to our own conditions. In addition, this Exhibition will give us a means of appraising our command of water-supply technology by comparison with the levels achieved in other countries, both advanced and developing.

In this contex I am pleased to welcome the Exhibition and Conference and to hope that its targets will be fully achieved, since it is clear that it can contribute towards our drive to see that the people of Indonesia are assured of clean water.

Further, I should like to suggest that participants from other countries use the opportunity of their attendance at this ASPAC RWSC Conference and Exhibition to take a look at the growth and development we have achieved in Indonesia to date. Certainly, we have a long way to go yet, but I am nonetheless convinced that, particularly perhaps at grass roots level in the countryside, even quite close to the Capital, the impact of national development is already significant.

May the Almighty bless all endeavours for the well-being of the peoples of the world.

MINISTER FOR HOME AFFAIRS

SOEPARDJO.

REPUBLIK INDONESIA
MENTERI PEKERJAAN UMUM

REMARKS FROM THE MINISTER OF PUBLIC WORKS

Like any similar exhibitions, the "4th Aspac Exhibition 1983" should be welcomed with appreciation, since, beside it is the first of its kind to be held in Indonesia, it also indicates confidence from others toward the improvements of Indonesia's business world within the water-supply industry, including relevant fields of activities such as system planning, instalation design, and the marketing of quality products as well.

We earnestly hope that this exhibition will become a land-mark for the escalation of Indonesia's role in the pursuit for providing sufficient pottable water for the community. Moreover, it is desired that in the future it would become an instrument that could develop into a device for measuring Indonesia's preparedness and capability to conduct competition that should be taken into account, by displaying and offering industrial products of which the quality, that properties as well as the reliability could meet the requirements.

We also expect that through this exhibition our future fully developed water supply industry, particularly pertaining to its effectiveness and efficiency, could be wider known and appraised by the consultants and contractors operating in this field. Moreover it is supposed that all interested parties could utilize the benefits that could be derived from the exhibition through attempts for transfering new and appropriate technologies as well as through intensifying the already existing ones.

On this occasion I would like to extend my highest appreciation and gratitude toward the organizers and also toward all participants of the "4th Aspac Exhibition 1983" for making this important event a great success.

MINISTER OF PUBLIC WORKS,

IR. SUYONO SOSRODARSONO

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MINISTER OF HEALTH
REPUBLIC OF INDONESIA

REMARKS FROM THE MINISTER OF HEALTH

Water should be viewed as Gods blessing of extremely great value and its merit to mankind is difficult to measure as water is a prerequisite to live and therfore a basic human need. All living creatures with no exception require water to live and function according to their destiny.

At present only a small part of our people have access to adequate clean and safe water, the majority however live under unfavourable condition far beyond the reach of save water supply facilities and have to satisfy themselves with available water within their reach. Some are fortunate to obtain pure water from wells, others however have to limit themselves to their basic needs from polluted river water or from swamps or waist water which may their health.

A large number of people do not realize such danger as they are not aware of the basic qualification of hygiene and sanitation. It is in this context that the Government some years back embarked on programme to improve water purification techniques to make potable water available to all people.

It is of great importance to study all possible applied technology which may bring us closer to our needs.

I have pleasure to welcome the "4th Aspac Exhibition 1983" held in Jakarta and it is our sincere hope that this exhibition will broaden our knowlwedge to solve our urgent need of water. It is obvious that all of us, the public as well as the private sector may learn from this expose.

On behalf of the Government may I convey my highest appreciation to the organizers and all participants to this exhibition and fnally wish you all the best and success.

Minister of Health of the Republic
of Indonesia,

Dr. Suwardjono Surjaningrat

Remarks From The Minister Of Industry

The "4th Aspac Exhibition 1983" is held in Jakarta at a most timely date, since only a few months from now Indonesia will launch its Fourth Five-Year Development Plan.

At present we have capacity in industries producing goods related to water supply systems, such as steel and PVC pipings, fittings and joints, meterings, sanitation equipment etc. And with the commencement of operations of the rolling mills at the Krakatau Steel complex in Cilegon, West Java, a large proportion of the core inputs of these industries can soon be sourced domestically.

Under the Fourth Five-Year Plan - to start next April 1st -- our manufacturing sector will develop even more basic and intermediate industries, as well as expand the capacity and spectrum of our engineering industry.

Now this Exhibition should afford a good opportunity for Indonesian industry to monitor the latest developments in the area of potable water supply. I hope also that it will help to stimulate, through both domestic and joint venture, the growth of new manufacturing capacity in related industries in Indonesia.

With these considerations, I cordially welcome the 4th Aspac Exhibition 1983, as well as the participants, and in particular our overseas guest. I should also like to congratulate the organizers for their initiative and foresight to hold the Exhibition in Jakarta.

Thank you.

Jakarta, 5 November 1983

Minister Of Industry

Hartarto

Gubernur Kepala Daerah Khusus
Ibukota Jakarta

MESSAGE FROM THE GOVERNOR OF THE CAPITAL CITY
OF JAKARTA

Honourable Delegates. Ladies and Gentlemen.

We are very pleased indeed to have this Fourth ASIA –PACIFIC REGIONAL WATER SUPPLY CONFERENCE be held in this city from the 5th to 11th of November 1983, at the same time with the Fourth ASPAC EXHIBITION an Exhibition of the technology of Water Supply and Distribution.
To all Exhibition participant, and to all coming from outside Jakarta to see the Exhibition our warmest welcome.

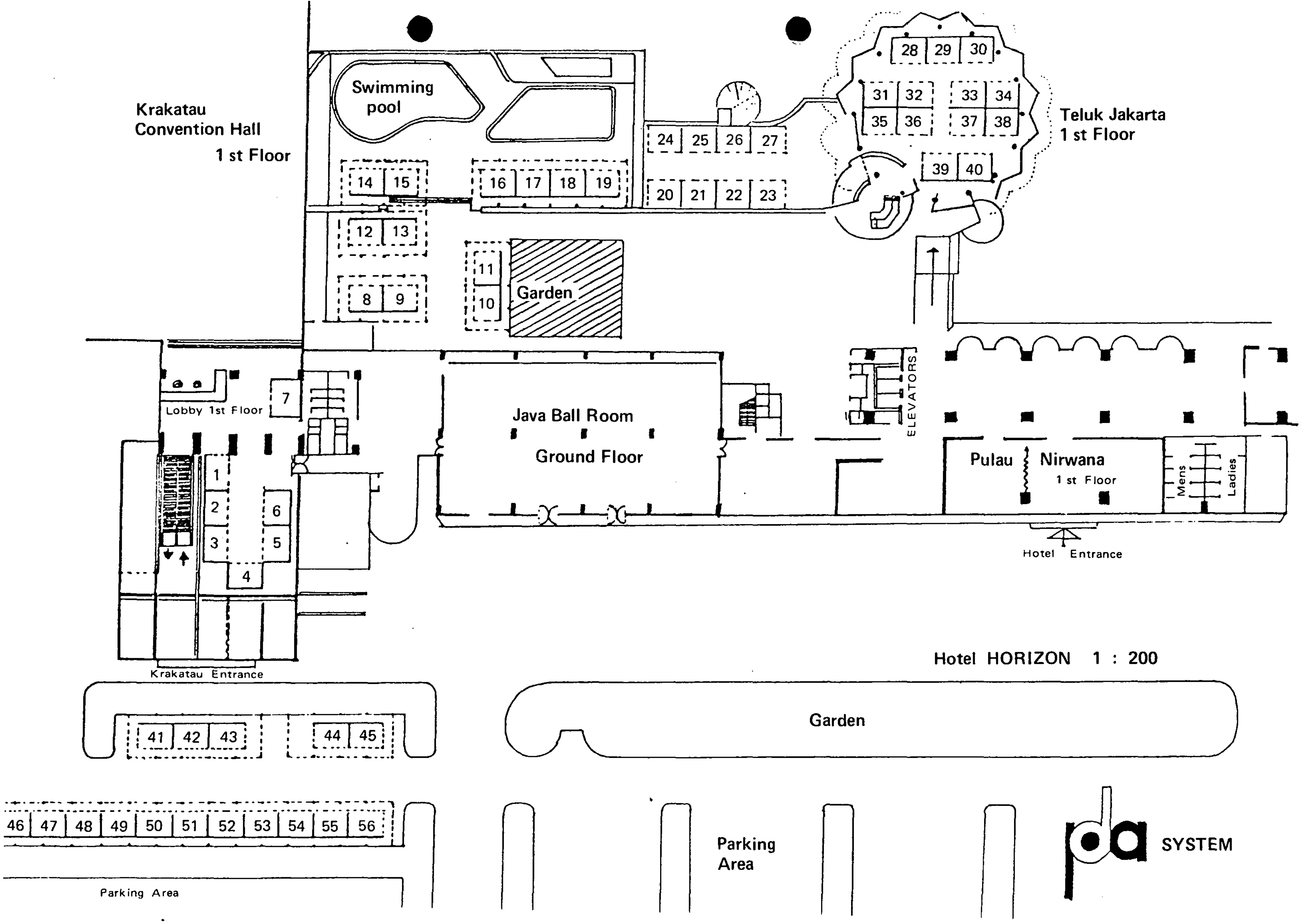
This Exhibitions of a technology of international standard such as this Fourth ASPAC Exhibition is very useful indeed so as to know more about and to make a study of, a variety of new discoveries in quest of increasing productifity. This is more important in the field or water supply, which for most of the developing countries still constitues a great challenge. In addition, an exhibition such like this also representing an effective means to meet advanced technology producers and consumers taking benefit of such advanced technology, each having a mutual interest with respect to each other.

We all are undoubtedly of the same opinion that potable water is representing one of the basic necessities in as well as of human life; and that it is presently increasingly difficult to get in due to the ever greater demand, abreast of the burgeoning population, and the ever better welfare condition. Also, because getting water suitable as raw material for potable water has become more and more difficult in great cities and densely populated areas. All of which is indeed a challenge to all of us, a challenge to find ways and means to overcome such untoward situation.
This confererence I am conviced-will be able to come out with useful and practical ideas to strenghten and enhance the role of water supply undertakings in Asia -Pacific Countries.
Finally, we wish every success to this Fourth ASPAC–RWSC and ASPAC EXHIBITION.
Thank you.

Jakarta, November 1983.

GOVERNOR OF THE CAPITAL CITY
OF JAKARTA,

R. SOEPRAPTO


Krakatau
Convention Hall
1 st Floor
Swimming
pool
Teluk Jakarta
1 st Floor
28 29 30
31 32 33 34
35 36 37 38
24 25 26 27
20 21 22 23
39 40
14 15
16 17 18 19
12 13
11
10
Garden
8 9
Lobby 1st Floor
7
Java Ball Room
Ground Floor
ELEVATORS
Pulau
Nirwana
1 st Floor
Mens
Ladies
1 2 3 4 5 6
Hotel Entrance
Krakatau Entrance
Hotel HORIZON 1 : 200
Garden
41 42 43
44 45
46 47 48 49 50 51 52 53 54 55 56
Parking Area
Parking
Area
SYSTEM

INTERNATIONAL WATER SUPPLY ASSOCIATION
IWSA

YESTERDAY – TODAY AND TOMORROW

The IWSA was formally established in 1947 and in 1949 about 400 people from all over the world, mainly from Europe, attended the first international Congress in Amsterdam, where the first General Assembly of the Association was held on 22nd Septem ber, 1949 and the Constitution approved. The Association was created:

- To establish an international body concerned with the supply of water for domestic, agricultural, and industrial purposes;
- To secure concerted action in improving the technical, legal, and administrative knowledge of public water supply systems;
- To secure a maximum exchange of information on research, methods of supply of water, statistics and all other matters of common interests;
- To encourage communication and better understanding between men engaged in the public supply of water.

Today the aims of the Association are still the same and the Association is very much alive with 53 countries in corporate (National) Membership and over 800 Associate and Individual members from more than 85 nations.

The main activity of the IWSA since 1949 has been its international Congresses. At first they were held every three years, but since 1972 they have been biennial. The 1984 Congress will take place in Tunisia. Subjects dealt with during the Congresses are mostly of a technical nature, including treatment processes, water resources, chemical and physical technology, planning procedures, corrosion, testing of materials, contruction, etc. Attention is also given to the trainning of personnel, management problems, public relations, and financial aspects of water supply. The subject of each Congress are chosen from a large number proposed by the corporate members (countries) of the IWSA and from a general call for papers. This provides subjects for everyone and thereby attracts a large audience with a wide range of interests.

The congress subjects are selected by the Scientific and Technical Council which consists of the representative of each and every corporate member of the Assocation. The corporate members are national organisations that represent water supply interests in the member countries and take part in IWSA's activities. At the moment Mr. R. Urbistondo (Spain) is Chairman.

IWSA has also a number of permanent committees appointed by the Association to consider a special subject. There are now nine standing committees. Associated with the congress are international exhibition organized by IWSA.

The governing body of the IWSA is the general Assembly consisting of all corporate members, and an Executive Board elected by general Assembly, consists of 12 members and the President, Vice-President, Past Presidents and the Secretary General. Each corporate member has the right to cast one vote at the General Assembly. The President is elected at the beginning of each Congress having previously been nominated by the corporate member in whose country the Congress is held.

In addition to its regular Congress and Exhibition activities, IWSA published its bi-monthly journal, AQUA, which is sent to its corporate, associate, individual members and to individual subscribers. Associate members are water undertakings, manufacturing or supply organisations with interest or involvement in water supply. All conference and congress papers, including the quartely review journal Watersupply are available to members at reduced rates. The Association also publishes a Directory of members.

The IWSA is directly linked to the United Nations International Drinking Water Supply and Sanitation Decade through a specialised Committee-COCODEV (Committee on Co-operation in Development). ciding with the launch of the decade 1981-1990 the Association introduced a programme of regional and specialised conferences. Further activities are being actively pursuues in the Americas, East and West Africa, Australasia, the Balkans and Middle East, in addition to the biennial exhibitions to be held in the years between Congresses.

THEME OF THE CONFERENCE

MASS PROVISION OF WATER SUPPLY FACILITIES IN DEVELOPING COUNTRIES

Objectives

Upon conclusion of the Conference, the delegates are expected to:

* show a strong interest in the new local as well as regional material and facility sources, or those already existing but as yet unknown.

* show a keen awareness of new appropriate techniques for mass provision of potable water supplies, especially for the benefit of the rural communities.

* demonstrate great enthusiasm in seeking ways for overcoming the general shortage of skilled and educated manpower as well as qualified consultans and contractors in the field of water supply and sanitation.

Technical Sessions

Main Topics

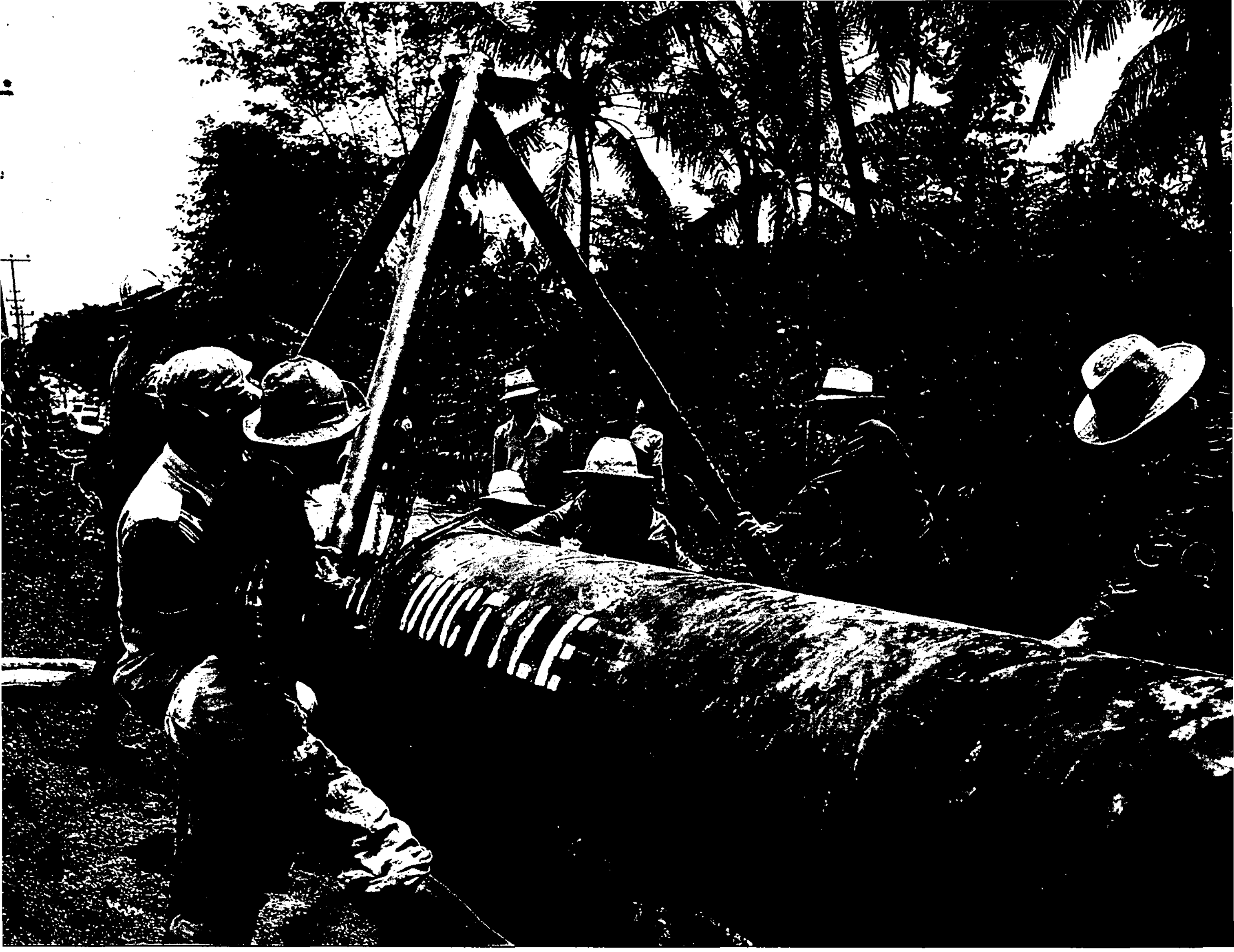
* Policies and Strategies

* Management, Manpower Development and Community Participation

* Technical Approach

* Logistical Support (Role of Water Supply Industry)

* Economic Approach



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6. PT METROPOLITAN KENCANA
7. DEGREMONT S. A.
8. PT PAKARTI RIKEN INDONESIA
9. PT ESLON JAYA CORPORATION
10. PT KEMENANGAN
11. PT KHLORIN INTI/ MITRA RATU
12. PT INTER INSTALASI INDONESIA
13. PT PRALON CORPORATION
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15. PT PURA JAYA AGUNG FIBER GLASS
16. PT BAKRIE BROTHERS
17. PT WAVIN DUTA JAYA
18. PT CAPITOL MUTUAL CORPORATION
19. PONT A MOUSSON
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28. KUBOTA LTD
29. KUBOTA LTD
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SHORT HISTORY OF

ASIA PACIFIC REGIONAL WATER SUPPLY CONFERENCE (ASPAC - REWC)

The conception of the Eastern Asia regional Conference of Water Supply as an organization for joint discussions and mutual improvements about common problems in water supply in this area was proposed around 1969 by Mr.Bearstein of the West Pacific branch of the WHO (Manilla).

Japan Water Works Association (JWWA) responded to joint consultations hereto. However, due to lack of interest in the area at that time, the proposal was left undeveloped. But potential wishes ecisted to organize such a conference deemed as a valuable occasion specifically exchanging opinions and ideas, though many amongst them were specifically concerned with the water supply managements in East Asia.

Under such a background, a proposal was tabled at the general assembly and executive board meeting of the International Water Supply Association (IWSA) September 1976, stating that although IWSA has no regional organization, it must be promoted to organize such conferences to discuss common problems in that specific area and jointly improve such problems in order to contribute worldwide development of water supply systems-the said proposal was approved by the corporate members of the IWSA. It was necessary then to create a voluntary cooperation amongst the respective members to promote the establishment of the regional organization, and such was requested to the respective members.

On this point of view, Prof.Dr.T.Ishibashi from Japan, IWSA Vice President and Mr.R.Obara, IWSA executive board member and JWWA Director General, responed to the above request and prepared the draft on the establishment of the Regional Water Supply Conference December 1976. Appeals to the related groups and persons which and who were engaged in the management of water supply systems in the Western Pacific regions as quoted hereinafter, were conveyed afterward.

The IWSA has now 40 countries as corporate members and numerous individual members for the purpose of promoting water supply systems and exchanging their informations throughout the world. The 11th congress was held in Amsterdam, the Netherlands, September 13 - 16, 1976, gathering 1,850 delegates from the country members Mr.Van der Veen, in his capacity of IWSA President, has strongly insisted on the necessity of regional conferences, apart from the main congress every two year cycle, in order to escalate and accelerate the percentage of population served by piped water systems, multi-lateral exchange of information, and multi lateral assistance for their respective benefit.

It has been recognized by those concerned with the management of many water supply systems in Western Pacific that increasing demand of such systems, improvement of technologies, mutual assistance and training of engineers shall hopefully be discussed on international level. It is regretful to say that earlier had not had such occasions to reach solutions through discusing these problems, and it should be understood that there were great disadvantages in our activities due to lack of communication amongst ourselves in the past. From this standpoint, I in my capacity of IWSA Vice President, nominated during the 11th congress, would like to point out the necessity of regional conferences.
In addition to the major activities of IWSA, but would also like to add that

these activities should be supported by the individual associated with the water supply matters such as :

a. Exchange of the respective national report on water supply as background
b. Detailed discussion of the relevant technologies
c. Mutual support for improving own technologies
d. Standardization of materials and equipments, and
e. Stipulations as the results of regional conferences.

A special request was forwarded by Mr.R.Obara at the conference to Mr.Sakoljit Panomvan, President of the Thai Water Works Association (TWWA), to host the 1st regional water conference in Tailand as the centre of the region, under the tentative agreement between JWWA and TWWA. The 1st regional conference was held in Bangkok as from November 27, 1977 with 171 participants from the East Asia region resulting a great success, of which some of the conference details were:

* Regional Conference on Water Supply Eastern Pacific :
  Date : November 23 - 30, 1977
  Venue : Narai Hotel, Bangkok, Thailand
  Number of Participants : 171
* 3rd IWSA Asia Pacific Regional Conference and Exhibition :
  Date : November 16 - 18, 1981
  Venue : Philipine International Conference Centre, Manila, Phillipine
  Nr. of Participants : 682
  Nr. of Exhibitors : 46

The Organizing Committee 3rd ASPAC-RWSC & EXHIBITION
MANILA, PHILIPPINES, November 15 - 19, 1981

MR. OSCAR I. ILUSTRE - Chairman.
MR. CARLOS C. LEANO. JR - Co. Chairman.
MR. JOSE V. ANGELES - Finance.
MR. WILFRIDO C. BARREIRO - Secretariat.
MR. PEDRO G. DUMOL - Operations.
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MR. JOSE ESPIRITU - Registration.
MR. RICARDO T. QUEBRAL - Program.
MR. TOMAS CARLOS - Hall AV/ Interpretation.
MR. SALVADOR J. RIVERA - Technical Papers.
MR. JOHNNY MERCADO - Awards.
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MR. MANUEL G. ANONUEVO - Airport Reception

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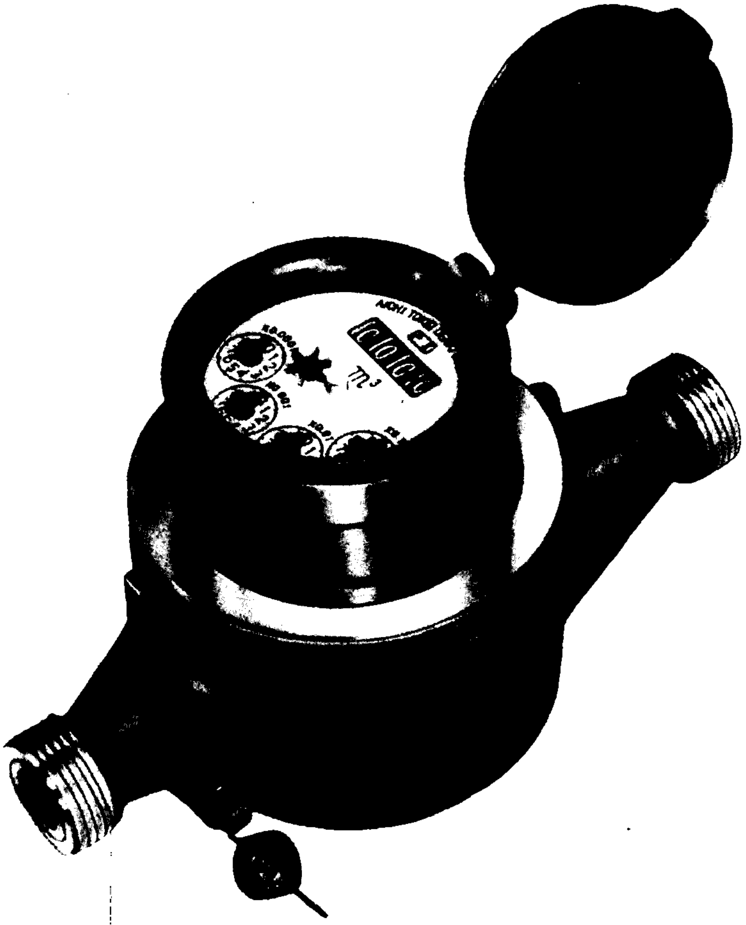

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Setia Mulyono (Director)

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Adv. Page 8.
PT. FAJAR MAS MURNI.
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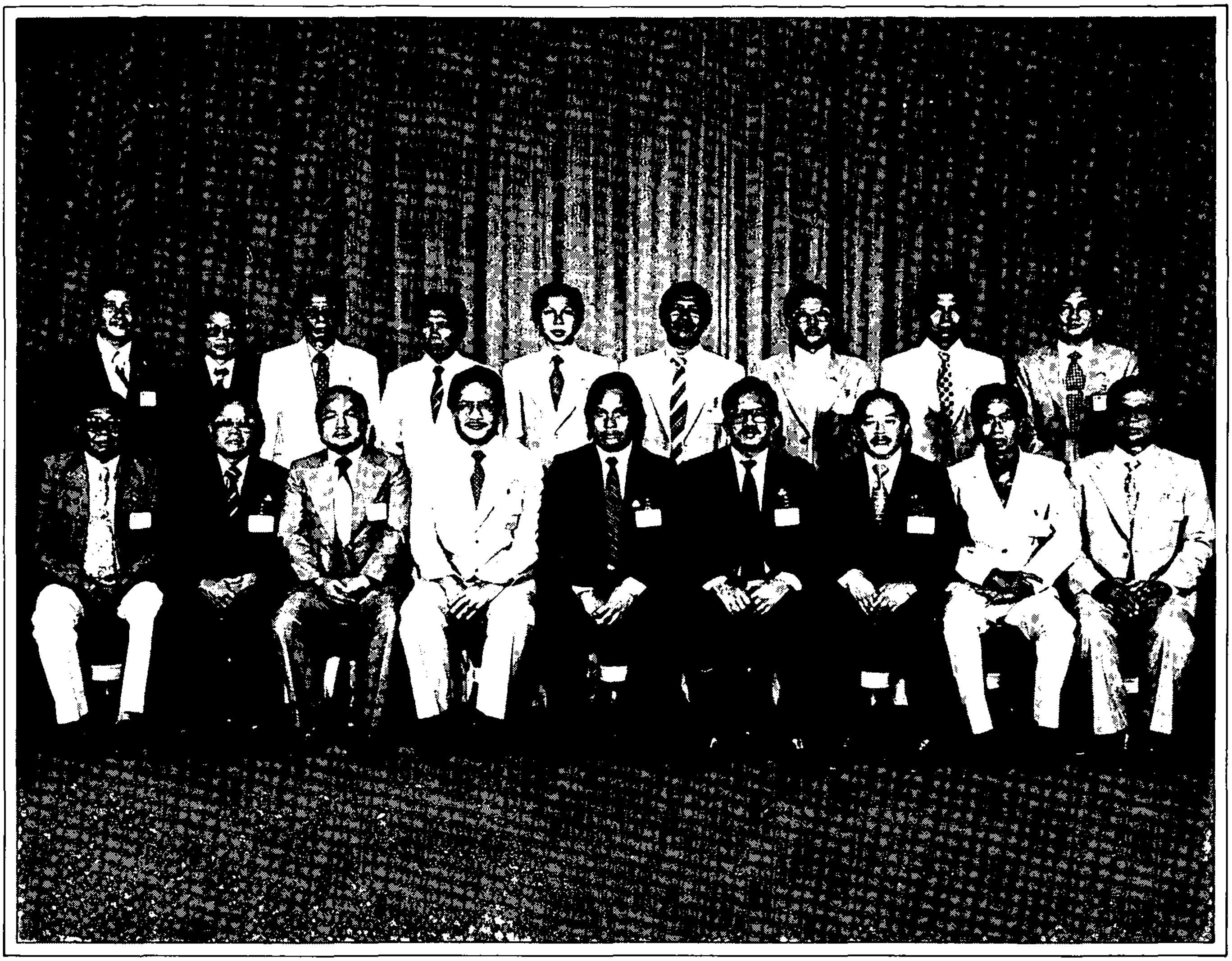
Telex : 47210, 47583 FMM JKT–46763 KIANI JKT.
Ingersoll Rand – Pumps.



SUSUNAN PENGURUS "PERPAMSI" PERIODE 1982 – 1985.

BARISAN ATAS : (dari kiri ke kanan).

1. Ir. Gebyar H. Triono. — Sekretaris Umum.
2. Ir. Djaelani Saberan BE. — Anggota.
3. H. Mochsen Rifai — Anggota.
4. Drs. Toalu Paleppang. — Anggota.
5. Drs. Wibowo Muktihardjo. — Anggota.
6. H. Tontowi. — Anggota.
7. Ir. T. Sasmito Oetomo. — Anggota.
8. Ir. Manan Lubis. — Anggota.
9. Hasanusi BE. — Anggota.

BARISAN BAWAH : (dari kiri ke kanan).

1. Ch. Pattinaya. BE. — Anggota.
2. Ir. Soebagiyo H. — Anggota.
3. Drs. Soepraptono. — Ketua Bidang III.
4. Ir. H. A. Bainon Bustam. — Ketua Bidang II.
5. Ir. Eddy Kurniadi. — Wk. Ketua Umum.
6. Ir. H. A. Razak Manan. — Ketua Umum.
7. Ir. Pribadi Soetadji. — Ketua Bidang I.
   (Ir. Zainudin Djapri).
8. Drs. Zainudin Fatbang. — Anggota.
   (A. Takbir Paduppa BA.).
9. R. Hariyono BE. — Anggota.
   (Drs. S. Soewardjono).

TIRTA DHARMA

LAMBANG :

PERSATUAN PERUSAHAAN AIR MINUM SELURUH INDONESIA

Menerima Rencana Lambang yang telah dipersiapkan dan dibahas dalam MAPAM II dan dinamai :

TIRTA DHARMA.

Tirta	=	a i r .
Dharma	=	hajat hidup.
Tirta Dharma	=	pengabdian PERPAMSI berupa penyediaan Air Minum bagi hajat hidup dan kesejahteraan rakyat.

PENJELASAN LAMBANG :

1. Lima bentuk yang berupa sebuah lingkaran dan empat buah lengkungan lainnya bermakna Pancasila.
2. Bentuk lengkungan sebagai Air terjun menyatakan Sumber AIR (Air baku) yang berlimpah-limpah.
3. Bentuk lingkaran penampang pipa yang dipenuhi Air Minum bermakna penyaluran Air Minum bagi kesejahteraan rakyat, yang memperlihatkan kwalitas dan kontinuitas pelayanan.
4. a. Warna hijau pada bentuk lengkungan melambangkan kwalitas Air baku yang belum diolah.
   b. Warna biru pada lingkaran melambangkan kwalitas air yang memenuhi syarat-syarat air-minum yang disalurkan bagi kesejahteraan rakyat.
5. Rangkaian bentuk-bentuk keseluruhan mewujudkan huruf-huruf P.A.M. yang sudah sangat dikenal kepanjangannya oleh masyarakat.
6. Lambang ini dibuat dengan ukuran perbandingan :
   panjang : lebar = 3 : 2.

I. Pendahuluan:

Menyadari bahwa air minum yang bersih dan sehat mempunyai peranan yang sangat penting bagi kehidupan manusia dan menguasai hajat hidup orang banyak serta merupakan sumber kesejahteraan rakyat yang menghendaki keselarasan dan kelestarian hubungan antara sesama manusia dan lingkungan serta alam sekitar, didalam menuju kebahagiaan hidup maka didorong oleh keinginan luhur agar dapat memanfaatkan air minum yang bersih dan sehat diperuntukkan sebesar-besar kemakmuran rakyat, maka dipandang perlu untuk menghimpun dan menyatukan semua unsur yang memiliki potensi di bidang air minum.

a. Di dalam satu wadah ini terwujudlah suatu kesatuan landasan untuk mengembangkan usaha perair minuman yang serasi dan seimbang di seluruh wilayah tanah air tanpa meninggalkan ciri khas dan kondisi yang dimiliki daerah-daerah.
b. Untuk mencapai tujuan tersebut, maka dengan rakhmat Tuhan Y.M.E. didirikanlah organisasi yang diberi nama Persatuan Perusahaan Air Minum Seluruh Indonesia yang disingkat PERPAMSI.

II. BERDIRINYA PERPAMSI:

1. Organisasi PERPAMSI didirikan tgl. 8 April '72 sesuai hasil Musyawarah Antar PAM Seluruh Indonesia I di Kopeng, Salatiga, Jawa Tengah dan dihadiri oleh PAM dari 54 Kota dan para pejabat Instansi Pemerintah dari berbagai Departemen.
2. Organisasi ini disyahkan oleh Menteri Dalam Negeri pada tgl. 23 Juni 1975 melalui S.K. Mendagri R.I. No. 136 Thn. 1975 tentang Pengesahan Organisasi Dewan Pimpinan PERPAMSI serta beberapa keputusan MAPAM II.

III. ORGANISASI PERPAMSI.

Organisasi ini merupakan satu-satunya organisasi Persatuan Perusahaan Air Minum yang besifat profesi semi official, berada dibawah satu Dewan Pembina yang secara fungsional terdiri dari Departemen Depdagri sebagai Pembina Umum, bersama sama Departemen PU, Departemen Kesehatan dan Departemen Keuangan sebagai Pembina Teknis serta mempunyai hubungan affiliasi koordinatif dengan BKS-AKSI.

IV. AZAS DAN TUJUAN.

1. A Z A S:

PERPAMSI berdasarkan Pancasila dan UUD'45

2. T U J U A N:

a. Membantu Pemerintah di dalam mewujudkan dan menegakkan cita-cita perjuangan Orde Baru menuju kepada masyarakat adil dan makmur berdasarkan Pancasila.
b. Membina dan mengembangkan kehidupan anggota atas dasar pedoman dan peraturan-peraturan yang ada dengan dilandaskan saling menghormati satu sama lain dalam rangka memenuhi kebutuhan air minum yang bersih dan sehat bagi masyarakat.
c. Membantu mewujudkan adanya usaha-usaha terpadu dan terarah dalam rangka memperbaiki dan memenuhi aspek-aspek teknis, hukum dan administrasi/keuangan.
d. Mewujudkan adanya tukar-menukar informasi dalam bidang penelitian, penyediaan air minum, statistik dan lain-lain bidang yang berkaitan baik tingkat Nasional maupun Internasional.

BEBERAPA CATATAN TENTANG PERKEMBANGAN/KEGIATAN PERPAMSI:

Tanggal 20-21 April 1968 PERPAMSI mengadakan Kerja Air Minum se Jawa Tengah di Semarang, hadir Direktur Teknik Penyehatan Ditjen Cipta Karya Dep PUTL dan Pimpinan PDAM Yogyakarta sebagai peninjau. Musyawarah dipimpin oleh Direktur PDAM Semarang yang keputusan a.l. Sbb.:

1. Dinas-dinas Saluran Air Minum se Jawa Tengah perlu dialihkan menjadi Perusahaan Daerah sesuai dengan Undang-Undang No. 5 thn. 1962.
2. Perusahaan-Perusahaan Daerah ini kemudian ditingkatkan dan dikoordinir dalam bentuk organisasi yang vertikal sehingga dalam tingkat Propinsi dibentuk Pusat Perusahaan Air Minum Propinsi Jawa Tengah dan dalam tingkat Nasional dibentuk Pusat Air Minum Negara.

Tanggal 16-17 September 1968 Workshop Teknik Penyehatan yang diselenggarakan oleh Direktorat Teknik Penyehatan Ditjen Cipta Karya, Dept. PUTL di Bandung dibuka resmi oleh Menteri PUTL dengan acara: Reorganisasi Air Minum Indonesia, sebagai tindak lanjut dari keputusan Musyawarah Kerja Air Minum se Jawa Tengah.
Workshop tersebut dihadiri oleh PDAM Kota-kota Besar Seluruh Indonesia dan beberapa Instansi dari berbagai departemen dan Perguruan Tinggi. Workshop menghasilkan beberapa rumusan tentang Ren-

cana-Rencana Reorganisasi Air Minum seluruh Indonesia dan akan dibahas dalam whorkshop berikutnya.

Pada tahun 1970 PERPAMSI kembali mengadakan pertemuan antara Pimpinan PDAM Ibukota Propinsi se Jawa di Tretes, Jawa Timur yang dihadiri PDAM DKI Jakarta, PDAM Bandung, PDAM Semarang, PDAM Yogyakarta dan PDAM Surabaya serta direktur Teknik Penyehatan Ditjen Cipta Karya Dept. PUTL. Pertemuan tersebut merupakan gagasan baru untuk merintis usaha kerja sama antar PAM se Indonesia mengingat adanya tanda-tanda bahwa hasil workshop I di Bandung thn. 1968 tidak akan dilanjutkan karena Dirat TeknikPenyehatanmulai sibuk menghadapi PELITA I (1968–1974).

Pada bulan September 1971 pertemuan kembali diadakan di Cipayung, Bogor, Jabar dengan acara dan peserta seperti pada pertemuan di Tretes. Pertemuan tersebut berhasil menetapkan penyelenggaraan Musyawarah Antar Seluruh Indonesia yang ke I di Kopeng, Jateng.

Tanggal 7-9 April 1972 Menyelenggarakan Musyawarah Antar PAM Seluruh Indonesia I di Kopeng, Jateng, yang dihadiri oleh PAM dari 54 Kota dan pejabat Instansi dari berbagai departemen. Musyawarah tersebut antara lain memutuskan untuk membentuk organisasi baru yang mewakili kegiatan PAM seluruh Indonesia yang disebut Perserikatan Perusahaan Air Minum Seluruh Indonesia atau disingkat PERPAMSI; juga menetapkan Anggaran Dasar dan Anggaran Rumah Tangganya serta susunan Pengurusnya yang berbentuk Dewan Pimpinan.

Tanggal 28-30 Agustus 1973 Mengadakan Musyawarah Dewan Pimpinan ke I (MUSDEP) PERPAMSI di Kaliurang, Yogyakarta yang membahas dan menetap kan Program Kerja Pelengkap PERPAMSI periode 1973/1974.

Pada Tanggal 23-25 April 1975 Mengadakan MUSDEP ke II PERPAMSI di Jakarta, dengan mengambil keputusan antara lain:

1. Musyawarah bersepakat menyelenggarakan MAPAM ke II di Prapat, Sumatera Utara dengan penyelenggaraan PAM TIRTA NADI MEDAN tanggal 22-24 Mei tahun 1975.
2. Disamping MAPAM II, bekerjasama dengan Dirat Teknik Penyehatan Ditjen Cipta Karya untuk menyelenggarakan Loka Karya dalam bidang Penyusunan Persyaratan Minumam Bangunan Pengolahan Air Minum.
3. Setelah MAPAM II dan Loka Karya akan dilaksanakan Study Tour ke Malaysia.

Tahun 1977 Pergantian Pimpinan PAM DKI JAYA dari Ir. Irwin Nazir kepada Ir Heri Prasodjo sekaligus merangkap Ketua Umum DP. PERPAMSI.

Tanggal 24-25 Januari 1978 Mengadakan kegiatan Loka Karya Air Minum dan Musyawarah Dewan Pimpinan PERPAMSI ke III di Pontianak.

Tanggal 7 April 1978 Menjadi Anggota Corporate Member dari I.W.S.A. (International Water Supply Association) dengan S.K. Mendagri R.I. No. Bkt.3/1 /38 – 41.

Tanggal 18-20 Oktober 1979 Mengadakan Musyawarah Antar PAM Seluruh Indonesia ke III di Ujung Pandang dengan tema "Meningkatkan Sistem Pengadaan Delapan Jalur Pemerataan Kesejahteraan".

Tanggal 15-19 Nopember 1981 Mengikuti The 3rd Asia Pacific Regional Water Supply Conference and Exhibition di Manila. Hasil Konperensi menetapkan untuk menunjuk Indonesia sebagai tuan rumah penyelenggaraan 4th Asia Pacific Regional Water Supply Conference And Exhibition yang akan diselenggarakan pada tanggal 5-11 Nopember 1983, yang merupakan kegiatan dari I.W.S.A. di kawasan Asia-Pasifik.

Tanggal 2-4 Agustus 1982 Mengadakan Musyawarah Antar PAM Seluruh Indonesia (MAPAM) ke IV di Malang dengan thema "Menjawab Tantangan Dasawarsa Air Minum tahun 1981-1990" di Indonesia.
Pergantian Pimpinan PDAM DKI Jakarta dari Ir. Prasodjo kepada Ir. H.A. Razak Manan dan sekaligus terpilih Ir. H.A. Razak Manan sebagai Ketua Umum DP PERPAMSI.

Penyelengaraan MAPAM–IV di Malang sesuai dengan Keputusan MAPAM–III No.:09/Kep.MAPAM/79 tanggal 20 Oktober 1979.

Tanggal 16 Agustus 1982 Pengukuhan Dewan Pimpinan PERPAMSI periode thn. 1982 –1985 hasil MAPAM ke IV oleh Menteri Dalam Negeri NO. 690-1057.

Tanggal 4-10 September 1982. Mengikuti Kongres ke XIV International Water Supply Association (I.W.S.A.) di Zurich, Swiss.

Tanggal 5-11 Nopember 1983. Melaksanaan penyelenggaraan The 4th Asia-Pacific Regional Water Supply And Exhibition (ASPAC-RWSC) –IV di Ibukota Negara Jakarta.

Main Topic I

WATER SUPPLY AND SANITATION GLOBAL POLICIES AND STRATEGIES

By ERDOGAN PANCAROGLU
Sanitary Engineer
World Health Organization

Sub Topic I-1

COMPREHENSIVE PROGRAM FOR MORE WATER TO MORE PEOPLE

By EUNG BAI SHIN, Ph. D., P. E.
Director, Environmental Engineering Korea

Sub Topic I-2

NATIONAL POLICIES AND STRATEGIES

By MINISTRY OF HEALTH & WELFARE and
JAPAN WATER WORKS ASSOCIATION
Japan

Sub Topic I-3

MASS PROVISIONS FOR VILLAGES WATER SUPPLY

By HSIEH CHI-NAN
The Deputy Chief Engineer
Taiwan Water Supply Corporation

Sub Topic I-4

WATER SUPPLY IN INDONESIA-REVIEW OF STRATEGY ENTERING THE 4th FIVE YEAR PLAN

By IR. SOERATMO NOTODIPOERO
Director of Sanitary Engineering
IR. PRIYONO SALIM Dipl. S. E.
Executive Secretary of Directorate of Sanitary Engineering

Sub Topic I-5

PROJECT PLANNING POLICIES FOR PROVINCIAL WATER SUPPLY SYSTEMS

By CARLOS C. LEANO, JR.
General Manager LWUA, Philippines
ANTONIO DE VERA
Chief Engineer LWUA, Philippines

Main Topic II

MANAGEMENT, MANPOWER DEVELOPMENT AND COMMUNITY PARTICIPATION

By HIDENORI AYA, D. E.
Japan Water Works Association
Japan

Sub Topic II-1

OPERATIONAL MANAGEMENT

By R. Franklin

Sub Topic II-2

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By: Roy B. Kelly

Sub Topic V-5

IMPROVEMENT OF THE MANAGEMENT OF WATER SUPPLY AND WASTEWATER

By: JACQUES COUSTILLAS
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A RESOLUTION BY THE CONFERENCE TO COOPERATE TOWARDS THE EVOLUTION OF UNIFORM DESIGN, CONSTRUCTION AND OPERATION STANDARDS IN WATER SUPPLY.

Rationale: The conference believes that in order to:

- Meet the increasing cost in both construction and operations,
- Enhance the water supply-affiliated industries,
- Provide for a speedier decision process in choice of standard,
- and finally, to ensure simplicity and appropriateness of the technology applied.

Resolution: Therefore the Conference hereby resolves:

a. To create a Standard Committee with representations from various sectors of the water community for the purpose of submitting a draft to be confirmed in the next Conference in 1983.

b. To solicit the cooperation of the member-governments for the purpose of legitimizing the standards and providing for its enforcement.

c. To empower the Secretary (General) of the Asia Pacific Group of IWSA to take the needed action to achieve the objective of this resolution.

Done this 18th day of November, 1981 at the 3rd Asia-Pacific Water Supply Conference and Exhibition in Manila.

PRESENTATION OF THE GAVEL
AT 3rd ASPAC–RWSC & EXHIBITION

Penyerahan Palu-Pimpinan, menandakan Indonesia menjadi tuan rumah/penyelenggara 4th ASPAC–RWSC & EXHIBITION

Ilustre shakes the hand of Notosugundo after the presentation of the gavel symbolizing the Indonesian's chairmanship of the next conference.

Ilustre & Notosugundo acknowledge the applause of colleagues.

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of
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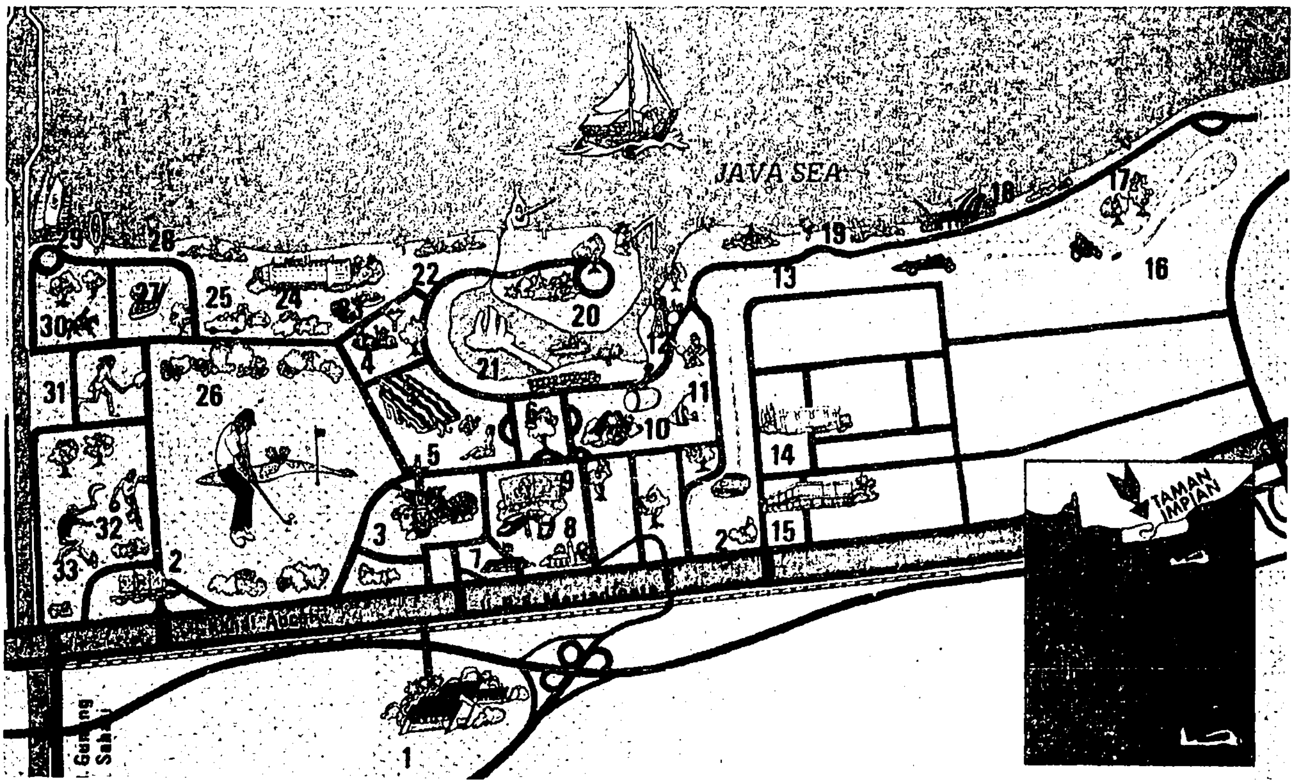

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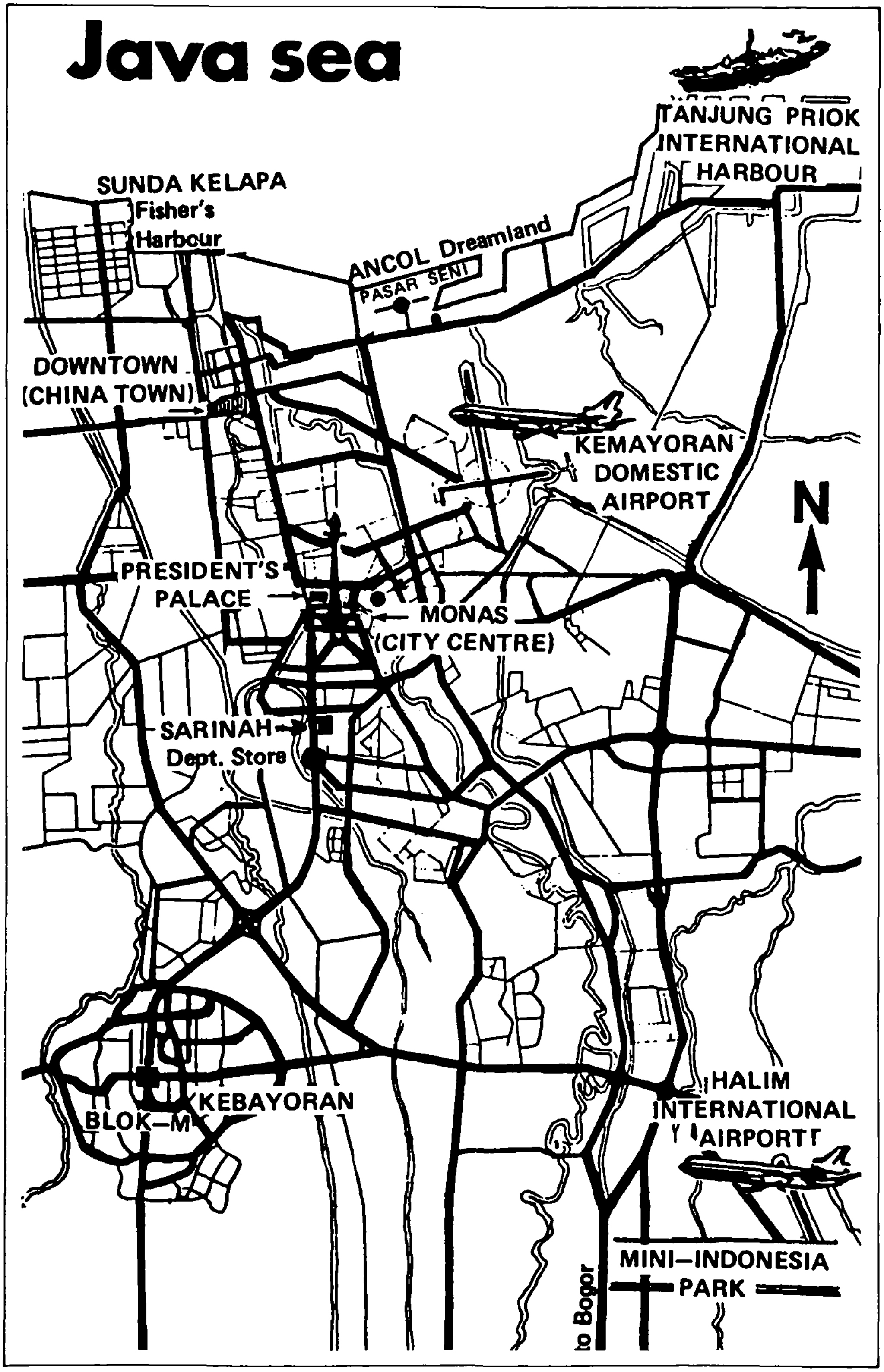

I N D E X

Halaman :

THEME OF THE EXHIBITION

TO BOOST THE UTILIZATION OF
THE RELEVANT DOMESTIC AND REGIONAL PRODUCTS
FOR PROVIDING SUFFICIENT CLEAN WATER
ANY TIME, ANY PLACE

OVERVIEW ON WORLD WATER PROBLEMS

KD 5017

Maarten Schalekamp, Dr. sc. techn. h.c. ETH Zurich
President IWSA

ABSTRACT

The state of the drinking water supply and waste water disposal as well as of the refuse disposal in this world is absolutely insufficient. Only a third of mankind posses irreproachable drinking water facilities, a third have unsatisfactory facilities and a third have no facilities at all. To solve these problems would require US$ 60 billionsper year. This is a lot of money, yet it is only 10% of the world armament costs. If, therefore, the priorities can be placed correctly in every country, the water supply and waste water disposal problems can be solved. Environmental pollution too, has taken on disastrous forms. However, where the problems have been recognised and something has been done about them, improvements are noticeable. As a result of this environmental pollution the surface waterworks of the Rhine and within its catchment area are equipped with seven to ten-stage treatment plants. Despite variable pollution such plants ensure the production of good, clean drinking water. Everything was done there to obtain good drinking water even though the environmental pollution is so extensive.

KEYWORDS

Drinking water supply; waste water disposal; refuse disposal; world armament costs priorities; environmental pollution; improvements are noticeable; surface waterworks; Rhine; seven to ten-stage treatment plants; production; clean drinking water.

GENERAL WATER PROBLEMS

Looking at a photograph of the Earth taken from the Moon, it suddenly becomes clear that today's mankind lives on a spaceship. Mankind must put up with the result of its pursuits, may they be positive or negative (fig. 1)

Water is always on the move through the Sun's energy. However, on the planet Earth it can never increase or decrease in volume. Only 0,007% or 97.000 km^3 of the total water reserve of the world of 1.384.000.000 km^3 is available as precipitation on the continents. Of that amount mankind requires 1.384 km^3 per year or 1½% of the continental precipitation (fig. 2). Even if mankind would increase tenfold, sufficient water would be would be available on earth. The precipitation chart (fig. 3) unfortunately shows that the rainfall is very erratic. This results in the so-called arid and humid zones. The population in these zones have their particular water problems (fig. 4). There are dry zones in countries having a satisfactory economic standard. People would like to live there, where the weather is nice and warm. However, water is very scarce there and has to be normally fetched from very far away, in order to supply these zones. Examples can be found everywhere in the world. e.g. California (fig. 5), etc.

There are also dry zones in countries whose economy is not very satisfactory. Here the nomads need water, but there is too little about; especially during long-lasting dry periods the puddles and wells peter out. Only the boring of 100 metres deep wells, operated by manual pumps, can bring relief. Vicarious for many others, the Sahara may be mentioned as an example (fig. 6). In many tropical, humid zones precipitations of 3.000 mm and more occur very often. This rain falls either during the entire year or during certain wet wheather periods. In principle, there is sufficient water here, only the means are missing for the construction of dams and efficient water supply facilities. Vicarious for many other zones the Amazonas region is shown in figure 7. Then there are humid zones like those in the North-east of the United States, Canada and Northern Europe. Sufficient water and plenty of money is here available to construct water supply facilities. It is, however, very expensive on account of the widespread water pollution (fig. 8).

Looking at the state of the drinking water supply and water disposal in the world the following discovery is made; namely that 1/3 of mankind possess an irreproachable drinking water supply, because 50 to 100% of the waste water and all the refuse is being disposed of. Another 1/3 of mankind also have a water supply, but one which is not sufficiently assured, because the problem of water disposal and refuse removal has not been solved; and the last third of mankind have neither a drinking water supply and waste water disposal nor a refuse removal (fig. 9).

The UNO-Decade from 1981 to 1990 has been given the target to supply the town and rural population, by the end of this period, with good clean drinking water and partly provide waste water disposal. Realisable most probably is, that the municipal water supply bodies will supply 60% of the population by domestic pipelines and 40% will receive their water by means of hydrants. In the rural areas it is reckoned to supply at the most 30 to 50% of the population with water from wells. The waste water disposal in the towns will then have reached 60% and in rural areas 25%, whereby here no waste water treatment is foreseen. In order to realise these effective targets approximately $ 60 billions of investments annually are required or in other workds 10% of the world armament costs (fig. 10).

If the priorities are properly set, the realisable targets of the Decade can be brought to fruition, albeit with much energy.

ENVIRONMENTAL POLLUTION — ITS CAUSE AND SOLUTION

The problems of water pollution are present everywhere in the world. Mankind requires only 1.384 km^3 sweet water. By its use the water becomes polluted and could thus contaminate the entire world water resources of 1.384.000.000 km^3. It is, for instance, possible that one litre poison or one litre oil can make one million litres of water unsuitable for consumption. This is no utopia, it is stark reality (fig. 11). That this is already a fact at many places is shown quite clearly by the pollution chart of the Mediterranean (fig. 12). In many places the waste water from the industries as well as from domestic users is discharged, without treatment, by means of canalisations directly into the ocean. There are even areas where it is permitted to discharge oil, as if the oil would remain at that particular site! This is also the reason, why all the beaches in the Mediterranean area are polluted by oil. Here immediate remedies must urgently be produced. When considering the world-wide pollution, the question arises: is man a parasite of this Earth (fig. 13)[The answer to this question is a clear YES. For instance the population of the Earth increases each month by about 6½ millions, that is the population of Switzerland. It is reckoned that this will be the case until the year 2025 (fig. 14). These people require food, water and energy (fig. 15). The consumption of artificial fertiliser increased nine-fold since the last war (fig. 16) and the energy consumption, world-wide, was doubled. In Northern Europe it increased 25-fold. It is usually not sufficiently realised that the human body discharges medicine one hour after it has been taken through the urine and again 24 hours later through the faeces into the water (fig. 18).

Despite becoming more environmentally conscious in the last few years, man has caused a change in the ecological balance of the world. This change can mainly be attributed to the population increase, energy consumption increase and the more intensive agricultural exploitation of the soil (figs 19 + 20). If also in future mankind wants to feel well on its spaceship Earth, the development of the abovementioned criteria must not increase beyond the point where the available measures completely cancel them, out. Countermeasures, among others, are treatment of waste water, fresh water and air, environment protection and population planning. As an example for the water pollution, air pollution may be mentioned. During the last 35 years the carbon dioxide content of the air increased four-fold. This results, on the one hand, in an oxygen decrease, because the green areas of the world produce much less per year than is used by the combustion engines, and on the other hand, in an acidification of the rain (fig. 21). A nicely evaluated example is the one of East-North-America (fig. 22), where the pH-values of the rain were reduced by several tenths during the last 20 years. The same phenomena occured in the Scandinavian countries (fig. 23). In the South of Switzerland too, an unmistakable trend towards lower pH-values has been ascertained, caused by the agglomeration zones in the lower Po area of Italy.

In Switzerland, energy consumption rose six-fold since 1940 despite the fact that during the same period the population increased by only about 50%, i.e. from 4,2 millions to 6,2 millions. The water consumption of the public works doubled itself during this time from 0,6 billions to 1,2 billions m^3/year. Chemical fertilizer, the sum of K + N + P, rose seven-fold to 110.000 metric tonnes/year. The consumption of organic fungicides increased 25-fold since 1954 and rose from 40 to European continent. In view of these values, it is easily understood why the water bodies in Switzerland and on the continent have been affected adversely by the present environmental conditions. Surface waters, like lakes and rivers, especially, have been strongly affected.

Comparison of organic substances of the sediments, vicarious for many other parameters, of the Lakes of Walenstadt and Zurich shows that those of the Lake of Zurich, measured on the ultraviolet (UV) values, are today four times higher than those of Lake Walenstadt (fig. 25). Carcinogenic substances, like phenanthrene, fluoranthene and pyrene, are ten times higher (fig. 26). Control of other Swiss lakes in the last 20 years shows unmistakable eutrophic features. At higher loads of organic substances in water bodies whose raw water serves for drinking water supply, carcinogenic matter is very often found in the drinking water and subsequently, albeit in a strongly reduced concentration, in the blood of the population. Figure 27 shows this situation very nicely in the blood and drinking water sample in New Orleans, USA.

The level on contamination of the Rhine and its tributaries has also increased during the past 20 years as the result of environmental pollution. In the River Rhine, chemical pollution takes precedence, considering that although the flow through the Rhine accounts for only 0,2% of all rivers in Western Europe, whereby 20% of all chemical industries in the West are situated in the Rhine area (fig. 28).

The salt contents of the Rhine increased steadily reaching inadmissible heights (fig. 29). The same happened to the phosphate content of the waters of its catchment area. As an example the Lake of Constance may be mentioned, where the phosphate values increased 40-fold to 90 gamma during the years 1955 to 1975 (fig. 30). The result was eutrophication, i.e. extremely heavy growth of algae in the lakes spaceship Earth can still be saved (fig. 32). The answer is YES (fig. 33). With the aid of its technology mankind can reach the moon, i.e. technology can certainly help. However, we must face the future problem conscious (fig. 34). By recognizing the problems, one is already on the road to recovery.

Much is already being measured today, but the interpretation of the values is for most people a book with seven seals (fig. 35). Therefore, a first step in the right direction, for our air as well as for our water, is the compilation of annual quality charts by means of aimed for appropriately comparable measurements. The criteria should be chosen in such a manner that they will disclose, if the water or the air are harmful or not for man, animal and plant (fig. 36). In future, these quality cards can be compared and from year to year it can be ascertained, if the countermeasures taken against pollution have been effective or not. Once more it must be pointed out that the proper criteria should be chosen. As an example the quality chart of the River Rhine may be mentioned. The Rhine must be judget only against the quality criteria of the water supply services, and not according to whether fish can again live in the river. This is also the reason, why the IAWR, working closely together with the German Gas and Water Services Association (DVGW), is publishing the "Rhine Report 1978", a guide (with maps) to the quality of the Rhine. In future the Rhine is to be assessed not only in terms of its "bed", i.e. according to the saprobe system; instead, the quality of the Rhine water will be evaluated in terms of the criteria relating to drinking water, which means those important for human health. The aim of this guide is to make clear to the authorities and those who deal with effluent where to set their priorities for conserving the Rhine.

IAWR "Quality Map" of the River Rhine ("Hotel Baedecker")

Arrocring to the IAWR report, when appraising the Rhine, the numerical values used must be independent the water flow at the time of the appraisal.

The appraisal of waters can only be carried out on parameters for which the relation between water flow and concentration is known and can be mathematically described. Sufficient analyzing data for various water flows must be available.

The parameters to be used for an evaluation should be representative of the type of contamination of the Rhine water and should also have been sufficiently measured. First of all one should limit the effort to the investigation and presentation of the following parameters (fig. 37):

1. dissolved organic carbon (DOC, g/m^3
2. ammonia NH_4^+; g/m^3
3. oxygen saturation deficit (ΔO_2), %
4. neutral salt burden, expressed in chloride (ΣNS), mg/m^3
5. disolved organic chlorine (DOCl), mg/m^3

When evaluating the analysis data, representative concentrations for the longyears average of the water flow as well as for a very low water flow with a probable maximum of concentrations should be determined.

The assignment of the representative concentrations (average and maximum) to the water quality parameters serves merely to illustrate the number values with reference to the concentration density. The basis of the evaluation scale is thereby the long-year experience of the waterworks in the catchment area of the Rhine. The following levels of water quality are distinguished:

1. practically uncontaminated water
2. moderately contaminated water
3. severely contaminated water and
4. excessively contaminated water

From the water qualities for the five single parameters an aggregate figure can be determined insofar as the highest value for the parameter is used.

The result of the evaluation according to the mentioned criteria, results, for the Rhine, in the quality card shown in figure 38. From Karlsruhe onwards, for instance, the Rhine receives the note 3 – 4, i.e. the water is severely to excessively contamined, the reason being mainly the amount of neutral salts in the water. Something must really be done here.

The quality chart shows for instance that the phosphate contents of the Lake of Zurich declined from 115 gamma per litre to 75 gamma per litre (fig. 39). The chart also registers that the ammonia contents of the Rhine water was reduced by 50% (fig. 40) and the oxygen contents increased by 50% (fig. 41). This recovery was made possible by the newly-constructed and operating clarification facility in the catchment area of the River Rhine (fig. 42). Obviously, if something is done, it is also beneficial. Of great importance is the combating the cause, i.e. for example the dosage of washing powder according to the hardness of the water. The population should be informed by PR-work and the stickers showing the water hardness should be given away free (fig. 43). Industries situated along the banks of the Rhine have also contributed much towards this improvement. The paper industry may here be mentioned as an example. Thrice within a few years the contents of lignin-sulphonic acid of the Rhine water were reduced (fig. 44). In order to get these problems under control (fig. 45). State and Cantons must pass environmental legislation and assure that the municipalities fulfil these laws. Furthermore, the water supply bodies and the industry can contribute their share. First by saving water, recirculatin process in industry, consumption-appropriate water tariffs, information of the public, application of modern installation technology such as automatic mixing devices, baths with permanently installed shower facilities, etc. and second, improved water treatment facilities.

It is quite clear that legislation and its application for the protection of the water is essential, but the measures taken by the waterworks themselves are of no less importance.

In the City of Zurich (fig. 46) four-stage clarification plants are being constructed, namely a mechanical, biological, chemical cleaning and filtration stage by means of micro-flocculation. It is only by these sewage treatment plants that the required quality criteria demanded by the government, for the discharging of treated water into flowing waters, can be adhered to. In case these various cleaning stages would not suffice, it is possible to add further stages such as the granular activated carbon filtration (GAC) and ozonation (fig. 47). This example shows that the problems of the waste water disposal can be solved. The drinking water supply bodies were forced to expand their treatment process from 2 to 8 – 10 stages. For the supply and disposal of water and for the refuse removal, Switzerland had to invest SFrs. 1,5 billions/year for the last ten years, whereby 3/4 was spent for the disposal and 1/4 for the supply. This corresponds to about 1½% of the gross national product (fig. 48). It is not even 10% of the total defense budget. The Swiss people spent SFrs. 22 billions for their waste disposals in the last 15 years, as much as they invested in the construction of their motorways. The drinking water supply bodies have the prblem of being forced to take the raw water as it comes and being obligated to produce from it good, clean drinking water. Their treatment facilities must, therefore, be able to cope with the worst.

THE WATER TREATMENT PROCESSES IN THE WATERWORKS OF THE RIVER RHINE AND WITHIN ITS CATCHMENT AREA

The possibilities of improving drinking water treatment are not unlimited. At the Lower Rhine waterworks, for example, practically all possibilities for water treatment have been used. These consist of riverbank filtration, ozonation, multimedia filtration, granular activated carbon (GAC) filtration, neutralization and safety chlorination.

The operating time before reactivation of the GAC filter was 13 – 14 months in 1966 and six weeks in 1974. In 1979 the operating period of the GAC filter is 3 – 4 months, because of improvement in DOC and lignin sulfonic acids in the Rhine. Many water treatment plants in Europe have done everything in their power during the last decade to supply first-class potable water. Three examples shall make this clear:

In Weesperkarspel/Netherlands a waterwork has been in operation since 1886 with rapid and slow sand-filtration of raw water from various lakes and the River Rhine. At the end of the treatment, the water was chlorinated, and the resulting quality sufficed in those days. As a result of the change in the raw water quality, water treatment for the Amsterdam supply had to be adapted constantly in the last years; today a very complicated treatment system is used to provide potable water of the required purity (fig. 49). This process consists of nine treatment stages; mixing Rhine water with water from the Betune Polder and subsequent cleaning in a self-cleaning pool, first rapid filtration, ozonation, addition of powdered activated carbon, coagulation, second rapid filtration, slow sand filtration, deacidification, safety chlorination.

The second example is the Water Supply of Wiesbaden, Federal Republic of Germany: In former years river bank filtration was sufficient. Through the contamination of the Rhine the capacity of the wells was successively and perceptibly reduced, so that artificial groundwater enrichment had to be initiated. Today, drinking water in Wiesbaden is treated in ten stages: aeration, sedimentation, breakpoint chlorination, flocculation with $FeCl_3$, rapid filtration, GAC-filtration, replenishment of groundwater by infiltration via well and basin, aeration, slow sand filtration and safety chlorination (fig. 50).

The third example is Zurich, where until 1960 two process stages for the treatment of lake water were in use: rapid filtration and chlorination or rapid and slow sand filtration. Within five years the difficulties increased to such an extent that the water treatment system in operation hitherto could not be justified any more. Therefore, the following eight-stage process had to be used in the two lakewater plants at Zurich: prechlorination, flocculation, rapid filtration, neutralization, ozonation, GAC-filtration, slow sand filtration and safety chlorination with chlorine dioxide (fig. 51).

LAKEWATER TREATMENT PROCESSES IN SWITZERLAND

Ten lakes and the River Rhine are used for drinking water supply in Switzerland (fig. 52).

Of the total of 36 lake water plants, 24 take their water from the Lakes of Constance, Zurich and Leman. With reference to the various lakes we have the following picture:

Lake Constance, Swiss side (German side, 10 plants)	8 plants
Lake Zurich	10 plants
Lake Leman, Swiss side	7 plants
Lake Lucerne	3 plants
Lake Neuchatel and Lugano (2 plants each)	4 plants
Lac du Bret, Lakes of Murten, Sempach and Biel (1 plant each)	4 plants
Total	36 plants

Of the river water plants, two must be mentioned, both situated on the banks of the River Rhine. They are the works of Hardwasser Ltd. and of the twon of Basle. Furthermore, there are five large industrial water supply plants, two on the Rhine, two on the River Rhone, one on the River Saane, as well as a number of plants on smaller lakes.

Of 36 Swiss lakewater plants (fig. 53) nine have (in 1982) adopted the rapid filtration with subsequent ozonation and chlorination. In nine plants the treatment process is as follows: prechlorination, multilayer rapid filtration with GAC and sand, subsequent ozonation, chlorination or chlorine dioxide treatment. A further nine plants possess prechlorination, multilayer rapid filtration with sand and pumice or anthracite, ozonation, GAC-filtration and chlorine dioxide treatment.

The last nine plants possess, the following treatment process: prechlorination, flocculation, multilayer rapid filtration (sand and pumice, neutralization, ozonation, GAC-filtration, chlorine dioxide treatment. The plants at Horw (Lake of Lucerne), Rolle (Lake Leman), St. Gall (Lake Constance), Zurich-Moos and Zurich-Lengg (both Lake Zurich) all have a slow sand filtration satege prior to the chlorine dioxide treatment. The City of Basle riverwater plant, Lange Erlen, has a rapid filter stage with chlorination prior to percolation. The river-water plant Hardwasser Ltd. operates according to the following process: flocculation with sedimentation, rapid filtration and percolation (slow sand filter).

In future the following treatment process will be employed in Swiss lake water plants:

1. prechlorination
2. flocculation
3. double-layer rapid filtration with sand and pumice
4. neutralization
5. ozonation
6. GAC-filtration
7. slow sand filtration and
8. chlorine dioxide treatment

The foregoing indicates that in practically every Swiss lake being used for drinking water production, the new treatment technique (today 80%) is already in operation. The same trend can be discovered in the river water plants, with the exception that flocculation with sedimentation is also foreseen. The question now arises, "Why and how are these processes used in Switzerland?" Following is a short outline of these processes:

1st Stage: Prechlorination of Raw Water

In the catchment head of the lake intake pipe raw water is chlorinated with 1 mg Cl_2/1. The prechlorination of the raw water is to be looked upon as necessary. This stage keeps the raw water facility up to the rapid filter absolutely clear (fig. 54) of any algae or Dreissena polymorpha pallas (DPP)-larvae deposit, and reduces the dissolved organic substances in the water by 6 – 20% (fig. 55). This reduction occurs, if one or several mg Cl_2 pe litre water are added. However, if only 0,5 mg/1 of Cl_2 is added, the reduction can almost not be ascertained. Also the DPP cannot be destroyed with any certainty. Tests have shown that an addition of 1 mg and a rest chlorine contents of 0,5 mg/1 in the rapid filters will eliminate the DPP within 13 days. It is known that the larvae require 14 days to pass through the filter, so that the elimination time is just sufficient (fig. 56).

Chlorination also brings an improvement of the colour of the water. In place of the greenish appearance it has a blue tint. The halogen compounds formed by chlorination (fig. 57) amount to only 10 – 15 ug/1 and, it is true, they are as yet hygienically harmless, but unwanted. That is the reason this process has been changed to chlorine dioxide (fig. 58).

Unfortunately, chlorine dioxide possesses an undesirable property. i.e. the freeing of chlorite in the water through drift. With a dosage of 0,8 mg of ClO_2, about 0,6 mg of chlorite is freed. During treatment with ozone, about 0,8 mg of chlorate is then formed in the water (fig. 59). The chlorate is not changed any further by the subsequent GAC and slow filtration, so that 0,8 mg of chlorate remain in the drinking water, which could, under certain conditions, be more harmful than the concentration of halogenated hydrocarbons as a result of the chlorination. However, the chlorite concentration in the water can easily be removed at the start of the treatment process by GAC filtration, so that no more chlorate is subsequently formed (fig. 60). This, however, is a very expensive method. Today, new experiences have been gathered with the preoxydation stage and the dosage is 0,6 mg Cl_2/1 and 0,3 mg ClO_2/1 or vice versa. The Zurich drinking water hardly contains any haloforms and the concentration of chlorite is only 0,01 mg/1 and chlorate $< 0,3$ mg/1, which is not harmful for human health. This system of precxydation is reasonable in price and very effective (fig. 61).

2nd Stage: Flocculation and Filtration

Rapid Filtration. Before the chlorinated water reaches the rapid filter, a flocculand and a flocculant aid are added. Tests have established that a flocculant addition of 1,5 mg, be it aluminum or iron sulfate, together wih a flocculant aid, will yield the optimum. The cleaning effect on the phytoplankton larger than 20 um an detritus larger and smaller than 20 um is 6%, i.e. without microflocculation 92,5% are kept back and with microflocculation the removal amount to 98,5% (fig. 62). The cleaning effect on the phytoplankton smaller than 20 um is considerable better; without microflocculation 50% are still present in the rapid filter, with microflocculation only 28% still exist. The target, however, is to remove also these 28% from the drinking water (fig. 63). Therefore, other filtration stages must come into use after the rapid filtration to reduce further the above percentage. The addition of flocculants causes, besides the above mentioned cleaning effect, a partial precipitation of phosphates, which serve as food for the plankton and bacteria. Efficient filtration of the plankton prevents the development, in the drinking water pipes, of higher organisms such as Ligochaeta, Nematodes, Ostracodes, Asellus, Nauplius.

Cyclops and Canthocamptus.

Multilayer Filtration (gis 64 + 65). By using the multilayer filtration with sand and pumice a six to eight times longer operation, the same cleaning effect is obtained. When one knows that, at peak times, many lakewater plants must wash their rapid filters twice a day, multilayer filtration is a decided improvement. Especially important is the fact that despite the longer operation time the efficiency of the cleaning remains the same.

This process is of great economical advantage, because considerably less scavenging water is required.

3rd Stage: Neutralization

Prior to or after filtration, the water is neutralized, i.e. deacidified (fig. 66). Most of the lakes have lost their carbon dioxide balance. The pH-value should be about 8.2, however, it is according to lake and intake depth 7 – 7.8. Flocculation with aluminum sulfate also reduces pH somewhat. It must, therefore, be corrected upward to prevent corrosion in house installations and water pipelines. The value will be corrected to within 10% above pH equilibrium. The waterworks of St. Gall, Basle and Zurich were very successful with this type of neutralization. Corrosion of the insides of the pipelines is now under control. Comparison tests at the Swiss Federal Institute for Material Testing (EMPA) between neutralized lake water and non-neutralized ground water are shown in figure 67. The effect is excellent.

4th Stage: Ozonation

Swiss people love good air and cleanliness. They are possibly spoiled by the fresh mountain air. Air which contains a minute quantity of ozone gives the impression of being fresh mountain air when breathing it. This is maybe one of the reasons that Switzerland is such an ozone-favouring country. The fact that 24 ozone production plants per million inhabitants are in operation, speaks for itself. This is more than twice the number of plants that France possesses and it brings Switzerland to the first place in the world (fig. 68).

Fisrt we will give an answer to the questions: "Why use ozone? And in what concentration?" To better answer these questions, the effect of a dosage of 1 to 5 mg/1 of ozone will be compared. Most of the results refer to investigations of lake water from Switzerland and cannot be used otherwise without necessary corrections.

Just as one can drink alcohol of various concentrations (fig. 69), so it is also possible to ozonate in smaller or larger concentrations. If one wants to stay fresh, a slightly alcoholic drink would be just right, to prevent a cold an alcoholic drink of a higher concentration is called for. What effects various concentrations of ozone can have shall be treated shortly. But first a few words about the behaviour of the germs.

Whether Lake Zurich water is treated with 1 or 5 mg O_3 makes no difference to germ development (fig. 70). After three weeks the first germ development starts and from the fourth week on the number of germs is 10^4–10^5/m1 The regermination in water, which has been chlorinated with 1 mg/1 prior to dosing with 1 and 5 mg O_3/1, starts from the sixth week onward instead of from the third week. Furthermore, it is important to know, how viruses behave. Figure 71 shows that, according to the studies of Katzenelson and Shuval (1975), the inactivation of viruses for the various ozone concentrations of 0,3, 0,8 and 1,5 mg O_3/1 is similarly effective. In conclusion it can be said that in regard to the destruction of bacteria and inactivation of viruses, in water of not too high a degree of contamination, a higher concentration of ozone than 1,0 – 1,5 mg/1 is not necessary.

Decoloration by ozone in various concentrations can be seen in figure 72. With an ozone concentration of 1,0 mg/1 the colour intensity is reduced by 50% and with a concentration of 5,0 mg/1 by 70%. For a better decoloration a higher ozone concentration could be used.

Contrary to the tests with DOC, where no alterations occurred with ozone of various concentrations, the $KMnO_4$-values decreased by 14% at a dosage of 1,0 mg O_3/1 and a decrease of 18% at a dosage of 5,0 mg O_3/1 was noted. The initial values of the UV-extinction values (fig. 73) are reduced by 33% at a dosage of 1 mg O_3/1 and by 57% at a dosage of 5,0 mg O_3/1. This means that, if a log of humic acid has to be removed, a higher ozone dosage will more easily reduce it.

Ozone is an excellent agent to remove the taste of phenol or trichlorophenol (fig. 74). A dose of 1,0 mg O_3/1 reduces 100 ug phenol and 500 ug trichlorophenol. 5,0 mg O_3/1 reduces 500 ug phenol and 2.500 ug trichlorophenol. It is of great advantage to be able to carry out a high ozone dosage when a phenol accident has occurred.

Ozone strongly reduces haloforms and produces large amounts of aldehydes and ketones. Let us consider the aldehydes (fig. 75). Laboratory tests at Zurich Waterworks confirm the values of Grob. With a reaction time of from ten minutes up to one day the concentrations of the aldehydes will be 9,5 times larger at a dosage of 1 mg O_3/1 and 30,6 times larger at a dosage of 5 mg O_3/1. Through their decay, aldehydes and ketones produce corresponding acids, which serve as food for microorganisms. Therefore, a higher concentration of ozone prior to a biological treatment stage should be of advantege. If the ozone is used as a last stage, the concentration should be as low as possible, because of the regermination. Figur 76 shows quite clearly that ozone during a very long reaction time reduces the halogen compounds by 31% at a dosage of 1,0 mg O_3/1 and by 77% at a dosage of 5,0 mg O_3/1. This long contact time is possible, if there is an intermediate reservoir after the ozonation, as is the case at the Lake Constance Waterworks, for instance. With a reaction time of ten minutes – the plants at Lengg and Moos operate like that – the haloforms at 1 mg O_3/1 are practically reduced for the same amount, at 5 mg O_3/1 by 47%, which means less than is the case with the longer reaction times. Looking at the flocculation effect (fig. 77) during ozonating at 1,0 to 5 mg O_3/1, one can say that the optimum lies between 1,0 and 1,5 mg O_3/1 and that at 5,0 mg O_3/1 the opposite of flocculation occurs. Before the selection of the proper dosage, an exact analysis should be made what the ozone will be required for. A high dosage can in many cases be of great advantage, however, in other cases it can be of disadvantage. Figure 78 shows quite clearly that a higher ozone concentration dosage is of advantage to reduce the phenol compounds and haloforms as well as improving the UV and colour values. However, it negatively influences flocculation and, if no refiltering takes place, also the regermination. For destruction of the bacteria and inactivation of the viruses as well as for flocculation, no increased dosage concentrations are necessary. In case of a breakdown, for instance, when a phenol accident occurs, it would be of advantage to be able to increase the dosage. At many waterworks in the world peak consumptions occur only during one to two weeks per year, which are twice as high as the normal average requirement. It is, therefore, possible during a breakdown, which will hardly occur at peak times, to dose higher ozone amounts by reducting the plant capacity. **Every plant manager should construct his ozone units in such a way as to be able through a reduction of the plant capacity to dose more ozone.** This is especially valid, if he operates a facility which has been designed for normal dosage. Everywhere where ozone is used, its concentrations in the water and in the air must continually be monitored. For those who do not possess an ozone unit, they should realize the following: Ozone can do a lot, but not everything. Ozone has saved many plant managers from ultimate disaster (fig. 79). Today, no water surface treatment plant should be built without an ozone stage.

5th Stage: Granular Activated Carbon (GAC) Filtration

To remove the excess chlorine and ozone from the water, it is passed over a GAC-filter. The GAC operating speeds vary between 10 and 20 min/h at a height of the filter bed of 1,20 m. The GAC-filters usually rest on a bed of sand of about 50 cm in thickness (fig. 80). Besides the removal of excess chlorine and ozone, the GAC-filter extracts from the water large amounts of organic substances (fig. 81). In one waterwork, for instance, it has been discovered that the uppermost layer, consisting of Pittsburgh F 400, after an operation of two months, showed a load of 37 g/kg. At the beginning, the new GAC-filter had a load of 4 g/kg. After three months of operation the load was 63,5 g/kg and after seven months of operation the highest load, 68,2 g/kg was measured (fig. 82). These tests have clearly shown that without GAC-filtration many more organic substances would still be present in the drinking water. Other tests have shown th these substances are absent from good, i.e. unburdened spring, water. One of the main responsibilities of a waterwork is the provision of water of unimpeachable quality, be it spring, ground or surface water. For that reason GAC-filtration is absolutely necessary for the purification of surface water in Switzerland.

Measurements have revealed that after six months, if no ozonation occurs and after three years, if a preozonation takes place (fig. 83), the GAC-filter layer is loaded with organic substances that a renewal and reactivation becomes necessary. The reactivation is carried out by means of the so-called "fluid bed process", system Norit. In this furnace were reactivated, besides the GAC Norit ROW 08 Super, which emerged from the latest comparison tests as the best GAC, also Norit PKST, a light GAC, and Pittsburgh 400. The losses were only 50% of the customary reactivation process. The GAC Norit PKST for instance was only loaded with 28 g/kg; the fresh GAC showed a load of 5 g/kg and the reactivated GAC only 8 kg/kg (fig. 84). The GAC loss amounts to 12%, measured from the filter via the silo, furnace, silo back to the filter. The results show that the efficiency of the reactivation can be classed as excellent. For the Water Supply Zurich there are three important criteria for changing the GAC: if the halogens (fig. 85) and UV (fig. 86) of the drinking water are higher than the permitted level or if the upper layer of the GAC in the filter is loaded to capacity (dimethyl formamide + dioxan extract) and the bottom layer is loaded with 70% of the maximum of the upper layer (fig. 87).

Although three- and four-digit germ figures occurred after monthly backwashing in the various GAC-filters of the Zurich test plant, it was then already discovered that after weekly backwashing the bacterial figures were four times less. In today's operating GAC-filters no higher than two-digit bacterial figures can be discovered (i.e. 0 – 5 per cm^3); however, this is only valid, if the filters are backwashed at least every two to three days by air and water. If the cleaning occurs at longer intervals and without air, the germ figure rises again, as experience has proved in Zurich (fig. 88).

6th Stage: Slow Sand Filtration

In Switzerland slow sand filtration is still in use at five lake water plants. This is a process which becomes more important for the artificial groundwater enrichment. Tests have shown that with an effective pretreatment the slow filtration can in future be operated at an average speed of 15 min/day instead of the now usual 3 – 7,5 min/day. It was discovered in actual operation, that because of a thorough pretreatment the operating period, without cleaning, is three years. Formerly, the filters had to be cleaned every six to nine months. The cleaning effect with reference to the filtration of the phytoplankton detritus as well as to the elimination of the germs is equally efficient, if the slow sand filter is operated slowly or rapidly (fig. 89). Investigations have established that the slow sand filter, with regard to the bacteriological and biological cleaning effect, has to be clearly classified as a spatial filter. It is only a surface filter with reference to the mechanical cleaning. Despite the higher speed, a slow sand filter with the same standard of water treatment is not more expensive than a rapid filter, not counting the price of land.

7th Stage: Pipeline Protection

The addition of chlorine dioxide does not only serve the water treatment, but also in pipeline protection, so that the water in the supply and distribution network remains hygienically perfect (fig. 90). The dosage is only 0,05 mg ClO_2/1, so that the chlorite production does not count.

Figure 91 shows the increase and decrease of the halogenated hydrocarbons during the treatment stage with and without ozone. It is quite obvious that without ozone, as a result of the chlorine drift, the halogenated hydrocarbons increase up to the GAC-filtration and are subsequently heavily reduced after this stage and the slow filtration. When ozonation takes place, the halogenated hydrocarbons at least do not increase anymore. After ozonation, they are even partly reduced, so that in any case, in the end a better result is obtained by the use of ozone.

The cleaning effect of the above described treatment process can be gathered from the following. The organic substances are reduced by 90%; this means that the UV-extinction, measured at 254 nm, amounts to 0,040 in raw water and 0,004 in drinking water. The effect of water treatment can be gathered from figure 92. On the right is the raw water and on the left the drinking water.

The high standard of the water treatment processes of the Swiss lake water plants also extends to the construction and technical realization. Furthermore, because of the shortage of personnel, most waterworks operate fully automatic. A remote control center monitors, controls and evaluates the operation (figs 93 + 94).

CONCLUDING CONTEMPLATION

The problems of the water supply bodies in Switzerland in Europe, yesterday and today, are as follows:

Water hygiene was one of the greatest problems of the water supplies in the last century. Only after the construction of the slow filters and since the introduction of chlorination, diseases which are transmitted through water, such as cholera, typhoid, dysentry, etc. vanished in the industrialized countries. However, if breakdowns occurred in the treatment stages, contamination of the water usually followed. As an example a typhoid occurrence in 1945 (14 deaths) in Glion, Vaud, may be called to mind, whose cause was the contamination of spring water by a defect waste water pipeline of an hotel. Also Zermatt with three typhoid victims in 1963 is still remembered. The cause there was the addition of creek water to spring water whereby the former was insufficiently disinfected.

With much trepidation the water supply bodies observe the transport and storage of oil. The surface water as well as the ground water can become endangered. The phenol accidents in St. Gall and Zurich in 1957 respectively 1967 come to mind. A specially big problem of the last few years is the eutrophication of our lakes as a result of the phosphate load and the renewed appearance in Switzerland, after 20 million years, of the Dreissena polymorpha pallas (migratory mussel).

All these problems could more or less be solved (fig. 95). But already new problems appear. It is common knowledge that nitrates for fertilisation are being used in agriculture.

Cases of ground water pollution occur more often which could not be detected in former times, mainly caused by chemical waste products such as tetrachlorethylene. Alone in the Canton of Zurich two such cases are known, one in the area of the ground water plant Hardhof of the City of Zurich and the other in a ground water resource in the Glatt-Valley. In Baden-Wurttemberg, in the Federal Republic of Germany, 30 such cases of contamination have been registered.

Another problem pose the haloforms. Because of the organic contamination of our water bodies chlorated hydrocarbons are formed, during the chlorination process, which – in certain concentrations – can be harmful to the health of human beings (fig. 96).

The targets in Switzerland, for its water supply and waste water disposal as well as for the refuse removal, are as follows:

In principle, pollution must be 100% compensated for. If possible by combating the causes and not the symptoms. The water supply bodies shall deliver enough drinking water of first-class quality, at sufficient pressure and, if possible, at a reasonable price. The wastewater diposal including rain water is foreseen to be available for the entire population and industry, i.e. everyone shall be connected to a canalisation. This aim has already been realised up to 82%. Furthermore, the aim is to treat 100% of the sewage water in an irreproachable manner. In 82% of the cases this is today already reality (fig. 97). The water in the connurbation areas shall be treated in four-stage, or more, treatment plants.

The problem of refuse removal has today been 100% solved, be it by means of organised depots or by incineration facilities. The targets of Switzerland are vicarious for the targets already set or yet to be a aimed for, in all countries of the world. If mankind desires to keep on living on the Planet Earth, it is high time to realise these targets in the shortest possible time in the whole wold (fig. 98). The imperilment of the future of the inhabitants of the spaceship Earth can without doubt be warded off. However, the necessary sacrifices must be offered and the proper priorities have to be set. When, this is the case in the whole world, then our children will still be able to drink water in future and the inhabitans of this Earth, just like you in this lovely Congress City of Jakarta/Indonesia will feel well and happy on our "Spaceship" (fig. 99).

The International Water Supply Association will do everything in its power to contribute to the aims of this most important target (fig. 100).

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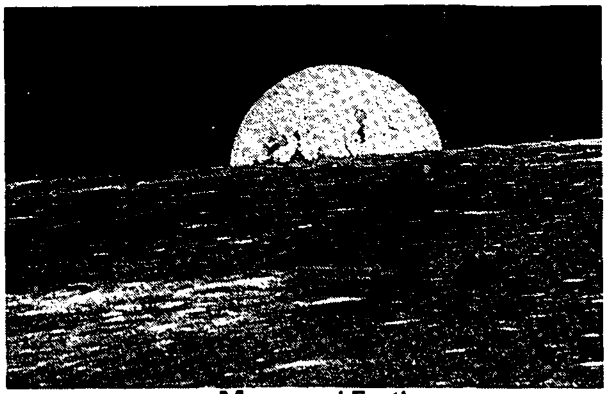


Moon and Earth

2

World-Water Survey

Water Resources	(100%)	1 384 000 000 km³
Sweet water	(2,6%)	36 000 000 km³
Sweet Water usable	(0,24%)	2 880 000 km³
Precipitation	(0,03%)	423 000 km³
on Continent	(0,007%)	97 000 km³
Human Population requires	(0,0001%)	1 384 km³

or 1,5% of the continental precipitation

28 10 82
1383 WVZ

Precipitation Chart

3

Worldwide annual precipitation distribution

<250 mm
250-500 mm
500-1000 mm
1000-2000 mm
>2000 mm

28 10 82
498 WVZ

On the average the earth receives about 423 000 km³ of precipitation, the continents, however, only 1/4 of this amount.

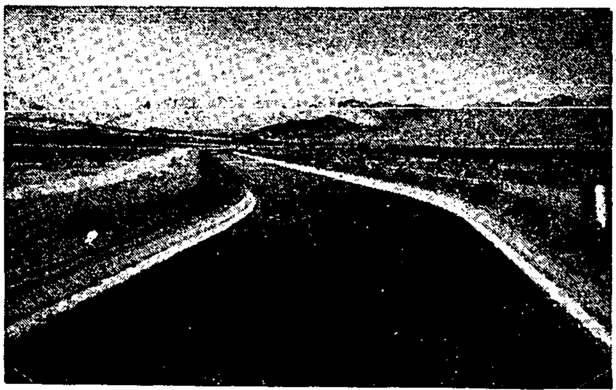
4

Problem I: Water Supply

1. Industrialised Dry Zones
2. Handicapped Dry Zones
3. Handicapped Humid Zones
4. Industrialised Humid Zones

28 10 82 1382 WVZ

5



California

6

Sahara

7

Indonesia

8

Europe

9

State of the Drinking Water Supply in the World

1/3 of the human population have unimpeachable drinking water because of 50 - 100 % waste water disposal and refuse removal

1/3 of the human population have no assured drinking water supply because of 0 waste water disposals and 0 refuse removals

1/3 of the human population have 0 drinking water supply, 0 waste water disposal and 0 refuse removal.

28 10 82 1386 WVZ

10

UNO - Decade 1981 - 1990

Target:	Town	Country
Water supply	100 %	100 %
Water disposal	100 %	100 % (without clarification)
Realisable:		
Water supply 60 % Domestic supply 40 % Hydrants	100 %	30 - 50 %
Water disposal without clarification plants	60 %	25 %

Costs: 60 billion $ per year or 10 % of the world armament costs.

28 10 82 1387 WVZ

11

Problem II: Water Pollution

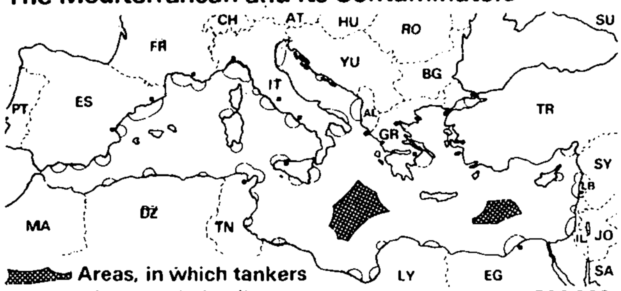
1 liter poison can spoil 1 000 000 litres of water, i.e. 1384 km^3 water which humanity needs can easily contaminate the entire water resources on earth, 1 384 000 000 km^3.

This is no utopia, it is reality.

28 10 82 1381 WVZ

12

The Mediterranean and its Contaminators



Areas, in which tankers are permitted to drain oil

Heavily endangered areas through industrial waste water or faeces

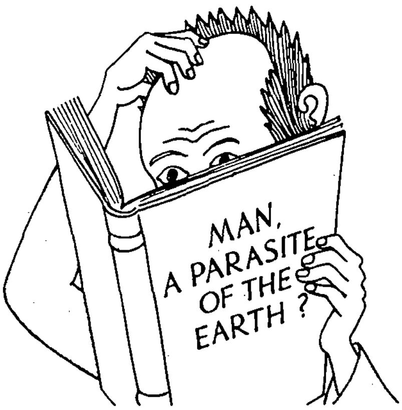
○ Towns of up to 500 000 inhabitants

● 500 000 to one million

■ above one million

28 10 82 514 WVZ

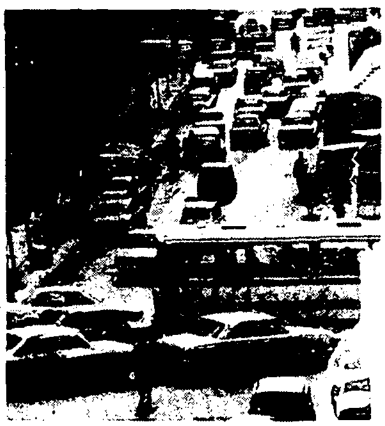
13



14

up to the year 2025
6,5 million more human beings per month

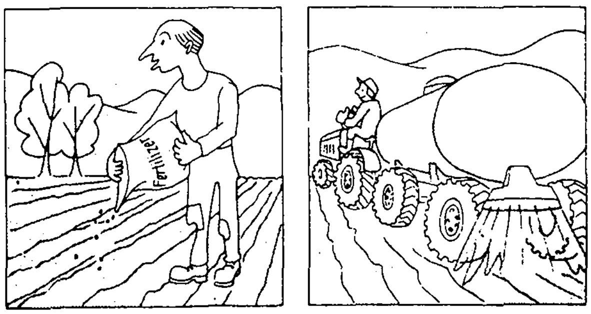
15



Increase of energy consumption

16

Increase in the consumption of artificial fertilizer



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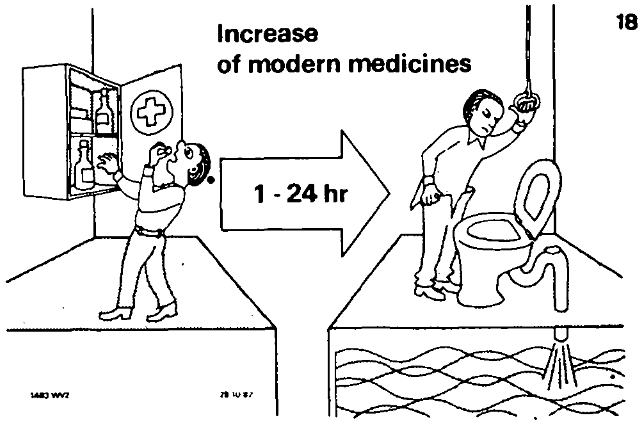
17

Increase of alien chemicals

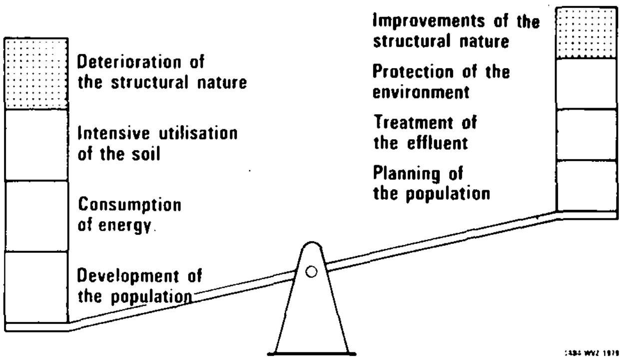
18



Causes of pollution

Counter - measures

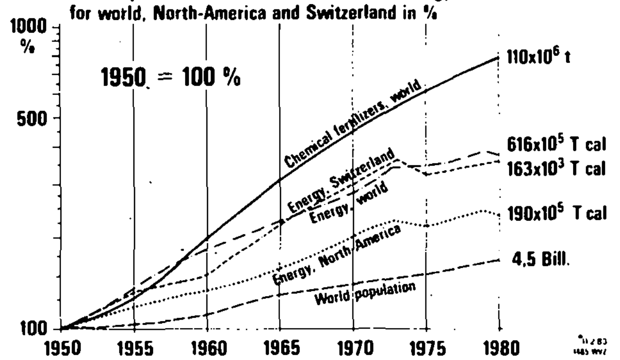
19



Growth of world population

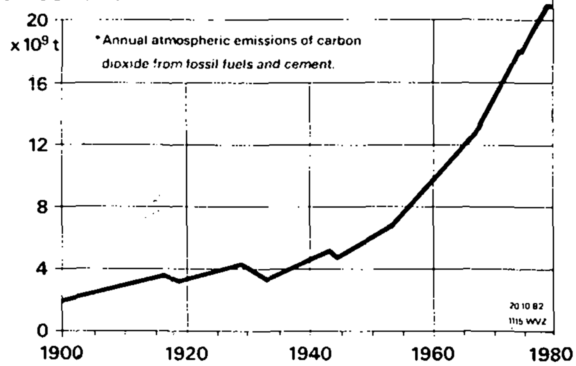
Consumption of fertilizer for world and of energy for world, North-America and Switzerland in %

20



Carbon dioxide emissions have quadrupled since 1945

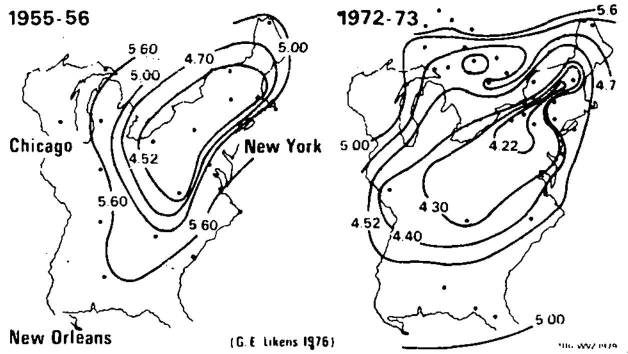
21



Acidity of precipitation in the eastern U.S.

Average pH of 12 monthly samples

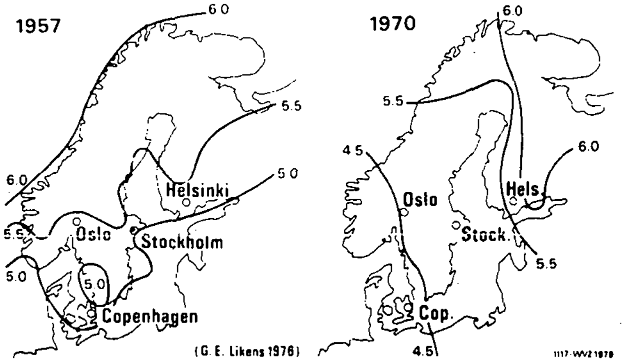
22



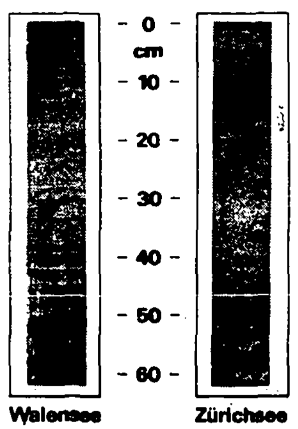
Acidity of precipitation in Scandinavia

Average pH from 12 monthly samples

23



24

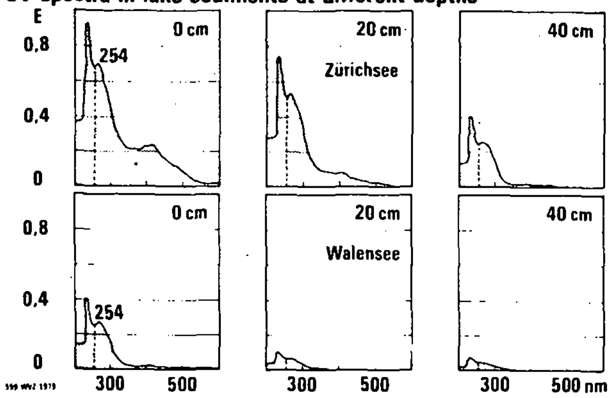


Sediment Cores of

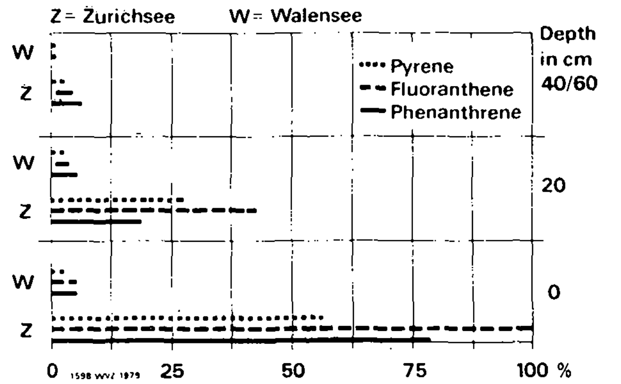
two Swiss Lakes

(1977)

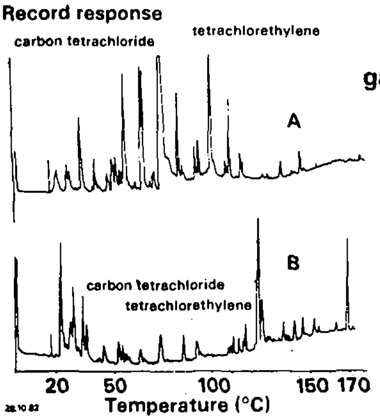
UV spectra in lake sediments at different depths 25



PAH in sediments of different ages 26



27



New Orleans USA gas chromatography

A Drinking water

B Blood plasma

(Dowty, Carlisle, Laseter, 1975)

28

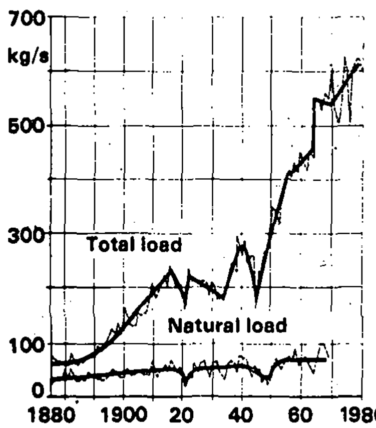
Rhine discharge

approx. 0,2 % of all watercourses in the western world

Chemical industry on Rhine

approx. 20 % of all chemical works in the western world

29



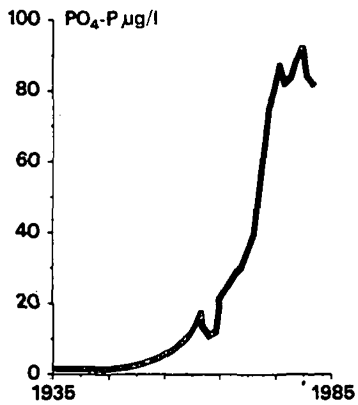
Salt load in the Rhine near Lobith

from 1875 to 1980

(Na Cl kg/s)

acc. to RIWA

30



Increase of phosphate in Lake Constance

(after BWV + AWBR)

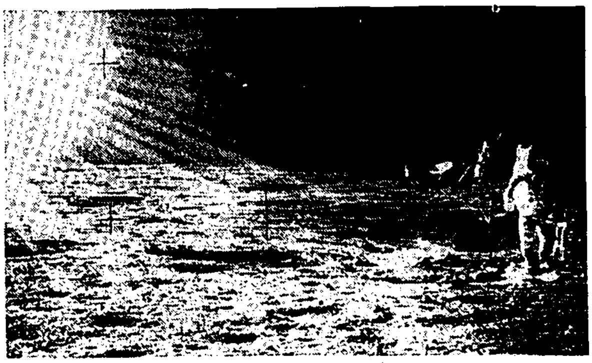
31

Result of eutrophication

32

Can our spaceship yet be saved?

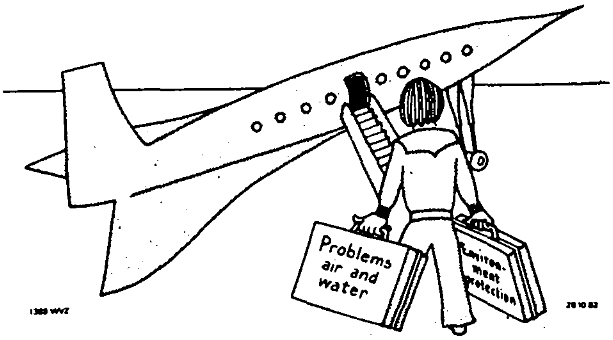
33



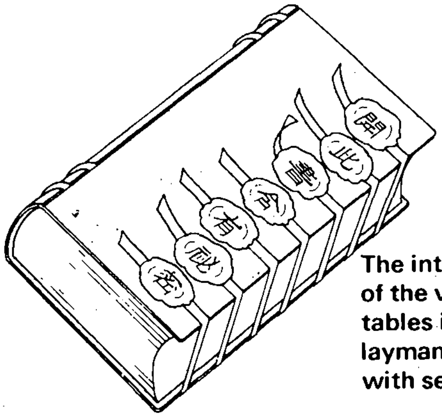
Yes! Technology helps, because only by its utilisation the moon can be reached

34

Yes! Yes!
If one looks problem-conscions to the future



35



The interpretation of the values and tables is, for the layman, a book with seven seals

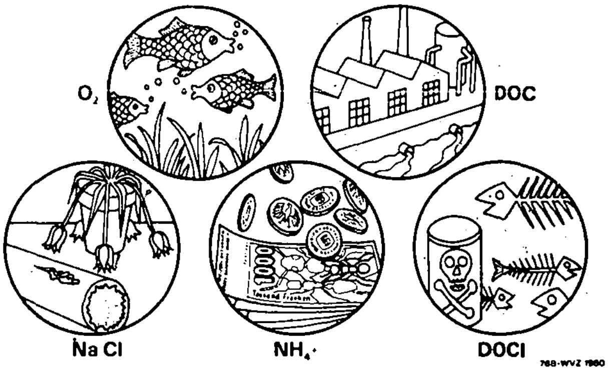
36

Worldwide Quality Chart

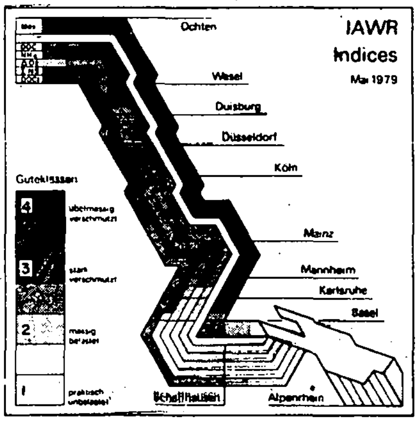
prepared for aiŗ and water according to relevant criteria, which are important for the health of man, animal and plant.

37

The five water quality criteria of IAWR



38



Vorschlag der IAWR
zur Bewertung der Gewässerqualität am Beispiel des Rheins

Proposition de l'IAWR
pour l'évaluation de la qualité des eaux dans le cas du Rhin

Proposal of the IAWR
for evaluation of water quality with reference to the Rhine

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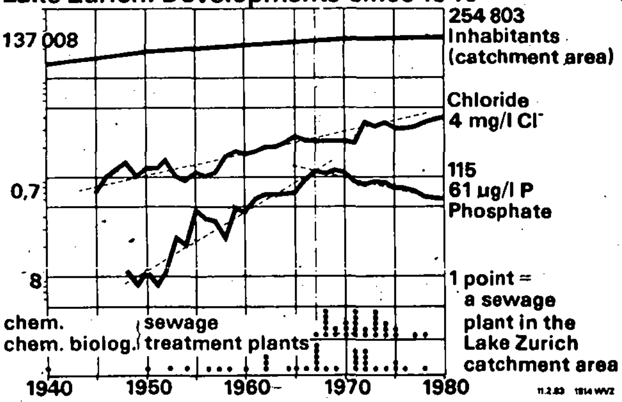
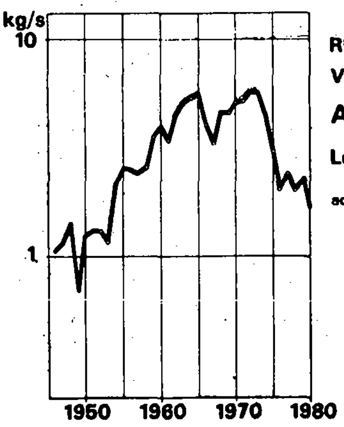
Lake Zurich: Developments since 1940

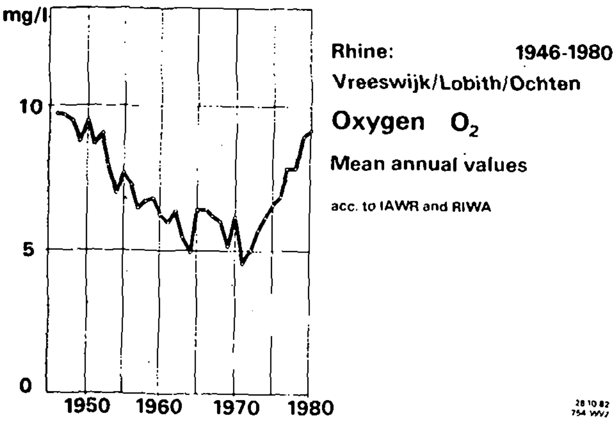


40

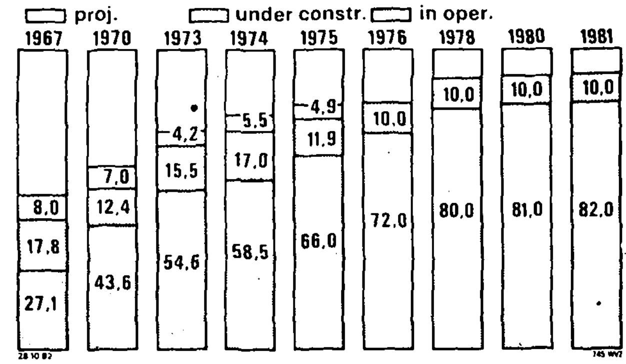


Rhine: 1946-1980
Vreeswijk/Lobith/Ochten
Ammonium NH_4^+
Load Mean annual values
acc. to IAWR and RIWA

41



Number of Swiss people in % of total inhabts. 42
who have or will get a water treatment plant



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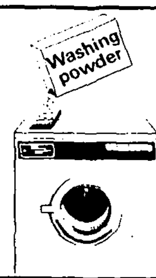
Too much is too much !

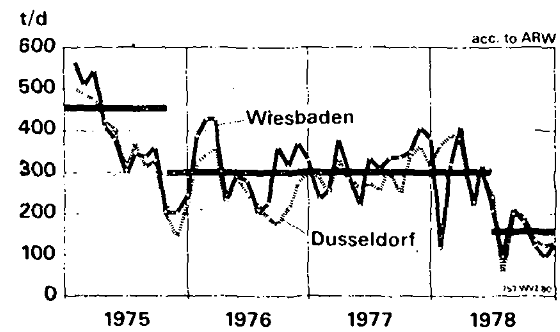
You can obtain your free water-hardness sticker from the Water Supply Zurich Tel. 01/435 21 11

Healthy Water – Healthy Life !



Combat causation

Load of Lignin Sulphonic in Rhine near Wiesbaden and near Dusseldorf 1976/1978 44



A. For government states and cities 45

1. Fighting against the cause of pollution by making laws and using them for the environment protection
2. Use of the laws for water protection and construction of water treatment plants until 1982

B For the water supply and industry

1. Saving of water
   - recycling processes in industry
   - progressive water tariffs related to consumption
   - public relations
   - use of the most up-to-date installations, mixing batteries, baths with fixed shower attachments etc.
2. Improve water treatment

City of Zurich 46

Water treatment plant Werdhölzli
Process Completion 1982

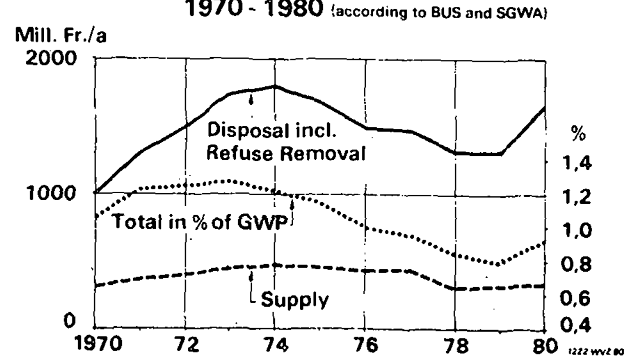
Primary purification	Screen Grit chamber Pre-purification
Biological purification	Activated sludge tank Secondary sedimentation tank
Chemical purification	Simultaneous coagul. with iron oxide in activated sludge tank
Filtration	Micro-flocculation with double layer rapid filtration

City of Zurich 47

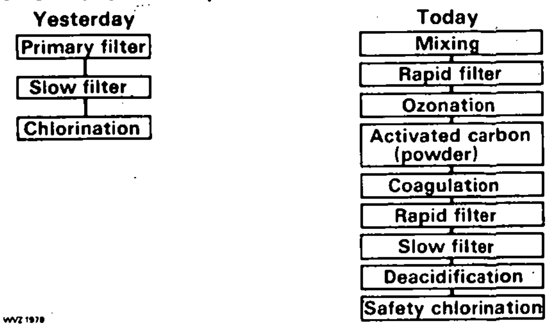
Water treatment plant Werdhölzli
Process Future

Mechanical treatment	Screen Grit chamber Pre-purification
Biological treatment	Activated sludge tank Secondary purification tank
Chemical treatment	Simultaneous coagulation with iron oxide in activated sludge tank
Filtration	Flocculation filtration with chemical flocculant agents and multi-layer filter.
Ozonation	
Filtration	by means of granular activated carbon

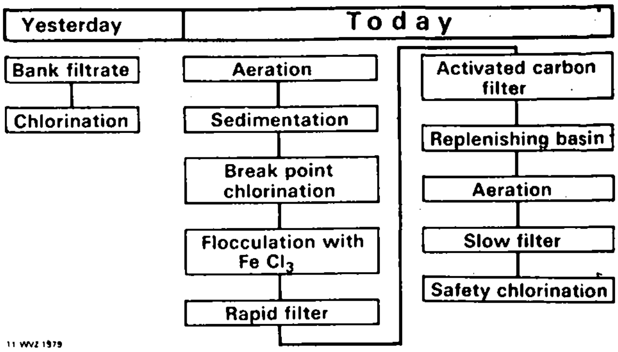
Switzerland Estimated Expenditure for the Supply and Disposal of Water 1970 - 1980 (according to BUS and SGWA) 48



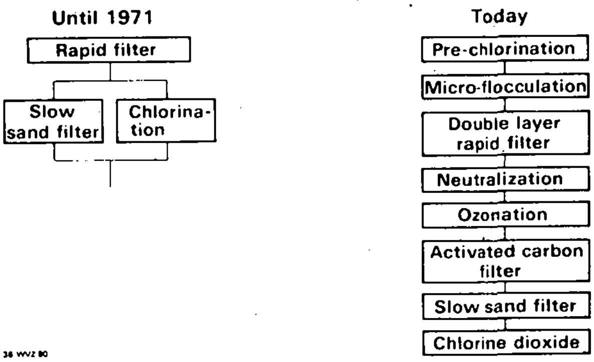
Treatment process at Weesperkaspel Lake Waterworks, Amsterdam 49



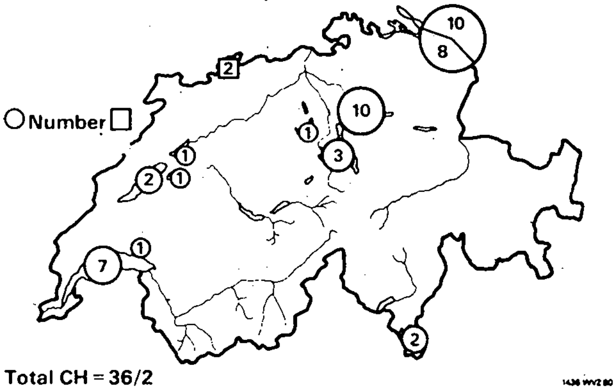
Treatment process at the Rhine Waterworks, Wiesbaden 50



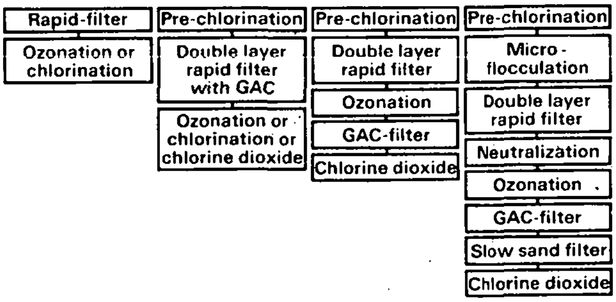
Treatment process at the Lake Waterworks, Zurich 51



Lake and river water plants 1978 52

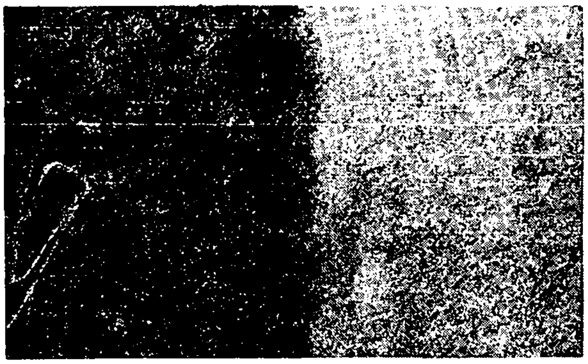


Water treatment process of 36 plants in Switzerland 1982 53



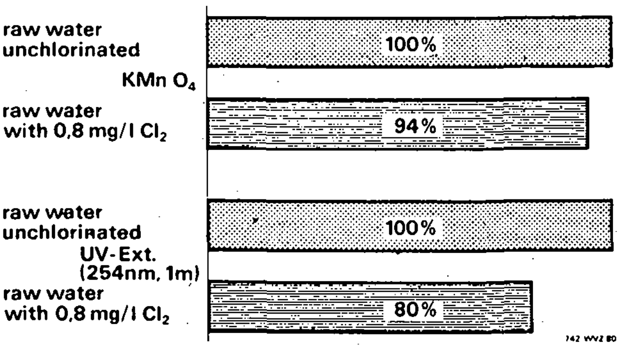
Works	25 %	25 %	25 %	25 %
Production	2 %	8 %	10 %	80 %

54



Left: Pipe surface without chlorine
Right: Pipe surface with chlorine

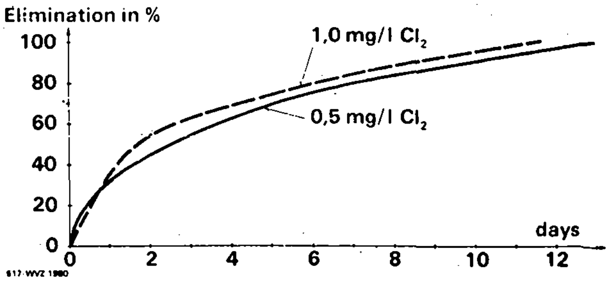
Decrease of KMn O_4 and the UV-Ext. by Cl_2 in % 55



Elimination of Lake of Constance - DPP - larvae 56

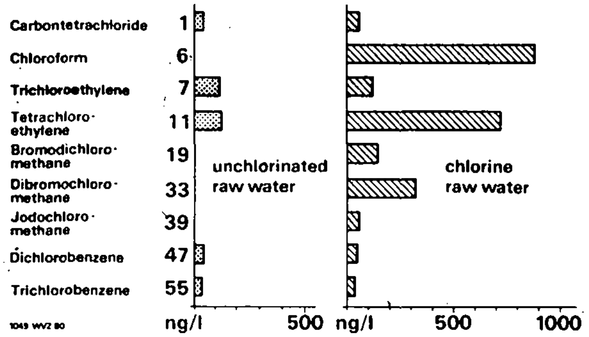
in raw water from the Lake of Zurich.

(based on Dr. Siessegger)



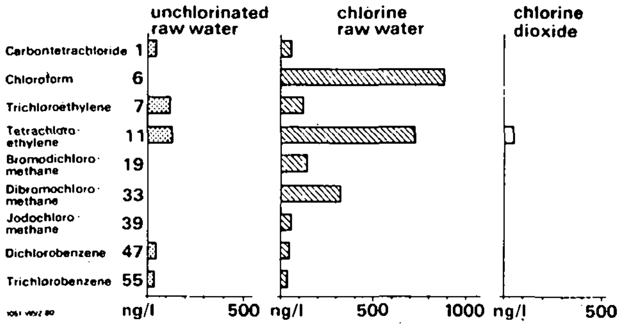
Formation or elevation of halogen compounds by chlorine

57



Formation or elevation of halogen compounds by chlorine and chlordioxid

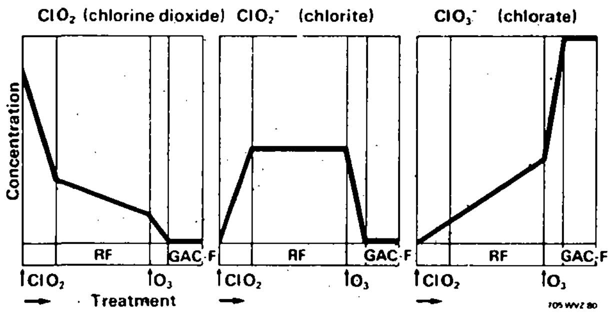
58



LWW Lengg Pre-oxidation by chlorine dioxide

59

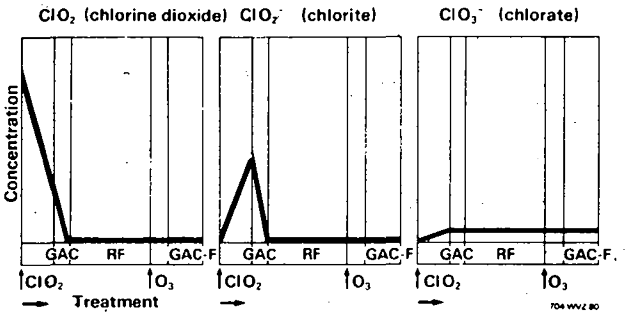
Formation of chlorite and thereby chlorate



LWW Lengg Pre-oxidation by chlorine dioxide

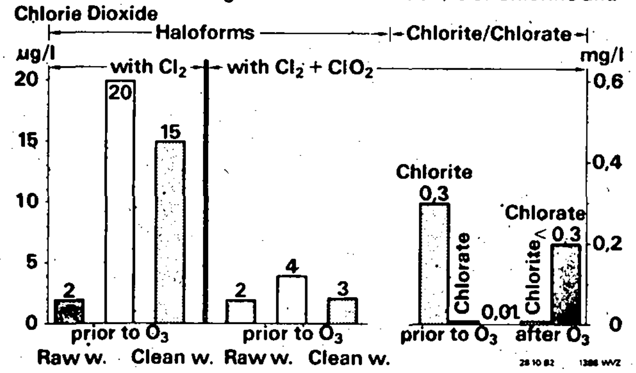
60

Prevention of the formation of chlorite- and by GAC



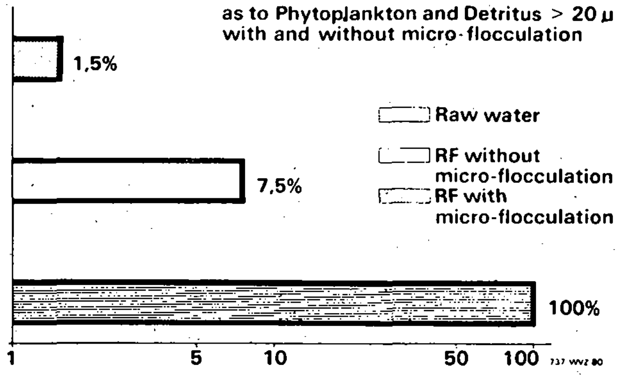
Formation of Haloforms as well as of Chlorite and Chlorate during Oxidation with Chlorine or Chlorine and Chlorie Dioxide

61



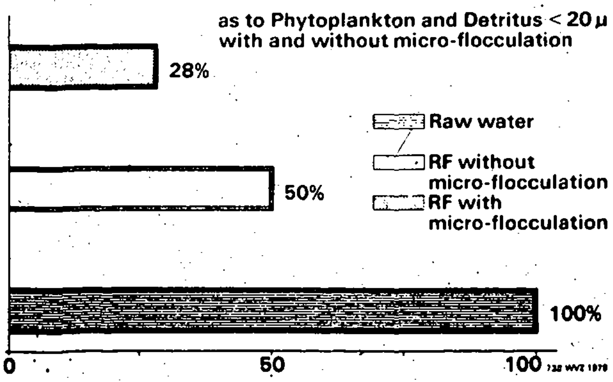
Cleaning effect of the double layer rapid filter

62



Cleaning effect of the double layer rapid filter

63



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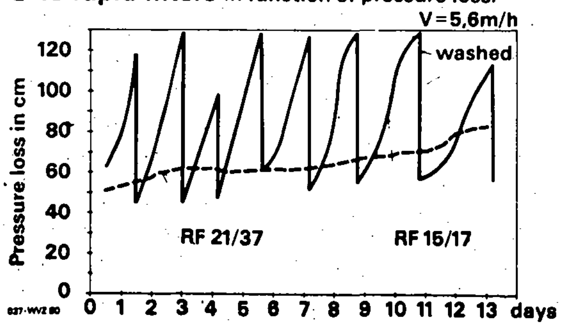
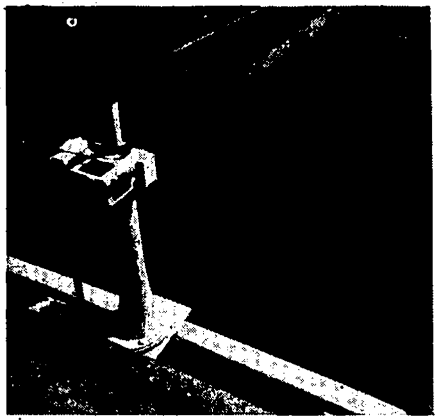
Operating time of 1-and 2-layer GAC rapid filters in function of pressure loss.



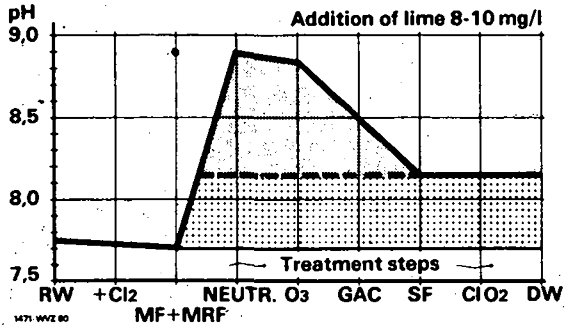
65



Double layer rapid filter Lengg

66

pH during water treatment process in WW Lengg Zurich

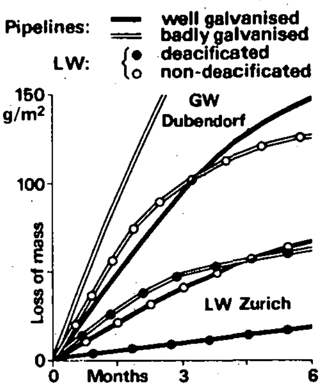


67

Internal corrosion: Counter-measures

1. Material quality
2. Work quality
3. Water throughput
4. Water equilibrium
5. Content of neutral salt
6. Org. substances
7. Warm water temperatures
8. Commissions-consultance
9. Research
10. etc.

Corrosion trials EMPA

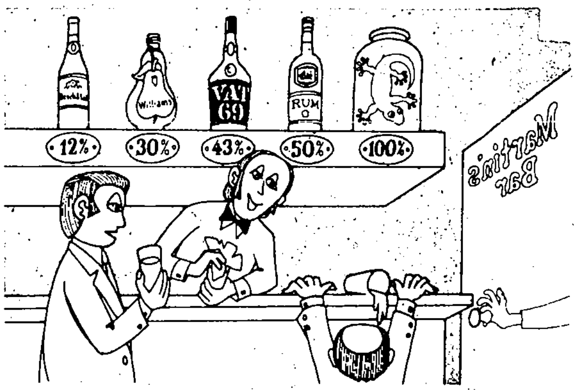


68

Ozone-plants per 1 mio. inhabitants in 17 countries.

No.	Country	Install.
1	Switzerland	24
2	France	11
3	Austria	6
4	Germany D	2
5	Canada	1
6	Netherlands	0.92
7	Belgium	0.90
8	Denmark	0.80
9	Norway	0.75
10	Sweden	0.37
11	England	0.32
12	Poland	0.18
13	Spain	0.17
14	Italy	0,09
15	Japan	0.04
16	USA	0.02
17	UdSSR	0.02

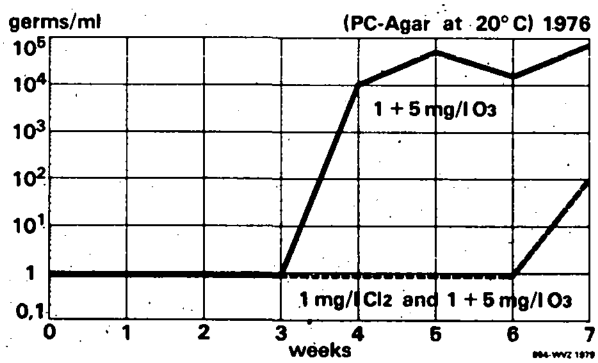
69



Comparison of percents of alcohol

70

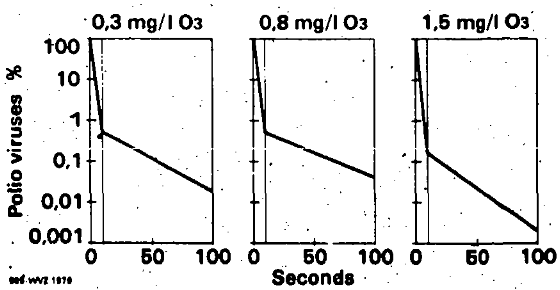
Germ development at 9° C
in O3-as well as in Cl2 + O3 water



71

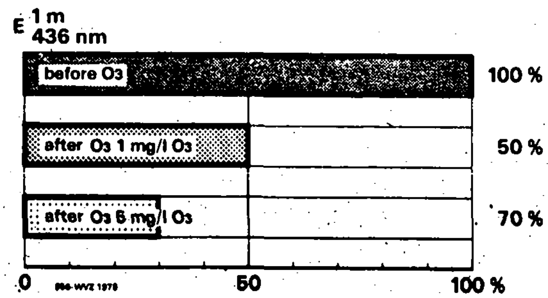
Inactivation of the viruses at various ozone-concentrations as a function of time.

(Katzenelson, Shuval 1975)



72

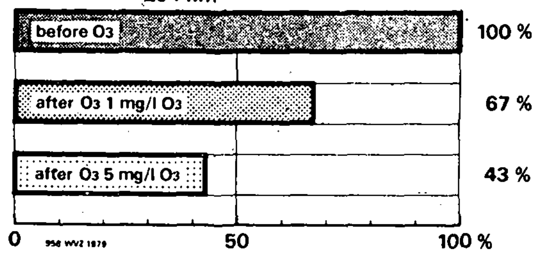
Decolouration through ozone at various concentrations



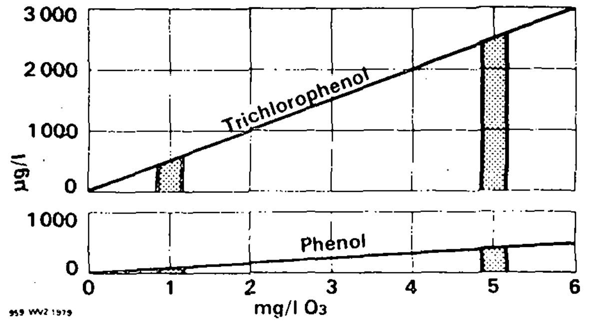
73

Decrease of the UV-extinction through ozone at various ozone concentrations

(100 % = 2,2 E $^{1\,m}_{254\,nm}$)

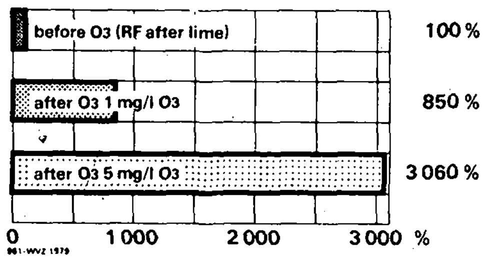


Decrease of trichlorophenol and phenol through ozone as a function of supplemental rates 74

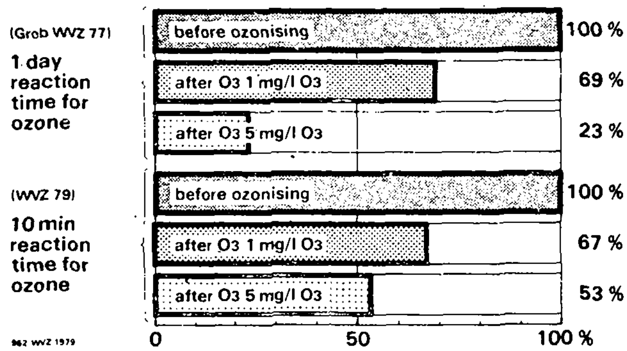


75

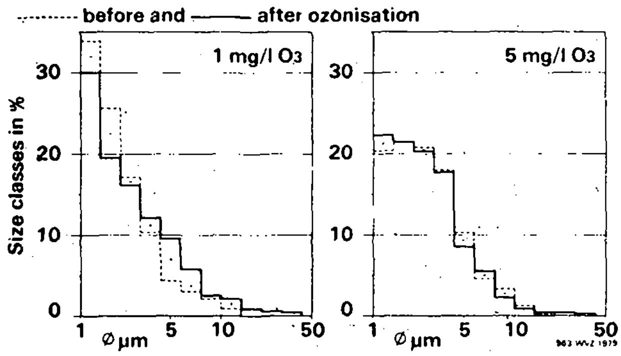
Increase of Aldehydes



Decrease of the Haloforms 76



Flocculation effect
Change of particle quantity and size 77

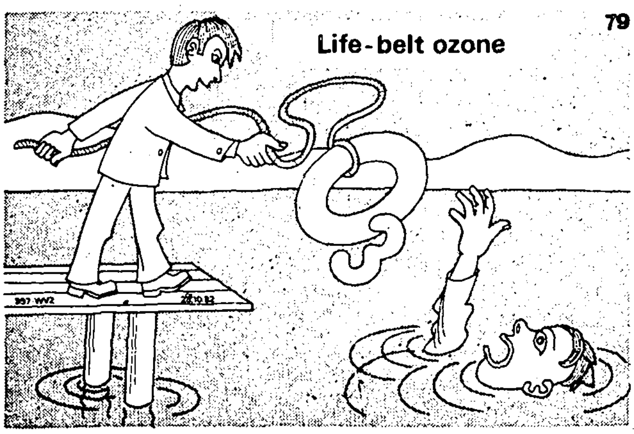


Effect of O3 on various parameters 78

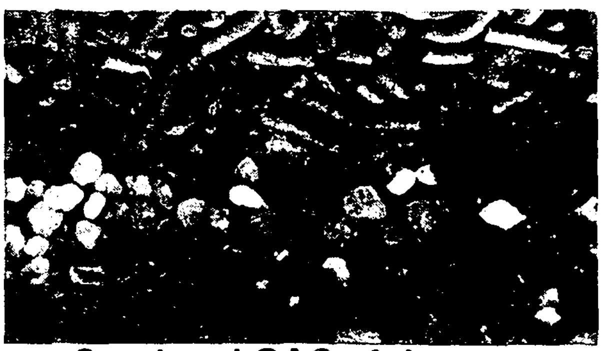
	1 mg/l	5 mg/l
Phenol	++	+++++
Viruses inactivation	+++++	+++++
Haloforms after 24 h influence	++	++++
Haloforms after 10 min. influence	+	++
UV-extinction 254 nm	++	+++
Colour	++	+++
KMn O4	+	++
Flocculations	+	-
Regermination	--	--
Aldehydes	--	----

+	positive	-	negative
+++	very good	---	poor
+++++	excellent	-----	very poor

79

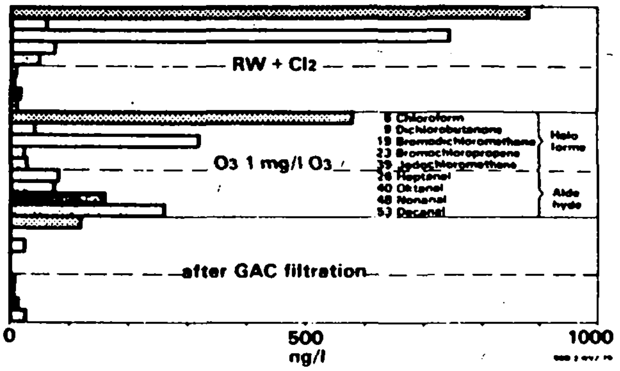


80

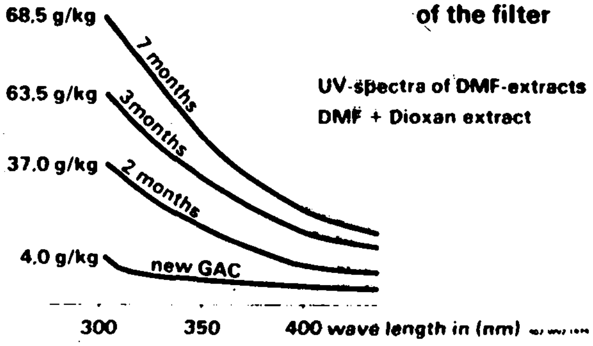


Sand and GAC of the double layer GAC filter

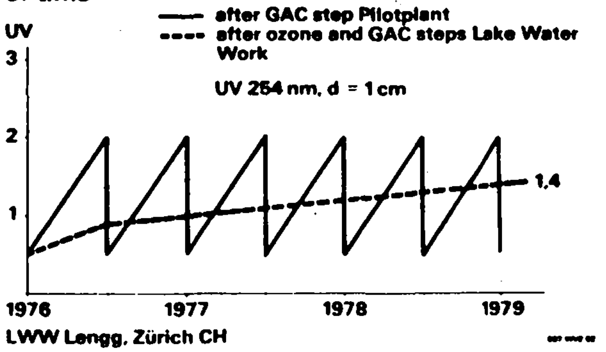
Organic contents GC 81



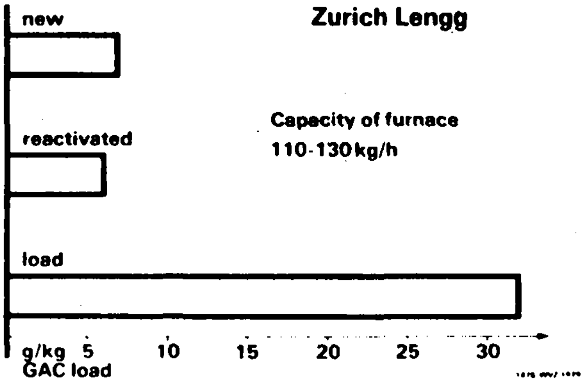
GAC load, new carbon as well as after 2, 3 and 7 months of operation; in the upper layer of the filter 82



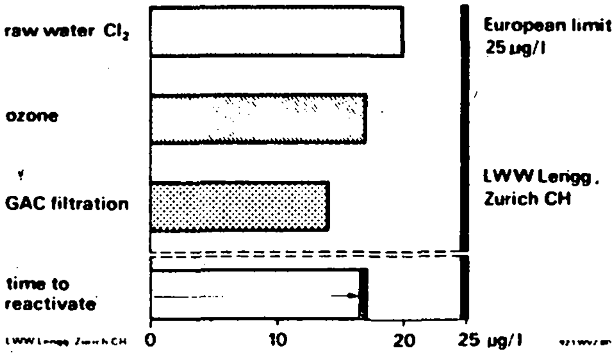
UV extinction in drinking water in function of time 83



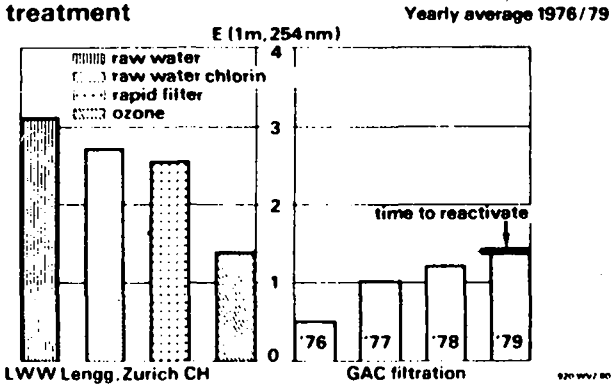
Effectiveness of GAC-reactivation Zurich Lengg 84



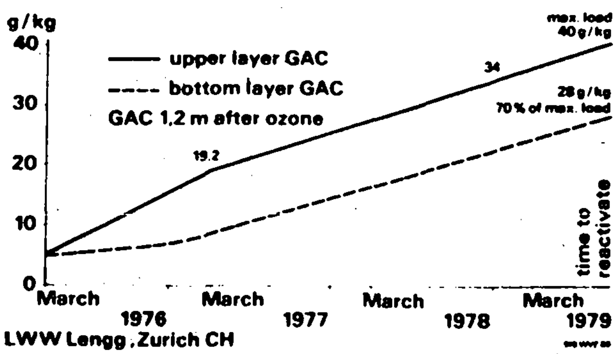
Halogenes in raw and drinking water of Zurich water supply 85



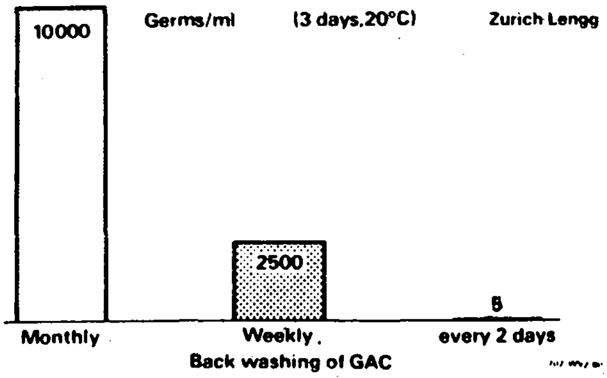
Variation of UV-Extinction during water treatment
Yearly average 1976/79 86



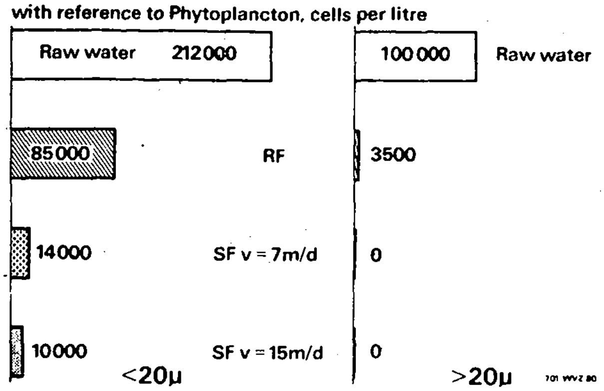
Load of upper and bottom layer GAC
in g/kg DMF + Dioxan extract as a function of time 87

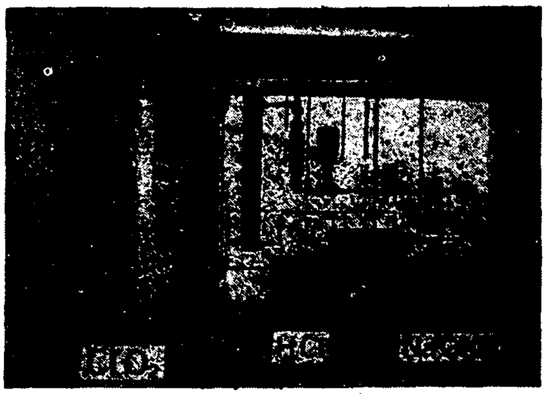


Regermination of GAC-filter 88



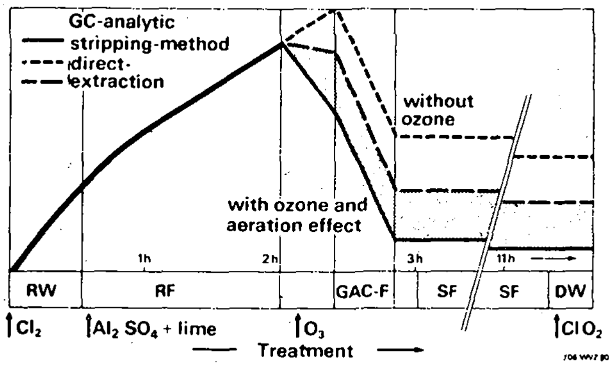
Purification Effect of Slow filters 89
with reference to Phytoplancton, cells per litre

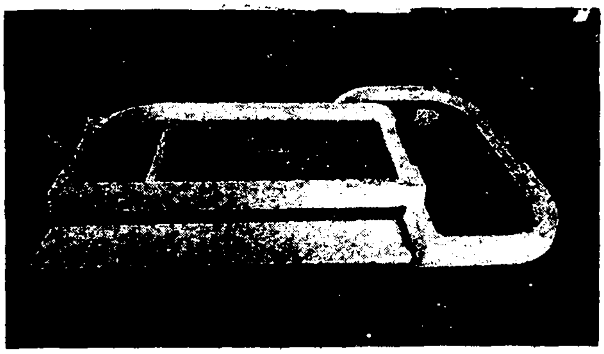




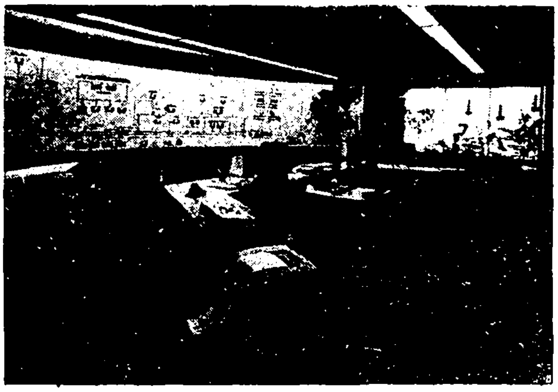
Cl O2 installation Lengg 90

LWW Lengg Haloforms in the Treatment Process 91



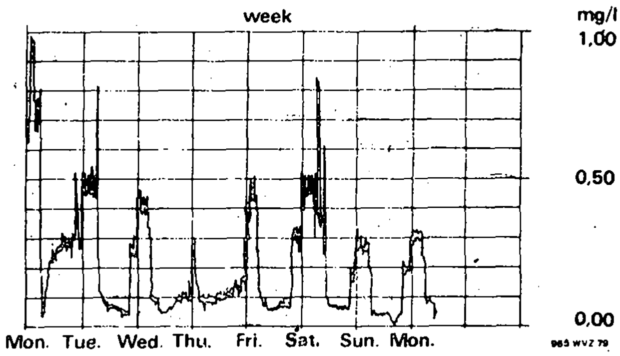


The effectiveness of the treatment 92
Right: Raw water Left: Drinking water

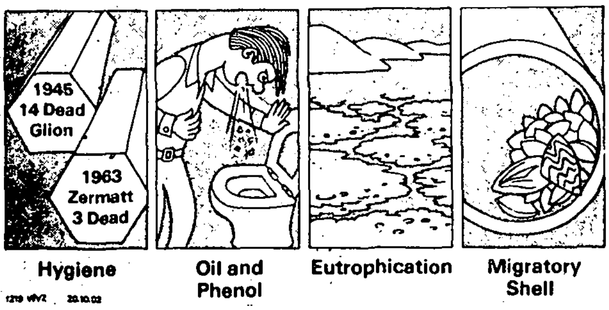


Remote control center, Hardhof Zurich 93

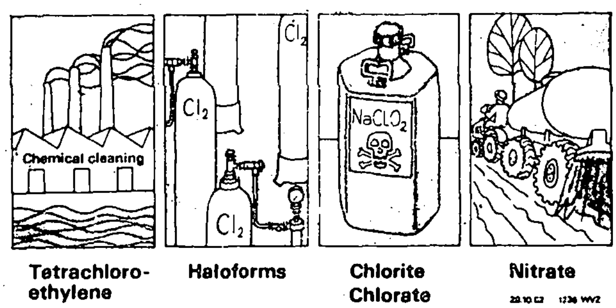
Display-diagram rest-ozone 1 week 94



Old (and yet topical) Problems of the Water Supply 95



New Drinking Water Problems with toxic Substances 96



97

Targets: in Switzerland for Water Supply, Waste Water Disposal as well as Refuse Removal

> **Principle:** Pollution 100% compensation, if possible by combating the cause and not the symptoms

Water: sufficient, exellent quality (100%)

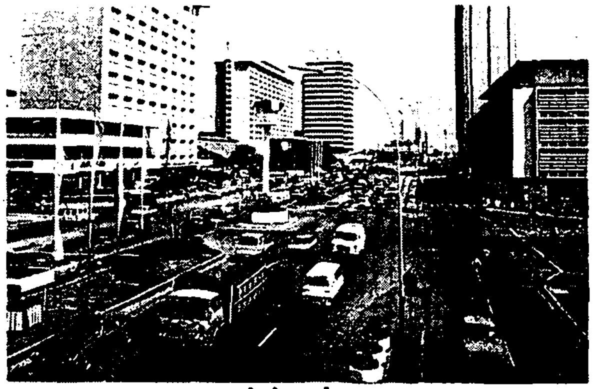
Waste Water Disposal: entire population and industry including rain water connected to canalisation (82 %)

100% irreproachable cleaning (82 %) conurbation areas 4-stage treatment or more

Refuse Removal: irreproachable refuse removal (100%) Deycosit or incinerution

98

99



Jakarta

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WATER SUPPLY AND SANITATION
GLOBAL POLICIES AND STRATEGIES

Paper for

4th ASIA PACIFIC REGIONAL WATER SUPPLY
CONFERENCE AND EXHIBITION

5 – 11 November 1983, Jakarta

presented by

Erdogan Pancaroglu
WORLD HEALTH ORGANIZATION

The views expressed in this paper are solely those of the author and in no way reflect the policies of the World Health Organization

WATER SUPPLY AND SANITATION GLOBAL POLICIES AND STRATEGIES

Erdogan Pancaroglu
WORLD HEALTH ORGANIZATION

I. INTRODUCTION

Along with the declaration of the period, 1981–1990 as the International Drinking Water Supply and Sanitation Decade, global policies and strategies have been evolved as a new approach for progress in water supply and sanitation development.

At the national level all developing countries were committed to lay more emphasis on water and sanitation in national plans, set their own goals and targets, and increase sources for programmes and projects in the sector and strengthen institutional arrangements.

At the international level, the United Nations bodies developed concepts for the Decade underlining the need for promotion and support of national Decade programmes through technical cooperation. Increasing external aid to developing countries; building up national capacities and generating self-sustaining programmes; emphasizing on rural development and primary health care; increasing transfer of technology to promote self-reliance, and promoting technical cooperation among developing countries (TCDC) were among the concepts in support of the national Decade efforts.

Among several UN agencies a global "Steering Committee for Cooperative Action" was formed to coordinate their work with governments in planning and implementing water supply and sanitation programmes and activities. The Committee is chaired by UNDP (United Nations Development Programme) and WHO through it's Global Promotion of Water Supply and Sanitation Unit (GWS) provides the secretariat. Eleven agencies of the UN family now cooperate in the Decade:

- UNDP – United Nations Development Programme
- WHO – World Health Organization
- IBRD – The World Bank
- UNICEF – United Nations Children's Fund
- UNESCO – United Nations Educational Scientific and Cultural Organization
- ILO – International Labour Office
- UN – United Nations
- UNEP – United Nations Environment Programme
- UNCHS – United Nations Centre for Human Settlements
- FAO – Food and Agriculture Organization
- INSTRAW – UN International Research and Training Institute for the Advancement of Women

UN Resident Representatives in developing countries serve as focal point for international support and coordinate assistance to the National Action Committee/ Steering Committees established by many governments for coordination of the National Decade activities.

II. THE SITUATION

Much is has been said about the global water supply and sanitation situation since the findings of WHO Mid-Decade Progress Report in 1975 on community water supply and sanitation. The report indicated that although investments and the number of the people served have increased considerably between 1970 and 1975, the percentage of the unserved/underserved changed only marginally. Evidently, the population growth,

TABLE 1 [(1)] : Service Coverage in 1980

	Total Population (millions)	WATER SUPPLY Pop served (millions)	WATER SUPPLY Persentage of Total Pop	SANITATION Pop served (millions)	SANITATION Persentage of Total Pop
URBAN	703 (30%)	537	75	372	53
RURAL	1612 (70%)	467	29	210	13
TOTAL	2314 (100%)	994	43	582	25

(1) Figures do not include the People's Republic of China
Source : WHO.

reflecting a substantial increase during the same period, was the major constraint inhibiting progress.

II. 1. The Global Situation

Estimates showed that in 1980 about 2.3 billion people lived in the developing countries (Figure excluding the People's Republic of China). More than half the above figure, represents the number of people in the developing countries without access to a safe and adequate supply of water. The situation is even worse with regard to sanitation; close to 90 percent of the developing world's rural population does not have adequate facilities.

Table 1 shows the estimated service coverage for drinking water supply and sanitation in developing countries in 1980.

An analysis of the above estimates clearly indicate that urban areas were better served in 1980 with about 75 percent of the population having access to water supply through house connections or public taps. However, in rural areas only 29 percent had water supply.
The coverage in adequate sanitation was relatively logging with 53 percent in urban and 13 percent in rural areas respectively.

Looking at the situation from a different perspective three out of five persons in developing counties do not have access to safe drinking water and three our of four persons without any excreta disposal facility. It should be noted that information reported referred only to access and did not indicate the condition or reliability of the water supply system.

Another fact deriving from above information shows the situation in the rural areas where about 70 percent of the population in developing countries live and are severely affected.

Recent statistics[2] provide demographic and other information on China. 1980 population is reported as 977 million and urban percentage of total population as 13. Thus, the total population of the developing countries has increased to about 3.3 billion and the rural component higher than 70 percent.

II. 2. Regional Outlook

More than half of the world's population live in Asia and the Pacific region. Table 2 shows population in 1980 by WHO regions[3]

TABLE 2[4] : Population in 1980 by WHO Regions

WHO Region	Population in 1980 (millions)	Percent
African	356	8
American	611	14
Eastern Mediterranean	268	6
European	834	19
South–East Asia	1,052	24
Western Pacipic	1,309	29
Total	4,430	100

Member countries of the WHO South-East Asia Region,[5] account approximately one third of the population in developing countries. It is estimated that people in this region without basic water supply and sanitation services amounted to 636 million or 60 percent of the total population. Where as, unserved population in sanitation totaled to 915 million or 87 percent.

Fig 1 shows the population and coverage level of the South-East Asia Region and Fig. 2, urban and rural coverage for individual countries.

It is of importance to note that roughly 500 million people live in absolute poverty in South, East and Soul-East Asia making up 89 percent of the world's poverty population. The situation looks equally grave than it did some ten years ago when the Decade concept was under formulation. Thus, the urgency in shiffting priorities and resources and paying more attention particulary to those living in rural and urban slum areas is recognized.

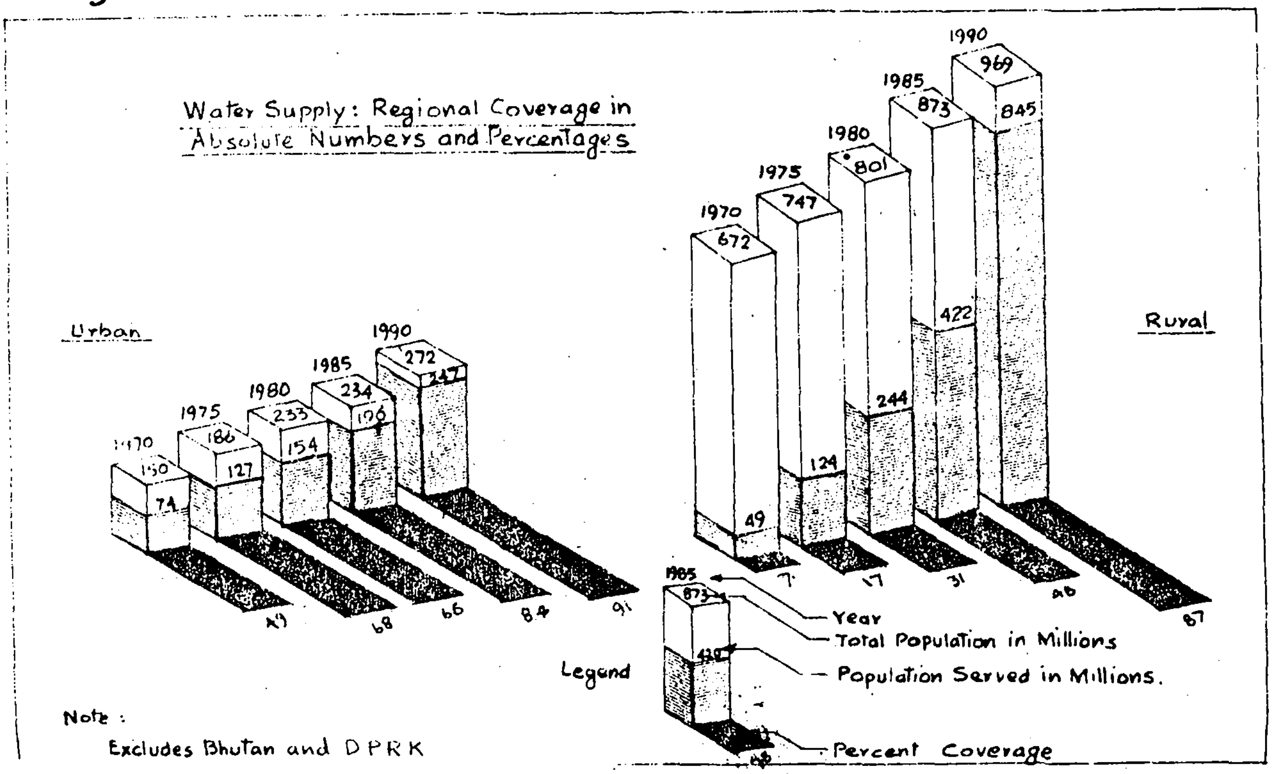
(2) 'World Development Report 1982" The World Bank

(3) Afganistan, Iran and Pakistan in ASPAC region are members of WHO Eastern Meditarranean Regional Office.

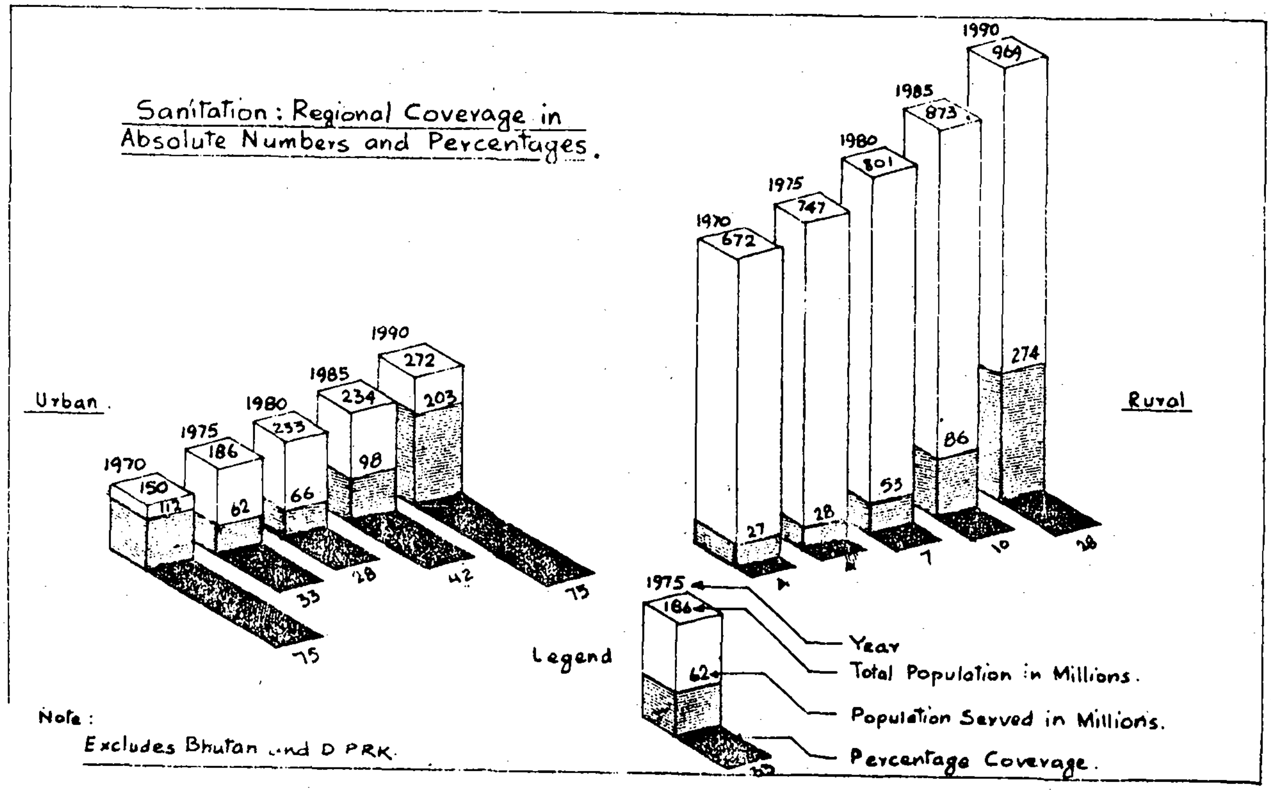
(4) "Bulletin of Regional Health Information, 1981" WHO Regional Office for South-East Asia.

(5) "IDWSSD Decade Commencement Report" 1983, WHO Regional office for South-East Asia.

Fig 1.

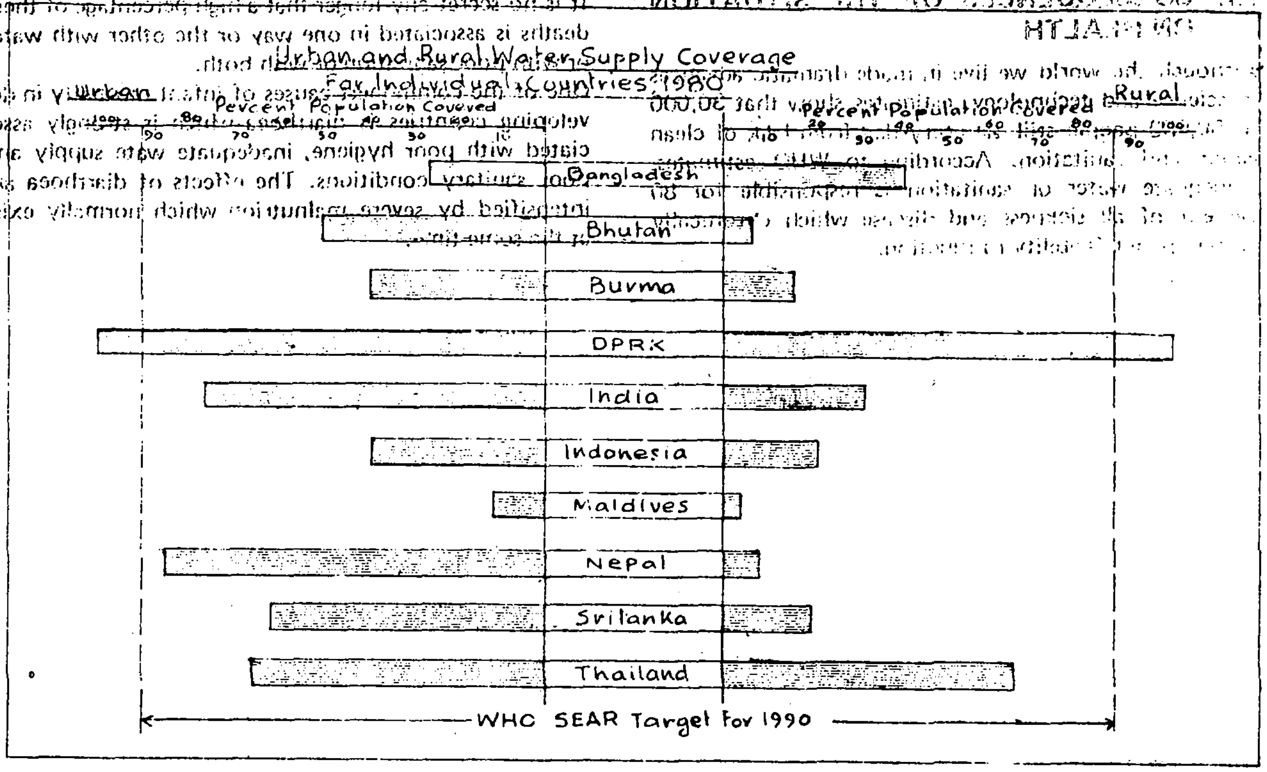


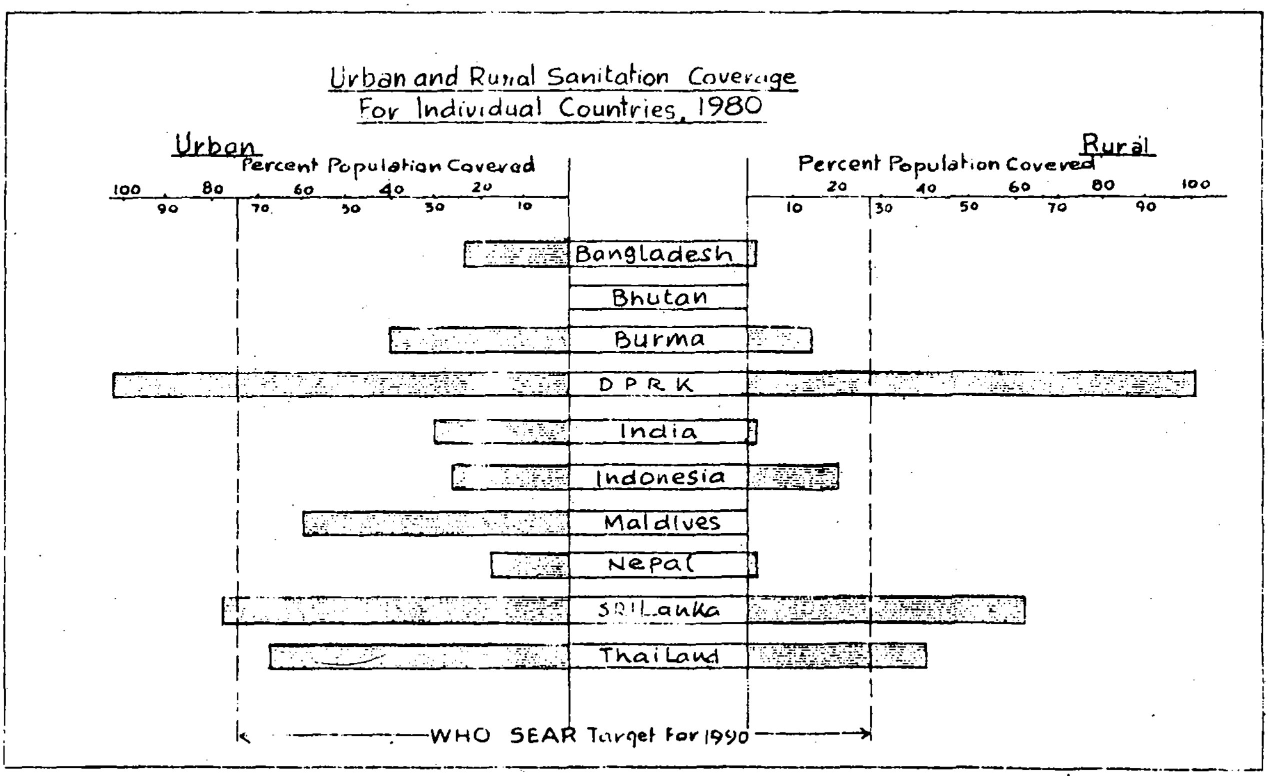
Water Supply: Regional Coverage in Absolute Numbers and Percentages
Urban
1970
150
74
1975
186
127
1980
233
154
1985
234
196
1990
272
247
68
66
84
91
Rural
1970
672
49
1975
747
124
1980
801
244
1985
873
422
1990
969
845
7
17
31
87
Legend
1985
873
Year
Total Population in Millions
Population Served in Millions.
Percent Coverage
Note :
Excludes Bhutan and DPRK



Sanitation: Regional Coverage in Absolute Numbers and Percentages.
Urban.
1970
150
112
1975
186
62
1980
233
66
1985
234
98
1990
272
203
75
33
28
42
75
Rural
1970
672
27
1975
747
28
1980
801
53
1985
873
86
1990
969
274
7
10
28
Legend
1975
186
62
Year
Total Population in Millions.
Population Served in Millions.
Percentage Coverage.
Note :
Excludes Bhutan and DPRK.

Fig. 2


Urban and Rural Water Supply Coverage
For Individual Countries, 1980
Urban
Percent Population Covered
Rural
Percent Population Covered
Bangladesh
Bhutan
Burma
DPRK
India
Indonesia
Maldives
Nepal
Srilanka
Thailand
WHO SEAR Target For 1990


Urban and Rural Sanitation Coverage
For Individual Countries, 1980
Urban
Percent Population Covered
100 80 60 40 20
90 70 50 30 10
Rural
Percent Population Covered
20 40 60 80 100
10 30 50 70 90
Bangladesh
Bhutan
Burma
DPRK
India
Indonesia
Maldives
Nepal
SRILanka
ThaiLand
WHO SEAR Target For 1990

III. CONSEQUENCES OF THE SITUATION ON HEALTH

Although the world we live in made dramatic advances in science and technology, estimates show that 30,000 to 50,000 people still die every day from lack of clean water and sanitation. According to WHO estimates, inadequate water or sanitation is responsible for 80 percent of all sickness and disease which chronically curtails people's ability to function.

The large and crowded populations living in underserved urban and rural areas are particularly at risk in being affected by communicable diseases which account as a whole for a high proportion of early deaths, particularly durig the first five years of life.

It is no secret any longer that a high percentage of these deaths is associated in one way or the other with water or with poor sanitation or with both.

One of the commonest causes of infant mortality in developing countries is diarrhoea which is strongly associated with poor hygiene, inadequate wate supply and poor sanitary conditions. The effects of diarrhoea are intensified by severe malnutrion which normally exist at the some time.

Health statistics in South-East Asia are indicative of the adverse effects of unsafe water supply and poor sanitation on health.

The rate of infant mortality with which the quality of life can be judged and some developed and developing countries are given in Table 3.

TABLE 3 : Infant Mortality, Child Mortality Rate and Life Expectancy

COUNTRY	Infant Mortality Rate	Life Expectancy at Birth
Afghanistan	205	40
Bhutan	150	43
Nepal	150	43
Bangladesh	136	46
Pakistan	126	51
India	123	49
Burma	101	52
Indonesia	98	53
Philippines	55	61
Sri Lanka	37	65
Malaysia	31	63
Thailand	26	62
Singapore	11	71
U S A	11	74
Japan	7	76
Sweden	6	75

Source : Population Reference Bureau, 1982.

Fig. 3, shows comparative ratings of infant mortality in the South-East Asia Region relative to water supply and sanitation coverage.

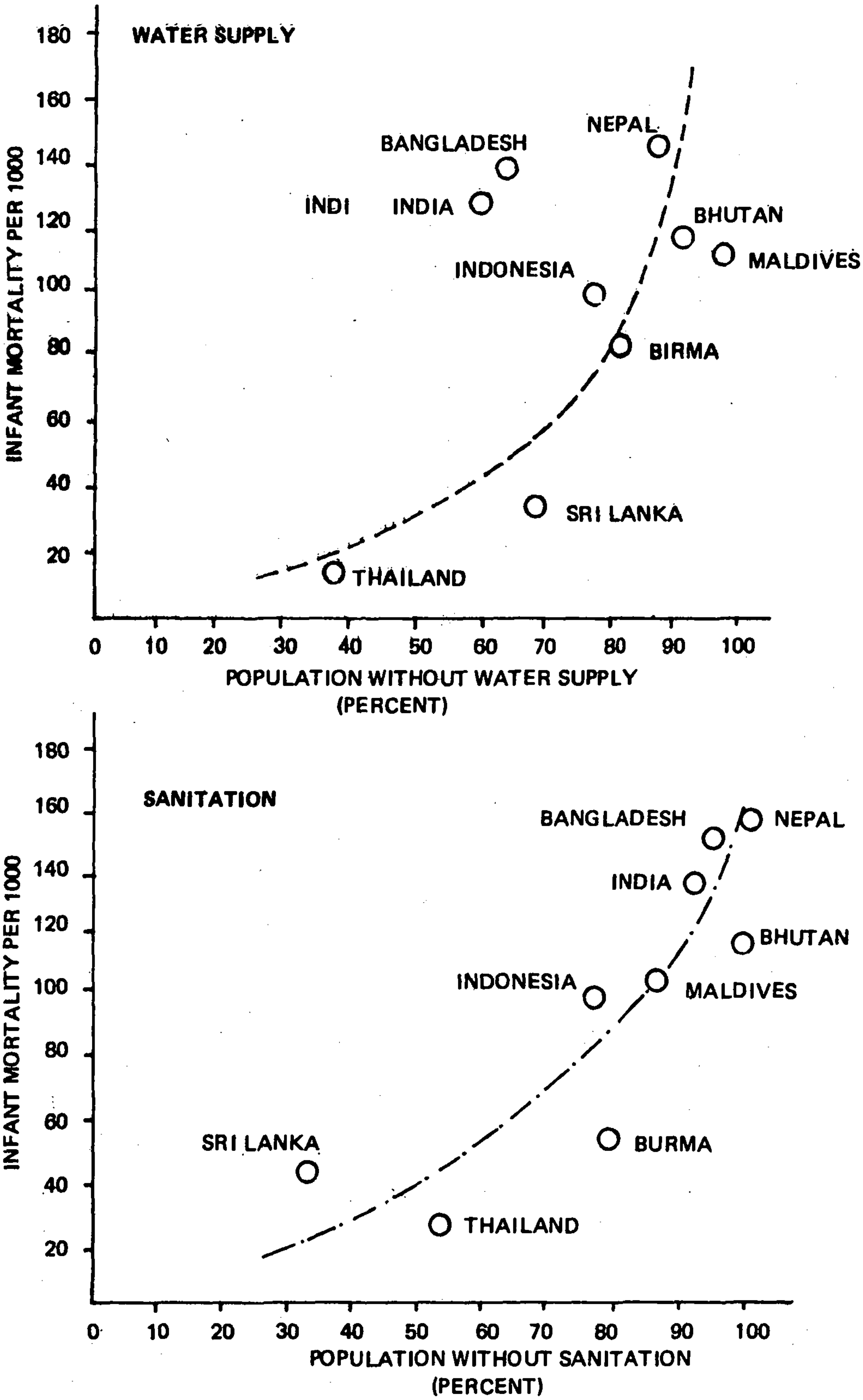
The acure diarrhoeal diseases with their continuing high prevalence and mortality rates, centred mainly on young children, present one of the greatest health problems of the developing world. UNICEF estimates that about 15 million children below the age of 5 die in the developing countries every year. The absence of water supply and sanitation represents a major factor in the high incidence of earlh deaths among young children. About 5 million children in developing countries die from diarrhoea alone.

The primary benefit to be achieved through improvements in community water supply and sanitation is the improved health status of the people. The health benefits in turn, will likely lead to social, economical and environmental benefits consequently. Some of the major direct and indirect benefits of improved water supply and sanitation services are listed below:

1. Health Benefits

- reduced waterborne diseases
- decreased mortality
- improved nutrition
- more surviving and health children
- reduced natality

FIG. A WATER SUPPLY AND SANITATION – SEAR COUNTRIES INFANT MORTALITY RELATIVE TO WATER SUPPLY AND SANITATION COVERAGE.



SOURCE : DECADE BASELINE REPORT, 1981 (WHO)

2. Social Benefits

- less burden, more convenience for women and children
- more time for productive, family and community activities
- greater satisfaction with rural life.

3. Economic Benefits

- less work time lost from sickness
- improved labour use
- enlarged farm/factory power
- less hospital expenditures
- higher income and purchasing power
- increased employment

4. Environmental Benefits

- cleaner home and community environment
- less stream and groundwater pollution
- reduces flooding and soil lost
- more rational, conserving water use

IV. THE DRINKING WATER SUPPLY AND SANITATION DECADE

Compared to other regions, the ASPAC Region has the highest population as well as the highest ratio of rural to urban population. The largest number and densities of urban and rural communties live also in this region in which the agricultural population forms the backbone of the national economics. Safe water supply and sanitation are among the greatest needs of the Region in particular and community health in general. Problems related to environmental health are extensive in nature and intensive in their impact and require a situation demanding accelerated solutions.

IV.1. Decade Background

The Second United Nations Development Decade (1971–1980), revealed how little has been done in the global coverage of safe water supply and sanitation and how big is the magnitude of the problem lying ahead. Although some of the developing countries have been engaged in the past with increasing emphasis and substantial investments, the achievement in terms of coverage was low. This deteriorating situation in meeting such basic human needs, has been observed with increasing concern by WHO during recent years. This concern eventually led itself to the generation of a sense of urgency by the United Nations Agencies resulting in the need of a new dimension to be added to development policies. This meant according more priority to activities that meet basic human needs for water, sanitation, basic education, health services, food and housing.

It also meant diverting additional funds to the sector, internally and externally.

Having received broad political and professional support, this new approach was mibilized by the three major international conference:

1. UN Conference on Human Settlements HABITAT (Vancouver, 1976).
2. The UN Water Conference (Mar del Plata, 1977).
3. The International Conference on Primary Health Care (Alma Ata, 1978)

Above meetings have led to adoption of the goal of "Health for All by the Year 2000" by the World Health Assembly and to inauguration of "The International Drinking Water supply and Sanitation Decade, 1981–1990" by the member countries of the United Nations.

Consequently, the Member States were committed to bring about a substantial improvement in the standard and levels of services in drinking water supply and sanitation by the year 1990.

It is important to bear in mind the Mar del Plata resolution on community water supply and sanitation which stated,

> "All peoples, what ever their stage of development and their social and economic conditions, have the right to have access to drinking water in quantities and of a quality equal to their basic needs".

Furthermore, it recommended, inter alia, that,

> "National development policies and plans should give priority to the supplying of drinking water for the entire population and to the final disposal of wastewater".

The Governments of the member states were asked to,

> "Adopt programmes with realistic standards for quality and quantity to provide water for urban and rural areas by 1990, if possible"

IV.2. The Decade Strategies

The new approach will serve to attain the goals of the Decade. It calls for changes in the standards of service and in the methods of implementation that have been used in the past.

Use of less sophisticated and low-cost technologies providing an acceptable level of service while meeting the basic human needs will be promoted. A wider mix of service levels in water supply such as house/yard connections and public tap services to smaller and urban slum communities will also offer economical solutions. For proper disposal of excreta there exists a wide range of low-cost facilities fully achieving the health objectives.

The new approach(6) comprises, at the national level:

1. Focus on unserved/underserved populations,

rural and urban.
2. Complementary water supply and sanitation development.
3. Generation of replicable, self reliant and self-sustainign programmes.
4. Development of socially relevant systems that people can afford.
5. Association of communities in all stages of projects.
6. Linking water supply and sanitation with other health programmes,.
7. Integration of water supply and sanitation programmes with other development setors.

At the international level emphasis is placed on:

1. Promoting and supporting national programmes for the Decade through technical cooperation.
2. Concentrating technical cooperation on building up national capacities and generating dynamic, self-sustaining programmes.
3. Promoting technical cooperation among developing countries.
4. Encouraging the external financing of the national Decade activities.

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3. Promoting technical cooperation among developing countries.
4. Encouraging the external financing of the national Decade activities.

Studies carried out in the recent years clearly show that improvements in water supply alone can seldom have a positive effect on health. in the tropical zones of the ASPAC Region where the conditions for multiplication of disease-producing organisms are ideal, good personal and household hygiene are required for control of diseases. To prevent contamination of water and food, proper disposal methods of excreta is also essential for concurrent implementation with water supply schemes.

In general, water supply, sanitation, health education and primary health care should be provided as an integral part of the total development process. Infact, this is one the important messages the Decade struggles to convey.

IV.3. Critical Issues of the Decade

There are several crucial issiues which are of utmost importance in relation to progress expected in programmes and activities of the Decade.

Emphasis on Rural Areas and Community Participation

Since most of the underserved people live in the rural areas, the Decade envisions greatly expanded efforts on their behalf. Members of local communities need to be involved in all aspects of water and sanitation programmes, from planning, implementation to operation and maintenance of facilities. This helps ensure that programmes are socially and economically relevant to individual communities, achieve self sustaining status and encourage self-reliance.

Education and Communication

The key to motivating community participation in water supply and sanitation is education and communication. Effective community-level education enables the people to understand the need for improved facilities; to create an awareness of the relationship between contaminated water and disease, to change their lifestyles for better use of wells and latrines. Communication programmes based on effective education will differ from community to community based on individual circumstances.

Manpower Development

Constrains in national water supply and sanitation programmes are mainly due to stortage of personnel required for management, planning, construction, operation, maintenance, evaluation and training. The task of training the required personnel to meet the Decade's target is enormous. Training should be relevant to actual needs. In the past, training neglected palnning, management, evaluation, methodology and the and the relationship between water supply, sanitation health and socio-economic development.
Special focus will need to be placed on training personnel at the village level.

Appropriate Technology

Technologies should be selected that are technically, economically and socially suitable for use in communities. In between the extremes of imported advanced technologies and very simple ones, there exists a whole range of choices.
Appropriate technologies normally,

- are low-cost and affordable,
- are people-oriented and effective,
- are produced locally, using available resources and expertise,
- are suitable for mass approaches,
- fit in with local cultural and geographical environments.

Operation and Maintenance

Although large sums have been invested in new water and sanitation systems in developing countries, negligible investments are allocated for operation and maintenance of these facilities. Operation and maintenance involves training members of rural communities to operate and maintain their facilities; making standardized tools and spareparts easily available; provision of back-up maintenance and repair service by regional authorities and monitoring to determine the performance of the system and the facilities.

IV.4. Financial Aspects of the Decade

The costs of the Decade in providing safe water supplies and sanitation facilities to everyone by 1990 can span over a wide range depending on the technology chosen.

Estimates made before the launching of the Decade indicated that providing 3 billion people with new or improved services would require between US$ 200 and 600 billion (1978 rates) again depending on the technology used.

Exactly three years after the lauching of the Decade in November 1980, we are still confronted with the same questions:

How much will it amount to? where will it come from?

Adoption of low-cost technologies is the answer in reducing the costs by as much as 50 to 80 percent enabling several fold coverage with currently available resources. With regards to financial sources, there is no doubt that the Governments of developing countries will have to bear the major responsibility. This means re-ordering of priorities and devoting a significant portion of GNP to the water and sanitation sector.

On the other hand, external aid will be expected at an increased level to keep pace with the Government allotments and Decade targets.

With three years of the Decade now behind us, we can see that the financial commitments from the Governments themselves and the donor agencies have fallen behind expectations. This situation is mainly due to the prevailing global economical crisis and the governments reluctance to increase the sector allocations in general.

IV.5. The Mass Approach

Targets for extending the coverage of safe water supply and sanitation in ASPAC countries during the Decade are indeed ambitious and require stupendous work.

The magnitude of the work lying ahead requires new approaches, improved technologies, various institutional reforms and other developments to occur rapidly if the targets are to be achieved.

Comparison of the rural population remaining to be served with water supply in 1983 (about 493 million) on a regional basis in South-East Asia with the population to be served in 1990 (about 845 million), yields in a population of about 352 million to be provided with water supply in seven years, (1983 to 1990). This estimate is equal to a population coverage need of 150,000 per day, or about 50 villages daily (assuming 3000 people per village). This situation clearly points at the need of phased programmes utilizing a mass approach and acclerated programmes for the development of water supply and sanitation schemes.

Since mass approach programmes are intended for target groups of small communities, it becomes also necessary to plan and implement concurrently essential support programmes to maximize the health benefits and for better use of facilities. Implementation of such programmes as community education and participation, operation and maintenance will also require a mass aporoach which may be somewhat difficult to plan and implement as they may require community based individual socio-cultural studies and suitable health education design.

The key to developing a mass approach for implementing water supply and sanitation programmes requires standardization in all respects: surveying, planning, designing, construction, materials procuring, storing, operation and maintenance.

Selected technologies should be reviewed and tested with regards to their suitability for standardization. Periodic evaluation procedures are needed to check the progress and identify the constraints for corrective measure neede.

In trying to formulate the scope of a mass implementation programme, subtantial data and information are needed to define the implementation strategy and the extent of standardization. For this purpose, pilot studies and demonstration projects need to be undertaken for accumulation of data required to establish the technical, financial and social feasibility of selected technologies and their applicability for mass aproaches.

V. THE POLICY OF WHO

As one of the main organizations concerned, World Health Organization has been a spearhead for the International Drinking Water Supply and Sanitation Decade.

Further to HABITAT (Vancouver, 1976) and the UN Water Conference (Mar del Plata, 1977), the Organization received a mandate from the Thirtieth World Health Assembly, to undertake and intensify cooperative programmes with member countries to assist them in the planning and implementation of expanded national programmes for community water supply and sanitation. The role of WHO in the Decade is health oriented and the major elements of the Organization's participation in the Decade are:

- Promotion of the Decade
- Institutional development in countries
- Development of human resources
- Information exchange and technology development
- Financial resources.

At the regional level, South-East Asia Regional Office of WHO collaborates substantially with member countries in different aspects of community water supply and sanitation. In respect of water supply and sanitation programmes, greater attention is now being paid to instituional and manpower development, appropriate technology, community health education and participation and other "software" components of the environmental health programme.

VI. CONCLUSION

It is the people of the countries in the ASPAC Region who suffer from lack of such fundamental services as water supply and sanitation. The communties therefore, should assume responsibility and participate in every phase of development to ensure that such basic services are provided and properly maintained.

In conclusion, it is prudent to emphasize once again that the magnitude of the work lying ahead to achieve the goals of the Decade is stupendous. Major efforts will have to be made by the member countries and their peoples of the ASPAC Region to accelerate programmes leading to phisical implementation, institutional development, use of appropriate technology, manpower development, community education and participation, and exchange of information.

At the international level, efforts will have to be directed towards increasing external resources required by developing countries to enable them meet their Decade targets and provide support and technical cooperation in developing programmes to achieve self-reliance.

DAMS AND MAN-MADE LAKES ENVIRONMENTAL CONSIDERATIONS IN PLANNING, INVESTIGATION AND DESIGN

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4TH Asia Pacific Regional
Water Supply
Conference & Exhibition
Jakarta, Indonesia
5-11 November 1983

TIRTA DHARMA

INTERNATIONAL WATER SUPPLY ASSOCIATION
ASSOCIATION INTERNATIONALE DES DISTRIBUTIONS D'EAU

~~5th~~ 4th ASPAC Reg. W.S. Conf. Jakarta 5-11 Nov.'83

I.R.C.

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EXPERIENCES IN WATER SUPPLY SYSTEMS DESIGN AND DEVELOPMENT IN THE PHILIPPINES

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(DCCD ENGINEERING CORPORATION, PHILIPPINES)

ABSTRACT:

The various techniques and devices for supplying water are in general well developed and well known. For developing countries, however, it is essential that the most affordable and appropriate techniques, devices and systems be those employed for providing safe, convenient and adequate water supplies. DCCD Engineering Corporation shares its experience in attempting to find these affordable and appropriate techniques and devices for water supply systems in the Philippines.

We relate affordability basically with money and appropirateness with program feasibility in terms of available overall resources, socio-cultural acceptability of system types, probability of future use and proper maintenance of the facilities; and feasibility of the levels of service proposed in terms of local economics and technological capability and local variations in culture, availability of water and other pre-existing factors.

EXPERIENCES IN WATER SUPPLY SYSTEMS DESIGN AND DEVELOPMENT IN THE PHILIPPINES

There was an experiment in the UK in which science students were asked to write a report on what they actually saw when they watched the dripping of a water tap. Prof. S. Stuart related' "All but few repreated, somewhat salvishly and with varying degrees of relevance, something from a textbook."

In this paper, DCCD Engineering Corporation shares a collective experience in trying to employ affordable and appropriate techniques and devices in water supply systems in the Philippines. These were events lived through and learned, in the context of personal and professional experience not swinging away from learning from observation. An interesting portion of these are cost saving measures which brought down costs through practical recognition of what are locally (or socio-culturally acceptable and reliable. Today, we consider these experiences as part of data, from which the practising engineer can update his engineering knowledge. Technical solutions and institutional implementation vary from place to place and from time to time.

DCCD AND THE EARLY WATER SUPPLY SYSTEMS IN THE PHILIPPINES

The effort to provide a convenient system for water supply started as early as 1690 in the Philippines. This was when a sizable spring was developed and connected to an open aqueduct to serve Manila residents. Thus, experience in water supply even in developing countries has been that long now. The gap between supply and demand in many developing countries, however, has even widened and the challenges and problems have not diminished nor become simple. This is probably because growth and development have inexorably pressed on existing supplies — both water and money supplies.

DCCD's experiences in water supply started only in the late 1950's. These were with small independent systems for subdivisions, resorts and institutional complexes. Most of these were in the private sector, small jobs that paid meagerly but "good to start with". Some provided enough challenge which compensated for the lack of pay; and probably paved the way to the growth of engineering ideas and the more advanced state of water supply engineering practice today in the Philippines.

One of DCCD's early projects was not for a high priority need but, the concept of the recommended solution we have considered these last few years as appropriate to the provinces in the Philippines.

Water supply was needed for a week-end resort complex near Manila. Peak hour and maximum day demands would only be experienced on week-ends, at most on a long 3-day week-end. The study recommended a service level consisting of individual house connections with individual house tanks. The individual tanks permitted a schedule of water distribution in geographic sections during the 4 to 5 days a week of low or zero demand. This in turn provided for smaller diameter pipes, smaller pumps and very efficient pump operation. Because individual household consumption was established in the volumetric capacity of the tank, metering was eliminated.

A small tank for storing water is a common fixture in provincial backyards in the Philippines. This is usually filled up with water from queing up in a public hand-drawn shallow well, hand-pumped well or a public faucet. If a piped water system is installed, these water tanks can be connected to the system and filled up according to the following steps:

1) A pre-arranged schedule of filling up for each household tank;
2) An automatic closure for each tank when filled up through a float valve.

Families can then decide on how much they would like to spend for their water, the daily water consumption based on planned needs. Water bills can then be based on the volume of each household tank.

The tanks can be of any material usually steel barrels, concrete hollow blocks or reinforced concrete (see figure 1 and 2) or even of an improvised number of kerosene cans. DCCD has included this concept in a 3-volume rural water supply manual (design, construction and installation, and operation and maintenance) it has prepared for the National Water Resources Council of the Philippines.

Before 1960 DCCD also started to design water treatment plant projects. One was for the water supply for the University of the Philippines' College of Agriculture campus in Los Banos town, Laguna province. This was definitely not a textbook case; it was a case of "common sense can do it" as DCCD steered to the "sensible lot". The rapid sand filters used underdrains with square cross-sections of 0.25 m side dimensions.

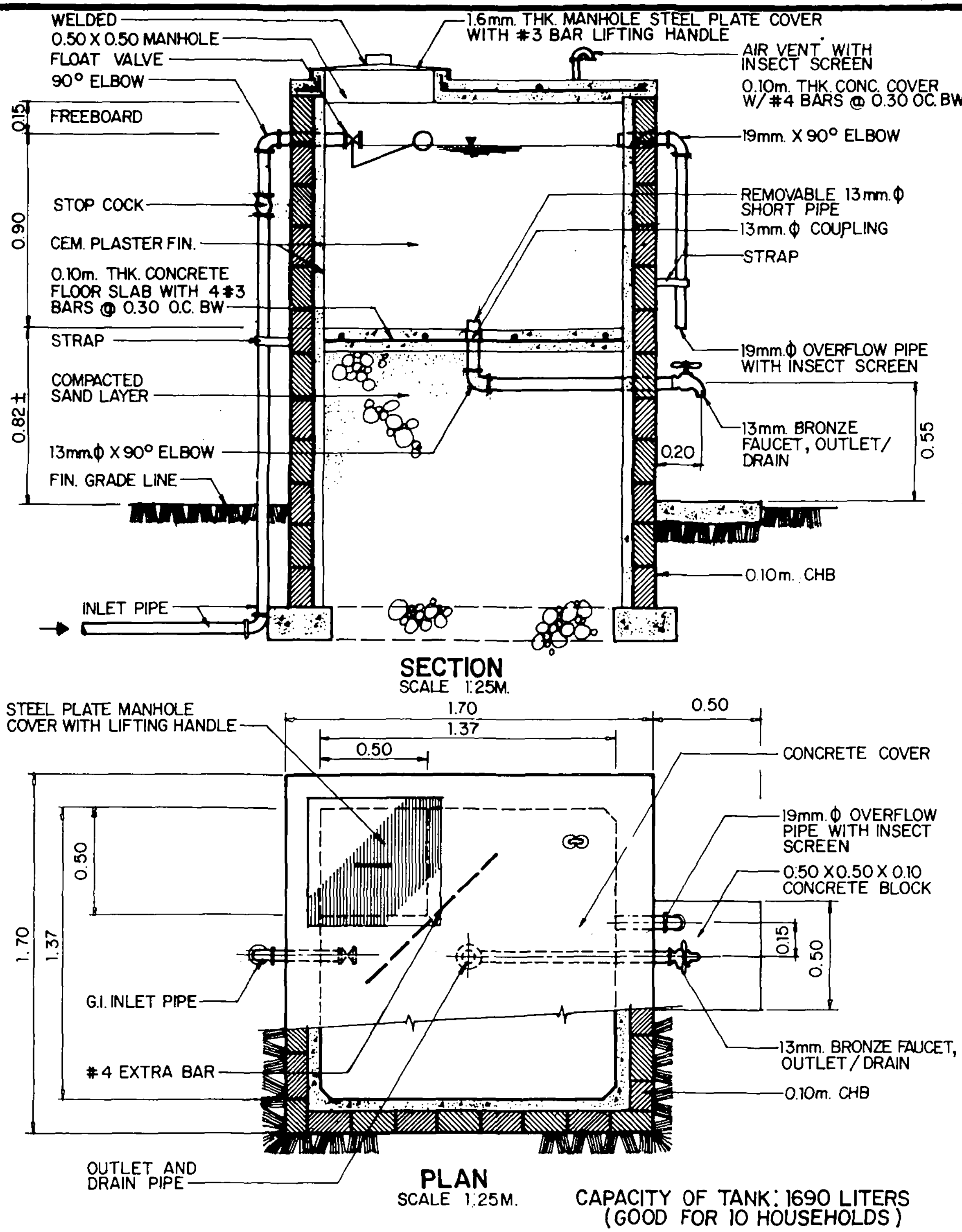
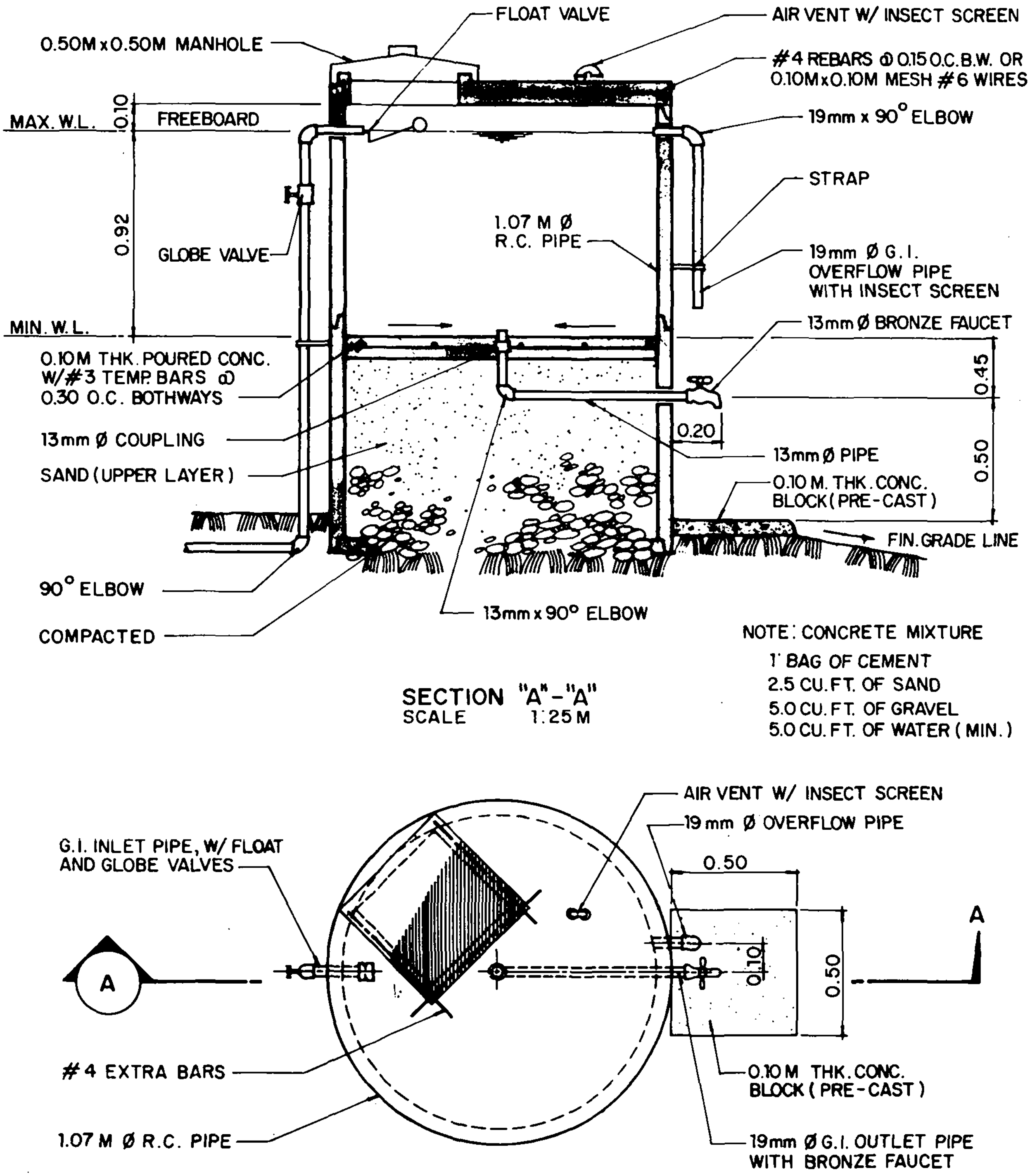


FIGURE 1

DETAILS OF CONCRETE HOLLOW BLOCKS (CHB) GROUND LEVEL STORAGE TANK



SECTION "A"-"A"
SCALE 1:25 M

P L A N
SCALE: 1:25 M

CAPACITY OF TANK: 827 LITERS
(GOOD FOR 5 HOUSEHOLDS)

FIGURE 2

DETAILS OF PRECAST REINFORCED CONCRETE GROUND LEVEL STORAGE TANK

Perforated brass tubes were fitted to two sides and capped with a metal plate the size of a Philippine one centavo coin. This helped spread the backwash water spray. It completely used local labor and materials. Backwash operation was understood locally. The filters were affordable and acceptable.

Then DCCD became bold. Its first bold experience was a situation where there was a good site to develop but there was no water. In 1961 it was given this problem to supply water to the Loyola Retreat Complex in Angono town, Rizal province. We surveyed, found and considered a stream; we put in a slow sand filter and designed our first high head pump. The pump brought water from stream level 30 metres up through rugged terrain to a elevated tank before gravity distribution. We subsequently supervised the contruction of this water supply system. The cost saving was in avoiding expensive groundwater exploration program when all visible indications were that there was little groundwater available.

This and later detailed design and construction supervision ventures showed that:

- o Finding an adequate water supply source is not a major problem in the Philippines.
- o Systems work well when fitted to local conditions.
- o Reasonable and timely cost savings can provide and affordable water supply scheme for any place an affordable water supply scheme for any place and in any time.

THE MAJOR ISSUES

During the period from 1955 to 1965, the more visible clients could only offer small water supply design projects. There were no major government appropriations for the rehabilitation or improvement of the water supply systems in the big cities and municipalitaties. But small water supply systems can be just as complicated or even more deceptive than the big city or municipal systems. DCCD took these as cases of "small can be just as beautiful" in a water supply context.

When there bigger appropriations for water supply, usually bilateral aid, consultancy went into the hands of the foreign experts. Several years back some water supply experts "aided" a rural village in the Philippines. They drilled a well and installed a closed handpump. The affordability analysis showed all positive indications for this relatively safe, convenient and adequate water supply source. The villagers used it for a few weeks and then abandoned it and went back to using their previous source which was a hand-dug open shallow well. This open well was naturally aerated, the iron precipitated in the water and left no reddish stains in their laundered clothes.

The various techniques and devices for supplying water are in general well developed and well known. For developing countries, however, it is essential that the most appropriate, and affordable techniques, devices and systems be those employed for providing safe, convenient and adequate water supplies.

Water supply consultancy in the Philippines has had its stages. From 1965 to 1975 when the organization and funding for the contruction, improvement or rehabilitation of water supply systems in cities and municipalities began to improve, feasibility studies and detailed engineering designs were mostly managed and supervised by foreign engineers and expoerts, and local staff provided back-up support. DCCD's Filipino engineers provided strong support from the very start. The Filipinos engineers provided strong support from the very start. The Filipinos were not wanting in western technology in almost all areas of water supply. With many of them having had training or post-graduate education in advanced countries' istitutions of learning, they soon were able to exhibit a profound skill to tone down the more sophisticated concepts to the local applicability level.

Today, many water supply system projects are done completely by Filipinos.

THE DIFFICULT OPTIONS

In the early 1970's, the first city or municipality water supply project component entrusted completely to a Filipino team was in detailed engineering design. Given such an important endeavor, we did not proceed immediately to fitting in the "nuts and bolts". Time was taken out to review and evaluate the feasibility studies which were mistly conducted by foreign consultants. Our reviews and evaluations were not only made to consider new information; we also ironed out sincere and honest differences of opinions on techniques, devices and systems for supplying water under Southeast Asian conditions.

They were all difficult options. In the end, however, many of our suggestions and recommendations were heard. We would like to think that our aim was to minimize change to what has been reliably used before, provide a certain degree of confidence of user acceptability, and accomplish cost savings. In summary, we wanted to reach more people for the same amount of budgeted money.

The cost-saving measures were generally applied in the following areas:

- o Standards and criteria uneconomical to the Philippines
- o Instrumentation and equipment not fitted to Filipino behavior and difficult to operate and maintain.
- o Conventional systems based on simplified field conditions when more site-specific effort and non-conventional engineeering were needed.

We now refer to several typical situations where we believe we were motivated to save costs because costs could be saved if designs were based on "locked-in" Filipino preferences; and to a compassion for the average Filipino family who ultimately has to pay back for what has been expended. However, our basic orientation has always been toward health; and adequency and relibility were never sacrificed.

1. We have recommended a change in the criteria set for minimum pressure in the distribution system of 20 metres head which we find to reduce affordability. The standard set now for minimum pressures is 14 metres in core areas of a city or municipality and 7 metres in outlying areas.

2. In the southern city of Davao, the feasibility study identified the Davao Basin as the major source of ground water for water supply. During the review and evaluation of the feasibility study, we extended our initial field surveys to include local knowledge of general availability of ground water in the study area, A fair compilation of facts and local information pointed to the Apo Basin west of the city to be where adequate ground water reserves to serve long term needs would be. This was proved correct.

Meanwhile, significant adjustments and revisions had to be made to the recommended water supply system scheme in the feasibility study. And expensive dry wells had already been drilled in the Davao Basin.

Experience: inexpensive initial field surveys and data gathering should extend far enough to include local knowledge. In several cases sufficient information are gathered for deciding on location of wells and saves the cost of unnecessary expensive geophysical subsrufface investigations, and dry wells.

3. In the same Davao City water supply project, a study was made on the economics of the recommended provision for stand-by generators for pumps.

Experience: under existing Philippine conditions, stand-by generators were found to be importantly uneconomical. Money for this could perhaps be used for items which would extend water service to more consumers. A more favorable option is to provide for use of mobile generators when the need comes. Mobile generators can be rented or can be made available from government agencies.

4. Baguio City, because of its mountainous topography, has the most difficult and complex water system in the Philippines. Consultants had to deal with the city's up-land plateau with very little surface water and re-change areas for its ground water aquifers; non-uniform water service area, with a ground elevation range of just about 200 metres; a complicated road network. a changeable population on account of the city's being a tourist and education centre; and a relatively high cost of electricity.

Several appropirate devices and cost-savers were recommended during our review and evaluation of the feasibility study and carried through in our detailed designs to meet the technological and engineering difficulties.

- The service area was divided into three pressure zones was treated hydraulically independent of each other having its own operational reservoir. We specially looked for appropriate locations at proper elevations for these ground reservoirs. The feasibility study never did that. Water sources supplying gravity flow were concentrated on the highest pressure zone. Pumping heads from deep well sources were minimized.
- Reservoirs were designed with overflow provisions and without altitude valves; overflowing water was redirected into the distribution system. Altitude valves are expensive, difficult to maintain and replace.
- While it was difficult to predict system behavior under abnormal or emergency flow conditions, allowances were made in the system design for such situations. This was achieved by providing normally closed valves between pressure zones which may be opened so that areas may receive supply support during pump outages. Otherwise, the interconnecting valves are closed are closed and kept locked in lockable valve boxes all the time.
- A large portion of the water supply is pumped from deep wells where in some, water levels vary signicicantly between the wet and dry seasons. Considering these factors, pressure can vary over a wide range. To improve the efficiency of pump operation, we recommended to pump froma deep well into a sump first before boosting the water into the system. This operation of pumping into the atmosphere increases the production capacity of pumps, and provides for chlorination contact time as well. Many of the deep wells are in the city proper and in built-up areas.
- A relaxing of the rigid standard set for the minimu pipe diameter of 100 mm in the distribution system was recommended. We felt it would save costs by providing certain areas with pipes of 50 mm diameter (on a looped main less than 50 metres in length) and 75 mm diameter.

5. In the central Philippine city of Dumaguete, we recommended to maximize use of the Maite creek, an existing surface source, and its transmission line which supllies water by gravity. A slow sand filter was recommended for installation adjacent to an existing settling basin to improve water quality. This was against that in the feasibility study which recommended the abandonment of Maite creek and its replacement with deep wells and booster pumping to areas which could otherwise be served by gravity from Maite creek. The Maite creek segment of the system has been in relatively reliable and acceptable use for many years already.

6. in Iloilo City, DCCD maximized use of existing reservoirs found to be still in good condition. This reduced the required volume of new reservoirs.

7, In the same Iloilo City water supply project, DCCD again exploited the optimum use of gravity flow. New deep well water water sources were to be developed about 10 kilometres from the city center but provided between 25 to 30 metres static head in the service area. We proposed a ground reservoir to be constructed in the vicinity of the well field. Water from this reservoir could be conveyed by gravity to the service area during minimum hour and maximum day demand periods. A local elevated tank was proposed inside the city of reduce the size of transmission ains and improve the pressure profile in the service area. Pumping would onlu be needed during peak hours.

This was opposed to a recommended ground reservoir inside the city (instead of in 'vicinity of the well field). Booster pumping was to deliver water to an elevated tank nearby before discharging into the system. In this case, booster pumping was required for all supplies.

8. DCCD conducted watet consumption rates study on a public fauced system in Sinisian, East Lemery, Batangas province for a rural water supply project. This was done for an initial indication of a realistic water consumption rate to avoid oversizing pipes and pumps. The affordability level in rural areas is relatively low.

The resulting water consumption rate for a public faucet system was found to be 60 1pcd.

9. Based on our observation, we believe that 4 residential blocks may comprise a reasonable single isolation area during normal maintenance and repair operations in the distribution system. The advantage is not only in the cost-saving due to a fewer number of valves required, but also in the fewer number of valves to maintain.

Today, water supply feasibility studies studies for the remaining smaller municipalities are being conducted by Filipinos. Surprisingly, not a few of these small water supply system studies prove to be challenging. Mr. R.H. Thomas of Camp Dresser & McKee, Inc. said: "The objective should be to propose facilities which are cost-effective and fully appropriate to the local conditions. In many cases in developing countries, this will lead to the use of relatively simle technology. However, simple technology does not imply simplistic analysis."

THE CHALLENGES AHEAD

What lies ahead are still challenges. DCCD suits each design to the needs of the particular situation and tries its best to provide the appropriate technological solution to water supply needs.

When we think about it, the wisdom behind all the engineering are experiences, but all the test are definitely pragmatic.

MEASURING CHARACTERISTICS OF WATER METERS

4TH Asia Pacific Regional
Water Supply
Conference & Exhibition
Jakarta, Indonesia
5-11 November 1983

TIRTA DHARMA

INTERNATIONAL WATER SUPPLY ASSOCIATION

ASSOCIATION INTERNATIONALE DES DISTRIBUTIONS D'EAU

Lecture for the

4. ASIA PACIFIC REGIONAL WATER SUPPLY CONFERENCE & EXHIBITION 1983

Measuring Characteristics of Water Meters

CONTENTS

MEASURING CHARACTERISTICS OF WATER METERS

1. Introduction

The following description deals with the measuring characteristics of water meters, which presently and in the near future are used as domestic and bulk water meters. These are:

single–jet meters
multi-–jet meters

oscillating piston meters

Woltmann meters

and

Compound meters as a combination between a small and a larger water meter for particularly high flowrate ranges.

Hereafter the group of single-jet, multi-jet and Woltmann meters are termed vane whell meters.

2. Error Curves

Being mechanical meters, whose measuring part – piston or vane wheel – is directly water-driven, all these meters show an essentially similar characteristics of the error curve.

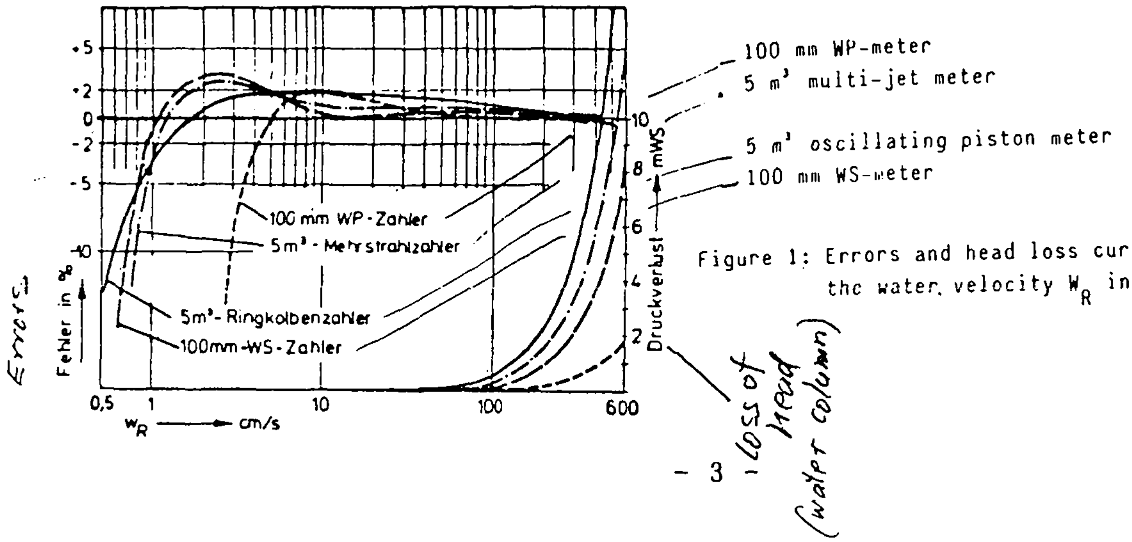


Figure 1: Errors and head loss curves related to the water velocity W_R in the pipe

Fig. 1 shows a comparison of the error curves at a water velocity above W_R in a pipe of corresponding nominal size to four typical meters, namely a 5m3 piston meter, a 5 m3 multi-jet meter, a 100 mm WS-meter and 100 mm WP-meter. The meters are new and of the latest design.
One can see the relatively low slopes of all four curves in the higher flow range and the ascent in the lower range. This is a particularcharacteristic of the WS and multi-jet meter. The piston, multi-jet and WS–meter have similar characteristics under – 5% from W_R = 0,08 to 1 cm/s.

Whereas the WP–meter starts at 3,5 cm/s, which is about a fourfold increase in flow velocity in the pipe.
The head loss of the WS–meter is less than that of both domestic water meters. And most advantageous is that of the WP–meters.
The logarithmic scale chosen for the axis of abscisses clearly illustrates the slope of error curves in the range of lowest flow velocities in the pipe and those low flowrates which can still be recorded by the corresponding meters.
A distinctive feature is the very large range of the

practically horizontal slope of the error cuvess at higher flow velocities and the positive error at low flow velocities, in the case of so-called velocity meters even exceeding + 2 %.
This obvious similarity in the water behaviour, particularly with respect to the error curve ascent at low flowrates, can be explained as being due to the laws of physics.
Therefore the standards divide the so-called measuring range into an upper and lower measuring range.
As error curve for the upper range is fixed at ± 2%, and the lower range at ± 5% (see fig. 2).

3. Ascending Tendency and Lower Measuring Range Limit Q_{min}

In the lower range where flow velocity is low and laminar flow occurs (see fig. 3) the curve slope is influenced by differently shaped boundary flow layers. The velocity in the flow core is higher and leads to an excessive ascent of the error curve, the so-called ascending tendency (see fig. 2).
This ascending tendency is particularly distinguished with those meters which work with negligible frictional resistance (light vanes of modern plastic material,

Figure 2

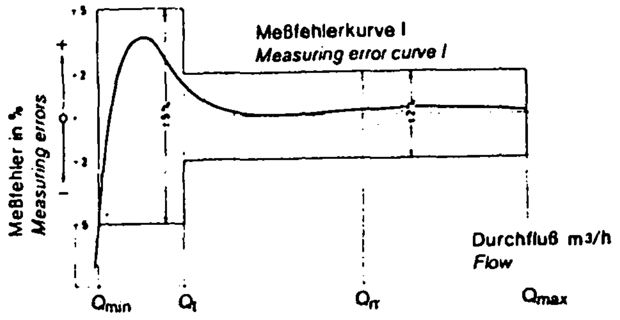
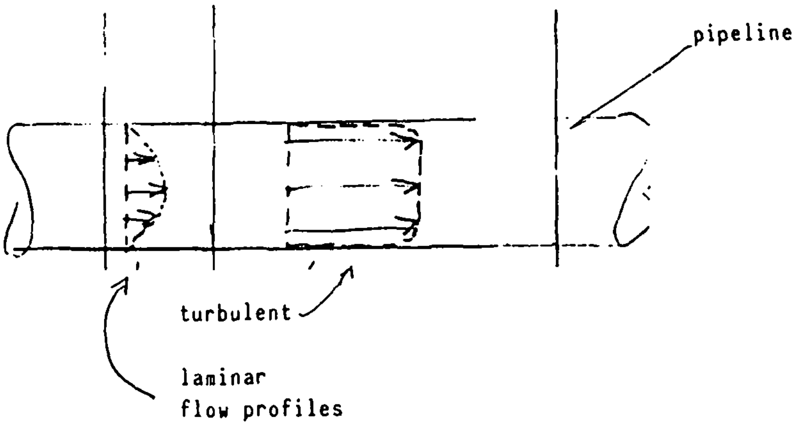


Figure 3



high-quality light-running bearings, friction-free gears). Furthermore these meters show a very good lower measuring range limit, i.e. they begin to operate at low flowrates within the measuring error limits which, due to the ascending tendency are fixed at ± 5 %. The parting line Q_t defines the flowrate at which the measuring error limit changes from 5% to 2% (on increasing flowrate).
Due to their light-running characteristics these meter also have very good starting values.
Although all water meters are subject to the same

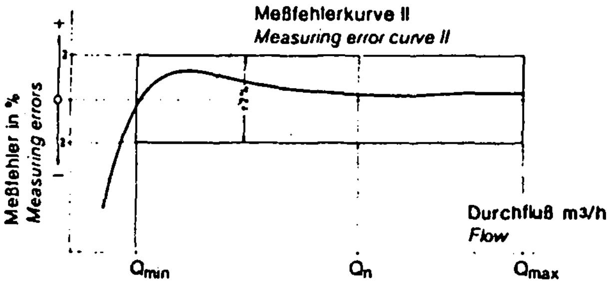


Figure 4

physical laws they show a different behaviour particularly in the lower part of the measuring range, as demonstrated in figure 4.
Curve slope II is characteristic of meters operating at high frictional resistance (heavy vanes, tight-running bearings and gears). This frictional resistance works as a brake and inhibits the ascending tendency. Furthermore these meters do not have as good a lower measuring range limit, i.e. they start operating within the measuring error limits at higher flowrates which, due to suppression of the ascending tendency, is now fixed within the entire range to ± 2%. By introducing an artificial brake into light-running meters a behaviour pattern according to curve II could be obtained. A procedure which would lead to a deterioration of the measuring characteristic.

4. Meter Test

As the error curves of all water meters are the result of clear physical interrelations only a minimum of testing is necessary to determine these curve adequately. Therefore the meters are normally only tested at 3 points:
The lower limit, the parting line and the upper test range limit. The first two test are necessary to control the descending and ascending part of the error curve. The test at the lower test range limit sufficiently defines the meter's behaviour below this limit. A further starting test can provide no additional security.

5. Disturbing Influences

5.1. Air

Air in the meters can make itself felt in form of disturbances, particularly during series testing domestic water meters.
There are two influences to be distinguished.
During small pressure fluctuations the compressability of the air leads to a pulsing overlap of the flowrate and to an additional plus indication.
Air bubbles at the gear wheels have a braking effect. This causes additional minus errors.
Both influences are more apprarent in the lower flowrange. At higher flowrates no disturbance can be detected.

5.2. Supply Disturbances

Further disturbing influences on using and testing the meters may be supply disturbances in form of bends and a asymmetrical velocity distribution. This is eliminated,, to a large exten, by installing lengths of straight pipe before the meter, the length of which is ascertained empirically. On test benches it is possible to use regulating devices such as flow starighteners and strainers or perforated sheeting. But due to the danger of blockage these devices must be accessible for control.
The meters themselves, depending on their design, are more or less susceptible to supply disturbances. The higher the head loss and the less even the flow through a meter the better it is able to handle an irregular supply flow profile.
Therefore the meter's sequence of increasing demand for a good supply flow profile is as follows .

oscillating piston meter)
multi–jet meter) very similar requirements
single–jet meters)

Woltmann meter WS
Woltmann meter WP

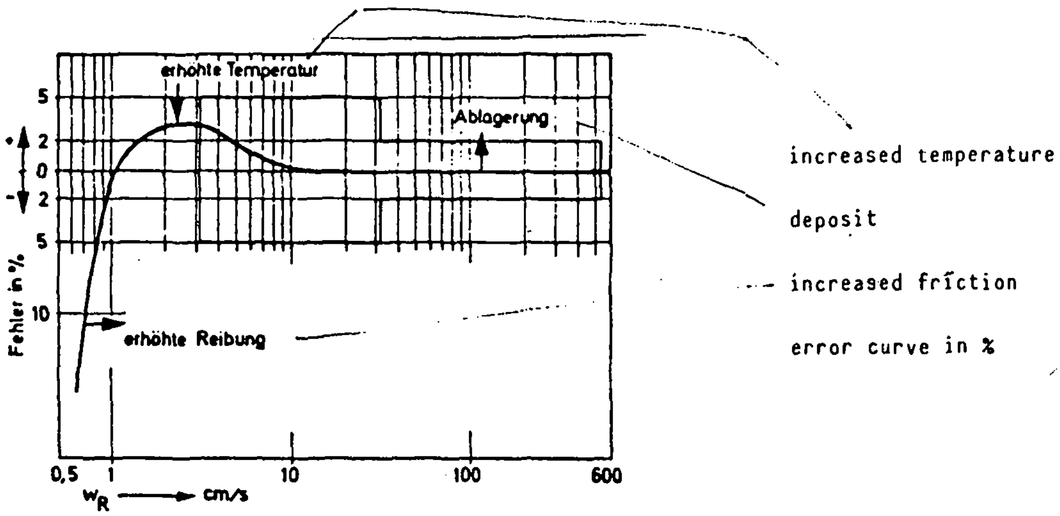
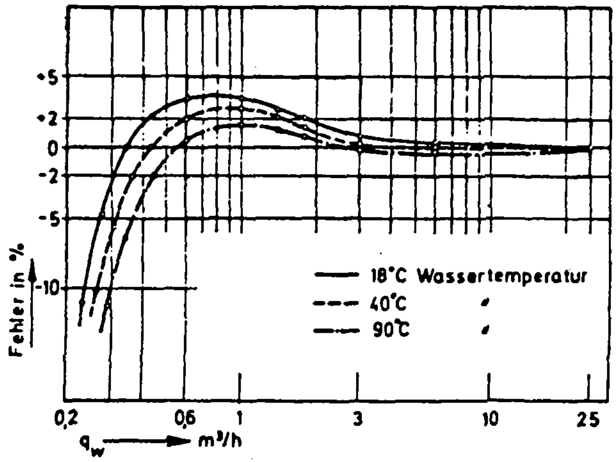


Figure 5: Influences on the error curve of a vane wheel meter during operation

5,3 Deposits

Deposits from drinking water narrow the original cross sections and thus increase the velocities at a given flowrate consequently causing a positive shift of the error curve. On the other hand, deposits increase the friction within the meter bearings.

The meters consequently become less sensitive. At higher flowrates the increased mechanical friction is of less influence. And at very high flowrates of none whatever. Only the lower descending part of the error curve is shifted towards the right.



——— 18°C water temperature
------ 40°C "
—.—. 90°C "

errors in %

Figure 6: Error Curves of a 50 mm WS-meter at different temperatures

Nowadays the gear and counter mechanism are normally mounted in a dry chamber to protect them from deposits. The vane rotation movement is transmitted by a magnetic coupling.

5.4. Temperature Changes

At higher temperatures the kinematic viscosity of water is diminished – and and therefore Reynold's number increased at a given flowrate. The same laminar rearrangement of the flow at lower flowrates and flow velocities occurs in the pipe and the excessive ascent of the error curve is diminished.

Furthermore the temperature rise causes the flow cross sections to increases and the graduation of the screw-like palettes of Woltmann meter grow. Essentially, at equal flowrates, both facts lead to a lower indication, that means the error curve shifts to minus.

Error curves at rising temperature have been recorded from a 50 mm WS–meter. As is to be expected the excessive asecent in the lower test range during the test with water at 18°C was slightly diminished during the 40°C test, and even more during the 90°C. But the second temperature rise by 50° did not result in much more change than the first rise by 22°. With further temperature increases still less change can be expected. In the range of higher flowrates only a slight shift of the curves toward minus was recorded.

6. Compound Meters

So far we have only discussed single meters. Picture 7 shows the error curve of a new 50 mm WS-compound meter. The left part can be seen to be the error curve of the 5 m3 meter, the right part to be that of the WS-meter. The change-over is carried out on increasing flowrate at point A, on decreasing flowrate at point B. The curve for head loss in the lower part shows the capacity at change-over at point A and here, too, the composition of the head loss curves of by-pass and main meter.

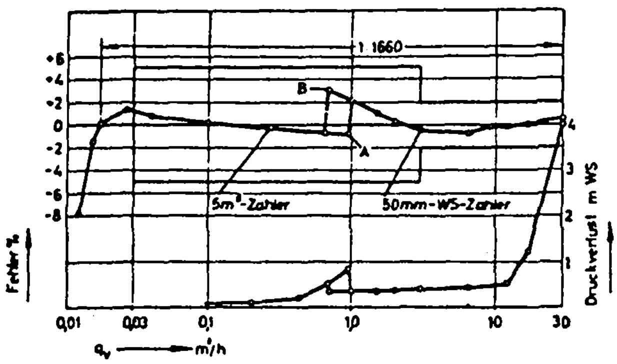


Figure 7: 50 mm compound meter, error and head loss curve

5 m³ meter 50 mm WS-meter

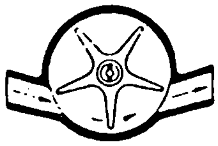
error in %

head loss m water column

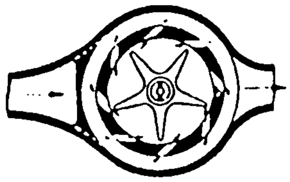
The entire test range is divided into an upper and lower range which is dictated by the large meter's parting line.

7. Type Comparison

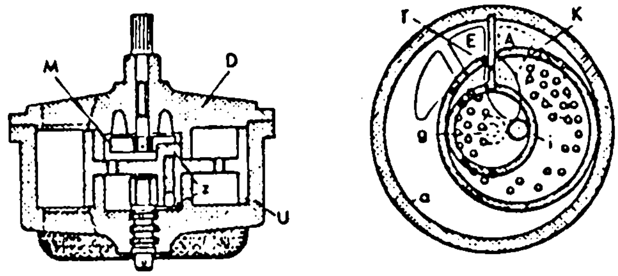
So far the descriptions have dealt with the properties and behaviour of the meters themselves. In conclusion the different types are compared with each other.
First, a survey of the sizes applicable to the different types.



Singl -Jet-Meter



Multi-Jet-Meter



Oscillating-Piston-Meter

Type	Meter Sizes (mm)	
single–jet meter	15 – 40	–
multi–jet meters	20 – 40	(50 – 100)
oscillating piston meter	15 – 40	50 – 100
Woltmann meters WP	–	(40) 50 – 500
Woltmann meters WS	–	50 – 150
compound meters	–	50 – 150 (200)
	domestic water meters	bulk water meters

( ) = rarely used

7.1. Single-Jet Meters

Contrary to the multi-jet meter where the water flow is guided to the vane in divided lots of small partial flows, the water flow of the single-jet meter is guided to the vane undivided and tangential.
The single-jet meter's design is simpler and its essential advantage is its price.
Due to the one-sided flow trough the vane the vane bearing is subject to a higher wear and therefore the life expectancy is shorter than that of multi-jet meters. Besides that deposits in the inflow field of the body influence directly the flow through the vane and therefore the measuring error. On the whole the measuring characteristics of the single-jet meter is not so good as that of the multi-jet meter.
Single-jet meters are only used as domestic water meters.

7.2 Multi-Jet Meters

The vane of multi-jet meters being exposed to symmetrical flow guarantees that it is charged equally from all sides and teherefore the radial bearing forces are less than those in single-jet meters. Furthermore, the vane bearing is not loaded due to the inner flow direction from the inlet channels axially upwards to the outlet channels – in opposition to the vane's dead weight.
This causes a reduction of the axial bearing forces. On the whole, due to the reduced bearing loading the multi-jet meter has a longer life expectancy than that of the single-jet meter.
It must be recognised that this advantage only applies to installations in horizontal pipelines. For vertical pipelines special ascending pipe meters have been developed.
Multi-jet meters are used as domestic water meters. Larger multi-jet meters are nowadays rarely used.

7.3 Oscillating Piston Meters.

The lower slope of the error curve at low flowrate is typical of this meter type. Normally the measuring error does not exceed the + 2% limit.
Besides, the piston meter achieves better lower measuring range limits. On average, they are some 50% better than vane meters.
A further advantage is that their function is not affected by the mounting position.
Practise has also shown that in case of good – clean – water piston meters measure accurately for a longer period of time than vane meters.
It must be mentioned that a disadvantage of the piston meter is their susceptability to mechanical failure and

wear accelerating conditions as well as to dirty, polluted water. Either the wear between piston and measuring chamber is excessive causing clearance losses quickly lead to unwanted minus errors, or the piston jams in the measuring chamber. This stoppage leads to an interruption of the water supply.

Further disadvantages are that the oscillating movement of the piston does not allow the meter to run beyond its design limit – for emergency cases – furthermore, high flowrates can cause annoying noises which can be heard through the pipework, even at long distances. Repair of piston meters is more expensive than that of measuring vane meters. The higher costs are due to the fact that complete inner parts have to replaced.

As the necessary water purity for piston meters is today rarely achieved vane meters are used almost exclusively. This applies particularly to bulk water meters, the majority of which are Woltmann meters.

7.4. Woltmann Meters and Compound Meters

Woltmann meters are equipped with turbine propellers through which are water flows axially and are designed to measure large water volumes. The head losses are negligible. Removable measuring mechanisms simplify service.

Two type area to be distinguished.

In case of type WP – 50 to 500 mm – the measuring vane shaft is paralell to the pipe axis. The water flows in a straight line through the meter. Due to the meter's design it can be mounted in horizontal as well as in vertical pipelines. The head loss of type WP is less than that of type WS described in the follwoing. The majority of Woltmann meters used are the WP types.

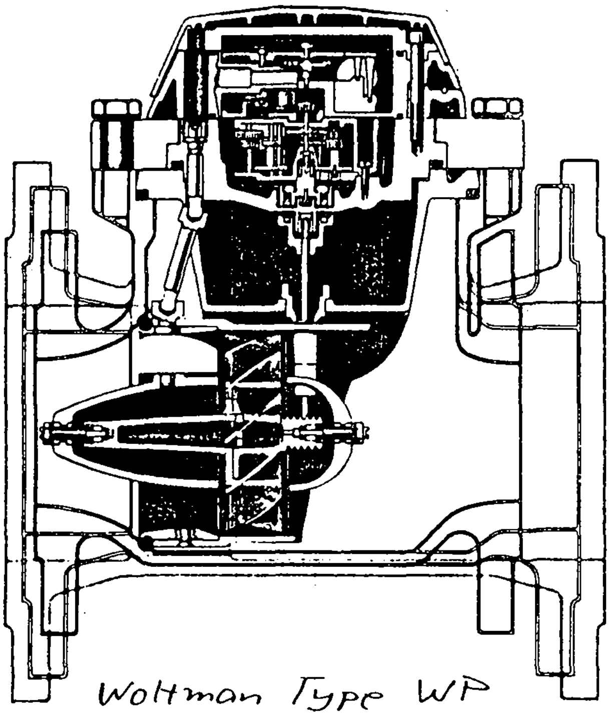
The measuring vane shaft of type WS – 50 to 150 mm – is arranged vertically and the vane runs very lightly on a bearing cone. Therefore type WS achieves a better lower measuring range limit.

In type WS the water flow is divided several times. The meter is only suitable for installation in horizontal pipelines. Its head loss is higher than that of type WP. Type WS is only chosen in cases where a better measuring range limit is required provided its disadvantages – only for horizontal pipelines and higher head loss – can be accepted.

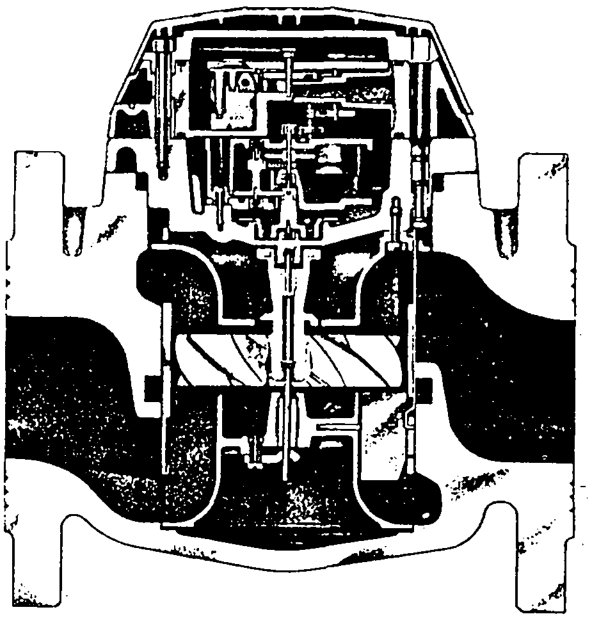
For still better measuring range limits the compound meters are used. They consist of Woltmann meter as main meter, a domestic water meter as by-pass meter and a change-over device.

The lower measuring range limit of the compound meter is that of the by-pass meter.

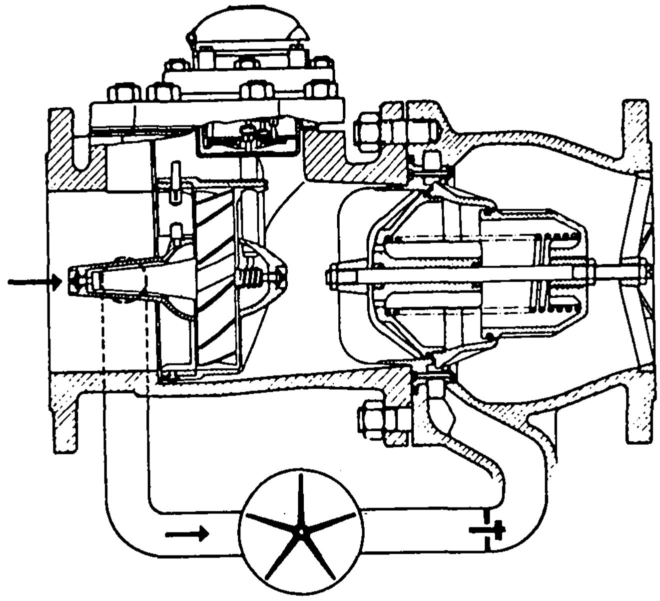
All discussed meter types are advantageous compared to other measuring systesm – for example inductive flow meters – because they operate independeant of any exterior energy supply. They are inexpensive and easy to service.



Woltman Type WP



Woltman Typ WS



Compound Meter

WATER LEAK DETECTORS

Walter MOSER
(SAFEGE FRANCE)

4TH Asia Pacific Regional
Water Supply
Conference & Exhibition
Jakarta, Indonesia
5-11 November 1983

TIRTA DHARMA

INTERNATIONAL WATER SUPPLY ASSOCIATION

ASSOCIATION INTERNATIONALE DES DISTRIBUTIONS D'EAU

WATER LEAK DETECTORS

Walter MOSER
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1. – SCOPE

A search for leaks in a distribution network is divided into several phases:

(1) – Measurement, metering and comparing inflows and outflows;

(2) – Search for and localization of underground pipe leaks;

(3) – Repair of leaks or replacement of sections which are onsidered too defective.

This text concerns the second phase.
It takes stock of the various processes which are used for the detection of leaks in underground pipes.

Water which circulates under pressure in a pipe generates acoustic vibrations when it escapes through an orifice caused by a defect in the pipe.

These vibrations have an audible frequency which varies according to numerous parameters (generally from 100 to 3 500 cycles per second). They are more or less propagated along the pipes and in the ground where they can be very quickly attenuated.

There has been no evolution for a very long time in the method used to search for and locate leaks: it consists in listening and analyzing the noises picked up from the ground or the pipes.

Practically all the apparatus at the disposal of the operator are based on the principle of the stethoscope, completed by mechanical or electronic ampifying systems.

They can be grouped into three categories:

(1) – Mechanical amplifiers;

(2) – Electronic amplifiers;

(3) – the new processes.

MECHANICAL AMPLIFIERS

The elder people in the profession used the handle of a pickaxe or an operating key to locates leaks. They placed one end on a point of the pipe or on the operating square of a valve and listened carefully at the other end.

If there was a leak they could hear a weak but reliable transmission of the noises propagated along a section of the network. But, to locate the leak, they had to judge the distance by analyzing the noises.

The HYDROPHONE, manufactured by Mr VAUDREY in Rheims, was most probably the first water leak detector to be commercialized in France.

Widely known as "canne Vaudrey" i.e. the Vaudrey stick, the Hydrophone is an acoustic amplifier of simple disign. An ear trumpet containing a vibrator amplifier which is adapted, as one chooses, to metal extension pieces or bamboo sticks.

This apparatus is still manufactured these days and used by numerous pipe repairers who are accustomed to it. It is practical, in particular, to listen to possible noises at the water inlet to water meters in private houses.

This apparatus was later improved by other manufacturers in order to notably amplify the noises which are detected. The HYDROSOL – sold by SCHLUMBERGER – seems to be the best known in this category.

It is composed of a transducer which is connected to the end of a metal bell acting as sound box onto which is fitted a metal rod used as sensor.

The mechanical detectors are generally used for direct listening of the network: either on the pipe or via cocks, valves or pipe connections.

The Hydrosol and the apparatus derived from it are the only apparatus through which the earth itself can be listened if the environment is sufficiently quiet. One can, in this case, locate a leak in the ground with precision.

ELECTRONIC AMPLIFIERS

The progress made by the electronic industry after the Second World War on the one hand and the interest of the Public Authorities and of the Operation and Maintenance Companies on the other to suppress the losses due to leaks from the buried networks have lead Manufacturers to study the problem set by the search for water leaks.

Electronic detectors were first used in the Fifties. They are based on the same priciple as the first apparatus but are entirely electronic. They are composed of three main elements:

– a sensor;

– an amplifier;

– the headphones.

These detectors are far more sensitive than the mechanical ones and the high amplification level of the signal which is detected makes it possible to search for and locate leaks precisely by listening directly to the ground.

In France one of the first apparatus of this generation to be found on the market is the TRIPHONE which is presently sold by PONT A MOUSSON. Over 50% of the leak detectors in France are still of this type.

A great step had been made from mechanical to electronic amplification systems. But, although these give good results, they require a more detailed analysis of the noises heard by the operator.

Indeed, if the vibrations caused by a leak are amplified so are the parasitic noises which need differentiation. This increased difficulty due to the great sensitivity of this type of detector is often the cause of useless trenching.

Fully aware of these problems, the manufacturers have tried to make improvements which essentially concern the amplifier and the sensor in order to enhance the leak noise in relation to the parasitic noises.

Frequency filters have been adapted to the amplifier. The Operator can now start working with a band of great width (generally from 100 to 3 500 Hz) and then select a narrow band of frequencies, thus eliminating a maximum amount of parasitic noises.

Improvements have been made on the sensor to eliminate the ambient noises and increase the directional effect of the microphone. Manufacturers offer accessories to adapt the sensors to the various types of ground which can be encountered.

Two methods of research are generally used depending on the results which can be obtained with the apparatus used and on the know-how of the technician whose job is to detect leaks:

1. – With a simple detector of the TRIPHONE type for instance the method consists in listening and analyzing the noises detected through the apparatus in direct contact with the network (valve heads, inlet to water-meters, etc.).

   As soon as the noise of a leak is detected, the technician searches for the peak noise between two connections and then located the leak point by listening to the ground, just above the concerned connections and the related piece of pipe.

2. When a more sophisticated detector (of the AQUAPHONE type for instance) is used and fitted in particular with a sensor designed to listen directly to the ground the method consists in analyzing the noises which are detected point after point along the layout of the pipes.

   When the noise of a leak is detected it is necessary to determine where it is loudest, to situate the defect.

If the Operator is skilled the first method can be used by day for the research operations and at night – in urban districts – when it is necessary to listen to the ground directly.

The second method requires an operator with greater skill and must be applied essentially at night in urban and semi-urban districts in order to obtain good results.

Some twenty leak detectors with an electronic amplifier are commercialized in France.
The results obtained with these detectors are generally good – if the operator is skilled. But the principle has weak points which are difficult to reduce:

– In urban districts the noise of a leak is drowned by those of the street which lead to long prospections and generally require night work.
– Depending on the type of soil, on the pipe and on the defect, locating it can prove very difficult or even impossible as the attenuation of the noise of the leak is very rapid.

The specific research made with this type of detector is generally done by a single operator by day or night according to the degree of urbanization and to the ambient noises.

The systematic research work, on the other hand, is done by a team of two or even three operators when the work is done at night.

The progress which is generally accepted for this type of work varies with the skill of the technician and the acchievements of the apparatus which is used. It varies between three to five kilometres a day of inspected pipes including the corresponding connections.

NEW PROCESSES

Acoustic correlation

Several manufacturers are marketing a new process for the research and localization of leaks, which was worked out by the Water Research Center in England. It is based on the acoustic correlation principle.

The apparatus, which includes a computer, compares two signals produced by a possible leak noise, detected in two different points of the pipe, and subjects one of the two to a series of time shifts so as to identify the one which precisely compensates for the propagation time difference of the two signals.

With the acoustic correlator one can therefore obtain simultaneously the detection of a leak (if there is a resemblance between the two signals) and its localization (by the determination of the shift corresponding to this resemblance).

The equipment is completed by a peripheral unit associated to the correlator; it is of the paper chart recorder type or of the oscilloscope type for the visualization of the intercorrelation function.

The results which have been obtained in field test with apparatus using this process are of interest and avantages can be expected in comparison with traditional methods:

- speed in prospection with results which are independant from the pipe material and from its depth;
- precision in the localization by a noticeable reduction of the human factor for the analysis of the noises;
- work done essentially by day and practically independent from ambient noises and atmospheric conditions.

The equipment which is relatively compact must, however, be mounted inside a vehicle of the 800 to 1000 kg van type to be operational; it must be prepared to be fitted correctly with the apparatus and its accessories such as cable winding drums, detectors/pre-amplifiers, operating keys and various tools.

The research team must normally be composed of three people: the operator and two aids who have a good knowledge of the network to be inspected.

According to a survey in seems that, as far as systematic leak reasearch is concerned, a pace of three kilometres a day is a generally accepted figure with this process.

Other processes

Two other leak research processes can be mentioned for information's sake:

- An American Service Company uses a frequency analyzing leak detector.

  The process consists in receiving a signal at a point of the piping by traditional methods and having it undergo a treatment to reveal a band of predominant frequencies.

  The apparatus is adjusted on this frequency band and the maximum amplitude of the signal is searched for by displacements of the detector along the element of pipe to be investigated.

  If there is a leak the signal which is received at the point where the amplitude is maximum will show the same characteristics as the initial signal.

  The method was tested a few years ago by the W.R.C., London: it was concluded that it was not of a quality superior to the traditional research techniques.

  Within a closer range a few Operation & Maintenance Companies use a leak reserarch process based on the introduction of a tracing gas in the pipes. For example: sulphur hexafluoride (SF6).

  Injected under pressure in the network sulphur hexafluoride is odourless, colourless, tasteless and not dangerous for consumption purposes. The water/SF6 mixture escapes through the orifice of the leak and the SF6 returns to the gas phase at atmospheric pressure.

  At the surface the leak is detected by means of a detector fitted with a probe which is introduced into small holes prevously drilled just above the pipe.

  This method is used in cases which are difficult to solve with traditional methods. However, it proves relatively inaccurate and fairly costly.

CONCLUSIONS

The mechanical detectors — of the HYDROPHONE or HYDROSOL type — are generally satisfactory owing to their simplicity and robustness.

The amount of amplification is hardly or not at all adjustable and there is no amplification device. The apparatus do not distort the noises which are detected and can be entrusted to non specialists.

The electronic detectors — from the simplest to the most sophisticated — give good results if they are entrusted to specialists.

The are relatively inexpensive and compact which makes them fit for quick and irregular detection work.

This type of apparatus will probably remain for a long time the most economical detector and the most suitable one for small and medium-sized water distribution departments for specific and even for systematic leak-search work.

The new process by acoustic correlation is a highly promising one, especially the French version which is fitted with a radio detector-to-correlator connection.

But, because of the relatively high cost of the equipment (approximately 220 000 French Francs with the vehicle), this detector will have to be used full time to pay off reasonably.

It is therefore necessary to assign it to large water distribution departments with systematic research programmes so that it can be used to a maximum.

The cost of the search work done by traditional methods is appreciably greater per inspected kilometer because of the night work which is necessary in urban districts.

DESIGN AND APPLICATION OF BURIED GLASSFIBER REINFORCED PLASTIC PIPES (GRP – PIPES)

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4[TH] Asia Pacific Regional
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SYNOPSIS

Large diameter glassfibre reinforced plastics pipe have been on the market for about 20 years for water and sewerage applications. The most spectecular market penetration is in the Middle East Gulf area where the excellent corrosion resistance of this material have made it first choise for sewer pipes.

The major production method of large diameter pipes is by continuous filament winding. These are around 15 factories in operation around the world utilizing this technology owned, managed, operated or working on a licence from Veroc Technology, Amiantus or Owens-Corning Fiberglas.

Pipe manufacturing on the Veroc continuous filament winding equipment is known by its special mandrel. This is formed by winding on endless steel tape onto a set of longitudinal beams, so arranged that the tape will move in a spiral fashion. Raw materials are applied onto the moving mandrel.

Pipe laminates are made up from glassfiber in the form of chopped roving and continuous hoop winding, aggregate sand and polyester resin. The components are varied to taylor-make the properties of the laminate to the requirements dependent on pipe class.

Design and installation of GRP pipes are based on standards. The most commonly used is a set of ASTM standards that covers product standards for pipes and fittings, relevent test methods and an installation standard for buried pipe. The newly published AWWA C 950-81 is expected to be widely used internationally for water supply.

Pipe design philosophy is the same for most standards. The three most important factors for pipe performance are pipe stiffness, pressure capability and chemical resistance. These factors are time dependent and it is generally found that a linear curve is obtained when the logarithmic decay of the property is plotted versus logarithmic time. The values used for pipe design is obtained from experiments extrapolated to 100.000 hours, 50 or 60 years. Appropriate safety factors are applied to the long term extrapolated value.

Theories for flexible buried pipes are used for pipe design of GRP pipes. ASTM and AWWA standards are considering three factors; deflection, strain and buckling. For deflection their approach is based on pionering work of Spangler later refined by Bureau of Reclamation in USA. These theories shows that even for poor soil conditions and the normal pipe stiffness, the contribution of soil modules to the stiffness of the pipe/soil system is about 20 times higher than the stiffness of the pipe itself. Pipe wall bending strain is calculated from the theories of J. Molin. Buckling calculations are based on the wodk of Lusher, later revised by AWWA.

Experience from several thousand km of installed large diameter pipes that have been designed and installed according to the ASTM and AWWA standards have shown that GRP pipes are a reliable and well proven product.

1. INTRODUCTION

Large diameter Glassfibre Reinforced Plastics (GRP) pipes for water and sewer application have been on the market for about 20 years. Such pipes are manufactured and used throughout the world today. The most spectacular market penetration is in the Middle East Gulf area where the excellent corrosion resistant properties of GRP coupled with light weight and ease of manufacture have made these pipes close to the only choise for trunk sewer systems.

Early developments were made in USA by United Technology Laboratories. Combining sand aggregate with a conventional filament wound pipe from glassfibre and polyester resin lead to a product with increased ring stiffness for lower material cost. This turned out to be a cost effective pipe for buried applications and the pipe was sold under the name of Techite.

With the advent of time two new manufacturing process evolved for the production of large diameter pipe from glassfibre, resin and sand aggregate:

- centrifugal casting
- continuous filament winding

Centrifugal casting of GRP pipes is comparable to centrifugal casting of pipes of other materials. Resin, aggregate and chopped glass is applied inside a rotating mould and the centrifugal force is used to get even distribution of the material along the circumference.

By continuous filament winding the component materials are applied onto a continous mould, making an endless GRP pipe that is cut to the desired length. The continous production ensures high quality and competitive price, making GRP and even more interesting choise for engineers.

Parallel to the product and process developments there has been a major effort, both national and international, for standardization of these pipes. The American ASTM standards covering product specification, testing and installation are internationally used. Recently the American Water Works Association published a GRP standard that is expected to be widely used for water application. Other standards referred to is the British BS 5480 part I with part II about to be published. International standardization work has been in progress for more than 10 years. Today there are several ISO drafts proposals covering products standards and test methods.

The pipe laminate has also undergone major developments since the early aggregate GRP pipe came on the market. Better raw materials have evolved, new ways to increase the sand aggregate loading have been found and improved laminate design have been developed.

2. CONTINOUS FILAMENT WOUND PIPE

The first equipment for continous filament winding was developed in 1967, and put into operation in 1968. The method was based on an idea of Ulrik Poulsen from Denmark, developed mechanically by Drostholm Products, and first used by Veroc Technology A/S who also developed the various GRP laminate compositions. Veroc Technology A/S, a joint company of Owens-Corning Fiberwinding process today and sells equipment and turn key factories world wide. Approximately 15 factories are currently in operation using this method to make pipes and tanks. To a large extent these factories are owned, managed, operated or working on a licence from Veroc Technology, Amiantus or Owens-Corning Fiberglas. So far, it can be estimated that a total of 2000 km of pipe of diameter 350-2800 mm primarily for water and sewage have been manufactured and installed. In addition approximately 500.000 tanks from a capacity of 1-150 m3 have been sold, primarily for the storage of oil and gasoline.

2.1. PIPE PRODUCTION

Pipe manufacturing on the Veroc continuous filament winding equipment, shown in fig. 1, is known by its special mandrel. This is formed by winding an endless steel tape onto a set of longitudinal beams. It is so arranged that the steel tape will move in the axial direction when the mandrel rotates. At one end the steel tape leaves the longitudinal beams and is guided into the mandrel's internal cantilevered core. It is then guided onto the mandrel again at the other end. In this manner the steel tape brings about a smooth mandrel surface rotation and a simultaneous advance in the axial direction, shown in fig. 2.

The laminate is applied onto the moving mandrel as shown in fig. 3. First a release fild, e.g. polyester film, is wound on the mandrel, followed by a surface mat. Filament winding, together with chopped glass, sand, aggregate, polyester resin and axial reinforcement are applied simultaneously. Finally a new layer of surface mat is applied.

Due to the working prin

Due to the working principle of the equipment, the layer supplied next to the steel tape builds the inner layer, and the material supplied next to the curing ovens builds the outer layer. The laminate build-up can thus easily be made to the appropriate design by controlling the amount and position by which the various components are applied.

After passing the curing oven, the pipe is automatically cut to desired lengths by the sawing unit, shown in fig. 4.

2.2. LAMINATE BUILD-UP

The described working principle leads to great flexibility in the laminate construction. To optimize the required properties of pipe stiffness and hoop tensile strength together with excellent chemical resistance, the pipe wall is constructed as a composite laminate with corrosion resistant interior and exterior and the structural laminate in between. The entire thickness of the pipe is chemically cross-linked resulting in an essentially homogenious structure.

Chopped roving and filament winding from continuously drawn glass fibre, and thermosetting resin make up the structural laminate. Aggregate sand is also added where required. The components are varied to taylor-make the properties of the laminate to the requirements dependent on pipe class.

Chopped fibreglass reinforcement is positioned randomly to give the pipe wall overall strength and particularly the strength required in the longitudinal direction. Longitudinal strength is needed for handling, thermal and poisons stresses, bending stresses from settlements of buried pipe, and axial stresses when installed above ground.

Continuous filament winding applied essentially in the hoop direction is the main component for a pressure pipe. The strength of filament winding alone is approximately 1400 N/mm2, several times stronger than steel and with a modulus of elstisity equivalent to that of aluminium.

Due to the high strength of GRP pipes with this laminate composition, pipes of lower pressure classes can be made with a small wall thickness relative to the diameter. For gravity pipes and pipes of lower pressure classes the pipe stiffness criteria have to be met in addition to hoop and axial strength. This is most economically done by building the wall thickness by adding sand aggregate. The sand aggregate will contribute to the stiffness of the laminate and is thus an integral part of the laminate design.

Polyester resin is needed to bind all the components together and to protect them from the environment. Generally the resin has mechanical properties that are 1/20 of those of filament winding. The resin content is governed by the type of reinforcement and filler used.

Typical compositions of continuous filament wound pipe for various pressure classes are shown in fig. 5. Corresponding initial mechanical properties for various loading conditions are given in fig. 6.

3. DESIGN OF GRP PIPES

Design and installation of GRP pipes are based on standards. The most commonly used is the set of ASTM standards that covers product standards for pipes and fittings, relevant testing methods and an installation standard for buried pipe, listed below:

ASTM D 3262	Reinforced Plastic Mortar Sewer Pipe
ASTM D 3517	Reinforced Plastic Mortar Pressure Pipe
ASTM D 3754	Reinforced Plastic Mortar Sewer and Industrial Pressure Pipe
ASTM D 3840	Reinforced Plastic Moartar Pipe Fittings for Nonpressure Application
ASTM D 3839	Underground Installation of Flexible Reinforced Thermosetting Resin Pipe and Reinforced Plastic Mortar Pipe.

The newly published AWWA C950-81 is expected to be widely used internationally for water supply. Tis covers pipe specification, design and installation of buried pipe.

Other published standards for buried water and sewer pipes is BS 5480 part I, with part II about to be published.

Considerable effort during the last 10 years have also been put into the development of ISO standards. Today there are several draft proposals covering product standards and test methods that are expected to be published within a reasonable time span.

All of these standards have been written around a common design procedure which is generally accepted by the industry. The most important aspects of this design philosophy are given in the following.

3.1. LONG TERM PIPE PROPERTIES

Mechanical properties and chemical resistance of all plastic materials are time dependent. This is also the case for GRP. A very important phenomena of the long term properties of GRP is that generally a linear curve is obtained when the logarithmic decay of the property is plotted versus logarithmic time. This has been verified by tests dating as far back as 1947. The logarithmic time decay means that the drop in properties is the same from 1 to 10 hours as e.g. 1.000 to 10.000 hours.

This means that tests can be carried out for approximately one year and the results extrapolated to 10 to 50 years with a high degree of confidence.

In pipe design, there are three properties of particular importance: pipe stiffness, pressure capability and chemical resistance.

When designing in accordance to ASTM standards the properties used are obtained from experiments lasting up to 10.000 hours and then extrapolated to 100.000 hours or 50 years, which is the design lifetime. A safety factor is applied to the long term extrapolated value where applicable.

PRESSURE REGRESSION

For a pressure pipe the long term pressure capability has to be determined. Pressure regression testing is done by applying a fixed pressure to a pipe and taking the time to the first sign of leakage. By using different pressure levels, different failure times are obtained when tested according to ASTM D 2992. 18 failure points have to be generated for up to 10.000 hours and the data extrapolated to 100.000 hours. The pressure class of the pipe is obtained by applying a safety factor of 2 to the long term extrapolated value. Typically, a GRP laminate exposed to a constant load, can stand about 1/3 of the ultimate load for a 50 years period. Thus, the working stress is about 1/6 of the shortterm strength.

Pressure regression data for VEROC GRP pressure pipes with 45% filament winding and 15% chopped glass is shown in fig. 7. In this graph the loading is given as hoop strain in the pipe wall.

From the data it can be seen that after applying a safety factor of 2 the allowable pipe wall strain is approximately 0,3%. In the design of VEROC pipes a strain limit of 0,25% is used to be conservative.

CHEMICAL RESISTANCE

GRP is well known for its excellent corrosion resistance. This has been proven by testing resistance to attack by several thousand different environments. GRP pipes do not require any coatings or cathodic protection devices, maintenance of these items are likewise eliminated.

For sewer pipes the conditions inside the pipe can become quite aggressive, particularly in warmer climates. The most aggressive component is sulphuric acid, formed by the combination of water and hydrogen sulphide from sewer decay. Concentrations of up to 7% have been reported.

It is this acid that degrades cement, asbestos cement and steel pipes. Therefore, GRP with its excellent chemical resistance is now rapidly gaining popularity, particularly in regions with hotter climates like the Middle East.

Sewer pipes can see a combination of chemical attack and pipe wall bending strain. Testing is carried out by combining these two effects in the "strain corrosion" test as e.g. described in ASTM D 3681.

A ring sample is kept at a constant deflection and the bending strain at the bottom of the ring is estimated.

5% sulphuric acid is placed inside, and time recorded to failure. A minimum of 18 rings have to be tested up to 10.000 hours and the data extrapolated to 100.000 hours. According to the ASTM standard the extrapolated strain to failure is to exceed 0,5%.

Considerable research has been carried out by VEROC on the mechanism of strain corrosion failure. As a result of these investigations new laminate formulations have been developed that give superb corrosion resistance towards sulphuric acid.

Fig. 8 A and B show strain corrosion properties for VEROC gravity and pressure sewer pipes respectively.

VEROC pipes outperform the ASTM minimum requirement by almost a factor of two.

PIPES STIFFNESS

The ring stiffness of the pipe will govern the performance of the pipe for a given burial condition. The stiffness is normally measured as pipe stiffness, S, determined by loading a ring sample between parallel plates and measuring the deflection.

$$S = 0{,}0186 \text{ load/deflection} = EI/D^3 = Et^3/12D^3$$

where
- E = Youngs modulus in bending, hoop direction
- I = second moment of area of pipe wall
- t = wall thickness
- D = pipe diameter.

The minimum pipe stiffness specified by ASTM D 3262, D 3517, D 3754 and AWWA C 950 is 10 psi or calculated as given above, S = 1285 N/m2. This is also the pipe stiffness most commonly used for GRP pipes installed with non-cohesive pipe zone backfill as it gives a good compromise between wall bending strain and stability against buckling. For certain applications like lines designed for full vacuum capability, the pipe stiffness has to be increased, typically to 2500 N/m^2 to resist buckling.

The pipe stiffness will change with time, with an amount dependent upon laminate build-up, loading conditions and environment. This change is not considered in ASTM and AWWA standards. Instead the long term effects of both laminate stiffness, soil stiffness and consolidation are grouped together to one factor, called deflection lag factor, to account for long term changes of installed pipes.

In ISO drafts, however, long term pipe stiffness is currently considered. Two moduli are considered, creep modulus (viscoelastic long term modulus) and ageing modulus (elastic long term modulus). These are specified measured on rings submerged in water. Creep modulus is obtained by loading a ring sample by a dead weight and measuring deflection with time. Ageing modulus is obtained from a similar test but by deloading and relading at specified times to get short term modulus at that specific time. Typical values for Vera gravity and pressure pipes are shown in figures 9 A and B.

3.2. DESIGN OF BURIED FLEXIBLE PIPES

When a pipe is backfilled during installation the soil will load the pipe on top and bottom. With a rigid pipe this loading will result in bending moments that have to be taken up by the pipe wall. In a flexible pipe, like GRP pipes, the pipe will have little stiffness and will deflect. Because of the soils stiffness, the deflection will activate a passive resistance that acts to help support the external load. The pipe and soil act as a structural system. Since the performance of flexible piping depends upon the surrounding soil, the pipe installation must be adequate to ensure good soil support.

The ASTM standard for buried installation of GRP pipes and AWWA C 950 are considering the following three important factors for buried pipe: deflection, pipe wall strain and buckling.

DEFLECTION

The pioneering work on deflection of buried flexible pipes was started by Spangler during the 1930's. His modified equation is most commonly used to calculate deflections. Some recent work by Bureau of Reclamation in the US has lead to further refinements of Spangler's original theories.

This is the basis for the calculation method used by both ASTM and AWWA, sown below slightly rewritten.

$$\frac{\Delta y}{D} = \frac{(D_L P_C + P_L)\,K_x}{8S + 0{,}061\,E'}$$

where
- $\Delta y/D$ = vertical pipe deflection
- D_L = deflection lag factor
- P_c = vertical soil pressure on pipe
- P_L = live load pressure on pipe
- K_x = deflection coefficient
- S = pipe stiffness
- E' = modulus of soil reaction

Deflection lag factor takes care of the soil consolidation with time. This factor converts the immediate deflection of the pipe to the deflection of the pipe after many years. It varies primarily with the pipe zone backfill material, degree of compaction, native soil condition and trench geometry. The values used by VEROC is shown in fig. 10.

The vertical soil pressure on the pipe will be less than the vertical column of soil for flexible pipes. This is because of higher settlements above the deflection pipe which means that part of the vertical load will be transferred to the surrounding soil by shear. An additional soil load reduction will be experienced in deep trenches by a similar mechanism. It is difficult to deal with these effects, termed arching, since they will vary with time and could disappear. To be conservative it has been chosen to calculate the soil pressure as the vertical column of soil above the pipe.

Deflection coefficient is dependent on the type of bedding for a particular installation. It relates to the equivalent bedding angle, which is the theoretical segment of the pipe bottom over which the soil pressure is constant. Values given in AWWA is shown in fig. 11.

Values used for modulus of soil reaction are based on the work of Bureau of Reclamation. The modulus is given in terms of type of pipe zone backfill material used, classified according to "Unified soil Classification" and on the degree of compaction. Values have been derived by backcalculating from measured deflection in numerous installations. Tables with figures used by ASTM and AWWA is shwon in fig. 12.

By carrying out a computation following the above procedure the average deflection will be determined. To obtain an estimated average deflection so that there will be a 95% probability that the actual average deflection will be less than the calculated value, two procedures are specified.

Procedure A : Use values of E' equal to 0,75 times the values given in fig. 12

Procedure B : Use given equation and values in fig. 12 and add the following percentages to calculated deflection.

Degree of compaction	**Additional deflection, %**
Dumped	+ 2
Slight	+ 2
Moderate	+ 1
High	+ 0,5

The Spangler formula shows that pipe deflection is proportional to the loading and inversely proportional to the sum of pipe stiffness and soil modulus. Even for a poor soil condition of E' = 2,8 N/mm2 and the normal pipe stiffness of S_p = 1285 N/m2, the contribution of soil modulus to the stiffness of the pipe/soil system is almost 18 times higher than the stiffness of the pipe itselt. This means that, the deflection is more or less completely controlled by the installation. In fact, for the system given, the pipe stiffness must be increased by a factor of 20 to reduce the deflection to half. Deflection as a function of pipe stiffness is shown in fig. 13.

For GRP pipes the permissible deflection is normally 3% during installation and 5% long term. With these deflections the pipe will perform as if circular.

PIPE WALL STRAIN

The bending strain at the crown and invert of a pipe is commonly calculated from the following formula:

$$\Sigma = D_f \frac{dy}{D} \frac{t}{D}$$

D_f is a factor relating to the deformed shape of the pipe, called deflection factor. D_f can be calculated from the moment equations derived by Spangler using his classical soil pressure distribution. For a relatively stiff pipe, the deflection shape will be elliptical and D_f = 3. Then decreasing the pipe stiffness, the deformed shape of the pipe will be more square and D_f will increase, theoretically to quite large numbers for very flexible pipes.

Investigations by J. Molin have shown that D_f levels out at a value of about 6 for flexible pipes. This is because the Spangler soil distribution does not hold for flexible pipes. The soil pressure will redistribute with decreasing pipe stiffness to a state where the soil pressure is inversely proportional to the local radius of curvature of the pipe. Pipe stiffness will not influence the deformed shape of the pipe and thus D_f will be a constant value, see fig. 14.

The AWWA standard is written for flexible pipes, and D_f = 6 is used for estimation of pipe wall bending wall.

Pipe bending stresses will increase proportionally to the wall thickness. This means that pipe either has to be thin and flexible with deflection controlled by installation or so rigid that the deflection is controlled by the stiffness of the pipe wall. For pipes with medium stiffness the bending stresses after installation will be at a maximum. This is illustrated in Fig. 15.

For gravity pipes, the strain calculated from the above equation has to be less than the extrapolated long term strain obtained from the strain corrosion testing with the appropriate factor of safety. For a typical gravity pipe with stiffness 1285 N/m^2 installed to 5% deflection the bending strain will be 0,36% assuming t/D = 0,012 and D_f = 6. Using a safety factor of 1,5 the strain in the strain corrosion test should exceed 0,54%. This is well exceeded for VEROC pipes.

For pressure pipes, hoop tensile strains will be established in addition to the pipe wall bending strain. The bending strain will be reduced due to re-rounding of the pipe when pressurized. This is treated in the AWWA standard by using the Spangler re-rounding equation to modify the bending strain. Consideration of combined strain is carried out by adding hoop tensile strain to the reduced bending strain. The combined strain shall be less than the strain determined from the pressure regression analysis with a factor of safety of at least 1,5.

BUCKLING

Flexible pipes may buckle in the ground due to loads from the soil pressure, live load, high water table and possible underpressure due to surge effects in pressure pipes. The surrounding soil stabilizes the pipe wall and significantly increases the critical external load on the pipe. Lusher has studied this phenomena using theories of buckling of beams on elastic foundations. His theories have been rewritten and reanalysed by AWWA, as shown below.

$$q_a = \left(\frac{1}{SF}\right) (32\ Rw\ B'\ E'\ S)^{1/2}$$

where

q_a = alowable buckling pressure
SF = design factor of 2,5
Rw = water bouancy factor
B' = empirical coefficient of elastic support, currently under revision
S = pipe stiffness.

Calculations using the above formula and revised B' by AWWA is shown in fig. 16. This shows that the stiffness of 1285 N/m2 gives sifficient stability towards buckling for most burial conditions. When a pipe has to be designed for full vacuum and water table to grade, a stiffness of 2500 N/m2 can be used for most installations.

4. CONCLUSIONS

VEROC GRP gravity and pressure buried sewer and water pipes are designed and installed according to ASTM and AWWA standards.

Experience from several thousand km of installed large diameter pipe around the world shows that the pipe design specified in these standards compares well with the performance of installed pipe.

The main areas of applications are:

Sanitary sewerage systems
Storm sewerage
Water distribution
Irrigation systems
Hydroelectric power stations
Sewerage outfall lines
Water intake lines.

Figures 17 to 23 show such application in various countries.

Fig. 1 Pipe manufacturing on VEROC continuous filament winding equipment

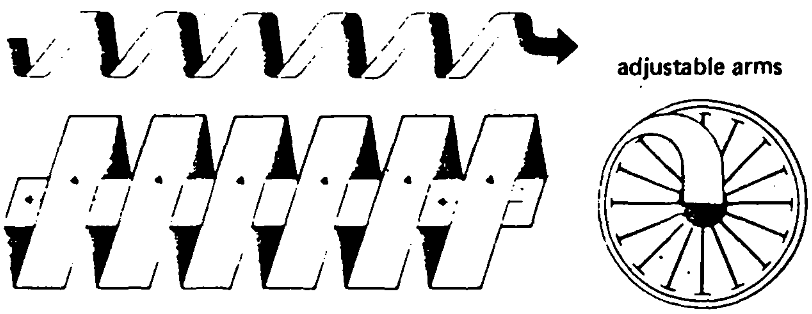


Fig. Mandrel build – up

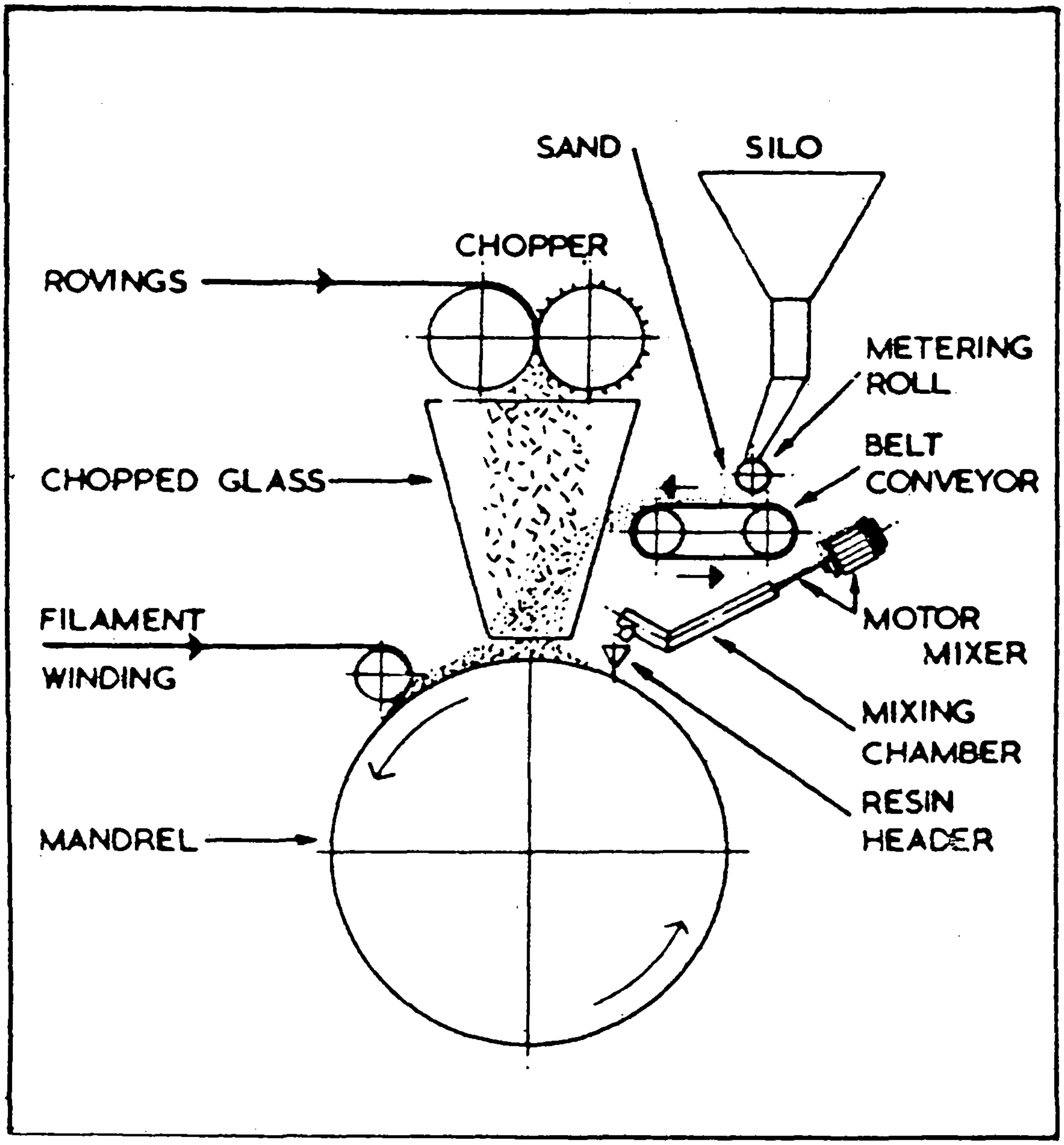


Fig. 3 Material application equipment on the Drostholm machine

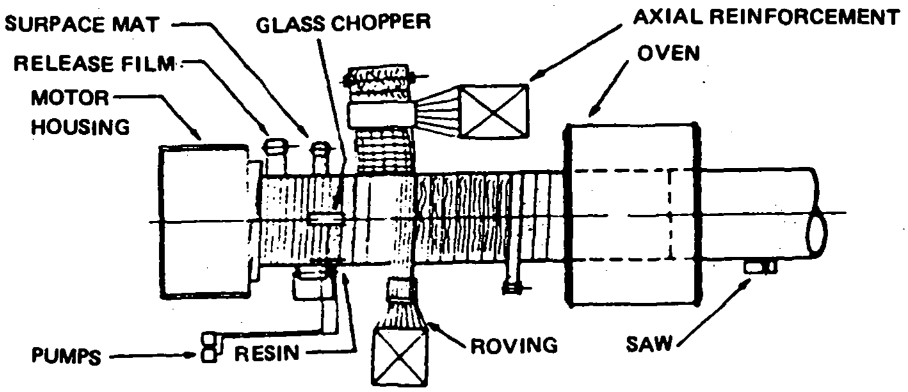
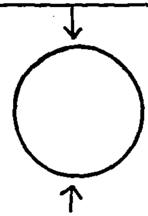
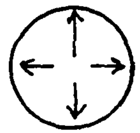
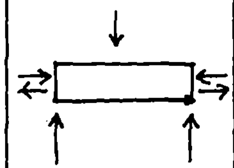
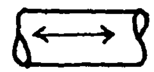


Fig. 4. Side view of winding equipment.

Type of material / Pressure class	Filament winding	Chopped glass	Aggregate	Axial Peinforcement	Resin
Gravity	2,5	10	50	0	37,5
6 bar	25	15	20	0	40
10 bar & 16 bar	45	15	0	0	40

given in % by weight

Fig. 5 Laminate composition of Veroc pipe

Property	Initial E – Modulus			Initial tensile strenght	
Type of stress / Pressure class	 ring bending	 inside pressure	 axial	 hoop	 axial
Graviry	9.000	10.000	9.000	60	40
6 bar	17.000	19.000	9.000	250	50
10 bar & 16 bar	24.000	27.000	9.000	450	50

All values are given in N/mm^2

Fig. 6 Typical short – term mechanical properties

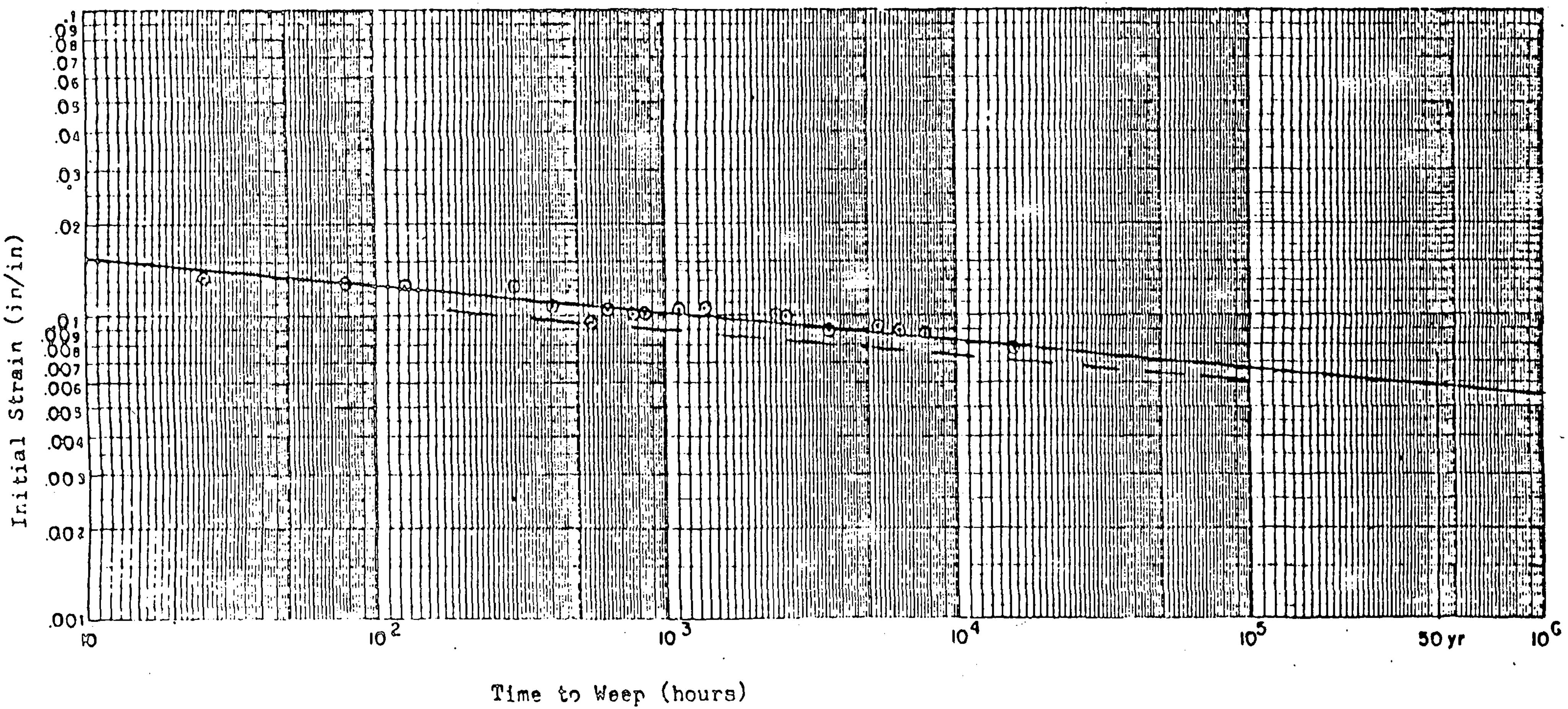


FIG. 7 PRESSURE REGRESSION TESTING OF VEROC PIPE

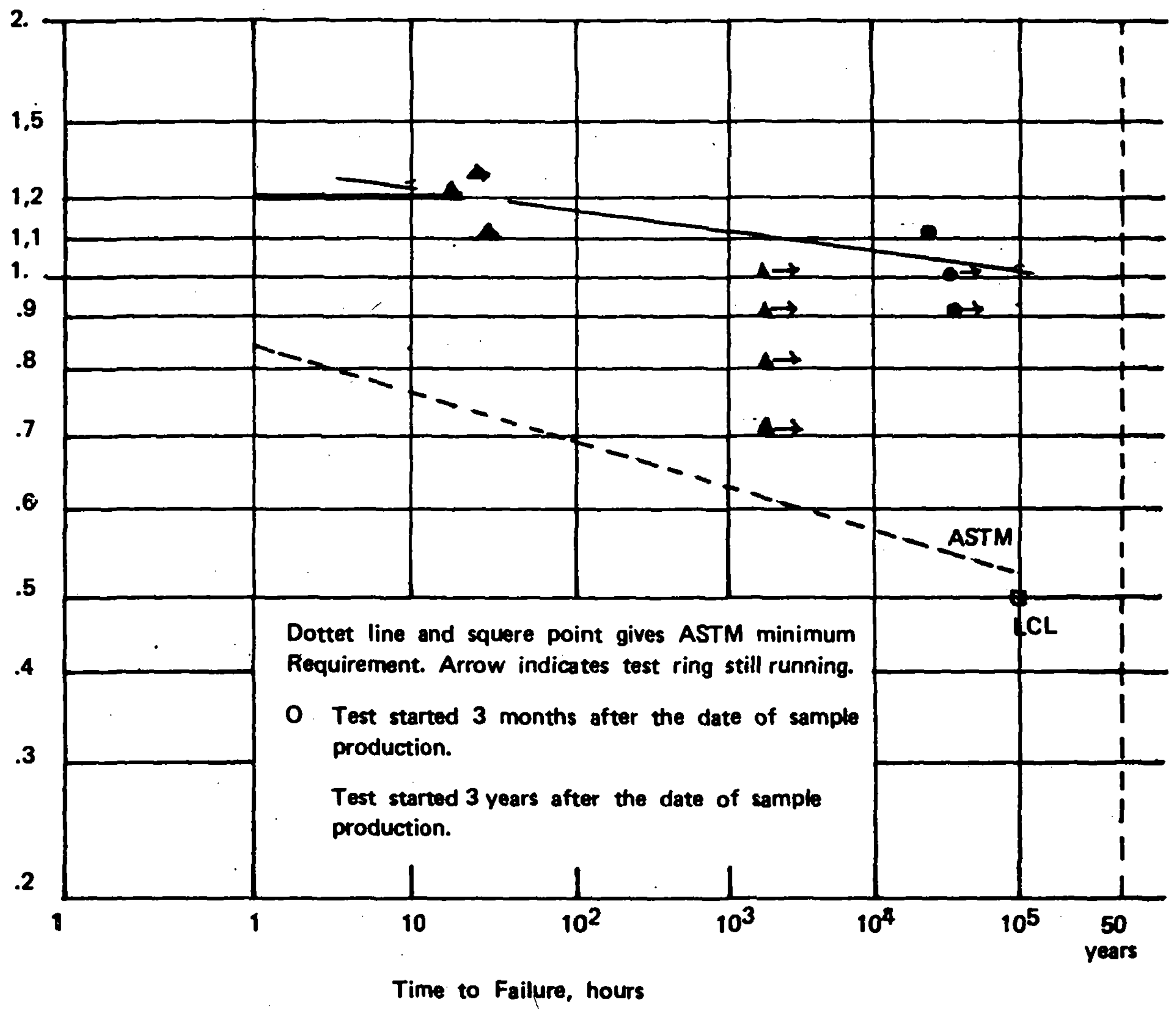


Fig. 8 A Strain corrosion performance of Veroc gravity sewer pipe

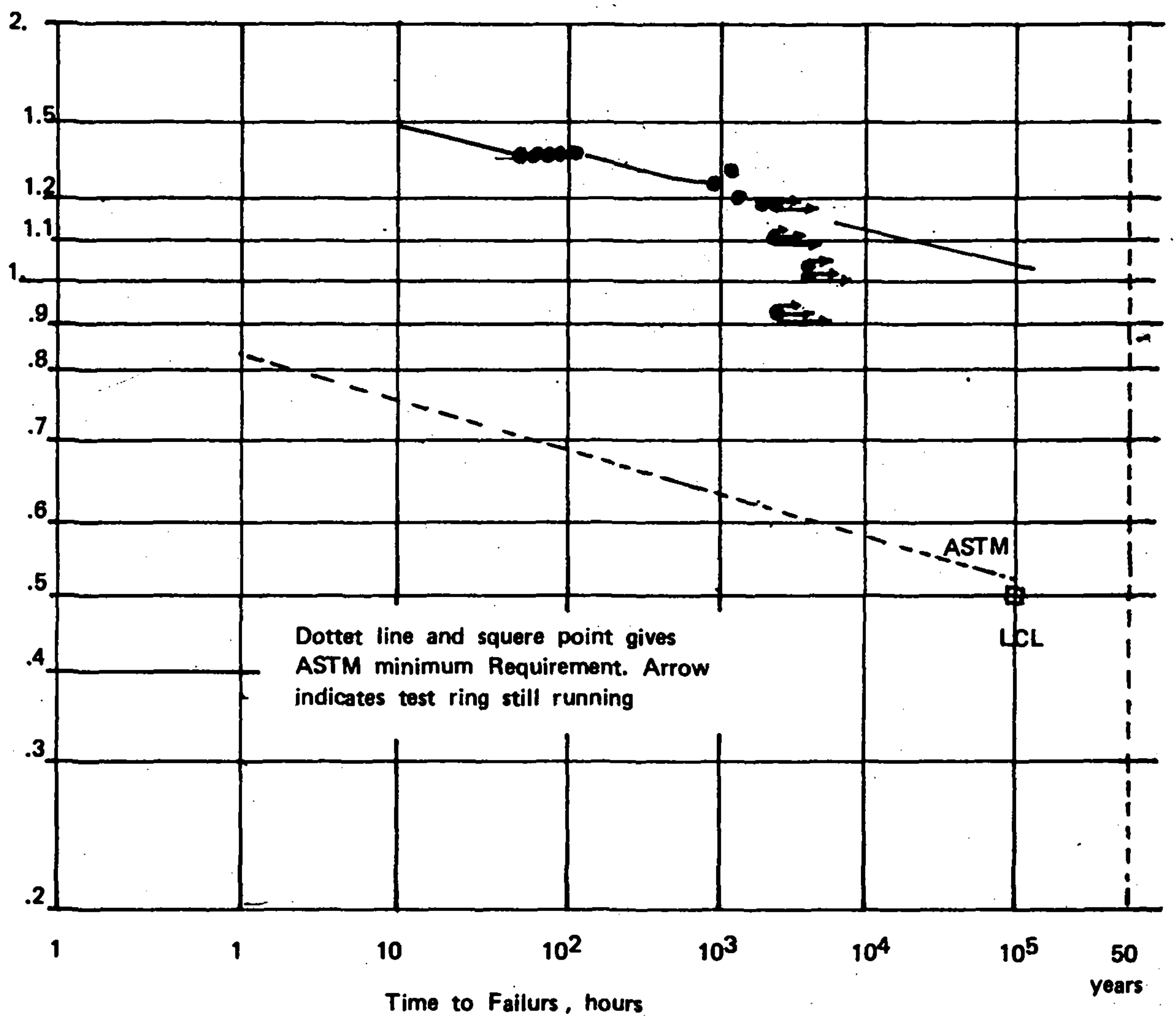


Fig. 8 B Strain corrosion performance of Veroc pressure sewer pipe.

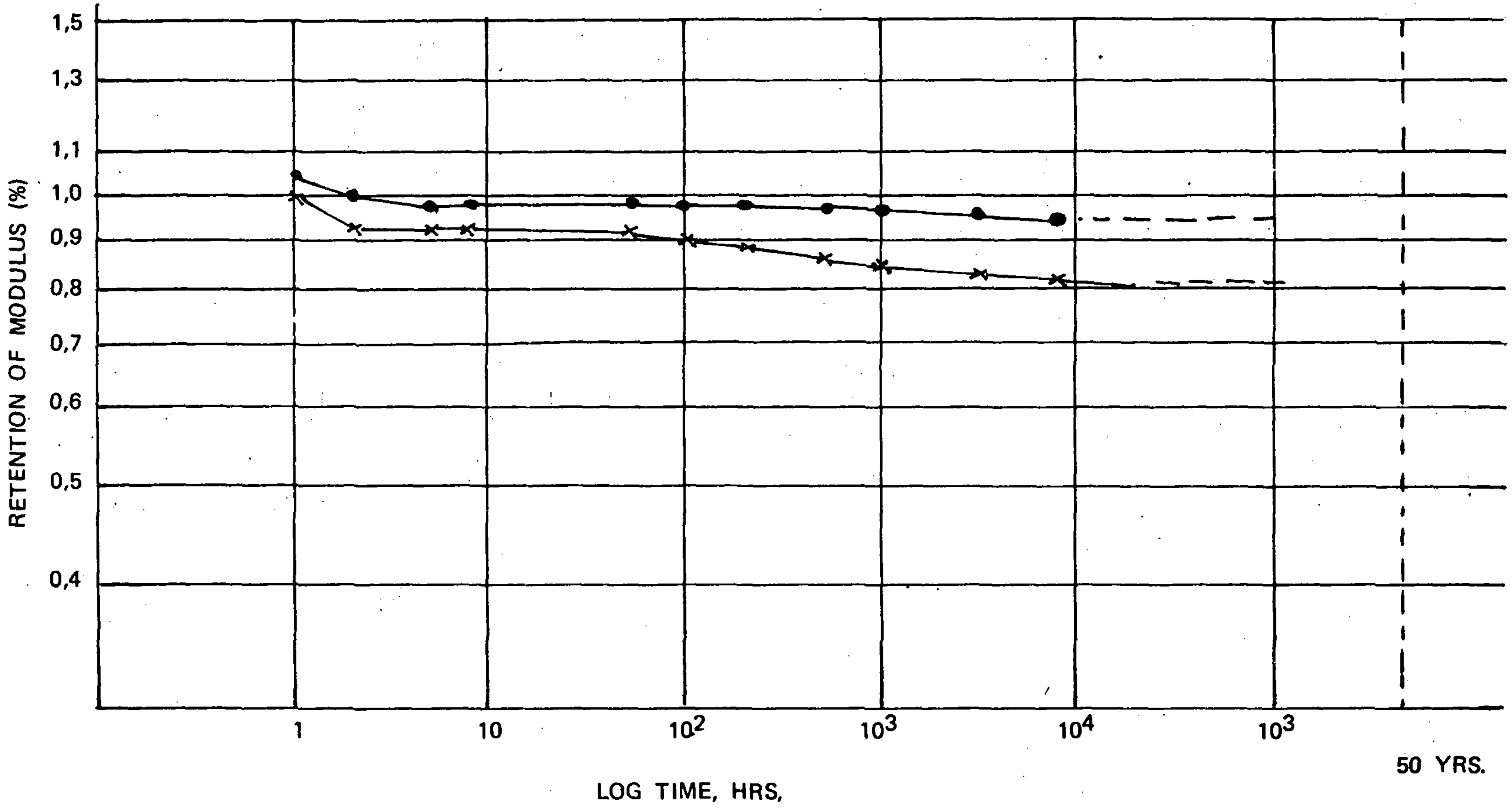


FIG. 9A. CREEP AND REAL MODULUS US TIME FOR VEROC PRESSURE PIPE

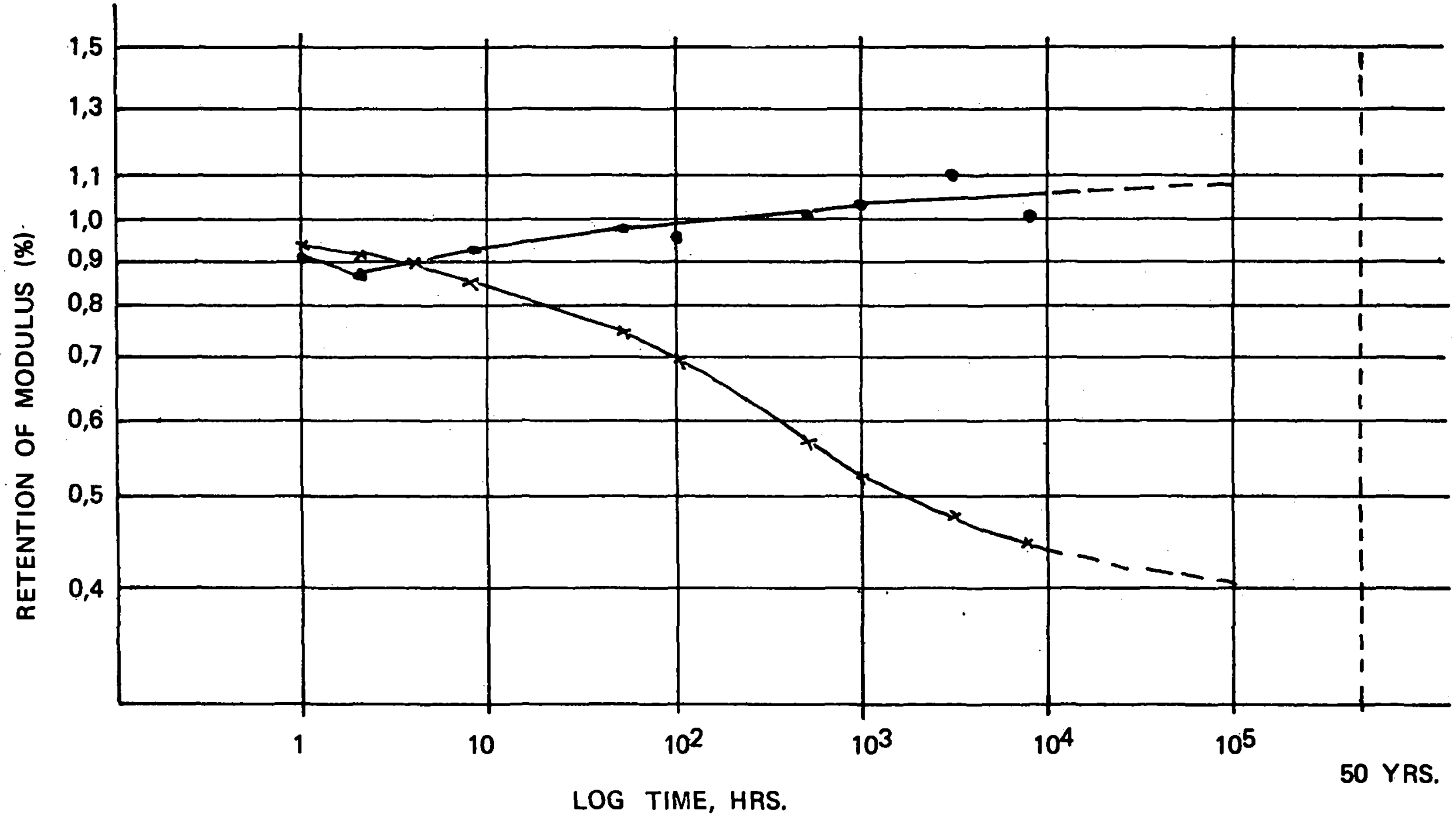


FIG. 9B. CREEP AND REAL MODULUS US TIME FOR VEROC GRAVITY PIPE

VALUES FOR D_1

			NATIVE SOIL				
			Coarse Grained Soils		Cohesive Material		
			Gravels GW, GP	Sands SW, SP	Low Compressibility Greater than SM, SC	Low Compressibility Less than 25% sand CL, ML	Figh Compressibility CH, MH, OL, OH, Pf
Pipe Zone Material	Coarse Grained Soils	Gravels GW, GP	1	1	1.5	1.75	2.0
		Sands SW, SP	1	1	1.5	1.75	2.0
	Cohesive Materials	Low Compressibility Greater than 25% sand SM, SC	1.5	1.5	1.6	1.75	N/R
		Low Compressibility Less than 25% sand CL, ML	2.0	2.0	2.5	3.0	N/R
		High Compressibility CH, MH, CL, OH, Pt	N/R	N/R	N/R	N/R	N/R

Note – N/R in above table indicates "not recommended"

Fig. 10 Deflection lag factor, D_L

Note – For h/D 0,5 or h less than 0,9 m, multiply D_1 with a factor of 1,5.

Type of Installation	Equivalent Bedding Angle θ^b *degrees*	Deflection Coefficient K_x	Moment Coefficient K_b
Shaped bottom with tamped backfill material placed at the sides of the pipe : 95% Proctor density or greater	180	0.083	0.125
Comparted coarse-grained shaped bedding with backfill material placed at the sides of the pipe : 70% - 100% relative density	180	0.083	0.125
Shaped bottom, moderately compacted, with backfill material placed at the sides of the pipe : 85% - 95% Proctor density	60	0.103	0.189
Coarse-grained shaped bedding, with lightly compacted backfill material placed at the sides of the pipe : 40% - 70% relative density	60	0.103	0.189
Flat bottom, with loose backfill material placed at the sides of the pipe (not recommended); less than 35% Proctor density; less than 40% relative density	0	0.110	0.294

a Values of K_x dan K_b can be taken from this table based on the description of the type of installation and the equivalent bedding angle.

b Equivalent bedding angle shown can be assumed to result for a given E value without special bottom shaping, provided that at least one lift of backfill material placed at the sides of the pipe is compacted below the spring-line of the pire in place.

Fig. 11 Deflection coefficients

Soil Type-Primary Pipe Zone Back-Fill Material (Unified Classification System)[b]	*E'* for Degree of Compaction of Bedding, *psi (MPa)*			
	DUMPED	SLIGHT 85% Proctor 40% rel. den.	MODERATE 85–95% Proctor 40–70% rel. den.	HIGH 95% Proctor 70% rel. den.
Fine-grained Soils (LL 50f Soils with medium to high plasticity CH, MH, CH - MH	Soils in this category require special engineering analyis to determine required density. moisture content. compactive effort.			
Fine-grained Soils (LL 50) Soils with medium to no plasticity CL, ML, ML-CL, CL-CH, ML-MH. with less than 25% coarse-grained particles	50 (0.34)	200 (1.4)	400 (2.8)	1000 (6.9)
Fine-grained Soils (LL 50) Soil with medium to no plasticity CL, ML, ML-CL, CL-CH, ML-MH. with more than 25% coarse-grained particles *Coarse-grained Soils with Fines* GM, GC, SM, SC[d] containing more than 12% fines	100 (0.69)	400 (2.8)	1000 (6.9)	2000 (13.8)
Coarse-grained Soils with Little or No Fines GW, GP, SW, SP[d] containing less than 12% fines	200 (1.4)	1000 (6.9)	2000 (13.8)	3000 (20.7)
Crushed Rock	1000 (6.9)	3000 (20.7)		
Accuracy in Terms of Difference Between Predicted and Actual Average Percent Deflection	± 2%	± 2%	± 1%	± 0,5%

a. As determined by the US Water and Power Resources Service
b. ASTM Classification D2487.
c. LL = Liquid limit.
d. Or any bordeline soil beginning with one of these symbols (i.e. GM-GC. GC-SC).

NOTE 1 : Values applicable only for fill less than 50 ft (15m).
NOTE 2 : For use in predicting initial deflections only, appropriate Deflection Lag Factor must be applied for long-term deflections.
NOTE 3 : Percent Proctor based on laboratory maximum dry density from test standards using about 12 500 ft-lbf/ft^3 (598 000 J/m^3) (Method D698. AASHO T-99).

Fig. 12 Average values a of modulus of soil reaction E'

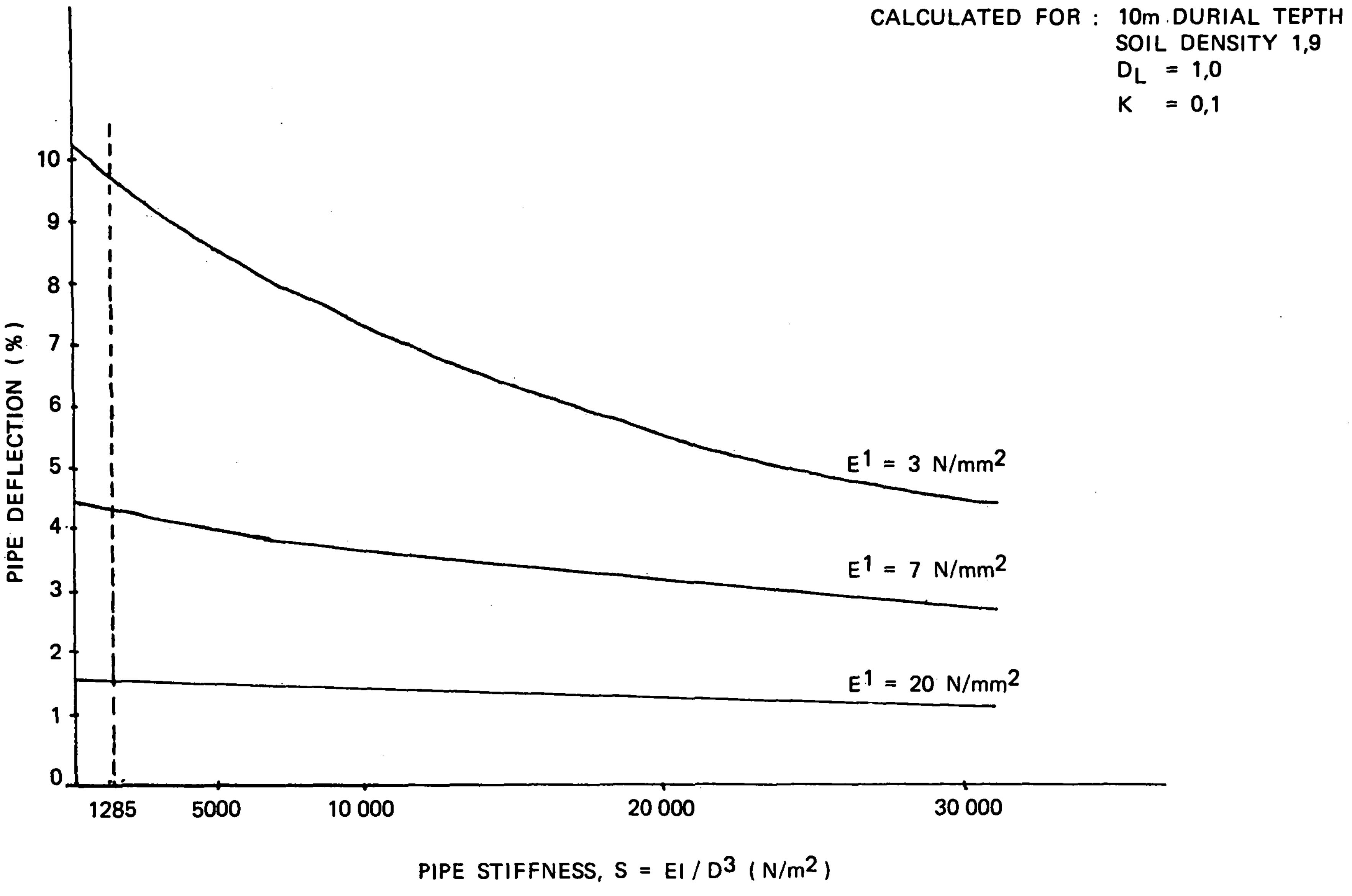


FIG. 13. RELATIVE DEFLECTION (%) AGAINST PIPE STIFFNESS

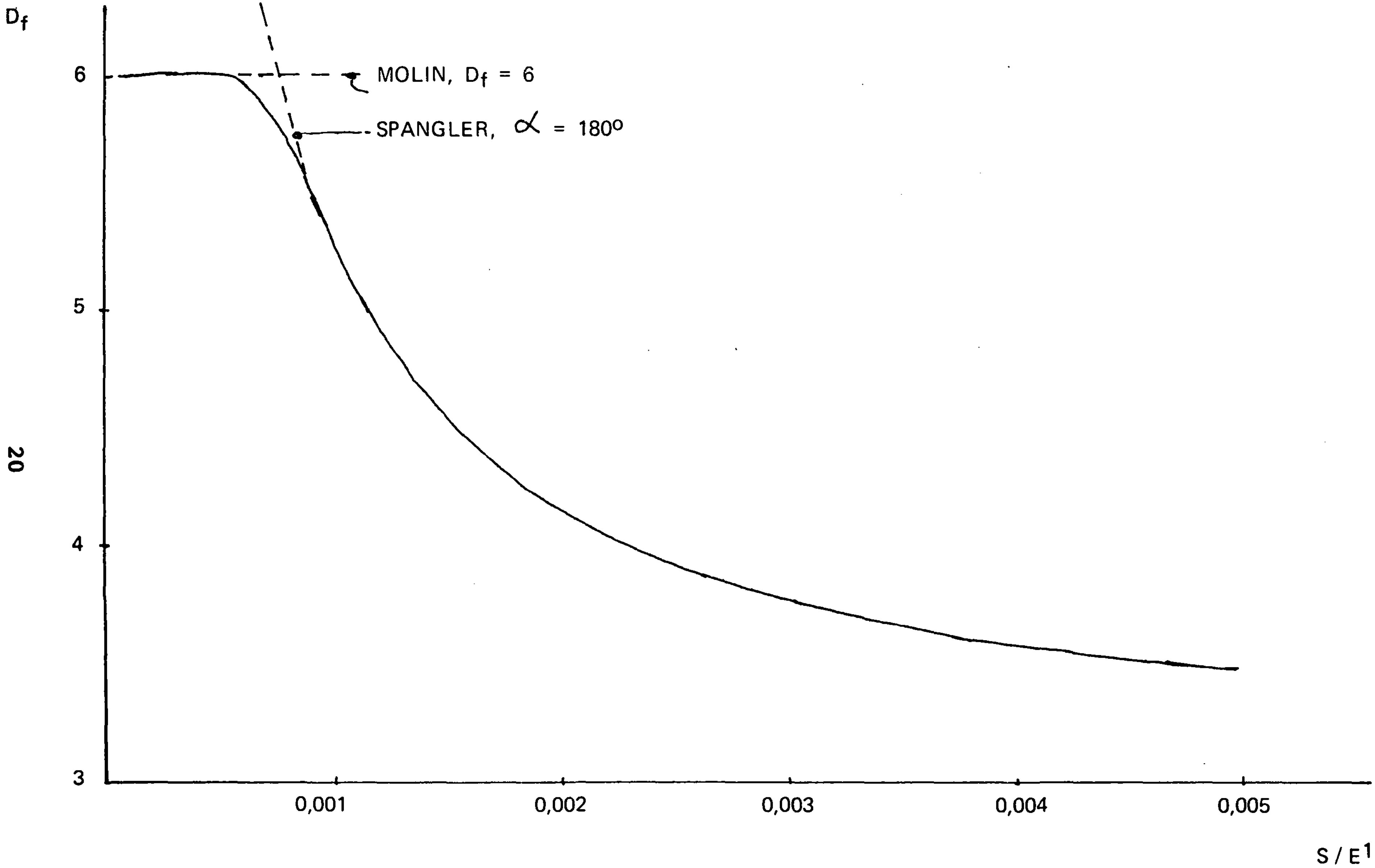


FIG. 14 DEFLECTION FACTOR D_f VERSUS PIPE STIFFNESS/SOIL MODULUS

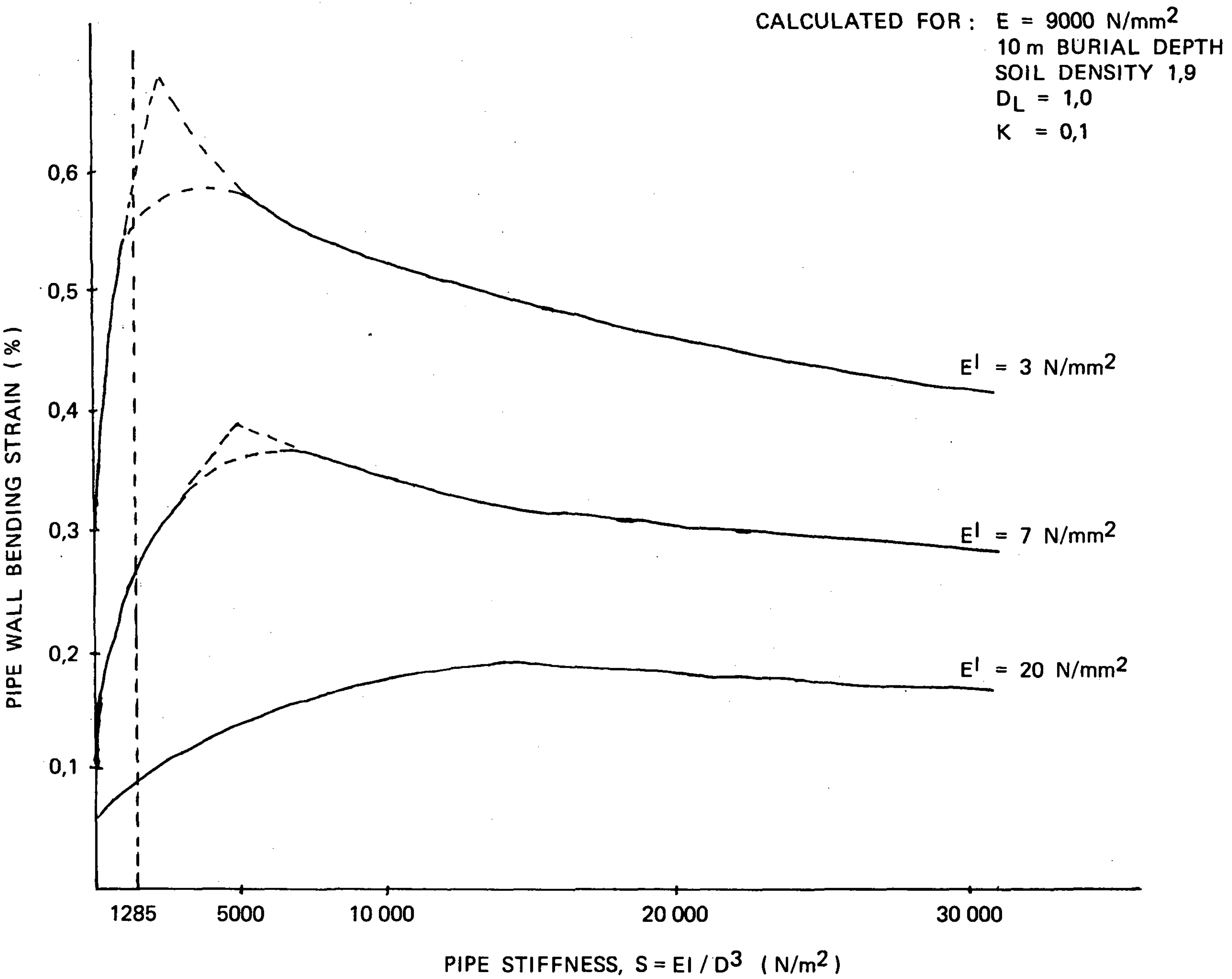
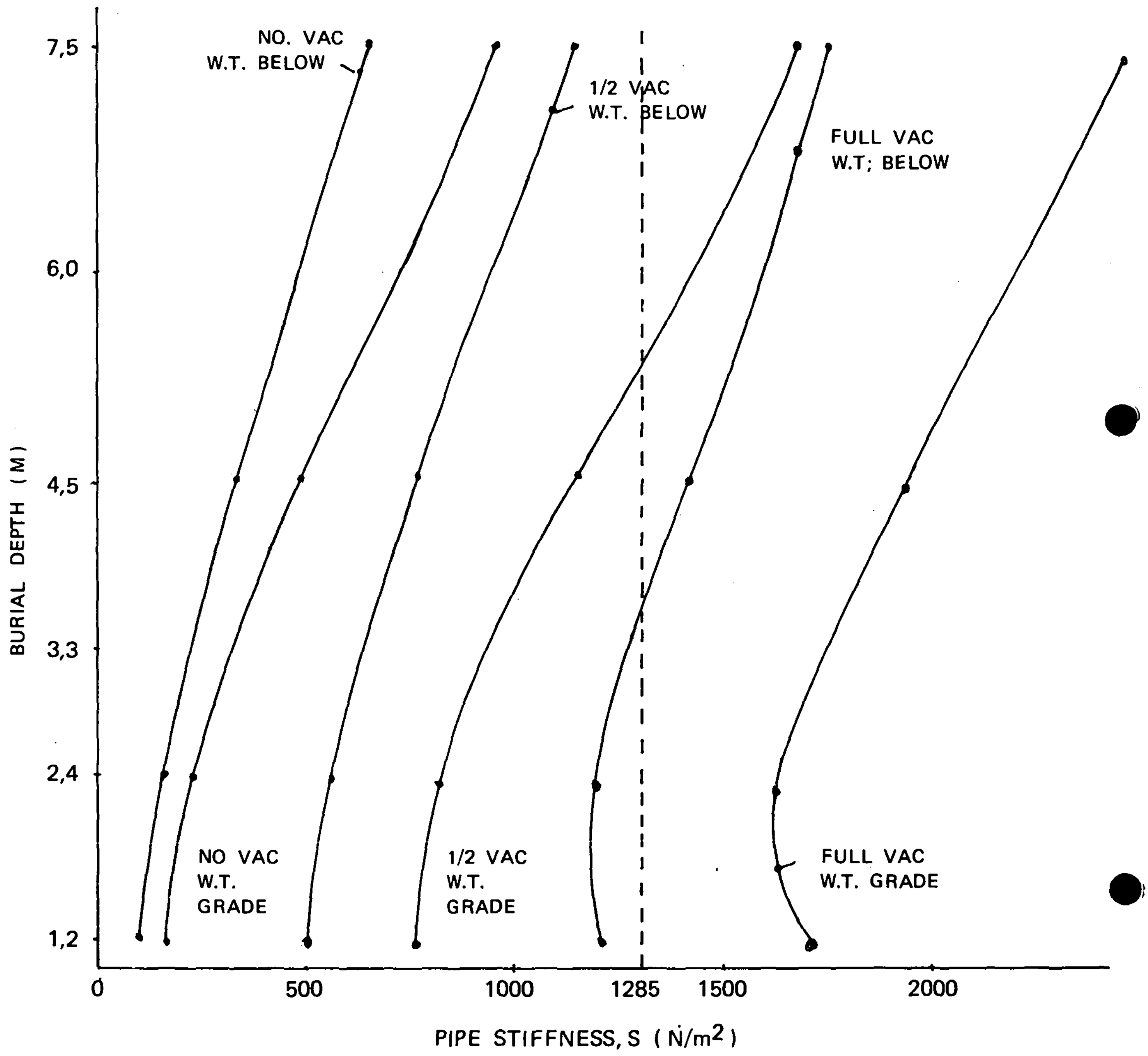


FIG. 15 PERCENTAGE WALL STRAIN AGAINST PIPE STIFFNESS



W.T. = WATER TABLE
VAC = VACUUM

FIG. 16 REGUIRED STIFFNESS TO RESIST BUCKLING WITH SF = 2,5 ACCADING TO PROPOSED AWWA REVISION.

Figure 17. Installation of sanitary sewerage system in Abu–Dhabi. Pressure, gravity to 10 bars. Total length 90 km. Diam. 1200 – 1300 mm.

Figure 18. Storm sewerage project 1600 mm, used to close a creek along a main road in Norway.

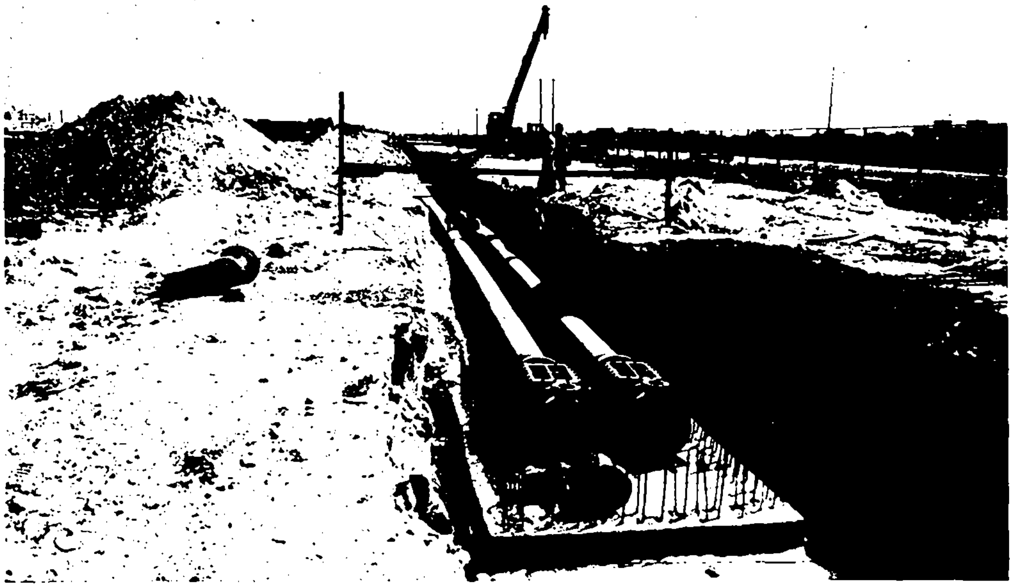


Figure 19. Water distribution pipeline, 600 mm, 10 bar operating 6 km length in Kuwait.

Figure 20. Installation of 600 mm, 12 bar operating pressure irrigation pipeline for agricultural use. Total length in this project 12 km.

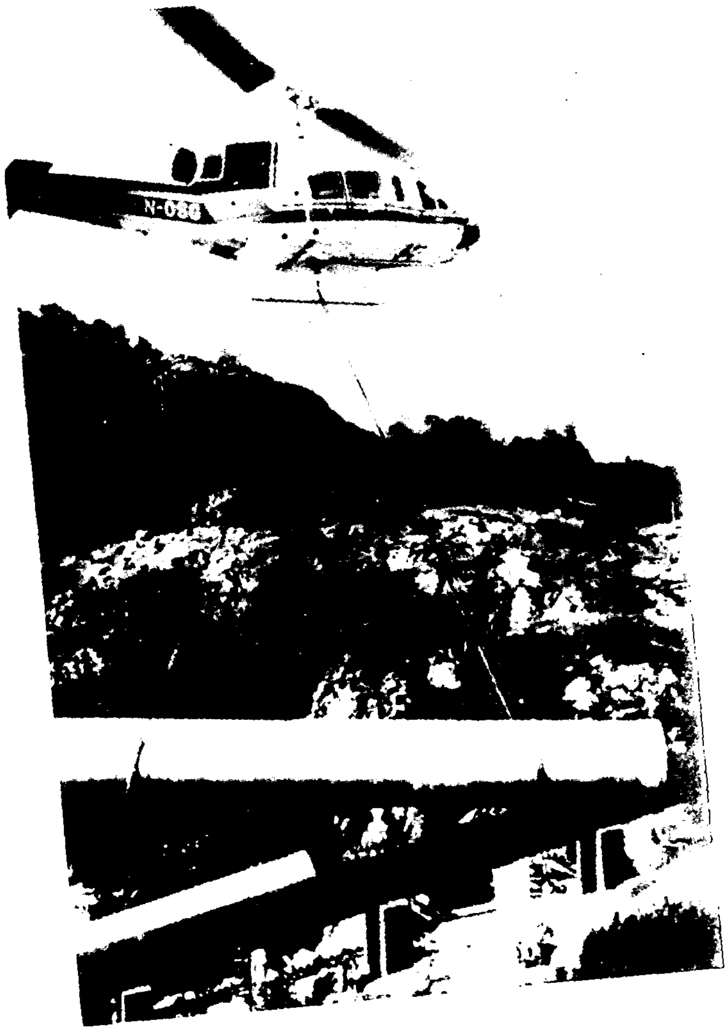


Figure 21. Installation of penstock pipe for hydroelectric power station, 1600 mm diam., 10 bar operating pressure, in Norway.

Figure 22. Sewerage outfall under installation.
800 mm diam., total lenght 1600 m, at 40 m depth.
Discharge of sewerage from the town of Sandefjord in Norway.

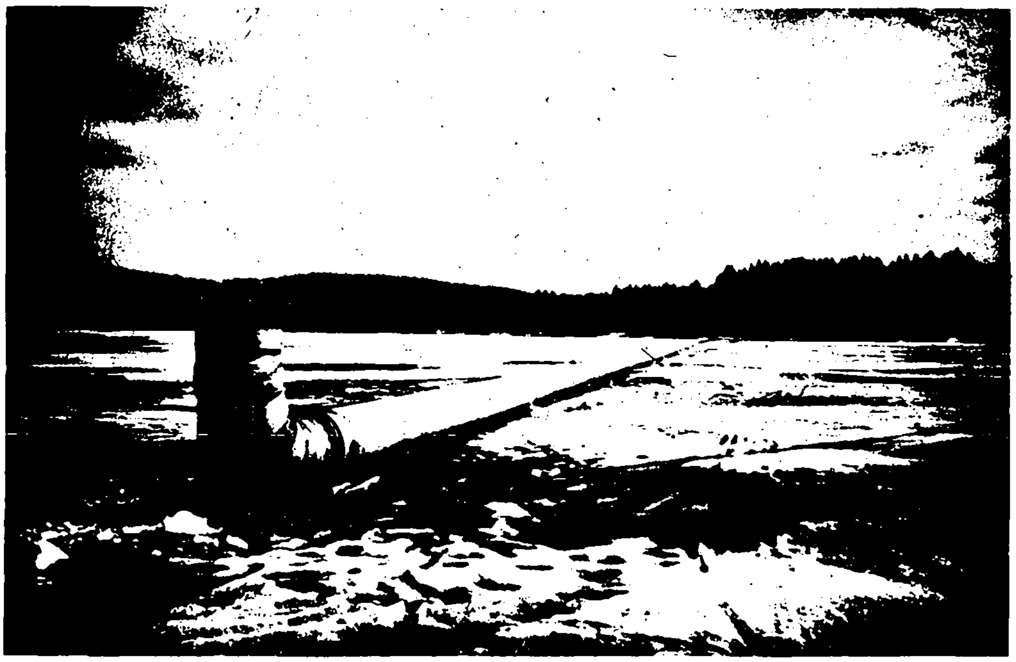


Figure 23. Water intake line, 1100 mm diam., under installation, from an ice–covered lake in Norway.

HYDRAULIC MODEL STUDY ON GROUND WATER PROBLEMS

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Water Resources Planning Commission
M.O.E.A., R.O.C.

4[TH] Asia Pacific Regional
Water Supply
Conference & Exhibition
Jakarta, Indonesia
5-11 November 1983

TIRTA DHARMA

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ABSTRACT

Increased demands for water have stimulated development of more dependable yet economical water resources. Continuous draft from stream flow at all seasons is limited because of its uneven flow. Again, most large rivers are polluted by wastes discharged from communities and industries. In order to improve those worse conditions, the Taiwan Water Supply Corporation is planning to construct two infiltration galleries (underground weirs) which are imbeded into alluvial deposits of Kou-Ping River to intercept the underflow. They are 1.65-m in diameter, 1500-m in length, and laid 8-m deep from river bed, more or less at right angles to the direction of river flow for carrying entrant water to pumping stations. Water is drawn into more or less horizontal conduits from all sides to yield as much as 360,000 tons of water daily. However, this internal disturbance will yield a reaction to both the surface and ground water flow system. In order to answer this question a vertical 1:50 scale and a horizontal 1:1500 scale Hele-Shaw model were constructed to simulated the vertically and horizontally two-dimensional flow process of reactions. Further more, a sectional sand model 1:40 in scale to simulate the longitudinal profile of river flow was constructed to study the processes of seepage distance and interaction between surface and underflow. Finally, a sectional model of infiltration gallery itself, 1:5 in scale, was built to study the clogging effect during infiltration process. The results indicate that it can be effectively applied to both the feasibility and design study of the project which will be constructed in the near future.

INTRODUCTION

The project which was proposed by Taiwan Water Supply Corporation is planning to construct two infiltration galleries (underground weirs) imbeding into alluvial deposits of Kou-Ping River to intercept the underflow. They are 1.65-m in diameter, 1500-m in length, and laid 8-m deep from river bed, more or less at right angles to the direction of river flow for carrying entrant water to pumping stations. Water is drawn into more or less horizontal conduits from all sides to yield as much as 360,000 tons of water daily (4.229 cms). However, this internal disturbance will yield a reaction to both the surface and groundwater flow system.

The complicated ground water problems that cannot be solved satisfactorily by analytical methods are exclusively verified by means of model techniques. In order to answer the question stated above, hydraulic models were applied to study the problems.

FIELD CHARACTERISTICS AND TEST APPROACH

1. Field Characteristics
   (1) river bed
   0 - 10 m depth from the bed: composited of gray silty sand with gravel
   10 - 20 m depth from the bed: composited of yellowish brown gravel, wealthing gravel and coarse sand
   (2) d_{50} = 0.5 - 1.5 mm
   (3) uniform coefficient : 110
   (4) specific weight 2.72, unit weight : 2.22 Ton/m^3
   (5) void ratio 0.36, porosity 0.27
   (6) depth of aquifer > 20 m
   (7) groundwater table : 1 m lower than river bed; grandient 1/1450
   (8) mean coefficient of permeability : 1.57 x 10^{-3} m/sec

2. Test Approach

The physical picture of filtration flows and the fields of their application are so different from the free flow that they are usually studied separately. Gravitational liquid, which forms the subject of filtration is continuously occupying the pores of the granular (or porous) medium. The characteristics of flow through porous media involved Reynolds' number, porosity and geometric properties of granular material can not be solved satisfactorily by theorical analysis. The tests are classfied into three stages, ie: pilot test, verification test and detailed test.

(1) Pilot test

A vertical 1:50 scale and a horizontal 1:1500 scale Hele-Shaw model were constructed to simulate the vertically and horizontally two-dimensional flow process.

(2) Verification test

A sectional sand model 1:40 in scale to simulate the longitudinal profile of river flow was constructed to study the processes of seepage distance and interaction between surface and underflow as well as to verify the results obtained from pilot test.

(3) Detailed test

A sectional model of infiltration gallery itself, 1:5 in scale, was built to study the clogging effect during infiltration process.

PILOT TEST - HELE-SHAW MODEL STUDIES

1. Vertical Hele-Shaw Model Apparatus

(1) Similarity

If a viscous liquid flows between two closely spaced parallel plates forming a narrow channel, its movement is analogous to that of groundwater flow in a two dimensional cross-section of an aquifer. With laminar flow between two parallel plates, it can be shown that the flow lines form a two-dimensional potential flow field. The derivation follows from the generalized Navier-Stokes equations of motion. For study flow with the Dupuit assumptions, the mean velocity of flow in the model is

$$V = \frac{b^2 \rho g}{12 \mu} \cdot \frac{dh}{dx} \qquad (1)$$

Where V is the mean velocity of flow

b is the distance between two plates

ρ is the density of fluid

μ is the viscosity of fluid

g is the acceleration of gravity

$\frac{dh}{dx}$ is the surface slope

It can satisfy Darcy's Law:

ie : $$V = -K \frac{dh}{dx} \qquad (2)$$

Where K is the coefficient of permeability of aquifer.

From the analogy to Darcy's law it follows that the plate spacing and fluid can be selected to correspond to a desired permeability. The velocity ratio between model and prototype is

$$V_r = \frac{V_m}{V_p} = K_r \qquad (3)$$

Which, together with a given length scale factor L_r of the model, enables the time ratio to be found from

$$T_r = \frac{L_r}{V_r}$$

However, the requirement of constant ρ and μ in order to have potential flow in the model is hard to satisfy because it is difficult in many cases to keep the temperature of the fluid in the model constant and because the viscosity of most liquid is very much temperature dependent.

(2) Design of Model

(1) Scale

The model was designed with length ratio 1:50 and the distance between two plates is 1mm. The relationships between model and prototype are shown in Table 1.

Table 1 The relationships between model and prototype, Vertical Hele-Shaw model.

Item	Relationships	Ratio
Length	Xr = Xm/Xp	1 : 50
Vertical	Zr = Zm/Zp	1 : 50
Permeability	Kr = Km/Kp	1 : 1.725×10^{-3}
Potential gradient	Sr = Zr/Xr	1 : 1
Mean velocity	Vr = Kr • Sr	1 : 1.725×10^{-3}
Unit discharge	qr = Vr • Zr • 1	1 : 8.628×10^{-2}
Width	br = bm/bp	1 : 1.5×10^{6}
Total discharge	Qr = qr • br	1 : 1.294×10^{5}

(ii) Model extent

The vertical Hele-Shaw model covered the analogy reach of 280 m above and 500 m below from the pumping station. Plate 1 shows the Vertical Hele-Shaw Model

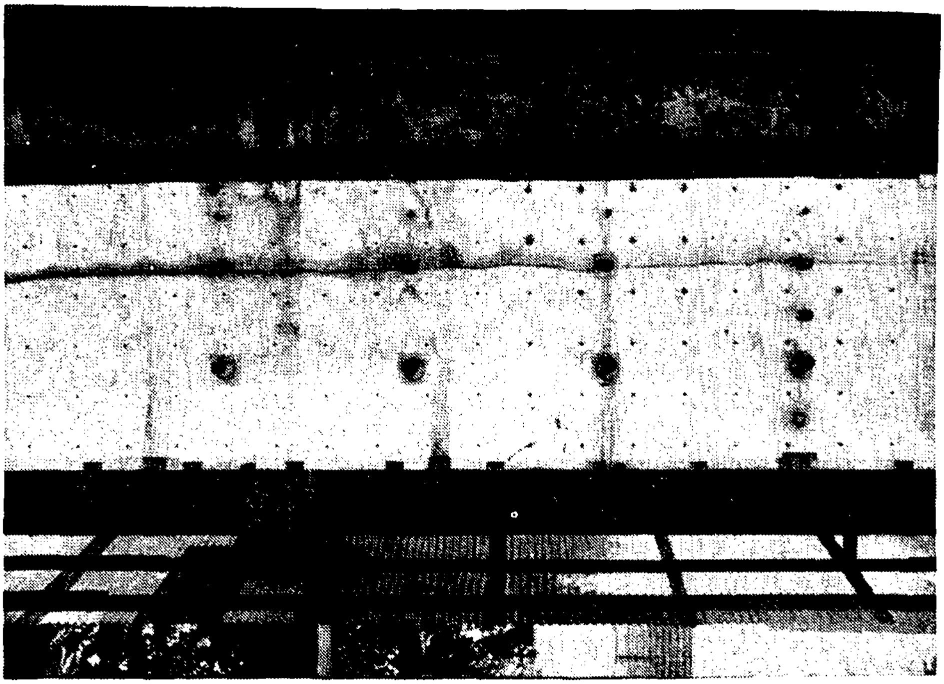

Plate 1 Vertical Hele-Shaw Model

(3) Basic Assumptions

The head difference between 280 m upstream and 200 m downstream from pumping station is adjusted to match the watertable gradient 1/1450.

(4) Test Results

The test results of vertical Hele-Shaw model studies are listed in Table 2. However, the result of the radius of influence area was derived from parabolic equation to complete the drawdown curve.

Table 2 Test results of vertical Hele-Shaw model studies

Discharge of aquifer : 0.60 cms

Design pumped discharge:

<u>Single gallery</u>

discharge of aquifer at downstream : 0.59 cms

water table drawdown at 220 m downstream : 0.60 m

radius of influence area : 260 m

<u>Double galleries</u>

discharge of aquifer at downstream : 0.57 cms

water table drawdown at 220 m downstream : 1.60 m

radius of influence area : 350 m

Maximum pumped discharge

<u>Single gallery</u>

probably pumped discharge : 7.00 cms

discharge of aquifer at downstream : 0.54 cms

water table drawdown at 220 m downstream : 4.90 m

radius of influence area : 1460 m

<u>Double galleries</u>

probably pumped discharge of upstream gallery : 8.00 cms

probably pumped discharge of downstream gallery : 4.30 cms

discharge of aquifer at downstream : 0.53 cms

water table drawdown at 220 m downstream : 5.30 m

radius of influence area : 1930 m

2. Horizontal Hele-Shaw Model Apparatus

(1) Similarity

In accordance with the similarity stated in the Vertical apparatus, the horizontal apparatus of Hele-Shaw model should satisfy:

$$Qr = Kr \cdot Xr^2 \qquad (4)$$

$$Sm\ Am = \pi r_m^2 \cdot 1 \qquad (5)$$

Where Qr: discharge ratio
Kr: ratio of permeability coefficient
Xr: horizontal scale
Sm: storage coefficient in model
Am: area of storage vessel in model
r_m: radius of model vessel

(2) Design of Model

(i) Scale

The model was designed with the length ratio 1:1500 and the distance between two plates 1 mm. The relationships between model and prototype are shown in table 2.

Table 3 The relationships between model and prototype, Horizontal Hele-Shaw model.

Item	Relationships	Ratio
Length	Xr=Xm/Xp	1 : 1500
Width	br=bm/bp	1 : 1500
Permeability coefficient	Kr=Km/Kp	1 : 1.25×10^{-3}
Storage coefficient	Sr=Sm/Sp	1 : 1
Unit Discharge	qr=VrAr	1 : 2.588
Vertical	Zr=Zm/Zp	1 : 2×10^4
Total Discharge	Qr=qr·Zr	1 : 5.177×10^4

(ii) Model Extent

The horizontal Hele-Shaw model covered the analogy reaches of 900m above and below from the pumping station. Plate 2 shows the Horizontal Hele-Shaw Model

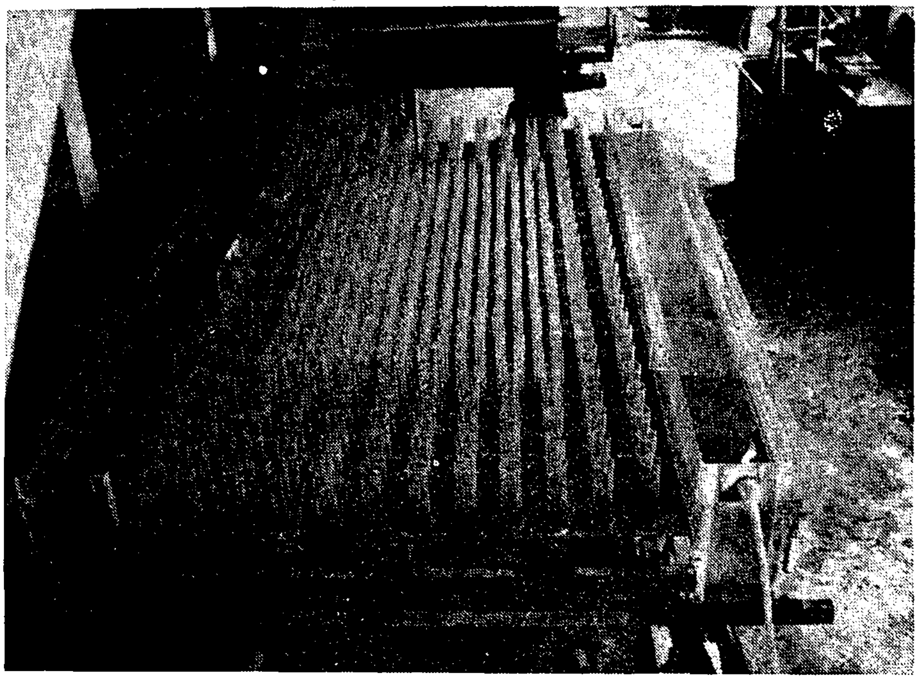

Plate 2 Horizontal Hele-Shaw Model

(3) Basic Assumptions

The gradient of ground water table was adjusted to match 1/1450.

(4) Test Results

The test results of horizontal Hele-Shaw model studies are listed in table 4.

Table 4 Test results of horizontal Hele-Shaw model studies

Design pumped discharge
<u>Single gallery</u>
discharge of aquifer at downstream: if
i)upstream gallery pumped : 0.58 cms
ii)downstream gallery pumped : 0.58 cms
radius of influence area : 730 m

Double galleries

discharge of aquifer at downstream : 0.546 cms

radius of influence area : 730 m

Maximum pumped discharge

Single gallery

probably pumped discharge : upstream gallery 3.39 cms
downstream gallery 3.05 cms

discharge of aquifer at downstream

upstream gallery pumped : 0.55 cms

radius gallery pumped : 0.57 cms

radius of influence area : 850 m

Double galleries

probably pumped discharge : upstream gallery : 3.29 cms
downstream gallery : 2.69 cms

discharge of quifer at downstream : 0.53 cms

radius of influence area : 850 m

VERIFICATION TEST - SAND MODEL STUDIES

1. Similarity

The flow through a porous medium of a specified geometry must be a certain function of the Reynolds number, Re, and of porosity coefficient, n , It can be expressed in dimensionless form as :

$$\pi A = \varphi A\ (Re,\ n) \qquad (5)$$

and

$$Re = \frac{VD\rho}{\mu} \qquad (6)$$

Where v is the filtration velocity

D is the selected typiscal grain diameter of the porous medium.

Consider the Bernouilli trinomial

$$H = \frac{v^2}{2g} + \frac{P}{\gamma} + Z \qquad (7)$$

Where $\frac{V}{2g}$ is the velocity head

$\frac{P}{\gamma}$ is the pressure head

then the energy gradient can be expressed as follows:

$$J = \frac{dH}{dX} = \frac{d(\frac{P}{\gamma} + Z)}{dX}$$

Where: X is the direction of the flow, The fact that $\frac{V^2}{2g}$ is negligible implies that the energy gradient $\frac{dH}{dX}$ (of a gradually varying filtration flow) coincides with the slope of the free surface (if it exists).

Let the property A under investigation be the gradient of the total pressure $P + \gamma Z$. We have:

$$A = \gamma J$$

Using ρ, V and D as basic quanties, yield dimensionless energy gradient as

$$\pi_j = \rho^{-1} V^{-2} D^1 \gamma J = \frac{\gamma JD}{\rho V^2} = \varphi J \text{ (Re, n)} \quad \text{———— (8)}$$

In the case of small values of Re, the contribution of inertia forces on the formation of the energy gradient J is negligible in comparison to that of the viscous friction forces. Thus, the parameter ρ must vanish from the relation in Eq.8, but μ must remain. It is obvious that such a requirement can be fulfilled only if the function in Eq.8 has the following form:

$$\varphi_J(\text{Re; n}) = \frac{\varphi_1(n)}{\text{Re}}$$

Thus, for small values of Re, the law of filtration can be expressed as

$$\pi_j = \frac{\gamma JD}{\rho V^2} = \frac{\varphi_1(n)}{\frac{\rho VD}{\mu}} \quad \text{———————— (9)}$$

or as

$$V = \left[\frac{1}{\varphi_1(n)} \cdot \frac{\gamma D^2}{\mu} \right] J \qquad (10)$$

which is nothing else but the well-known Darcy law

$$V = KJ$$

where K is the coefficient of permeability

ie :
$$K = \left[\frac{1}{\varphi_1(n)} \cdot \frac{\gamma D^2}{\mu} \right] \qquad (11)$$

The function of two variables $\pi_J = \varphi_J(Re, n)$ can be represented by the following form:

$$\frac{1}{2} \pi_J = \frac{1}{n^6} \left(0.01 + \frac{1}{Re}\right) \qquad (12)$$

It should satisfy in the model as well as in the prototype. ie:

$$\frac{1}{2} \pi_{Jp} = \frac{1}{n_p^6} \left(0.01 + \frac{1}{Re_p}\right) \qquad (13)$$

and
$$\frac{1}{2} \pi_{Jm} = \frac{1}{n_m^6} \left(0.01 + \frac{1}{Re_m}\right) \qquad (14)$$

one has to satisfy in addition

$$\lambda_{\pi J} = \frac{\pi_{Jm}}{\pi_{Jp}} = 1 \qquad (15)$$

form Eq.13 and 14, yield

$$\frac{\pi_{Jm}}{\pi_{Jp}} = \left(\frac{np}{nm}\right)^6 \left(\frac{0.01 + \frac{1}{Rem}}{0.01 + \frac{1}{Rep}} \right) \qquad (16)$$

from Eq.15 and 16

$$\left(\frac{nm}{np} \right)^6 = \frac{0.01 + \frac{1}{Rem}}{0.01 + \frac{1}{Rep}} \qquad (17)$$

ie: $$\lambda_n^6 = \frac{0.01\ Rep + Re^{-1}}{0.01\ Rem + 1}$$

In the case of the model operating with the prototype fluid, we have

$$\lambda_\rho = \lambda_\mu = \lambda_r = 1 \qquad (18)$$

$$\lambda_{Re} = \lambda_v \lambda_D \qquad (19)$$

So: $$\lambda_n^6 = \frac{0.01\ Rep + \left[\lambda_v \lambda_D\right]^{-1}}{0.01\ Rep + 1} \qquad (20)$$

and $$\lambda_v^2 = \lambda_D \qquad (21)$$

Finally, let $\lambda_n = \lambda_v = \lambda_{\bar{D}} = 1$ and if λ_L is selected, then

$$\lambda_A = \lambda_L \times \lambda_L = \lambda_L^2$$

$$\lambda_Q = \lambda_v \times \lambda_A = \lambda_L^2 \qquad (22)$$

2. Design of Model

(i) Scale

After considered the experimental space, the scale in 1:40 was selected to construct the sand model. Table 5 shows the relationships between model and prototype.

Table 5 The relationships between model and prototype, sand model

Item	Relationships	Ratio
Length	$Lr = Lm/Lp$	1/40
Effective grain size	$Dr = 1$	1
Velocity	$Vr = 1$	1
Void ratio	$n_r = 1$	1
Area	$Ar = Lr^2$	1/1600
Discharge	$Qr = Lr^2$	1/1600

(ii) Model extent

The sand model covered 660 m above and 260 m below from the pumping station as well as 48 m channel width and 20 m aquifer depth. Plate 3 shows the sand model.

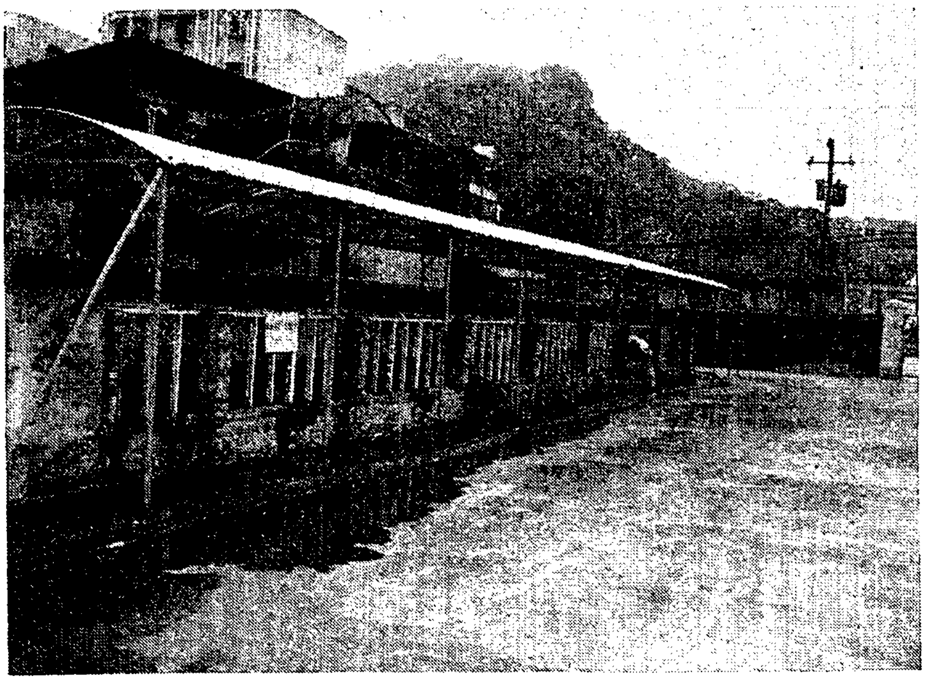

Plate 3 Sand Model

(iii) Sand material

Difference compositions of sand materials were tested to obtain the desired material with the coefficient of permeability 1.57×10^{-3} m/sec. Finally, the ratio among sand, fine gravel and gravel in 3:5:2 was adopted to pave the sand model bed for studying.

3. Test Process

The test processes were divided into two stages;

First stage: i. considered the underflow only

ii. assumed the water table gradient between 320 m above and 560 m below from the pumping station be 1/1450

Second stage: i. considered the interaction between surface and underflow

ii. assumed the discharge of surface flow and underflow be 6.1 cms and 0.6 cms, respectively.

4. Test Results

The test results of sand model are shown in Table 6.

Table 6 Test results of sand model

Item	1st stage	2nd stage
Discharge of aquifer	0.60cms	0.71cms
Design pumped discharge		
<u>Single gallery</u>		
discharge of aquifer at downstream	0.28cms	0.709cms
water table drawdown at 220m downstream	1.54m	0.12m
<u>Double galleries</u>		
discharge of aquifer at downstream	0.213cms	0.642cms
water table drawdown at 220m downstream	5.17m	0.28m
Maximum pumped discharge		
<u>Single galleries</u>		
probably pumped discharge	6.79cms	6.33cms
discharge of aquifer at downstream	0.14cms	0.373cms
water table drawdown at 220m downstream	6.26m	6.20m
<u>Double galleries</u>		
probably pumped discharge of upstream gallery	6.16cms	5.96cms

probably pumped discharge of downstream gallery	0.61cms	0.40cms
discharge of aquifer at downstream	0.06cms	0.362cms
water table drawdown at 220m downstream	6.98m	6.08m

DETAILED TEST — CLOGGING STUDIES

1. Description of the model

Instead of theoretical similarity, the comparison of relative merits for different infiltration filters were adopted to interpret test results.

The upper cross section of the gallery was built in the scale of 1:5. Plate 4 shows the model.

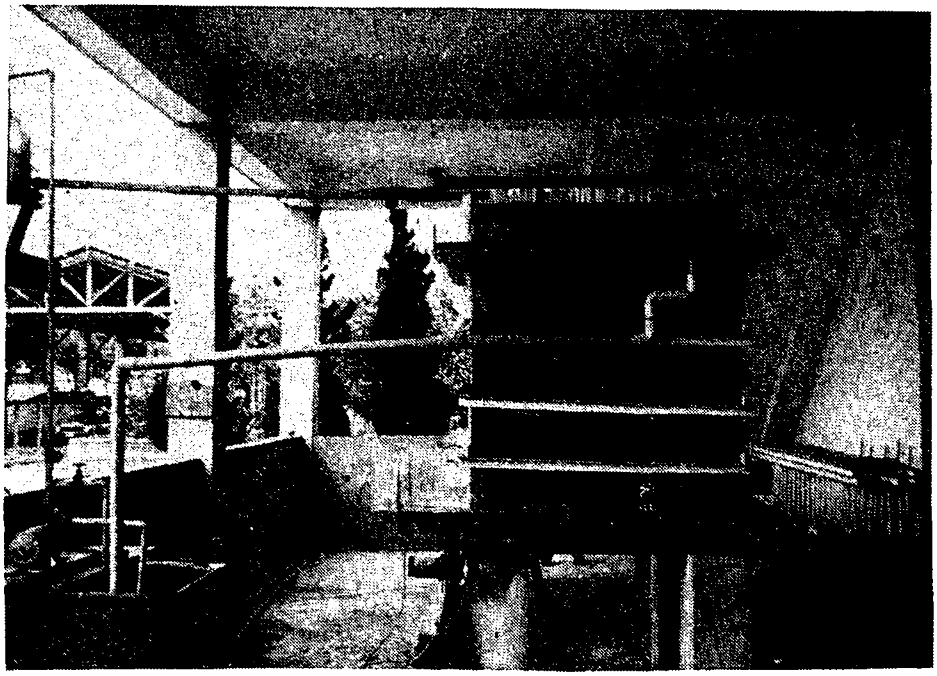

Plate 4. Sectionial Gallery Model

In the model, the gravels in the size of 2 - 3 cm, 1 - 2 cm, 0.2 - 0.6 cm were used to fill three filter zones, and the bed materials in the prototype were used as overburden materials.

2. Infiltration tests

Four different numbers of collecting hole in the diameter of 0.5 cm were selected to measure the collecting discharge under nine different filter layouts. Table 7 shows the test results.

Table 7 The comparison of collecting discharge

Time hr	Filters cm	number of collecting hold			
		1	5	13	25
0	70 70 70	26.8	237	288	306
24		28.7	160	183	142
0	50 70 60	33.5	203	243	233
48		26.5	162	180	150
0	60 60 60	41.3	169	214	166
48		39.2	143	168	155
0	70 50 60	31.3	120	131	109
24		20.0	113	125	104
0	70 60 50	41.8	173	184	150
36		36.0	122	124	98
0	60 70 50	41.5	132	140	106
48		38.0	93	94	74
0	50 50 60	40.2	131	134	104
24		37.5	103	107	81
0	50 50 70	41.2	121	131	103
24		39.2	96	105	82
0	60 70 60	38.8	145	123	112
48		34.3	119	90	89

Remark : unit cm^3/sec

3. Clogging tests

The concentration of suspension solids of outflow was examined to interprete the clogging effects. The test results showed that the concentration of S.S. rapidly decreased from 449ppm to 13ppm in the begining 2 hrs, and after 19 hrs it decreased to 2ppm, and then almost kept constant.

The clogging performance showed that the collecting discharge tend to decrease after 35 days in the model.

DISCUSSION AND CONCLUSION

Three empirical equaltions were adopted to calculate the discharge of infiltration gallery to verify the test results. They are:

(a) $$Q = \frac{KL\ (H^2 - h^2)}{R}$$

(b) $$Q = \frac{1.36K\ (H^2 - h^2)}{\log \frac{\pi R + L}{\pi r + L}}$$

(c) $$Q = \frac{0.68K\ (H^2 - h^2)}{\log \frac{\pi R/2 + L}{\pi r/2 + L}}$$

Where K: coefficient of permeability
L: length of infiltration gallery
H: depth of aquifer before pumping
h: depth of aquifer after pumping
R: radius of influence area
r: radius of infiltration gallery

Table 8 shows the comparison of probably pumped discharge between empirical calculation and model test results.

Table 8 Comparison of pumped discharge between empirical calculation and model test results.

Empirical Calculation		Model Test	
pumping Q cms	Equation	pumping Q cms	Model Type
6.55	b	7.0	Vertical Hele - Shaw Model
6.55	b	6.79	Sand Model
2.86	a	3.05 (D/S gallery)	Horizontal Hele-Shaw Model
3.27	c	3.39 (U/S gallery)	Horizontal Hele-Shaw Model

The complicated problems such as boundary conditions, aquifer depth, engineering layouts, etc. involved in pumping groundwater by infiltration gallery are difficult to solve. The approximate results of empirical calculations and model tests in this study gave the feasible data for field works. However, the realiability of application to the results still depends on the field verification.

PLANNING, DESIGN AND TENDERING OF CHIH-TAN WATER TREATMENT PLANT

C.C. Kang
J.C. Huang

Contents

Planning, Design and Tendering of Chih-Tan Water Treatment Plant

by C. C. Kang
J. C. Huang

1. Introduction

The service area of Taipei Water Department includes Taipei City and its four satellite townships of Sanchung, Yungho, Chungho and Hsintien as shown on Fig. 1. Sharp population growth and rapid industrial development in the service area have led to large increase in the demand for water. Although in 1977 Taipei Water Department completed the Third Stage Development of the Taipei Regional Water Supply Project which increased water supply by 480,000 CMD, the supply is still not sufficient to meet the long-term demand which shows a distinct trend of increase in the future. Hence, planning for Fourth Stage Development began in 1973, immediately after completion of the detailed design of Third Stage Development. Fourth Stage Development's major works include reservoir, raw water transmission tunnel, water treatment plant, clear water transmission tunnel, water distribution mains, clear water reservoirs and pumping stations, etc. Among these works, the Chih-Tan Water

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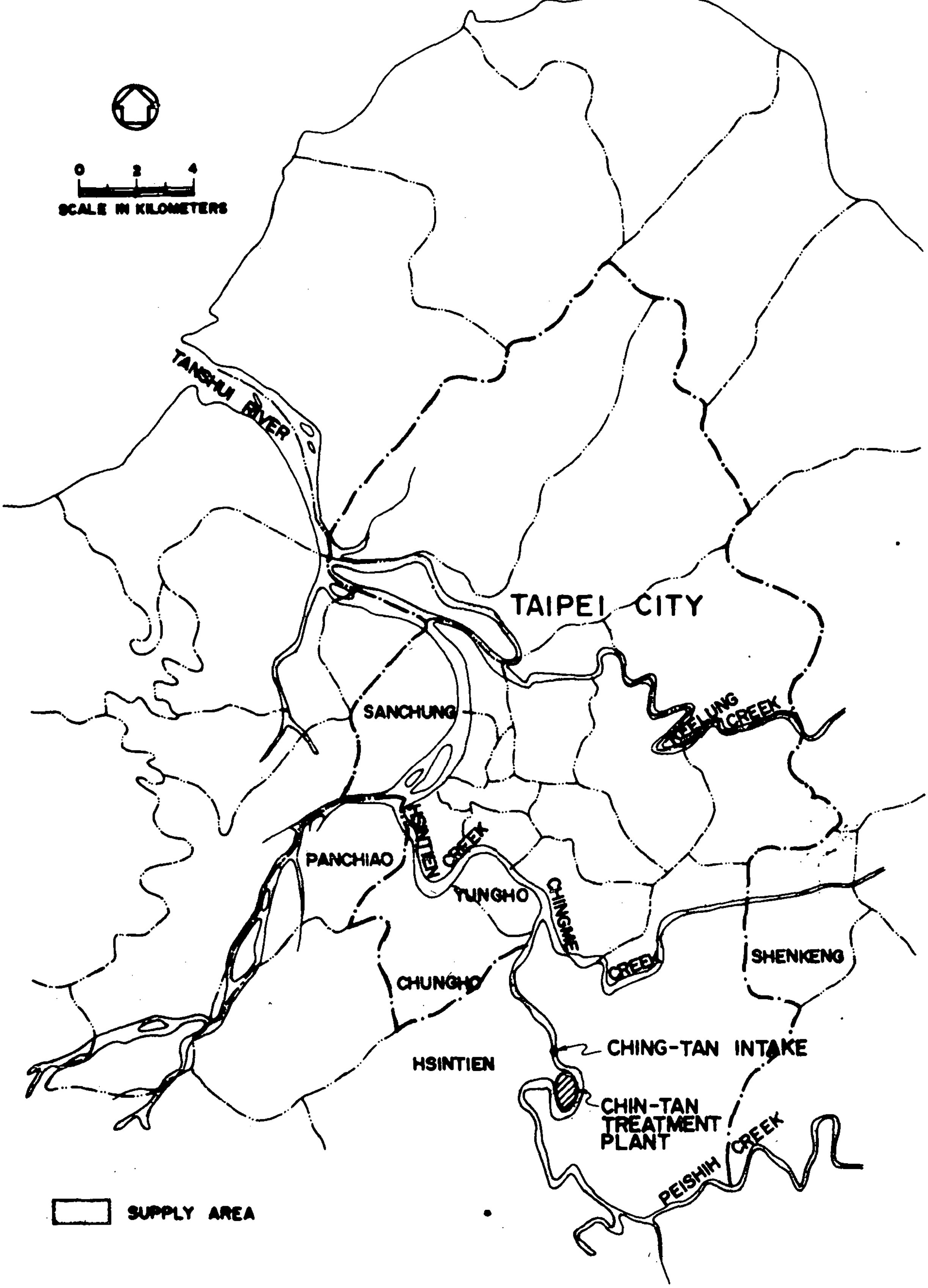

FIG. 1 WATER SUPPLY AREA OF TAIPEI WATER DEPARTMENT

Treatment Plant comprises five water treatment units, each of a design capacity of 550,000 CMD for a total capacity of 2,750,000 CMD which is sufficient to meet the demand for water in the service area till 2011. Planning of Fourth Stage Development which includes water sources, water treatment plant and water transmission and distribution facilities, etc. began in August 1973 and was completed in December 1974. Pilot plant and Definite Plan Study of Chih-Tan Water Treatment Plant began in March 1980 and was completed in March 1981. Detail design followed immediately and from June 1982, contracting for various items of works commenced one after another. Construction of the civil portion began in October 1982 and is scheduled to be completed in June 1984.

2. Water Quality of Hsintien Creek at Chingtan Intake

Before the treatment process of a water treatment plant is studied, an understanding of the raw water quality must first be obtained. The raw water quality of the Chihtan Water Treatment Plant is as shown in Table 1. The turbidity of raw water is normally quite low (usually below 10 NTU) but will sharply increase to 3,000 NTU during a flood brought by typhoon. The content of organic matter is quite low, there are no problems with the color, iron, and manganese. The water temperature drops to about 11°C during the winter and rises to 30°C in the summer. Some quantities of bacteria and coliform group are existed during the dry season in summer, indicating that the water source has been polluted to some extent by domestic wastewater. Apart from a slight degree of pollution, the water quality of the Chihtan Water Treatment Plant's water source is generally quite good. Hence, the major objective of water treatment is elimination of turbidity and bacteria in the raw water.

Table 1. Water Quality of Hsintien Creek at Chingtan Intake

Item		Maximum	Medium	Minium
Temp °C		30	23	15
Turbidity NTU		6.2	1.5	0.8
Alkalinity	mg/l	36	28	16
PH		9.1	7.4	6.8
Chloride (cl^{-1})	mg/l	8	6	5
Sulfate ($SO_4^=$)	mg/l	33	21	10
Ammonia (NH_3-N)	mg/l	0.40	0.02	0
Nitrite (NO_2-N)	mg/l	0.005	0.002	0
Nitrate (NO_3-N)	mg/l	0.40	0.15	0.06
DO	mg/l	10.7	8.8	6.6
BOD_5	mg/l	5.5	1.6	0.2
COD	mg/l	10.4	5.4	2.0
SS	mg/l	80	5.2	1.3
TDS	mg/l	85	57.8	37
Conductance $\mu\Omega$/cm		160	100	62
Floride (F^-)	mg/l	0.9	0.4	0.1
Cynide (CN^-)	mg/l	0.007	0.0005	ND
Hardness	mg/l	50	34	24
Calcium	mg/l	13.6	8.8	8.0
Magnesium	mg/l	4.5	3.0	1.5
Iron	mg/l	3.32	0.17	0.10
Manganese	mg/l	0	0	0
Bacteria 35°C		3,000	1,315	80
Coliform Group MPN		2,500	150	23
Phenol	mg/l	2.43	0	0
ABS	mg/l	0.049	0.033	0.0208
TOC	ppm	3.4	1.7	0.4
Total Solid	mg/l	128	72	62

3. Water Treatment Process Considered in the Planning Stage

Although in normal time the turbidity of Chihtan Water Treatment Plant's raw water is below 10 NTU, but it sharply increases to 3,000 NTU during a flood. Moreover, for about 50 days in one year the turbidity rises over 100 NTU and the treatment plant must continue its normal operation even at high turbidity. Hence, the direct filtration method is not considered, the treatment process will consist of two parts: sedimentation and rapid filtration.

For the sedimentation part, the upflow clarification, conventional double deck sedimentation, high-rate sedimentation with sloping plates, high-rate sedimentation with tube settlers and conventional single deck sedimentation were selected for comparison at the planning stage. The results showed that the capital cost and annual cost of the conventional single deck sedimentation were the lowest, operation and maintenance were simpler, and the space at the treatment plant was adequate for the process. Hence, the conventional single deck sedimentation process was selected.

For the rapid filtration part, the cluster filter, the conventional constant rate filter and the green leaf filter were selected for comparision. The results showed that the capital and annual costs of the conventional constant rate filter were the lowest, and also operation, maintenance and treatment efficiency were better. Hence, it was decided to adopt the conventional constant rate filter. It was also decided to adopt the dual media of anthracite and sand. For the filter rate control method of rapid filter it was decided to adopt the decline rate filter because its control equipment is simpler, and the filtered water quality is stable. Furthermore, the air scouring method was adopted to supplement filter back wash in order to increase the efficiency of back wash.

Back wash wastewater and sludge were discharged to a sludge holding tank, the upper layer of supernatant recirculate to the flash mixing tank for reuse and the sludge was discharged into a temporary lagoon at the downstream of the river. The treatment flow is as shown in Fig. 2: Chihtan Treatment Plant Flow Diagram.

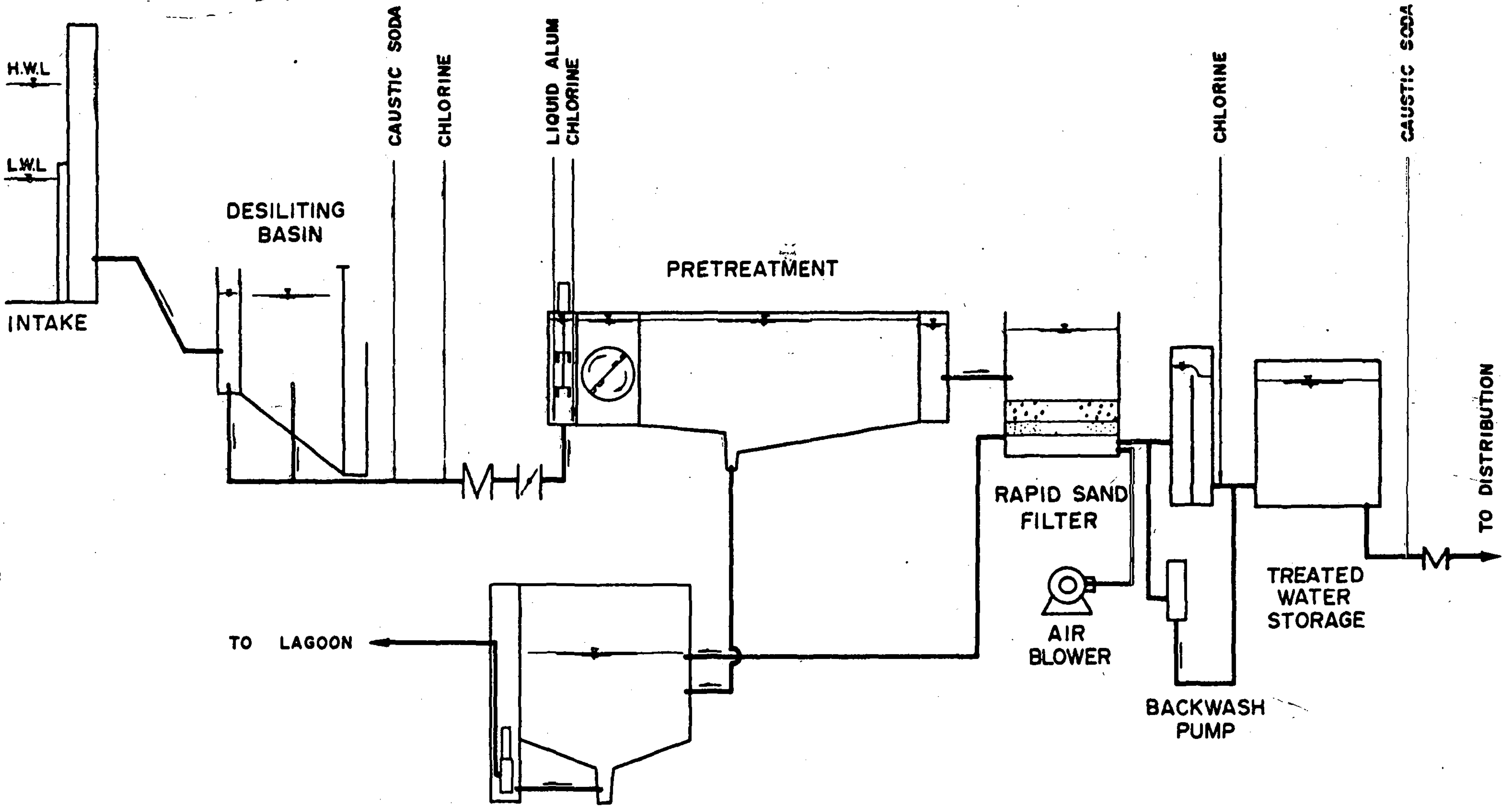

FIG. 2 CHIHTAN TREATMENT PLANT FLOW DIAGRAM

4. Pilot Plant Study

Seven years have elapsed from planning to definite plan study, during this period considerable progress was made in the water treatment process. Hence, it was decided to compare once again the different sedimentation and filtration methods. Moreover, in order to accurately compare different processes and obtain design criteria so as to assure successful operation of the treatment plant in future and to avoid wastage in construction by conservative design, it was decided to conduct a pilot plant test. In the past several years, the Third Stage Expansion Project's Hsintienchi Water Treatment Plant adopted sloping plants sedimentation. However, because plates were easily damaged and maintenance was quite difficult, they were not considered in the definite plan study. Since the performance of the tube settlers sedimentation was good and its operation and maintenance were easy, it was being considered. At the time of the definite plan study, there were three water treatment plants in Taiwan adopting pulsator, of which one had started operation, the second was near completion and the third had completed tendering and construction was about to begin. Hence, puslator was also considered in the pilot plant test. As for upflow sedimentation, because its past performance in

Taiwan was not ideal, it was also not considered. . The three different types of conventional single deck sedimentation, tube settlers sedimentation and pulsator were compared in the aforesaid definite plan study and pilot plant test. Apart from comparing the types of sedimentation tanks in the pilot plant test, sedimentation water was utilized for rapid filtration test. The major objectives of rapid filtration test are to compare the merits and shortcomings of single media filter, dual media filter and mixed media filter; to obtain the optimum diameter, depth and maximum filtration rate of the various media. Preliminary results of tests indicate that the mixed media did not show any outstanding merits and the garnet price was quite high. Thus, mixed media was not considered any more in later tests.

Apart from comparing the efficiency of the aforesaid sedimentation and rapid filtration and obtaining design criteria, the pilot plant test also compared the efficiency of various types of coagulant such as alum and PAC (Poly Alum Chloride) and various types of polymer so as to obtain the best coagulant or polymer. Furthermore, sludge thickening and dewatering tests were also conducted so as to obtain the design criteria for sludge thickening and dewatering. The methods and results of sludge thickening and dewatering tests are given in the proceedings of the Third Asia

Pacific Regional Water Supply Conference and Exhibition.

The plan of the pilot plant is shown in Fig. 3 and the flow is shown in Fig. 4. Both the conventional static sedimentation and the tube settlers sedimentation consist of rapid mixing tank, flocculation tank and sedimentation tank. Because pulsator did not require rapid mixing and since flocculation and sedimentation occurred in the same tank, there were no separate rapid mixing tank and flocculation tank and chemicals were added directly into the raw water pipe.

All the designs of the pilot plants sedimentation tank conform to the requirements of the design criteria of a real treatment plant and strict control was exercised so that the operation of all sedimentation tanks was carried out under the optimum condition. In the day time the turbidity, alkalinity and pH value of raw water, settled water and filter water were measured once every two hours. Similarly, every two hours the head loss of rapid filter tank was recorded and the chemical dosage was corrected and adjusted. At night, the same procedures were carried out once every four hours. Water quality tests of raw water and filtered water comprise color, SS, alkalinity, iron, manganese and aluminum. Chlorine demand was checked once daily.

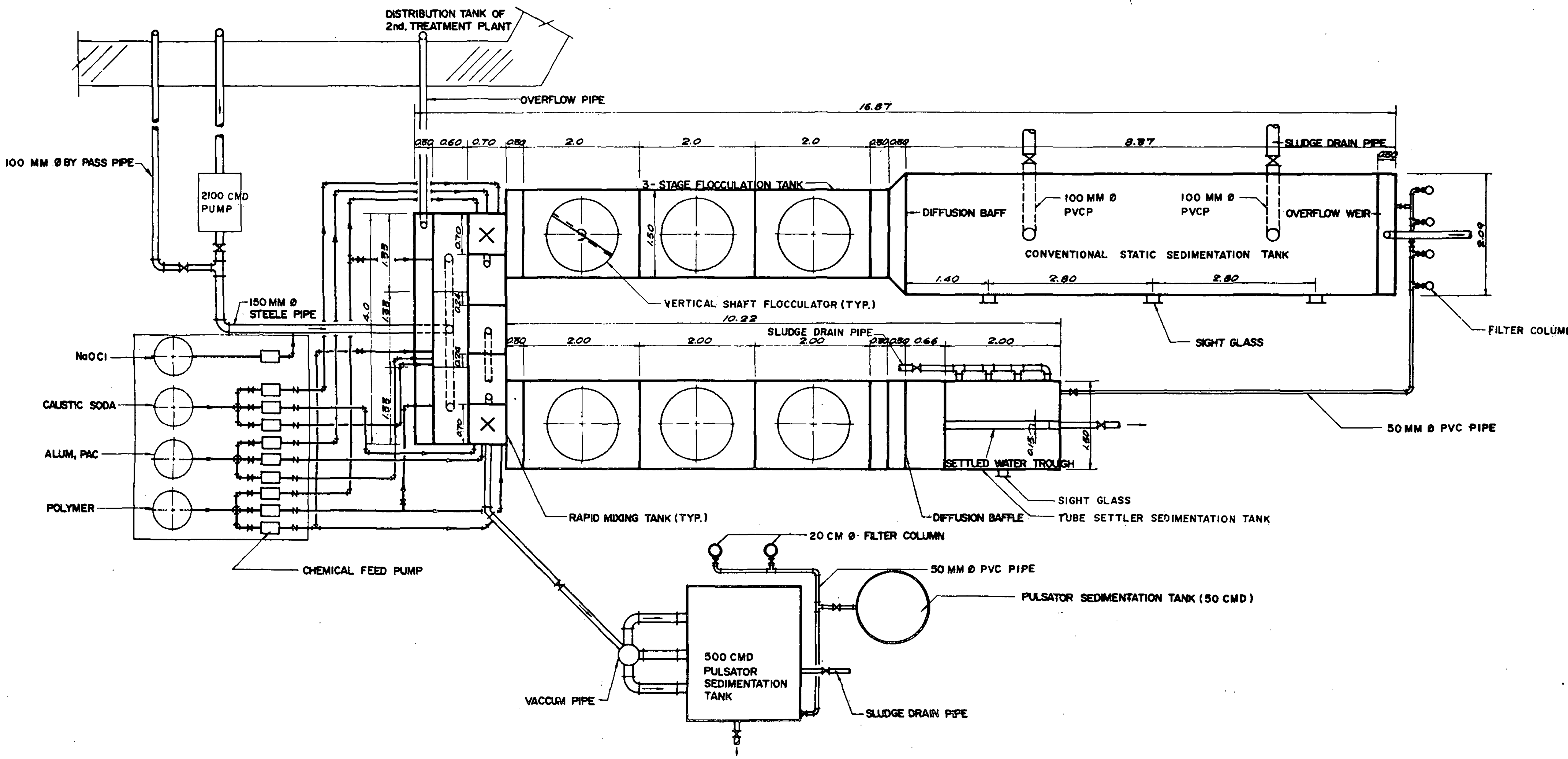

FIG. 3 PLAN OF PILOT PLANT

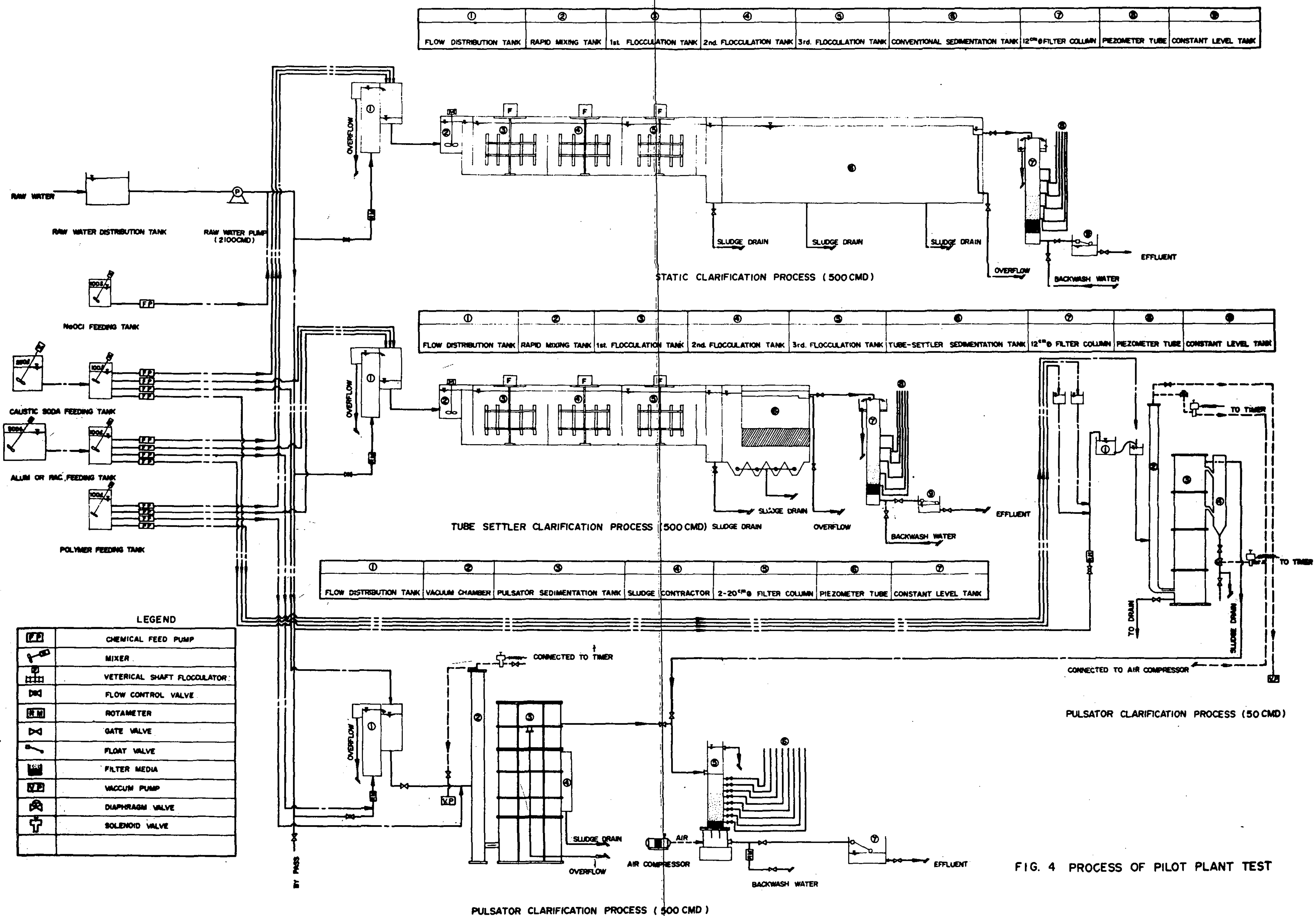

FIG. 4 PROCESS OF PILOT PLANT TEST

The major conclusions of pilot plant tests are as follows:

(1) Form the results of coagulation, sedimentation and rapid filtration tests it is known that if alum and PAC are used as coagulant, the effects of coagulation and sedimentation are similar. However, because the strength of alum floc is too weak, turbidity breakthrough easily occurs in rapid filtration; whereas the strength of PAC floc is adequate and turbidity breakthough will not occur. If alum is used as coagulant then polymer must be added to enhance the strength of floc. The dosage of PAC is lower than that of alum, the sludge is two to three times lower and concentration is higher than those of alum. The expense on chemicals is lower than that of alum and operation is simple and convenient.

(2) With PAC as coagulant and maintaing the same outlet water turbidity, the relative overflow rates of the conventional, the tube settlers and pulsator are as follows:

Type of Sedimentation	Overflow Rate (CMD/M^2)			
Conventional	20	24.2	26.8	31.9
Tube Settlers	80	90	100	100
Pulsator	117	137	148	180

The maximum possible overflow rates in operation are as follows:

Type of Sedimentation	Max. Possible Overflow Rate (CMD/M^2)
Conventional	30
Tube Settlers	120
Pulsator	180

(3) With PAC as coagulant and when the total water head-loss of dual media filter is 2 m, the optimum media grade and combination of the conventional rapid filter are as follows:

media	Effective Size (mm)	Uniform Coefficient	Depth (cm)
Anthracite	1.0	1.4	35
Sand	0.50	1.3	40

When the total water headloss is 2.0 m, the optimum media grade and combination of the single media filter are as follows:

media	Effective Size (mm)	Uniform Coefficient	Depth (cm)
Sand	1.0	1.3	140

(4) At normal chemical dosage both the dual media filter and single media filter can operate normally at a filter rate of 15.6 m/hr, the filter run is shorter than that at the

filter rate of 12 m/hr, but the difference in filtered water volumes is not large.

(5) Both the dual media and the single media can attain the same filtration effect, the 0.75 m depth of dual media is equivalent to 1.1 m of single media.

The above conclusions are reached from the tests conducted on the raw water of Hsintien Creek. If the quality of raw water is not the same, the results may also be different. Thus, the above results cannot be quoted directly.

5. Alternatives of Treatment Process

According to the results of pilot plant test, the design criteria of various types of sedimentation (including rapid mixing and flocculation) are as shown in Table 2. Comparison shows that the capital and annual costs of the pulsator are the lowest, but the efficiency and operation and maintenance are equal to those of the other types of sedimentation.

The green leaf filter which was considered during the planning stage had been given up because equipment must be imported and cost is higher. The modified green leaf filter which has gradually become popular in Taiwan was considered. The cluster filter was also not considered due to the difficulty in layout. The conventional constant rate filter and the aquazur V filter were also considered for comparison of the three types of rapid filter methods. The design criteria of the three types of rapid filtration are as shown in Table 3. The results show that the difference in the capital cost and annual cost of aquazue V filter and modified green leaf filter was not large and the capital and annual costs of the conventional constant rate filter were the highest. However, for the modified green leaf filter, considerable drop occurs at the inlet of the rapid filter which will easily cause a breakdown of floc. Moreover, backwash flow rate is not easy to control and adjust and it is not recommended for adoption in this type of large scale water treatment plant.

Table 2: Design Criteria of Sedimentation

Type	Capacity	Rapid Mixing Tank (Mechanical Mixer)					Flocculation Tank (Horizontal Paddle Type)				
		No.	Capacity of each tank (m^3/day)	Dimention		Detention Time (sec)	No.	Capacity of each Tank (m^3/day)	Dimention		Detention Time (min)
				Area (mxm)	Depth (m)				Area (mxm)	Depth (m)	
Conventional Static Sedimentation	Design	2	250,000	2@4.0 x4.0 =32m³	4.0	44.2	10	50,000	(3Q C x12.0 =360m²	4.5	46.7
	max. day		275,000			40.2		55,000			42.4
	max. hydraulic		375,000			29.5		75,000			31.1
Tube Settlers Sedimentation	Design	Ditto					4	125,000	34.0x 25.0 =850m²	4.5	44.1
	max. day							137,600			40.0
	max. hydraulic							187,600			29.4
Pulsator	Design	1	500,000	3@4.8 x4.8 =69.1 m²	5.0	59.7					
	max. day		550,000			54.3					
	max. hydraulic		750,000			39.8					

Table 2 Design Criteria of Sedimentation (continue)

Type	Sedimentation										
	No.	Capacity of each Tank	Dimention				Detention Time (hr.)	Overflow Rate (CMD/m²)	Horizontal or Vertical Velocity (cm/min)	Weir Length (m)	Weir Loading (CMD/m)
			L (m)	W (m)	D (m)	Area (m²)					
Conventional Static Sediment	20	25,000	73.0	16.5	4.0	16.5x58.0 =957	3.67	26.1	26.3	178.8	139.8
		27,500					3.34	28.7	28.9		153.8
		37,500					2.45	39.2	39.4		209.7
Tube Settlers Sedimentation	8	62,500	55	18.5	4.5	18.5x55 =1,017.5	1.76	61.4 (102.4)	7.1	480.0	130.2
		68,800					1.60	67.5 (112.6)	9.8		143.3
		93,800				(18.5x33) =610.5	1.17	92.1 (154)	10.7		195.4
Pulsator	6	83,300	34.9	34.8	5.0	14.9x34.9 =1,040	1.75	80	5.5	570	146
		91,700					1.59	88	6.1		161
		125,000					1.17	120	8.25		219

Table 3. Design Criteria of Filters

Type	No.	Capacity of Each Filter (m^3/day)			Dimension		Filtration Rate (CMD/m^2)			Back-wash Water Rate (m^3/day)	Surface Wash Water Rate (m^3/day)	Air Scouring Rate (m^3/hr.)
		Design Capacity	Max. Capacity	Max. Hydraulic	Area mxm	Depth m	Design Capacity	Max. Capacity	Max. Hydraulic			
Conventional Constant Rate Filter	14	35,700	39,300	53,600	2@4.25x 16.8 =143	4.6	250	275	375	130,000	6,100	-
Modified Green Leaf Filter	20	25,000	27,500	37,500	2@4.3x 11.4 =98	6.3	255	281	383	90,000	4,600	-
Aquazur V Filter	14	35,700	39,300	53,600	2@5x 14 =140	3.32	255	281	383	50,000	-	8,000

Since the single media filter does not have the problem of anthracite loss, and using air scouring and backwash which produces lesser quantity of wastewater, and the capital and annual costs are lower than those of the conventional constant rate filter. Hence, this type of European single media filter is quite good and deserves promotion.

6. Tendering

According to the aforesaid results, the pulsator and aquazur V filter combination are lower than those of the tube settler and conventional constant rate filter or with single media filter combination in terms of capital and annual costs, the treatment efficiency is quite good and operation and maintenance are not difficult. However, because pulsator and aquazur V filter are manufactured only by Degremont and there is no competition. To protect the Client from losses, direct price negotiation is not recommended. Hence, bidding documents were prepared for open competition between pulsator + aquazue V filter (Scheme I) and tube settlers sedimentation + single media filter (Scheme II). In the resultant bidding the price offered by the manufacturer of Scheme II is lower than that offered by the manufacturer of Scheme I, but due to some dispute about the qualification of Scheme II manufacturer, the bidding was eventually nullified. At that time the civil portion has already been contracted and construction of the treatment plant must be completed by June 1984. Thus, the type of process must first be decided so that construction of civil portion could start, otherwise water treatment would not be able to begin on schedule. After intensive studies it was decided to adopt the tube settler sedimentation and conventional constant rate filter which do not infringe on patent and most of the equipment can be designed and purchased in Taiwan. The civil portion is expected to be completed in April 1984 and the mechanical and instrumentation protions to be completed in June 1984.

7. Conclusions and Recommendations

(1) Pilot plant study can compare various types of processes, obtain definite design criteria and through test can also forecast possible operational problems of treatment plant in future. However, the design, operation and data analyses of pilot plant require engineering personnel of high caliber and considerable time and finance are also required. Hence, unless a new process is developed, pilot plant test is not recommended for developing countries. Time, and manpower can be saved in desing by referring to the operational data of existing water treatment plants.

(2) Although simultaneous bidding for different treatment processes can lower construction cost, but desing work load will increase and the time of design must be prolonged and design fee will increase. Moreover, simultaneous open bid will bring many trouble and problems and delay contracting. Hence, it is not recommended for developing countries. It is simpler by selecting a popular and reliable process and then entrust an engineering firm to design and prepare bidding document for purchase of equipment.

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MANAGEMENT; MANPOWER DEVELOPMENT AND COMMUNITY PARTICIPATION

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I. Management

We will limit ourselves in this first paragraph to a piped water supply, serving an area of some importance. Serving water in small villages and by wells will be discussed in the last paragraph.

To manage a water supply company in principle is not very different from any other type of management. However, there are a few features which give water supply management a recognizable colouring. First of all: nearly always water supply is a monopoly. Secondly it has a definite health impact. Thirdly, because of these two items, the government is involved in most cases to a high degree. Very often water supply is managed by a public authority or it is part of a public authority, such as Public Works.

All three aspects have a certain impact on management of water supply. We will comment upon them later in this paper.

Management is knowing what has to be done and getting it done.

The aim of a water supply company therefore has to be laid down and the means are to be provided to reach this aim. Management has the task to realize the aim the necessary means. Management takes place at all levels in the company.

The aim of a water supply company is to supply wholesome and palatable drinking water to all customers in its distribution area under such pressure that supply is guaranteed to each customer 24 hours a day.

To reach this aim the necessary means are personnel, knowledge and skill, money, installations and equipment, administration and water quality control. These together with a proper management are necessary to shape a water supply company into an organisation up to its task.

An organisation needs a structure or framework and a steering and decision making part; the heart of the organisation are the people who work in it.

In order to clearly distinguish the different functions, these functions should be recognizable in the **structure** of the water supply company and its departments.

One could distinguish in principle the following main departments:

1. **the processing department**
   This department is charged with the daily task to abstract water, treat, distribute and supply it (primary process),
2. **the materials department**
   This department supplies and constructs the material means, such as pipes, pumps, treatment – equipment etc. and by good maintenance keeps them in good order.
3. **the personnel department**
   This department is charged with supplying the personnel means by attracting qualified personnel, setting out and maintaining rules concerning salary, and other labour conditions, social conditions and training.
4. **the finance department**
   This department has to take care of the financial well being of the company and to see to it that the cost of water supply can be borne by the various categories of customers. The finance department has amongst its task to attract money on favourable conditions, to administer all costs and incomes, and to prepare and send out the bills to the customers. It should also report on the general financial aspects of the company. Cost accounting should be such that the costs can be related to specific activities.
5. **the management service department**
   This department provides general secretarial support, library, documentation, canteen and watchmen services and so on;
6. **the water quality control department**
   A laboratory should be charged with chemical and biological control of the processed drinking water in all stages of unfinished and finished product.

Depending on the size of the company all or some of the six departments are necessary. If the company is small (total personnel less than 100–200 people), the personnel department might be included together within the management service department in a small staff attached to the top manager. Also the laboratory could then be a part of the processing department, provided the laboratory chief can report directly to the top manager. In larger organisations the six different functions should preferably find their expression in the structure of the organisation.

To make the structure work it is necessary that a steering and decision making proces is going on and that there are clear vertical and horizontal, two ways acting, lines of communication. The vertical lines are hierarchical lines. In a day and night business as water supply they are very important. It is essential not to have too many levels of management along these lines, as each level in the line of communication takes its own time and procedures.

In the main 5 levels could be distinguished. The description of these levels are taken from the IWSA Standing Communittee on Education and Training of Waterworks Personnel in its report to the Amsterdam Congress 1976:

Manager
The activities of managers are essentially concerned with setting objectives and deciding priorities, devising and implementing the means to achieve the objectives successfully, and the means to assess the results achieved.

Professional Person
A professional person is competent by virtue of his fundamental education and training to apply scientific method to the analysis and solution of business problems. He is able to assume personal responsibility for the development and application of science and knowldge. His work is predominantly intellectual and varied, and not of a routine mental or physical character. It requires the exercise of original thought and judgement and the ability to supervise the technical and administrative work of others.

Technician
A person who carries out functions of an intermediate grade between the technologist on the one hand and the craftsman on the other. The education and specialist skills of a technician enable him to exercise technical judgement, i.e. and understanding, by reference to general principles, of the reaons for, and the purposes of his work, rather than reliance solely on established practices or accumulated skills.

Craftsman
A skilled worker in a particular operation, trade or craft who is able to apply a wide range of skills and a high degree of knowledge to non-repetitive work with a minimum of direction or supervision.

Operator
A manual worker who possesses a degree of skill and knowledge of a narrower range than that of a craftsman, and who is capable of a lesser degree of adaptation.

These five levels are not absolute but more of an illustration how in a company the number of levels can be limited.

At each level not only technical or administrative skill is necessary but also general qualities of management, such as planning and control, decision making, communication and so on.

In and between each of the six departments mentioned in this paper the various levels should be integrated in such a way that the required results are obtained with minimal number of people.

By using in each department the same system of levels the necessary horizontal communication is made easier.

In this concept of organisation the decisions at the top are taken by the topmanager in consultation with the six department heads. It is essential that the decisions are based on a planning basis: long term, medium term and on an one year basis. Long term programming is mostly part of planning on coutry or region basis, in which the government has a large influence. For a water company the medium term planning (ten year) is the most important.

In this concept the medium term planning should come from the various departments and be coordinated by a staff that is responsible to the topmanager, who in consultation with the topmanagement team takes the final decision.

On the basis of the medium term planning a detailed year plan should be made in which all the activities are summed up, budgetted for and allotted to the departments.

Each department is responsible for its own budget and related activities. Coordination takes place in the team of the topmanager and the heads of department, mainly through the instruments of 10 and 1 year plants. The staff attached to the topmanager controls the activities and reports on the effectiveness. On each department level the same steering and managing function should be organised. In that respect every unit within the organisation should be organised and work along the same pattern. At each level it is necessary to make daily decisions. At higher level they are more complicated, general and abstract; they are more important because more important a spects are at stake. Communication throughout the company is essential. A clear functional organisation facilitates the communication, but cannot replace it. Communication should be based on acceptance and support of the companies aims and values, mutual respect and understanding and orientated on quick decision taking. We will now look on manpowers development, necessary to enable the rapid growth of water supply as foreseen in the U.N. Water Supply Decade.

2. Manpower Development

Estimates on the number of persons needed as employees of water supply undertakings to keep up with the scheduled increase in watersupply worldwide vary considerably. Furthermore a considerable backlog exists, because the training of personnel has not — timewise — kept in pace with the establishment of new watersupply purification plants, watersupply distribution pipelines-network, installation and maintenance of watermeters etc. etc.

II-0 Whay train?

At the U.N. Water Conference in Mar del Plata the following recommendation was accepted:

"At the national level each country should assess the manpower situation on the basis of this assessment, establish sector training programmes to meet immediate and future needs for additional staff at the professional, intermediate and rural levels".

Already at the time (1977) it was clear that newly commissioned water systems were underutilised due to lack of trained personnel and the subsequent rapid deterioration of plant. This problem of getting not sufficient return on invested capital due to lack of trained personnel is still with us to-day. This is one of the reaons why World Bank and other leding agencies do require as a pre-requidite for an investment loan for a watersupply project real evidence that training plans exist to ensure that upon completion the project will be effectively operated and maintained. Costs of training personnel can nowadays be included in the investment cost covered by these loans.

Training can represent in financial terms an investment in human resources greater than is normally made in physical resources e.g. water systems. The water manager is properly concerned and vigilant about his return on investment in physical assets and should equally recognise and accept that a training investment in people will increase the yield from this more valuable resource. Skill and knowledge about a job or work are best acquired through an appropriate blend of organised training and supervised experience.
If the acquisition of skill and knowledge is left solely to unsupervised or indequately supervised experience on-the-job (exposure training), employee performance will develop slowly and may never reach an acceptable leverl.

Organised and systimatic training will assist waterworks staff, at all levels, to reach the standard of an experienced person in the shortest possible time. This will reduce unit costs.

Closely allied to this trend is the growing recognition among the lower echelons of the waterworks labour force that job aspirations and career expectations should be no less available to them than they are to other levels of employment. The message appears to be that preoccupation with only training the professionals and technologists, important though this is, has gone on long enough. In this sense the reason for training is one of maintaining the right balance of skill, knowledge, performance and motivation at all levels of the organisation pyramid.

II-1 What are the problems

The delegates attending this Congress know better than anyone the extent, the nature and the variety of their manpower and training problems.

The following observations can be made:

a. **Despersion of the Workforce**
The nature of waterworks operations is such that the labour force is scattered thinly across the area of supply. There is a problem of time and space; operational control by the supervisor is difficult.
In such a situation there is a strong argument for the workforce to be versatile and multi-skilled. But, with such dispersion, how can this be achieved by training on-the-job? How can there be enough trainers to go round and what training use can be made of supervisors and technicians in this situation? The problem is to identify the appropriate mix of centralised and de-centralised training, particularly at the operator and craft levels of employment.

b. **Availability of Training Material**
There is no great overall shortage of training material presently available for waterworks training at a given level or function.
The problems are the usual ones of dissemination, adaptation, language, transfer from one level of ability to assimilate to another, and perhaps the cost of setting up a system to overcome these problems. But the waterworks training know-how does exist. The International Watersupply Association are in the progress of editing small booklets with valuable information for the personnel in the field of leak-detection, how to record plans, material for pipes, administrative procedures etc.

c. **Urban and Rural Priorities**
How far and how fast a developing country can afford to get to grips with the problems, which must include manpower and training, of expanding and improving water services in municipal authorities while at the same time not neglecting the circumstances in which rural communities exist. This may be the most difficult problem of all.

d. **The shortage of Trainers**
The solution may well be to persuade and encourage managers and supervisors that they have, as an integral part of their duties by devinition, a clear reponsibility to train, tutor and develop subordinate staff. The problem is to get them to do it.
The day to day operational waterworks problems in developing countries do not readily convince those in authority that they have time to train others. The paradox is that it is the operational managers and supervisors who have the greatest accumulation of knowledge and experience to impart.
In regional training centres these operational managers and supervisors should pass on this knowledge and experience. It is understood that standards of basic education should be such that participants in regional water supply training centres do master basic elements as reading and writing.

e. Manning Levels

There is a tendency to over-man the developing country public service enterprise. This probably arises from unemployment and political pressures. The corollary to this is usually underutilisation of waterworks personnel, employment inflexibility and a reluctance to learn new and improved job methods.

Manpower planning is as important, if more difficult, when obliged to carry a surplus of manpower as it is when manning levels are based upon work measurement or when the labour market is tight. The problem remains, how to quality the amount and quality of training required and this could be regarded as a high priority for management training.

f: Finance and the Training Budget

Good training is not cheap. To make a lasting, if not permanent impact a training programme requires a training budget.

The absence of an equitable rating system or charging scheme for water services provided, will retard training as it will any other improvement activity or project. In developed countries it is the experience that in times of inflation and economic restraint, the training budget is among the first to become vulnerable. All the more important therefore for training to demonstrate that, done well, it provides a pay-off, although training evaluation is yet another problem.

g. Public Response

The response of the consumer can be stimulated by Community Participation. This is dealth with later on in this paper.

III. Community Participation

Devinition: Community Participation is active involvement of the local population (future users) in the decisionmaking concerning development projects and/or in the implementation of same.

III-1 Why should Community Participation be considered?

The case for community participation in many fields of development is now well recognized. In the field of health services, for instance, it is a central aspect of the concept of Primary Health Care, which has been adopted by the World Health Assembly as the organising principle around which to "bring health to all by the year 2000". The advantages which are foreseen as arising from community participation include the expectation that governments' budgetary resources can be stretched or complemented by the efforts which can be made within local committies, but they go well beyond this. Altogether, at least ten distinct reasons have been advanced in favour of participatory methods, as discussed below.

Ten reasons advanced for Community Participation

1. With participation, more will be accomplished.
2. With participation, services can be provided more cheaply.
3. Participation has an instrinsic value for participants.
4. Participaiton is a catalyst for further development.
5. Participation encourages a sense of responsibility.
6. Participation guarantees that a felt need is involved.
7. Participation ensures things are done the right way.
8. Participation uses valuable indigenous knowledge.
9. Participation frees people from dependence on others' skills.
10. Participation makes people more conscious of the causes of their poverty and what they can do about it.

All of these reasons will not be found equally valid from every point of view and some may apply in some situations and others in different ones. However taken the 10 together they make a pretty strong argument.

The types of Community Participation

1. Consultation.
2. A Financial Contribution by the Community.
3. Self-help Projects by Groups of Beneficiaries.
4. Self-help Projects Involving the Whole Community.
5. Community Specialised Workers.
6. Mass Action.
7. Collective Commitment to Behaviour Change.
8. Endogenous Development
9. Autonomous Community Projects.
10. Approaches to Self-sufficiency.

Ad.1. **Consultation**

The object is to consult the community with the intention to involve it in the decision-making. Purpose: to have the project introduced by an outside agency, adapted to the needs of the community.

The extent of the consultation (who?, how many?) will vary from case to case.

Ad.2. **A Financial contribution by the Community**

Cash collections made by and within the community, generally prior to or at the time of implementation of a project, usually as a contribution to capital construction.

Ad.3. **Self-help Projects by Groups of Beneficiaries**

In these projects a specific group of local inhabitants contribute their labour (and perhaps other inputs) to its implementation, while there is also the assistance of an external agency.

Ad.4. **Self-help Projects Involving the Whole Community**

Projects in which every family in the community is expected to make a contribution (usually in labour), while there is also and input from an external agency.

Ad.5. **Community Specialised Workers**

The training and appointment of one or a few community members to perform specialised taks (e.g. as community health worker, or operator of a community water supply system). The training and technical supervision are carried out by an external agency, but some form of community authority is usually also exercised over the specialised workers.

Ad.6. **Mass Action**
Collective work in the absense of a major input from an external agency. Often such actions are directed at environmental improvements (e.g. to drain waste water).

Ad.7. **Collective Commitment to Behaviour Change**
Cases where a community makes a collective decision to change customs or personal habits, and collective social pressure is exercised for the realisation of such changes. Examples range from penning of domestic animals to construction and use of latrines, or to the reduction of excessive expenditures in connection with weddings, funerals, etc. While changes of behaviour may of course occur in other ways, community participation is involved when an explecit decision is collectively taken.

Ad.8. **Endogenous Development**
Cases in which there is an autonomous generation within the community of ideas and movements for the improvement of living conditions – as opposed to simulation by outside agents. The community may, however, have recourse to external agencies to help with implementation, or indeed press for such help. On the other hand, where this is simply pressure for services to be provided, it hardly qualifies for the term "community participation", though in a wider sence this is an example of political participation.

Ad.9. **Autonomous Community Projects**
The ambiguous "self-reliance" is often understood in this sense: projects where any external resources are paid for by the community with funds raised internally, including the hiring of any outside expertise or professional staff. Such projects are therefore under community control.

Ad.10. **Approaches to Self-Sufficiency**
Projects in which the objective is to satisfy local needs as far as possible by using local materials and manpower directly, not by purchasing goods and services from outside. "Self-reliance" is also sometimes understood in these terms.

III.2. Community **particiption** should have beneficial results and should not be community **manipulation,** in the sense of "Not just involved in water-supply but being involved in politicsmaking".

With the availability of water it is much the same as with availability of minerals, the owner of the land where water is found can be a powerful man with a lot of political influence, if he is inclined in that direction.

In this respect we like to quote from a paper by Mr. Z. Chowdhury from Bangladesh:

"Hand pumps: some "good" water for some of the community
In Bangladesh, there is approximately one handpump tubewell to every 150–200 people. But as concentration varies, there are villages without pumps.
20–30% handpumps were installed on private initiative, the remainder provided by UNICEF through central and local government. However, this does not give us a picture of how many people use the handpumps.
Inaccessibility, unreliability and poor tasting water are the main reasons given for not using the pumps. Distance is a major factor of inaccessibility, though there are others.
Up until 1975, handpumps were provided free, including installation and maintenance.
Due to the structures of society the pump almost invariably ended up in the courtyard of a rich man who led the villagers to believe that the village only had the pump because he had the necessary power and prestige to get it. No one was refused use of the pump as long as he was willing to given the pump "owner" whatever support was needed or requested at a particular moment – be it a vote in the coming elections of whatever.
When he might need a tutored witness, the man whose wife uses the well will vouch for him. People are becoming increasingly aware of the value of tubewell water, through education, and, at least for drinking, they will be willing to go a quarter of a mile for it. There is a catch for the rich man though, and that is the Union (smaller administrative unit) mechanic who is in charge of repairs and has been quite often known to set his own price for fixing the well. The result is that when the well falls into disrepair, it suddenly becomes "Government" property once agains.
UNICEF, which was supplying the pumps, thus become more concerned about community participation, and since 1975 they have asked the community to pay a nominal charge for the installation of a pump. To collect this charge from the members of community is cumbersome, so they depend on the important man of the village to do this work.
He however, gladly pays this fee himslelf for the cause and betterment of the village (1). Of course, after installation, as people know he has paid for it, he becomes the pump's legal owner.

Community Participation and Handpump Repair.

At any given time, 25–30% of the handpumps installed throughout the country are in disrepair. WHO estimates it to be 50%. (Provision of Safe Water Supplies to rural Communities in Sout-East Asia, WHO, 1974).

As a remedy to this situation a training course has been initiated recently for 200.000 caretakers who will be maintaining the pumps. This will be "voluntary" work with a small allowance given to trainees and trainers, while candidates will be chosen by local officials. Women are the ones who use the tubewells most often. They are therefore the ones most inconvenienced when the pumps are not in working order. And they would be the ones most motivated to get the pumpos back into repair. But it would also be very bothersome for UNICEF and Government to train women instead of men. The village elders would have to be approached and convinced, the training schedule would probbly have to be adjusted etc. So, the women who could and would really participate in keeping the wells in order will be passed by, while a group will be trained up that, experience shows, will utilize their position, not to fix a well, but to something that would be more beneficial to their individual needs".

The same article dwells on known cases where the supply of water for irrigation purpose interferes with the supply of water for drinking purposes due to the fact that community participation was influenced in such a way that wrong interests got the upper hand.

Community participation as such is therefore not a remedy for all injustices. It can however be one, provided the rules of the game are applied in such a way that the interest of the poor and the underpriviliged has priority.

Mr. Ludo Welffens, a young senior programme officer of the UNICEF. in Lagos, dealth with the subject of CP. at a national workshop on the decade in Nigeria (Owerri, 21/2/83). He had been closely connected in a rural pilot project in Imo-State (handpumps and ventilated pitlatrines). He made some interesting remarks on the far reaching effect of C.P., provided the right breeding ground was established. He started with stating that for many years "Community Development" had been used as a convenient extension in the conceptual thinking that "social development" was an envitable benefit of economic growth. However, delivery of basic services to the greatest number of people did not occur. He continued :

"Why not? Because the modes and degrees of perception of realities and priorities by the disavantaged und unserved themselves were never integrated in coherent plans, and translated into budgets and programs. People do not perceive sectoral goals to be attained by a discrete set activities. Sociological participant observation in selected areas of the Imo State pilot project showed evidence of people's spontaneous integration of related concers within their own time frames.

What is so new about this "integral" approach?

Government in all manifestations uses most often community participation in its most mechanical form: labour, materials, cash for schools, health centres, clearing roads, and the like. "Self reliance", "self-help" and potentially rich concepts used only to refer to village-based projects. In fact, they often imply "you are poor, and you are far away, physically and culturally, from where things are changing and where decisions are made". They free elites from sharing resources and power. People taking part in activities initiated, designed or controlled by others, is not participation.

Community participation has more often than not, served to make populations execute sectoral program, and adhere to inappropriate schemes. Do we change methods? Is reliability of water supply the issue in the minds of the unserved population? Can community participation have this allembracing capacity to guide social change? But then, aren't we all members of the underserved community? Achieving the goal of, say, decreasing infant mortality in Nigeria from 200 per thousand to 100 per thousand in ten years, requires indeed new modes of action.

Community participation is like breast-feeding; it has only advantages. However it calls for a radically new set of responsibilities. Bureaucracies need to be overhauled. The knowledge-base must be re-arranged. The challenge is a mother-and child-specific operational knowledge base. How do mothers-and older sisters of children become the first actors?

Making a village mother understand step by step the causes of water and sanitation-related morbidity, and practice what is learned, calls for two general goals, combined with two specific objectives.

1. Implement a pluri-disciplinary development approach: A sectoral approach generates a "top down" sequence of "knowledge" and information of the community: people never really integrate these as theirs, but that is exactly what is happening now in delivery systems of social services.

2. Reach the unserved first. Without that decision, there can be no changing impact on the nature of Nigeria's macro-economic priorities, and infant mortality rate will not change over the next two decades.

3. Introduce cost-effectiveness. This concept relates to the processes of dialogue between professionals and community leaders to make appropriate technology credible to all.

The Imo-State pilot project has proven the formidable validity of this action patch (which leads to the political acceptance of the replicability of the model).

4. New functions and roles for women. Seeing that clean water is used consists of a set of responsibilities which belong to all women: the "animatrices", the trained village based workers, as well as the mothers themselves are the primary actors for changing attitudes and practices vis-a-vis water and sanitation related morbidities. Getting rid of children's excreta has a greater impact on health than 20,000 gallon of water tanks. The program package tested in Imo facuses on girls and women-specific roles in the villages.

Finally, one quite challenging principle is the total compatibility of technologies. The S300 handpump in Umodobia for the next ten years is totally compatible with computerized monitoring of its utilisation. Accepting the implications of this, calls for attidudinal changes at all levels, and leads us to some final thoughts for action.

Integrated Programme building with total community involvement aims at solving one set of problems to to generate opportunities to redefine others. It its concerned with a set of convergent processes at different levels of society, geared towards a social agreement. towards participatory change. It accepts conflicts, and uses it with creative imagination. Priority action has four parts linked in integral fashions. Yet the facts are known: producing water, improving sanitation, initiating other basic services, advocating women's roles and training them, are achieved at lower cost when these issues are addressed together rather than separately.

1. Inform and mobilise rural communities with a view to train village based workers (VBW), women and men, prior to the production of clean water with the best handpump technology and the proposal of improved sanitation (Ventilated Improved Pit Latrines are our example). In the Imo State project, the best manifestation of real mother's participation, is the self-monitoring of children's diarrhoea episodes, which leads towards their understanding of the causes of water borne desease. This is only one tangible result of innovative methods of VBSs' training.
2. Train local government level social development workers and technical staff to enable them to learn the changing nature of their work with up to now unserved communities. New aptitudes to listen and monitor dialogue will render existing behaviour of one-way communication obsolete.
3. Conceive with senior civil servants the alternative ways of generating basic services, mobilise them to initiative action aimed at structurally changing now disfunctioning sectoral bureaucracies.
4. Create a permanent dialogue with elected representatives of the people, about the real issue: hard budget-choices between either cost-effective technology resulting in sustained impact on children's health, or infrastructural investments with no measureable returns".

Mr. Welffers made in this way a link between community participation and manpower development and stresed big advantages of tackling (all for rural circumstances) the four action points (produce water, improve sanitation, initiate other basic services and advocate the important role of woman) in an integral fashion. We must be thankful to him.

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A COMPREHENSIVE PROGRAM FOR MORE WATER TO MORE PEOPLE

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TIRTA DHARMA

INTERNATIONAL WATER SUPPLY ASSOCIATION
ASSOCIATION INTERNATIONALE DES DISTRIBUTIONS D'EAU

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1. INTRODUCTION

The Republic of Korea, with a land area of some 99,000 sq.km., had total population of 38.7 million at the end of 1981. Of the population 23.2 million (60% of total) are urban dwellers, officially defined as those living in 50 si. The remaining 15.5 million (40% of total) area rural inhabitants, defined as those living in eups and myeons. The population is projected to grow at an annual rate of 1.59% during the next several years. During this period, the rural population is projected to decrease at an annual rate of 0.6% so that by the year 2000, Korea will be approximately 75% urban and 25% rural.

Administratively, the country is, as of March 1983, divided into the capital city of Seoul, the city of Busan, the city of Daegu, the city of Inchon and 9 dos (provinces) which are further subdivided into 46 sis (cities) and 139 guns (counties). The guns are further divided into 188 eups (towns) and 1,253 meyeons (rural districts). Eups and myeons are further subdivided into 36,953 ris (villages: the smallest administrative units).

A si has populations of over 50,000 while an eup has populations of between 20,000 and 50,000 and a myeon with populations of less than 20,000. A ri is composed of more than 20 households.

The Ministry of Construction (MOC) has historically been the agency responsible for planning and coordination of larger scale water supply projects for larger communities such as sis and eups in connection with nation-wide water resources development. The responsibility, however, has been split since the Ministry of Home Affairs (MHA) initiated water supply probrams for smaller communities, generally eups and myeons in 1979.

The Ministry of Health and Social Affairs (MOHSA) continues to be responsible for the implementation of the rural piped water supply programs for smaller villages, generally farming and fishery villages since late 1960s. Water supply systems administered by MOC and MHA employ installed and operated on a self-helf basis employing appropriate technologies. The operation and maintenance of all public water supply is the responsibility of individual local authorities whether they be at the city or the village level.

In Korea, hydrogeological conditions are not considered to be conducive to groundwater development and little attention has been paid to investigating the possibility of utilizing groundwater for sizable domestic or industrial water supply systems. Major groundwater developments have, however, been attempted for meeting emergency demands for irrigation purpose during a severe drought period throughout the country.

Surface water has been the major sources of water, some 76% of total domestic demand in 1981 being drawn from direct river flows while 10% is from impounded reservoirs, 11% from riverbed waters and only 2.2% from groundwater as shown in Figure -1.

An annual average precipitation is 1,159 mm over the country, resulting in total of 114×10^9 cubic meter per annum. Of this total quantity, 40.5×10^9 m^3 is lost as a flood flow in addition to the loss of 47.8×10^9 m^3 due mainly 11.4×10^9 m^3 per annum is actually available for abstraction because of the highly skewed seasonal distribution of rainfall, inadequate impoundment facilities and poor river embankments. From supply and demand point of view, an availability of water resources is unevenly distributed, i.e., available water is normally short of demand where there is a large demand, thus resulting in a large expenditure for the construction of lengthy transmission pipe systems. Furthermore, densely populated urban areas are situated in near the month of rivers where there exist significant salt water intrusion problems. Because of heavy dependency upon river waters, 76% as described previously, the quantity of intake water is heavily dependent upon the natural river flow conditions which are normally beyond artificial control.

2. PAST AND PRESENT SITUATIONS

In retrospect, the history of public water supply in Korea goes back to 1895[2] when the first system of this kind was instituted in Busan city. In the year 1908 a slow sand filtration plant was put in operation, with a capacity of 12,500 cmd serving 125,000 people. Ever since water plants were constructed in various municipalities such as Inchon, Pyongyang,

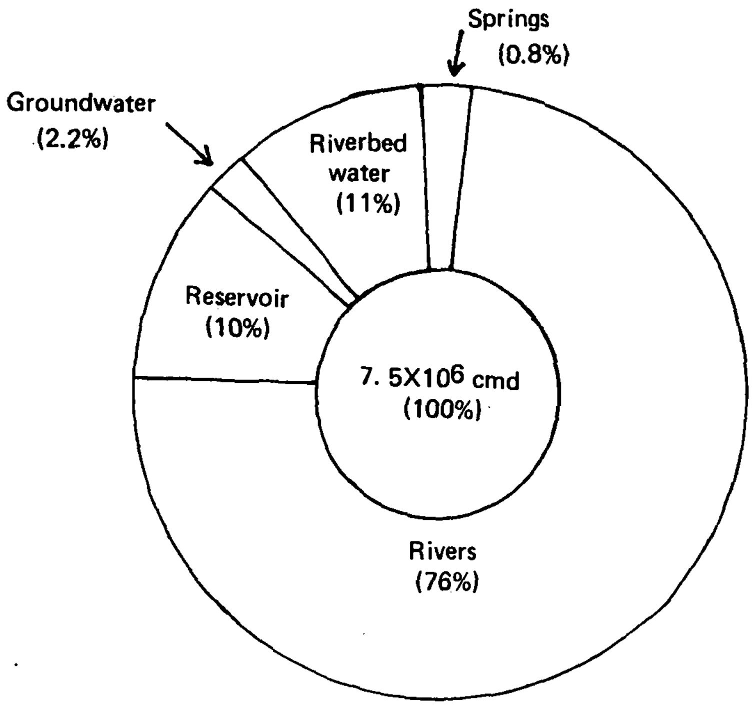


Figure – 1 : SOURGE OF RAW WATER (1981)[1]

Busan, Daegu, and other larger municipalities.

As illustrated in Table -1 only 3.28 million people (18% of total population) living in forty municipalities could enjoy public water supply in 1947, two years after the end of the second World War. Unfortunately, most of the water works were destroyed during the Korean War (1950–1953). Since 1954 major effort was given to rehabilitation and enhancement of the existing systems, and to development of new ones. As a result the total capacity had been graudally increased to 517,000 in 1960, 750,000 in 1965, 2,166,000 in 1970, 3,842,000 in 1975, 6,756,000 in 1980, and 7,508,000 cmd in 1981, respectively.

At the end of 1981, water supply systems provided through the Ministry of Construction were in operation in 263 municipalities.
In case of larger municipalities (50 sis) with populations of more than 50,000, the systems were providing a service by house connections to some 20 million (86%) of the 23.2 million inhabitants, which constitutes 60% of total national population as mentioned previously.
20 million urban dwellers served constitute 91% of the total population of 22.2 million served throughout the nation. The remaining 9% of the total population served (some 2.1 million) are those living in eups and myeons as listed in Table -2.

(1) Water Supply Staistics : 1982, Korean Water works Association
(2) Sanitary Engineering, Y. Choi and W. Oum 1977

Table –1 : NATIONAL WATER SUPPLY BY YEAR

Year	total population	population served	% served	installed capacity	per capita per day consumption	number of muni cipality served
	10^3	10^3	%	10^3 cmd	lpcd	
1	2	3	4	5	6	7
1908		125		12,5	100	1
1947	17,800	3,280	18	240	66	40
1955	21,526	3,475	16	270	71	50
1960	24,954	4,210	17	517	99	58
1965	28,317	6,000	21	750	106	78
1970	31,435	10,430	33	2,166	158	117
1975	34,709	14,961	43	3,842	216	172
1980	38,124	20,809	55	6,756	256	243
1981	38,723	22,088	57	7,508	264	263

Data : Water Supply Statistics, Ministry of Construction, 1982

Table – 2 : MUNICIPAL WATER SUPPLY (1981)

	total population	population served	% served	installed capacity	per capita per day consumption	number of municipality served
	10^3	10^3	%	10^3 cmd	lpcd	
1	2	3	4	5	6	7
National total	38,723	22.088	57	7,508	264	263
Total in sis	23,187	20,015	86	6,786	278	50
Total in eups and myeons	15,536	2,073	13	722	137	213
Largest 4 sis						
Seoul	8,676	8,103	93	3,470	350	
Busan	3,250	2,860	88	765	267	
Daegu	1,838	1,672	91	350	209	
Inchon	1,142	1,053	92	370	323	

Date : Ten year plan for National Water Supply (1982–1991), Ministry of Construction, Dec. 1982

The ministry of Home Affairs has drawn up a comprehensive plan for the development of the urban water supply sector, a particular attention being given to the provisions of supplies in eups and myeons, areas which had previously received little attention by the Ministry of Construction. MOC's attention had been rather directed to larger municipalities including sis and larger eups. Execution of the MHA program had commenced in 1979 thorugh the agency of the provinvial (do) and country (gun) administrations, technical inputs being provided by consulting and local government engineers as MHA has no technical staffs within the ministry. MHA's principal function is therefore concerned with financial supports in terms of grants and loans. The program provides loans to local governments. The loan has to be paid back during a period of 15 years with 5-year grace period at an annual interest rate of 10%.

Surmmarized in Table -3 are the numbers of municipalities (eups and myeons) that have received the loans from the Ministry of Home Affairs and the corresponding expenditures.

Table – 3 : MHA PROJECT FOR EUPS AND MYEONS
(Data from The Ministry of Home Affairs)

	1979		1980		1981		1982		Total	
	ongoing	Completed								
1	2	3	4	5	6	7	8	9	10	11
New Expansion	40 31	14 6	89 46	27 10	110 42	38 14	104 62	52 24	343 181	131 54
Total	71	20	135	37	152	52	166	76	524	185
Expenditure (10^9 W)	10.57		20.04		31.33		46.16		108.10	

The Ministry of Health and Social Affairs made simple piped water supplies (SPWS) available in 29.145 villages by the end of 1981, in addition to the water supply systems provided by the Ministry of Construction and the Ministry of Home Affairs. SPWS system provided safe drinking water to some 8 million rural dwellers in villages where there are so small numbers of households in each village that large scale water supply system is not likely. The group of people receiving waters from SPWS systems constitutes 51% of total rural population of 15,536,000 people who live in the 32,624 ris which comprise the target group for this type of supply. There are 62,368 small community units in the nation, which are considered to be a group of households where a SPWS system may be institutionalized. A ri, in often case, encompasses more than a small community unit.

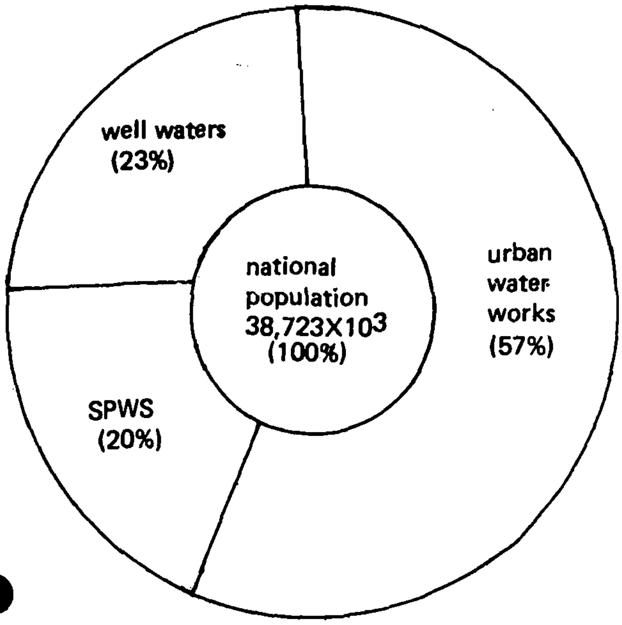
Illustrated in Figure -2 are the 1981 national figures as expressed in percentage of total population regarding water supply by different catagories. Urban water works derive 100% of their raw water from surface sources while SPWS systems for rural community rely 90% on ground waters from wells and/or springs.

3. NATIONAL STRATEGIES AND GOALS

To ensure stable year round sources of water to meet the ever increasing demands for agricultural, industrial as well as public uses, certain basic measures must be taken to enable the smooth implementation of the desired water resources development program. This is essential for the fullfilment of important national goals of the fourth and the fifth five-year economic plans with more emphasis on attaining self-sufficient economy with balanced trade, promoting more balanced social welfare.

The nature and the role of the Fifth Five-Year Economic and Social Development Plan (1982-1986) has been redefined to better serve the goals of national economic strength, steady growth, and advances in the peoples standard of living in qualitative as well as in quantitative terms. The evolving policies of the nation in several five-year plans have clearly shown that the more and more attention is being directed to environmental integrity. A financial plan in the amount of some 120 million US dollars is proposed for the 1982-1986 period for water supply sector.1)

(1) Kyu-Hong Ahn, A National Program for Environmental Control in Korea, Ph.D. Thesis, Cornell University, August, 1983



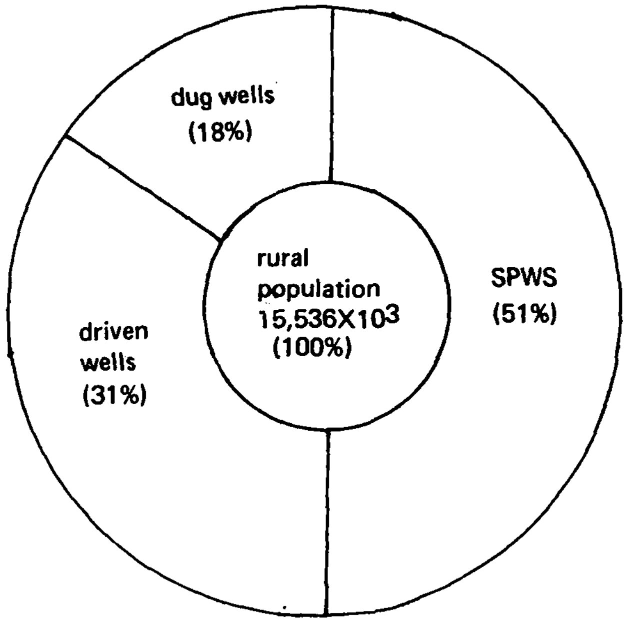


Figure — WATER SUPPLY BY DIFFERENT CATAGORY (1981)

The need for formulating a national water policy is identified as a basic requirement to enable measures to be instituted for the rational management of the country's water resources in the long-term.

A progressive increase in the percentage of population to be provided with this basic amenity is in line with the government's policy of more safe water to more people, thus raising the standard of living of all sections of the community. Given the policy, the current water supply expansion program will be continued for the next decade, increasing the service of 57% at present to 70% by 1986 and 80% of the national population by 1991. The total public water demand by the year 1991 will thus be more than double the 1981 demand.

On a country-wide basis, the supply far exceeds demand both for the present and in the future. Even if supply is in excess of demand in some locations pressures on water quality have created local deficits and have forced to relocate intakes to further upstream as has been the cases of the Metro Seoul.

Large scale integrated regional water supply systems have already become necessary and have been proposed in connection with comprehensive river water resources development plans for all major rivers. This will ensure regulating storages and transferring waters to distant municipalities within the region.

4. NATIONAL NEEDS AND FUTURE PROSPECTS

Overall improvement of public health and sanitation for the urban poor and the rural dwellers, thus enhancing the quality of life is vital importance to the ultimate national goals of socio-economic development plans. An integrated approach concerning more water to more people is also of vital importance to ensure that the plans would be carried out in a way that reflects the overall needs and aspirations of the people. Moreover, promotion of rural development is a matter of urgent necessity in order to implement the concept of creative self-reliance, to promote equity in income distribution, to ensure relative absence of regional stratification, and to eliminate urban-rural gaps.

It has been shown that the estimated demand for domestic water supply will rise markedly in the future, being more than double in a period of ten years from the year 1981, In absolute term, the demand will increase from $7.5x10^6$ cmd in 1981 to $16x10^6$ cmd by the year 1991, implying that a great deal of investment on public water supply program will be necessary to cope with anticipated demand. Since the more readily available portions of water resources have already been developed, the investment per unit quantity of water for any period of time in the future will far exceed that for any equivalent period of time in the past. Moreover, further development involving large scale of development will have to depend more on regulating storage and transfer of water over long distances. In addition, water courses are increasingly subject to pollution from a variety of sources and higher costs are therefore anticipated for treatment to an acceptable quality for use. The difficulties are compounded by a heavily uneven distribution of water availability in time and space in Korea.

A comprehensive ten-year plan (1982 to 1991) is proposed regarding the existing plant expansions and the new plant constructions for public water supply throughout the nation. The plan includes the national goals and criteria based on which the plan will be implemented, budgetary program and phased financing schecules (1), as summarized in Tables -4 through -8.

Table -- 4 : TARGET POPULATION AND PER CAPITA CONSUMPTION

population Group	1986		1991	
	% Service	Consumption	% Service	Consumption
	%	lpcd	%	lpcd
1	2	3	4	5
National Ave	70	300	80	350
>3,000 x 10^3	90	350	95	400
400–3,000 x 10^3	85	300	90	350
50–400 x 10^3	80	250	85	300
20–50 x 10^3	70	200	80	250
<20 x 10^3	40	120	70	150

A service ratio will increase from 57% (1981) to 70% (1986) and 80% (1991) on a national basis. Even for smaller communities the ratio will increase to 40% (1986) and 70% (1991) from the current ratio of 13%. Moreover, the national average per capita per day consumption will rise from 264 (1981) to 300 (1986) and 350 lpcd (1991).

The total amount of water for public supply will increase from 7.5 million cmd to 12 million in the year 1986 and to some 16 million cmd in the year 1991 while the number of municipality having water works plants is expected to increase from 263 to 442 (1986) and 562 (1991).

In addition, it is planned that by 1986 total of 46,824 community units will have been provided with SPWS. This will serve some 13.8 million rural dwellers which represent 93% of total rural population of 14.9 million (36% of national population of 41.8 million). The remaining 1.1 million rural inhabitans living in 15,544 small unit communities will have been dependent upon private dug wells and driven wells. These communities are the most remote areas across the country and will have high quality of ground water free of pollution even in 1986. Expenditures required to cover all these remote communities are not justifiable not only from the cost-effectiveness point of view but also from the point of view of water quality improvement.

To these national goals, several river basin-wide integrated water supply systems are either being planned or being under construction as listed in Table-6, These systems when completed in the year 1991 will have served some 7 million more peoples. The total investment required for the completion of these systems is amounted to some 532 billion wons, being equivalent to 710 million US dollars. 62 percent of the total investment is financed through national budgets while the remaining 38% is financed through foreign loans by such organizations as IBRD, ADB, and OECD.

Apart from the river systems, local water works plants will be constructed in 249 more municipalities, mostly eups and myeons with estimated cost of 1,591 billion wons (equivalent to US $\$2.1x10^9$).

The total of investment will then be 2,123 billion wons, equivalent to $2.8 billion with total capacity of some 8.5 million cmd in the year 1991 in Korea as summarized in Table-8. Figure-3 shows the actual

1) Ten Year Plan for National Water Supply (1982-1991), Ministry of Construction, Dec. 1982.

Table – 5 : WATER SUPPLY PROSPECT OF TEN YEAR PLAN

	Unit	1981	1986			1991		
		Total	total	sis	eups & myeons	total	sis	eup & myeons
1	2	3	4	5	6	7	8	9
Population total	$x10^6$	38.72	41.84	26.94	14.90	44.86	30.49	14.37
Population served	$x10^6$	22.09	29.24	24.62	4.62	35.65	29.68	5.97
Percent served	%	57	70	91	31	80	97	41
Capacity	$x10^6$cmd	7.51	11.98	10.71	1.27	15.84	14.15	1.69
Consumption total	lpcd	264	300	335	195	350	380	210
Municipality total		263	442	50	392	562	50	512
eups		146			188			188
myeons		65			202			322
others		2			2			2

Table – 6 : RIVER SYSTEMS : WATER SUPPLY AND EXPENDITURE

System	Q	Total cost (82–92)			82 – 86		87 – 91	
		total	domestic	foreign		cost	cost	
	10^3cmd	10^9won			10^3cmd	10^9won	10^3cmd	10^9won
1	2	3	4	5	6	7	8	9
Geum River	300	67.4	52,4	15.0	300	67.4		
Nakdong River	150	7.1	7.1		150	7.1		
Daecheong Dam	400	126.4	74.2	52.2	200	56.0	200	70.4
Metro Seoul Phase III	1,300	178.2	104.8	73.4	400	92.1	900	86.1
Seomjin River	100	48.4	33.6	23.0	40	12.8	60	35.6
Namkang River	150	56.6	28.1	19.7	50	19.8	100	36.8
Geumho River	100	47.8	28.9	19.5	40	28.5	60	19.3
Total	2.500	531.9	329.1	202.8	1.180	283.7	1.320	248.2

and the projected figures of public water supply in Korea. also shown in the figure are the such pertinent information as total national population, percent ratio of population to be served. It should be noted that a rapid increase in rate of population to be served is now being experienced since the late 1960s.

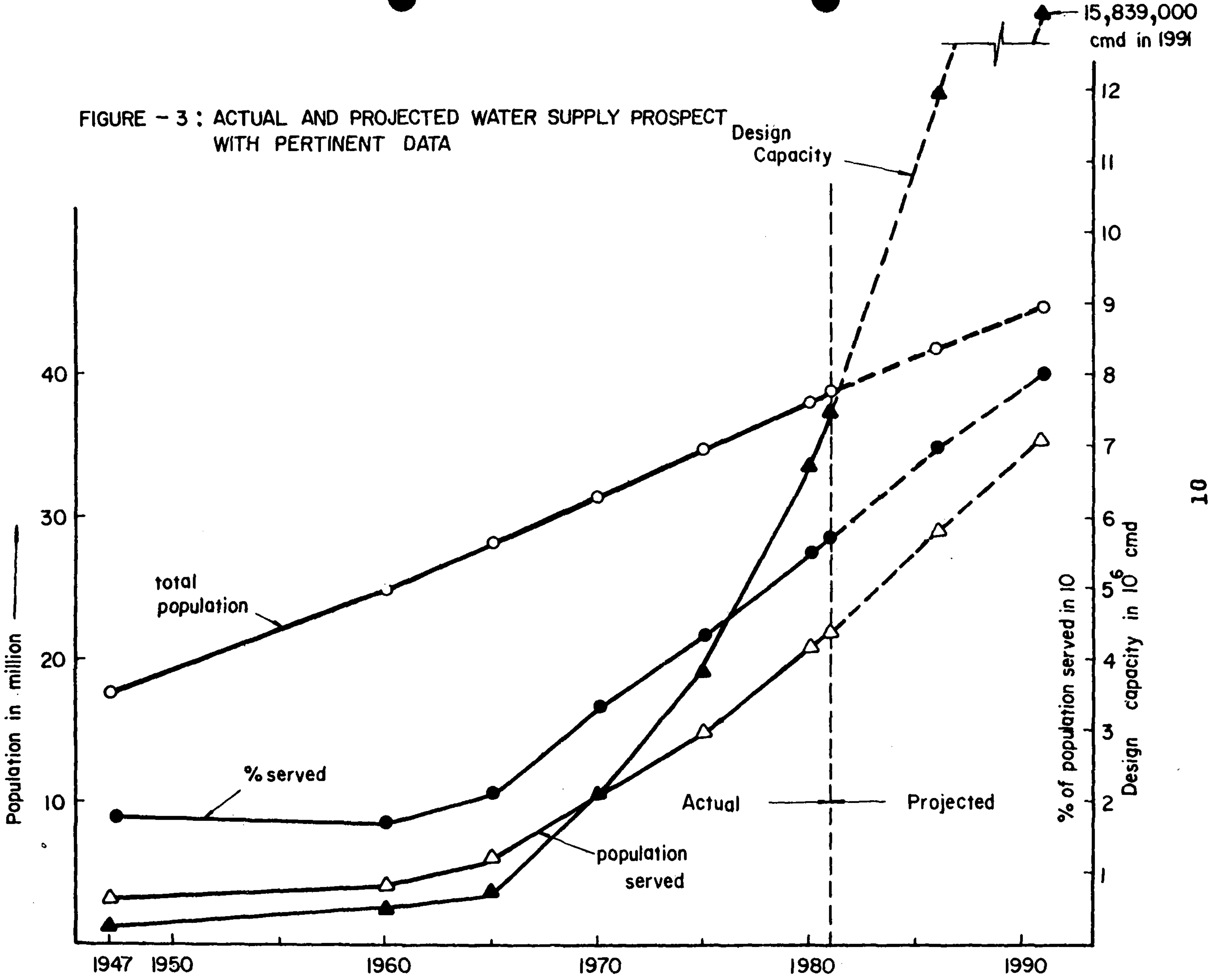
Table – 7 : EXPENDITURES FOR THE TEN YEAR PLAN

		Total (82–91)		82 – 86		87 – 91	
		10^6cmd	10^9won	10^6cmd	10^9won	10^6cmd	10^9won
1	2	3	4	5	6	7	8
Water supply from River System	New Construction	2.50	532	1.18	284	1.32	248
Local Water Supply	New Construction	8.48	1.224	4.62	693	3.86	531
	Upgrading	–	367	–	147	–	220
	Sub-total	8.48	1.591	4.62	840	3.86	751
Nation total	New Construction	8.48	1.756	4.62	977	3.86	779
	Upgrading	–	367	–	147	–	220
	Total	8.48	2,123	4.62	1,124	3.86	999

Table – 8 : SUMMARY OF THE TEN YEAR PLAN

	Number minici-palities	1981	82 – 91			82 – 96			87 – 91		
		Ω	Δ O	Σ O	Cost	Δ O	Σ O	Cost	Δ O	Σ O	Cost
		10^6 cmd	10^6 cmd		10^9 w	10^6 cmd		10^9 w	10^6 cmd		10^9 w
1	2	3	4	5	6	7	8	9	10	11	12
Sis (new construction)											
SEOUL	1	3.47	1.50	4.97	100	0.90	4.37	75	0.60	4.97	25
$>10^6$ population	3	1.49	2.47	3.96	302	1.64	3.13	182	0.83	3.96	120
$>0.2 \times 10^6$ pop.	16	1.83	2.45	5.35	398	1.11	3.34	226	1.34	5.35	172
others	30		1.07		170	0.40		80	0.67		90
sub – total	50	6.79	7.48	14.28	970	4.05	10.83	563	3.43	14.28	407
Eups & Myeons											
new construction		0.72	1.00	1.72	254	0.57	1.29	131	0.43	1.72	123
upgrading					367			147			220
sub total	512	0.72	1.00	1.72	621	0.57	1.29	278	0.43	1.72	343
River system											
total					532			284			248
GRAND TOTAL											
NATION	562	7.51	8.48	16.00	2,123	4.62	12.12	1,125	3.86	16.00	998

FIGURE – 3 : ACTUAL AND PROJECTED WATER SUPPLY PROSPECT WITH PERTINENT DATA



5. PROBLEMS AND CONSTRAINTS

Major constraints encountered in Korea are lack of funds, man power, institutional arrangement, awareness of people with respect to public health and community sanitation, and community willingness of participation.

Economic instruments for water supply encompass financial aids to carry out projects and financial levies which act as incentives to comply with the water policy adopted. Financial aids usually take the form of grants made available for particular works to ease the beaden of expenditure on the immediate beneficiaries. Financial levies are determined by pricing policy and include uniform charges unconnected with the amount of water use and charges and taxes on water which are related to water use.

Funding of major non-urban water supply projects is undertaken by the provincial government although specific purpose grants have been made available from time to time to provincial government from the federal government for water supply development. Urban water supply charges in most municipalities are such that the revenue obtained covers capital as well as operating maintenance costs. Potentially, pricing is an important policy instrument through which efficiency in the use of water may be encouraged, thus enlightening people of water conservation practices within their properties.

People with appropriate skills and adequate education and training are essential components of any water management system. This applies to decision makers, technical experts and users: each group requiring its own forms of education and training. While education and training is a basic requirement for both decision makers and technical people, water users also require development of an increasing awareness of the problem of water supply and its relation to public heath and community sanitation, thus promoting public willingness of participation to enhance living standards.

Education and training for professional development in Korea is reasonably well catered for through universities, colleges of advanced education and engineering colleges. Most tertiary institutions offer a variety of courses at both profesional and subprofessional level. In addition to formal courses offered by universities and colleges, a number of community technical colleges conducts education and training of technicians. There are also a number of training centers and other organizations that conduct workshops and short courses with the on-the-job training purpose.

There has been increasing recognition in recent years of the constraints that can be imposed by existing institutional arrangements for water resources management as a whole. Administrative responsibility for water resources in Korea has tended to develop on a functional basis to the extent in some cases of separate responsibility for different purpose of use; irrigation, urban, flood mitigation, soil conservation and environmental protection. This has the disadvantage that competing demands for use of the resource must be resolved on an inter-agency basis. Some of the effects of this constraint are being alleviated by the development within the federal government of restructured water management agencies with broader, more comprehensive functions and development also of coordinating agencies and mechanisme.

It is increasingly recognized that public participation as a whole results in an overall improvement in the performance of the water supply program. It is especially so when one deals with self-helf water supply systems in rural areas. The imvolvement of water users in association with responsibilities in operation and management of their own system is essential for the efficient operation. Rural dwellers are normally willing to help and participate the program because they are the direct beneficiaries. There is, however, a need for improved technical education of participants, and particularly for the training of suitable leaders in the community so as to ensure proper performance of the systems. It is difficult to prove the improved health effects empirically by field surveys, although a direct link between the effects and SPWS seemed obvious as noted by the statistics of water borne disease outherak (1). The sucessfulness of the program has been evidenced by the decrease in numbers of incidences of water borne disease which had been in endemic proportion until 1970, average number of incidences being 4,300 per annum between 1963 and 1970 thorughout the country. The number of outbreaks was declined markedly since 1971, the records being 3,146 in 1971, 2,030 in 1972, 787 in 1973, 304 in 1977, and 201 incidences in 1980. It should be pointed out that the full health benefits of the water supply improvement will not be realized until excreta disposal improvements are made as well (2).

In most countries, developed or developing, research activities are of utmost importance. Research is not only a quest for knowledge, it is a vital instrument for finding solutions to numerous problems in optimal planning and operation of water supplies, the river system development in particular, as well as efficient implementation and management of overall projects. The problems have first to be identified. Many of these problems, however, have to be resolved

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1) Rural water supply programs in the Republic of Korea, Ministry ot Health an Social Affairs, 1981

2) John M. Kalbermatten, et al , Appropriate technology for water supply, vol. 2, A Planner's Guide, World Bank Dec., 1980

taking into consideration specific situations with regard to technical, social, economic, and environmental matters prevailing in the particular area. These problems not only call for knowledge of local conditions but also underscore the need for finding solutions which can be successfully implemented by adoption of proved technology. There is, therefore, a need for developing competence amongst the research workers to enable them to find appropriate and timely solutions to various problems. There is a research need for finding ways to minimize leakage if not possible to avoid completely through the distribution systems, thus minimizing amount of unaccounted-for water. This will not only increase revenues but also avoid to spend unnecessary expenditures for quantitative expansions.

MASS PROVISION OF WATER SUPPLY FOR VILLAGES

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1. Foreword

The recent industrial development in Taiwan inevitably results in the change of economic structure as well as the change of economic structure as well as the living standards of the people here. The basic living requirements are the same weather the people are living in the rural or in the urban area. It is obvious that the government is asked through their legislative representatives to supply potable water not only in the cities, but also in the villages.

For rural customers, they demand the same basic needs of potable water supply as those who live in the cities, eg.; same standard of potable water quality, same price and same kind of services. On the other hand, to fulfill the government's desire to provide low-cost utility services to the people, especially for those in the lower income bracket, the Taiwan Water Supply Corporation (TWSC) is under considerable constraints in setting a workable tariff. The results of such constraints are: huge investment, high operation and maintenance cost and difficulties in management.

Although the tariff for the rural water supply cannpt reflect the cost for providing such services, the TWSC, under very heavy financial burden, just have got to carry on the rural potable water supply programme.

Three years ago, the Taiwan Provincial Government of the Republic of China granted a sum of NT$2,100 millions (US$52.5 million) to TWSC for stepping up the rate of rural population served, and at the same time help to reduce the burden of loan interest.

2. The Mode of Executivon.

2-1 The Basic Planning Work.

2-1-1 It is impossible to carry out the water supply projects without a wall established master plan. Begining from 1980 TWSC has started and accomplished several regional master plans of potable water supply for the rural areas covering the whole Taiwan (except the metropolitan district of Taipei) and the out-lying islands. They have been drawn according to the geographical environments and the regional needs in combination with the effective use of water resources.

2-1-2 The scope of the regional master plan covers rural settlements with population of more than 200 up to 2500. However, villages with population even less than 200 but reasonably near the route of the pipe mains are also included.

2-1-3 There are two important parameters worthy mentioning in the planning work.

2-1-3-1 The unit construction cost of purification plant based on design capacity is as follows:

Design Capacity CMD	Unit Construction Cost NT$/CMD
less than 500	4000 – 5500
500 – 1000	3000 – 4000
1000 – 2500	2500 – 3000
2500 – 5000	2000 – 2500
5000 – 10,000	1500 – 2000
10,000 – 50,000	1250 – 1500
50, 000– 100,000	1000 – 1250
mor than 100,000	800 – 1000

2-1-3-2 The pipe line cost per linear meter, excluding road repairing cost, based on pipe material at a maximum working pressure of 6 kg/cm^2 is as follows:

TABEL I

Abbreviations

PVCP	Polyvinyl Chloride Pipe
NVP	Nan-nya Value Pipe
MJCIP	Mechanical Joint Cast Iron Pipe
MJDIP	Mechanical Joint Ductile Iron Pipe
PSCP	Prestressed Concrete Pipe
FRP	Fiber-glass Reinforced Plastic Pipe
ACP	Asbestcs Cement Pipe
SP	Steel Pipe.

TABLE I

Pipe Line Labor & Material Cost Per Linear Meter 1982

Unit : NT$/m.

pipe diameter (mm)	PVCP	NVP	MJCIP	MJDIP	PSCP	FRP	ACP	S.P
50	120	220						240
63	150	290						330
80	210	360	570	750				400
100	280	450	700	950				540
125	360	610	880	–				650
150	450	750	1000	1350			500	780
200	650	1050	1400	1800			700	1350
250	900	1400	1750	2200			900	1700
300	1250	1900	2200	2600	1200	1500	1200	2000
350	1600	2300	2800	3100	1500	1850	1600	2200
400	2100	3000	3450	4000	2000	2100	2050	2600
450		3800	4350	4900	2400	2600	2400	2900
500		4600	5000	5600	2850	3100	2950	3200
600		6400	6600	7600	3650	3950	3700	4200
700			8800	9700	4650	5300	4700	5600
800			10900	12400	5700	6500	6000	6500
900			13900	15400	6800	7900		7300
1000				18800	7900	9600		10000
1100				22900	9500	1100		12200
1200				27000	10800	12500		14000
1350					13000			
1500					15500			
1750					21000			
2000					32000			

2-1-4 The financial and the water pricing problems in each individual supply system are not necessarily to be taken into account in the planning. Because of the unified water tariff policy since 1975, as a result, the overall financial distribution is automatically done. The important considerations in deciding a project to be taken up are therefore, technical and aconomic analyses as well as the assured success and reliability in the operation and maintenance.

2-2 The Important Elements for the Design

The Problem of how to reduce the supply cost is considered to be essential, since the unit cost of water supply is always higer in the village than in the cities. From the design points of view, TWSC has made a great effort to solve the problem effectively, by considering the following points.

2-2-1 Because of many different kinds of house-hold sanitary equipment and of the water use habits of counsumers, the water consumption, per capita per day, varies greatly in villages as in cities. Thus the design criteria of water consumption expressed as iped for ten years design period to be used in villages is much lower than that used in the cities. Therefore, it is necessary to conduct a survey of householders for testing public acceptability and the degree of felt need before the design work starts in order to make the best use of the investments.

2-2-2 As said before, the potability of the water supply in the rural areas must be same as in the urban areas. The final water quality must meet the Taiwan Provincial Drinking Water standards. With regard to the problem of health requirement, disinfection by chlorination is strictly provided. Residual chlorine is made available down to the very end of the distribution line uninterrupted. Standby chlorination unit must also be made available and kept in operating condition at any time, by operating staff or miscellaneous labors who routinely travel around from plant to plant.

2-2-3 Most of buildings in the rural area are one or two stories with a height less than 6 meters. In order the main systems and in the interior pipings, it is reasonable to restrict the service pressure at 1 to 3 (kg/cm^2. Based on the topography of the area served, the introduction of pressure reducing and pressure sustaining valves into the main sistems will assist in supplying water to all consumers at a more steady service pressure.

2-2-4 The water consumption during a fire fighting is very high and much greater than all other uses combined. Since fire accident can not be forecasted, therefore, in the rural areas, it is economically impossible to design a water supply system covering the fire fighting requirement. In order to provide the minimum safeguard against fire losses, fire hydrants are provided on the pipelines larger than 100 mm diameter for the state of emergency.

2-2-5 All types of underground pipings, which are recognized as the most expensive part of a water supply system, should be laid in good condition. In order to reduce the cost, TWSC has set-up a policy to encourase market competition that contract bidders are allowed to quote alternative kinds of pipe with diameter larger than 250 mm. For both laying and supplying of materials, as long as its strength is equivalent or better than the contract specifications. Pipeline with diameter less than 200 mm TWSC will supply the pipes and contractors are asked to quote labor cost only.

2-2-6 In order to facilitate speedy delivery and to reduce unit cost, certain materials and equipment are purchased in large amount collectively. These include pipes, cement, reinforce steel bars, pressure filter tanks, filter sand, small tanks up to 50 m^3 made of reinforced fiberglass, chlorinators, deep well submersible pumps, butterfly valves, gate valves, check valves, pressure reducing valves, pressure sustaining valves, and other automatic control valves, etc.

2-2-7 In designing the water system, it is essential to integrate and incorporate small systems into larger ones as far as possible. And to save operation cost, the supply area should be served by gravity, Howevers, wherever it is feasible in certain cases, limited by local conditions, pumping is inevitable.

2-2-8 If land should be acquired, public land or public provisions in reservation should be considered first. Some lands might be provided free of charge or with considerable fair price by the local governments. As for the private land, negotiation has to be made, which usually requires time and money. Should the negotiation failed, the TWSC is obligated to save an act of enlistment in solving the problem through the provincial government.

2-2-9 During the period of pipe line design, it is necessary to contact with the road authorities to ensure when and where the roads will be renewed or expanded. In this case the laying of the pipe lines can be synchronized with the construction of the roads to save the surface pavement renovation expenses. In most cases, the pipe laying is a serious roblem, because digging and excavation of the road surface is not allowed within three years after the pavement is completed. But, sometimes it can be waired and all or part of the renovation expenses will be paid by local governments owing to the great urgency of the need of supplying water.

2-3 Quality Control in the Construction

2-3-1 The quality test of pipes, fittings and valves, etc., according to defined standards, is entrusted to the Chinese Water Works Association with service charge.

2-3-2 The leakage test of reinforce concrete tank is done according to the AWWA committee report. The recommendated leakage allowance is 0.1% of total volume in 24 hours, as measured by the drop in water surface over a period of not less than 5 days.

2-3-3 The inner water pressure test of field pipe lines is based on 1.5 times of the maximum working pressure of the pipes instead of 1.5 times of the working pressure of the pipes resulted by hydraulic analysis.

2.4 Operation, Maintenance and Management

For sound operation, maintenance and management of water supply in the rural areas, the following procedures are adhered to:

2-4-1 The final water quality should be examined, except in TWSC's routine double check, at fixed time by the local health authorities. The results should be made knoew to the public, in order to ensure the safety of water supply.

2-4-2 The charges are based on the consumtipn registrated by meters. All users are billed at bi-monthly intervals. The users may make payment through local banks or post office transfer. In the event of non-payment, the sanction applied is to cut off the water supply. In actual practice, the charges are paid satisfactorily.

2-4-3 Another measure of saving personal cost, TWSC has employed a number of general labors and given them comprehensive operation and maintenance training courses at fixed intervals to improve their awareness and to familiarize them with the standing orders and handbooks issued to them.

3. Water Tariff and Management Cost

The current water tariff since jan. 1, 1983 is regulated by the Taiwan Provincial Government with the sectional type charge as follows :

Table-II Regulated Water Charges, 1983

Section	Water Consumption (m^3)	Price (NT$/$m^3$)
1	1–10	5.00
2.	11–30	6.50
3.	31–50	8.00
4.	51–200	10.00
5.	201–2,000	8.50
6.	over 2,000	7.00

3-1 The average charge rate in NT$6.60, and the price is uniform throughout the whole supply area no matter it is a rural or urban district.

3-2 Up to 1982, TWSC has 228 water supply systems and the statistics data of cost summary are as follows :

TABLE III

Cost Data 1982

System Size (CMD)	The range of population served in systems	Number of systems	Management cost in NT$/$m^3$ (US $/$m^3$) max.	min.	Average
below 500	200 – 3600	66	83,52	1.72	11.00 (0.275)
500 – 1,000	720 – 7000	30	24.22	2.40	8.53 (0.213)
1,000 – 5,000	2,700 – 45,000	66	13.93	2.18	6.38 (0.160)
5,000 – 10,000	12,000 – 54,000	18	9.00	3.12	5.38 (0.135)
10,000 – 50,000	28,000 – 142,000	35	10.08	3.01	4.88 (0.122)
50,000 – 100,000	72,000 – 250,000	4	5,03	4.01	4.67 (0.115)
over 100,000	33,00 – 1,450,000	9	6.23	0.64	3.83 (0.096)

According to the Table III the average management cost of water supply system in the rural area (500 CMD–5,000 CMD) is NT\$8.64/m^3 and in the urban area, is NT\$4.67/m^2. The management cost in rural water supply system is much higher than the average management cost for the urban system (over 5,000 CMD). The cost of which is lower than the average management.

3-3 The result of the policy adopting a unified water tariff sees a rapid increase of the water consumption in the villages. Another symptom observed, also due to the policy on the requirement to provide potable water to remote rural settlement to provide potable water to remote rural settlements, TWSC has stepped up the construction and installation programme to meet the expanding demand. Because of the above reasons, the cost of the management and the increase both the percentage of population serbed and the amount of water consumed have increased considerably due to TWSC's continuing efforts, the revenue obtained from selling water to the rural area cannot cover the huge debt charge and the high operation and maintenance cost. Thus the increase in water sale does not, in fact, help in improving the financial condition of TWSC.

4. Summary of several significant Achievements

Several notable achievements have attended during recent three years from the beginning of 1980 to the end or 1982.

These are tabulated in Table IV below :

Table-IV Substantial Achievement of Rural Watre in Taiwan.
(January 1980 – December 1982).

Year	Item / Classification of community (based) on aggregated rural population)	more than 10000	2501 – 10000	501 – 2500	201 – 500	less than 200	total
At the end of 1979	Number of served community	126	463	1,721	675	–	2,985
	Population served x1,000	6,076	2,014	1,840	210	–	10,140
At the end of 1982	Total number community	130	620	2,928	1,756		5,434
	Number of served community	130	594	2,325	1,002		4,051
	Total population xl,000	6,666	2,988	3,875	670	1,932	16,131
	Population served x 1,000	6,666	2,625	2,592	332	40	12,255
Significant Results	Increased number of served community	4	131	604	327		1,066
	Increased population served x1,000	590	611	752	122	40	2,115
	Rate of community served	100	95.8	79.5	57		74.5
	Rate of population served %	100	87.9	66.9	49.5	2.1	76.0

From the above table, it is clearly seen that the significant achievements of mass provision are: 1,066 additional communities and 2,115,000 persons now serbed by the new water supply systems which have been built in a period of only three years. The percentage of community serbed is raised to 74.5% and the that of population serbed is 76/ now.

One special project is worthy mentioning here is to supply water to Hsiao Liu-Chiu, a small island south of Kaohsiung with population of 16,000. TWSC finished a submarine pipeline from Lin-Pien located at the southwest coast of Taiwan to Hsiao Liu-Chiu, in the July of 1981. The pipeline is made of armoured high density polyethene with 200 mm inner diameter and a total length of 14.1 km. The total investment amounts to more than US$5,000,000. It supplies drinking water of 3000 cubic meters per day.

5. Conclusion

In the beginning of 1980, TWSC received NT$ 2,100,000,000 from the Taiwan Provincial government as grant and NT$3,100,000,000 from the local banks as loan the total is NT$5,200,000,000 (=US$77,500,000) earmarked as the development funds for mass provision of rural water supply. In the period of execution, TWSC faced with many difficult problems such as the acquisition of land, the application for road excavation, and the obtainment of water rights, the communication and cooperation with the villages, etc. difficulties and got significant achievements as a result of every body pitching in for the common goal of providing adequate and safe water to the rural population.

In the coming years in accordance with the lonrage water supply development plan, TWSC is continuing to take up its sacred duty in providing water to more remote villages, specially those with population under 2500.

The shareholders of TWSC are the provincial and local governments. TWSC is basicall a social service unit but operating like an economic undertaking. It mus meet both requirements. As far as the economical aspect is concerned, TWSC must consider the cost and profit, and runs it as an enterprise. For the social aspeckt, TWSC must observe the government's policy to meet the demand of water consumption for all people both in the urban and rural areas. These goals very often run in opposite directions, and thus result in management difficulties. Therefore, TWSC has to apply most effective methods to increase the sale of metered water, to limit the of use man power and the materials and to reduce the expenses in the construction operation and maintenance. TWSC is working toward the goal of the cost reduction and trying its best to provide the best service. The major contents of this paper is to decscribe the endeavours of TWSC for rural water supply, the mode in executing the works as well as its significant achievements in the past three years. The author takes this opportunity to thank the Chairman and President of TWSC for permitting him use the data and figures from the TWSC and to those we help to edite this report.

PROMOTING THE DISSEMINATION OF WATER SUPPLY SYSTEMS AND THE ROLE OF PUBLIC RELATIONS

Toshio Nagase
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Japan

4TH Asia Pacific Regional
Water Supply
Conference & Exhibition
Jakarta, Indonesia
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TIRTA DHARMA

INTERNATIONAL WATER SUPPLY ASSOCIATION
ASSOCIATION INTERNATIONALE DES DISTRIBUTIONS D'EAU

POLICY FOR THE DEVELOPMENT OF WATER SUPPLY IN JAPAN

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1. Introduction

There is virtually no problem about hygiene and accessibility of daily water use in Japan now. In 1981, authorized public water supply systems covered 91.9% of all Japanese people and small scale water supply installations and individual wells provided reasonable water to the rest.

However, this progress of public water supply started in 1950 and at that time merely 20% of all the people was covered by modern water supply systems. As a result of this remarkable progress, the number of patients of dysentery caused by contaminated water has been decreased from 6 persons per 100 thousands in 1950s to virtually 0 in 1982. At the same time, this progress has released the people in rural areas from the hard work of water fetching. According to this progress the popularization of electric washing machine, pourflush toilet, provate bath and other water use facilities has contributed not only to the improvement of environmental sanitation but also to the promotion of healthy and comfortable living life.

2. Investment for the development of water supply

2-1 Development of public water supply

Modern water supply system in Japan has about 100 years' history since the first one began to supply water in 1887. In the first stage of construction, it took 30 years to cover 10% of all the people and 20 years to cover another 10%. In 1950, about 20 million people, one fourth of all the people, was covered by public modern water supply systems. Table-1 shows the change of percentage of population served in 1950–1981 and 108 million, 92% of all the people, was covered by water supply system in 1982. About one million people at most were provided with water supply facilities every year until 1950 and 3 millions people annually in 1950s. In 1960s, the number of people newly covered by water supply facilities reached 3.5 million in average every year but this number has decreased to 300 chousands in these days as water supply systems have been developed.

2-2 Investment for the construction of water supply

This rapid development of water supply in Japan has been accomplished by continuous investment for the construction of water supply facilities. In 1955, the amount of the investment was merely 78.9 billion yen (in 1982 price) but this figure increased to 487.9 billion yen in 1965 and 1284 billion yen in 1975 (Table-2). This annual average investment in these years is about one trillion yen but the total investment between 1955 and 1985 is more than 20 trillion yen or 750 billion yen each year.

This investment occupies 4 to 5% of all public investments in Japan and the ratio for BNP is 0.44% in average. It means that Japanese people has invested 7500 yen per person every year for the construction of water supply facilities in these 30 years.

2-3 Procurement of investment

The necessary investment for the construction of water supply facilitieis are fundamentally managed by national subsidy and bonds. National subsidy is provided mainly for the investment such as small water supply system construction and water resources development. National government subsidizes 25 to 50% for the construction of water resources development or regionalization of water supply systems. In average, this subsidy occupies about 10% of total investment for the construction of all water supply systems in Japan and the rest is usually managed by the bond which is arranged for waterworks bodies under the guarantee of the government. The sources of this bond are (1) the deposit to the national bank which is managed by the Ministry of posts and Telecommunications and that for the national pension system and (2) ordinary national loans to city banks. This bond system is used not only for the water supply but also for road construction, river improvement, sewage systems construction and for other public facilities. But in the case of the construction of water supply facilities, the interest rate is lower (usually 7.2 to 7.3% per year) and the term of redemption is longer (30 to 35 years) than those of others.

If the funds is insufficient, waterworks bodies must collect the rest by issuing own bonds from any other city bank. In this case, the condition is usually 10 years in the term of redemption and 8.2% in the interest rate.

3. Policies and strategies for the development of water supply

3-1 Development of small scale water supply

It was same in Japan that the development of water supply in the initial stage was introduced mainly for the prevention of epidemic diseases. The rapid development after 1950 was resulted from the adequate recognition of the people about the role of water supply as a sanitation facility.

The Japanese Government also has concentrated her effort on the development of water supply, and especially in the past 40 years, the construction of small scale water supply systems with ground water which could supply water without any treatment except chlorination was thought better for the development of water supply than large scale one which use surface water because Japan had abundant ground water with good quality. In 1952, national government started the 25% subsidy for the construction of small scale water supply system which covers 5000 people or less, and this ratio of subsidy has been improved to 40$ for the construction in bad conditioned area such as mountainous area or particularly scattered habitation area. This subsidy system had been proved very efficient as a leading measure to develop water supply and 1378 small water supply systems had been constructed in 5 years after the establishment of this system while only 89 systems were constructed in 1950 before the establishment of subsidy system. As a result of this, 500 thousands people could enjoy a benefit of water supply from these small water supply systems every year between 1955 and 1970.

3-2 Consolidation of waterworks management system

For the development of water supply, it is also important to consolidate the system for the management of waterworks. In 1957, new Waterworks Law was enacted and the procedure for the management of waterworks was clearly decided. Waterworks Law provides that (1) fundamentally waterworks should be managed under the responsibility of municipalities (2) authorization by the Minister for Health and Welfare is required to start a waterworks or to change its supply plan. At the same time, in the provision of Local Government Law, it is provided that the management of waterworks is inherent in municipalities. Thus waterworks is decided to be managed by municipalities fundamentally in Japan.

Waterworks Law also provides the drinking water quality standard, the facilities standard, qualifications for the person in charge of the management of water supply. These provisions concerning technical matters is much effective to keep water supply facilities in high level.

Waterworks is regulated its management, finance, etc. as a local public work and provided fundamentally to be managed with self-supporting system under the provision of Local public works Law. In a case of small scale waterworks, however, subsidy for the management from general account of local government is admitted to avoid the delay of construction because of the financial difficulty.

3-3 Financial supporting measures.

There are subsidy system and bond system to assist waterworks bodies. This subsidy aims to lead the construction of water supply systems and to decrease the water charge which might become expensive because of high construction cost. For this purpose, construction, elargement and repairing work of water supply facilities located in uneconomical conditioned areas are subsidized. The cost of water resources development and regionalization which causes extensive increase of construction cost of all system is also subsidized. The total amount of subsidy for the waterworks is about 130 billion yen per year in these years and occupied 0.3% of total national expenditure.

The rest of the total construction cost is collected by bonds. Using these systems, municipalities virtually can construct water supply systems without self-funds.

3-4 Training of engineers

For the appropriate management of waterworks, it is indispensable to train engineers who can operate and construct water supply facilities properly. Under the provision of Waterworks Law, each waterworks is imposed to secure and executive engineer who is finally in charge of the management of water supply facilities. For this purpose, national government is promoting several methods to train engineers.

(1) Training of senior engineers

Training of senior engineers for water supply is undergoing at universities. There are 93 national universities, 34 public universities and 324 private universities in Japan. In these universities, 30 national ones, 2 public ones and 41 private ones have courses concerning water supply and 400 students graduate from these courses every year. Especially, there are 4 national universities which has specialized sanitary engineering department and all of these department were established in the latter half of 1950s to cope with rapid development of water supply. The graduates from these universities comes up to 170 every year.

In addition to these, there is a three months training course in the National Institute of Hygiene which belongs to the Ministry of Health and Welfare. This course aims to give specialized practical knowledges concerning water supply engineering to those who graduated from other courses and has actual experience of water supply.

(2) Training of other engineers

To be an above mentioned executive engineer for the management of water supply facilities, he is required to have some qualifications under the provision of Waterworks Law. If he does not satisfy these qualifications, he can do that work after being authorized by the Minister for Health and Welfare following the two months training course organized by the Minister.

In addition to these some training courses are undergoing by Japan Waterworks Association (Table-3) with about 2000 participants every year. And many other training courses are managed in prefectural level and about 3000 engineers (one tenth of all) are attending these courses. There are also many kinds of courses for the management of waterworks aiming at office workers.

4. Policies and strategies for the development of water supply

Although the deffinit purpose of water supply is that all the people can enjoy the benefit of water supply there remains some difficulties to achieve this goal such as funds, feasibility of the management, shortage of engineers for maintenance, etc. As it seems to be difficult to solve these problems by municipalities themselves, *national government, prefectural* governments and public organizations such as Waterworks Association should carry out their role respectively.

Japanese policy and strategy for the development of water supply have functioned well because Japanese people had a good understanding of sanitation as a result of prevailed education and it was relatively easy to get funds because of the high growth of ecnomy. At the same time, we must evaluate the efforts of municipalities to develop water supply with the understanding that water supply facilities are indispensable for the development of their comunities.

The most important thing is that national government, municipalities and people themselves play the role of their own activity with the understanding of the necessity of the development of water supply.

Table-1 Population served by water supply system

Fiscal Year	Total Population*(A)	Population Supplied*(B)	B/A (%)
1950	83.2	(20)	(25)
1955	89.2	33.9	37.7
1960	93.4	49.9	53.4
1965	98.3	68.2	69.4
1970	103.7	83.8	80.8
1975	111.9	98.4	87.6
1980	117.1	106.9	91.5
1981	117.9	108.3	91.9

Remarks * million
( ) estimated

Table-2 Investiments for Water Supply.

Fiscal Year	GNP	Investments	Investments (in 1980 price)
1955	8,865*	14.0*	78.9*
1960	16,207	44.6	203.1
1965	32,813	135.7	487.0
1970	73,284	251.8	673.1
1975	148,031	844.4	1,284.3
1980	234,949	975.4	975.4

Remarks * billion yen.

Table-3 Types of training courses organized by JWWA

Name of the course	Participants	Since	Number of participants par	Period
Training course for senior engineers	senior engineers	1971	330	2 days
Re-training course for engineers	medium class engineers	1971	50*2 times	24 days
Specialized subject course	specialized engineers	1972	50*2 times	8 days
General training course	ordinary engineers	1962	200*7 places	2 days
Others	not specified	as occasion demands		

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PROMOTING THE DISSEMINATION OF WATER SUPPLY SYSTEMS AND THE ROLE OF PUBLIC RELATIONS

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Water Works Bureau
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1. Purpose and effect of public relations

The purpose of public relations in promoting the dissemination of water supply systems consists of appealing for the understanding and cooperation of inhabitants in order to realize the advancement of public sanitation and the improvement of the life environment.

If the comprehension of inhabitants regarding water service is increased, we will be able to expect the following results.

(1) The environments of water sources will be kept clean, and this will aid in the simplification of purification facilities.
(2) Water will be used more carefully so that we will be able to cut down on the facilities for water.
(3) In conducting water supply construction works we will be able to get the cooperation of the inhabitants more easily, and by the work proceeding smoothly, expenses will become less, etc.

As mentioned above, we can expect that public relations will result in decreased construction expenditure.

One of the important factors in promoting the spread of water service is to pursue cheaper costs of construction works. Therefore, I think that public relations is a means of administration on one hand, and of management on the other.

The most important thing about public relations is to establish "Two-way communication". This includes "Public Information" to offer timely information, and "public Hearing" to hear opinions, complaints and estimations. When "Two-way communication" is achieved and both complement each other, we can get effective working of public relations.

However, according to different circumstances and conditions, we can think of different varieties in the combination and contents of public relations. For example, people who have become accustomed to living without water service for a long time, generally do not have a positive interest in it, even if they recognize they are in inconvenient and insanitary living conditions.

Under these circumstances, at the early stage of promotion of water service in order to awaken the inhabitants' interest in laying a water main, we need to appeal concretely and simply about the effects on the prevention of epidemics and fires, and about convenience in daily life.

As a result, we need to lay emphasis on public information activities in order to give a good impression to the inhabitants about water service.

Next, when the plan advances to a certain extent, we need to provide as much information to inhabitants as we possibly can, to gain their understanding and cooperation. Then, according to how the inhabitants respond to the information provided, and what they expect of us, we must incorporate these reflections into the paln, and so the relative importance of hearing activities gradually begins to increase.

As a result, inhabitants who were passive in the beginning gradually begin the water undertaking. Therefore, we can say that the costs of public relations are not simply that fiscal year's costs, but are invested costs.

2. The progress of the spread of water service in Japan and a report of public relations.

The dissemination rate of water service in Japan is now a fairly high level of 92 percent. However, we needed a long time, many policies and the inhabitants' cooperation to realize this high rate.

The beginning of the modern pressurized public water service in Japan was established in Yokohama, in 1887. In the early stages of promotion of water service, it was the government's policy to concentrate on big cities and cities with port facilities.

Afterwards, the policy was extended to a nationwide campaign, but the dissemination rate of water service up to 1955 was only 32.2 percent, because of the influence of World War II and other things.

Due to these circumstances, the financial aid of the government was increased in order to promote dissemination of water service as a nation-wide movement. In response to this, water undertakings in each district began to relay information eanestly by distributing advertising and pamphlets which dealth with the problems relating to the particular region.

These activities were carried out independently in each district throughout the year, but the opinion gradually became stronger that we had to establish recognition of the fact that dissemination of water service was one of the national problems, and also that it was. necessary to make public relations activities more effective.

Therefore, it became a rule to set up a week for stressing unity nation-wide, by the combined efforts of the Ministry of Health and Welfare. This came into practice in 1959, and continues now. Now, this special week (The Water Service Week) is held from June 1 through 7 before we meet peak water consumptiin in July and August.

During this week, the national slogan is decided on and incorporated in posters and other printed material for distribution. Also, these are put up on the main buildings in the streets to draw people's attention to the signboards and advertising sheets. Several examples of these slogans are as follows; in the beginning period, there were many such as "Let's get cheerful and healthy by water service", or "Be full of health and joy by water service".

Getting to the middle of the 1960's stability of water resources became the main subject in order to cope with the rapidly increasing water demand. The slogans changed to "Let's secure water resources for water service". or "Let's take good care of water, because of limited resources".

As mentioned above, in the beginning period, public relations of water service placed emphasis on public sanitation and improvement of living circumstances. Now with the recent high rate of dissemination, it has changed to deal with problems related to water conservation. In this way, public relations of water service reflects the changing of the times.

As result of these activities being performed as a nation-wide event, interest in water service began to increase gradually. Since 1979, during this week, the central place of meeting being set up in Tokyo by the Ministry of Health and Welfare, the Japan Water Works Association and other parties, efforts to show water service to be of national importance have been made every year.

As well as this, a week to think about future water problems in Japan (including all problems concerning drinking, agricultural and indutrial water, as well as conservation of under ground water) has been carried out every August since 1977 under the proposal of the National Land Agency.

Now, I will introduce several examples of the events which take place during this Water Service Week.

(1) Lectures or discussion meetings are carried out in every district, and these are passed on to many people through articles in the newspaper. As we can get direct contact with people by such meetings, even though the numbers are limited, it is more effective than distribution of pamphlets. Because of this, we have begun to utilize to the full every opportunity of meetings with the inhabitants. For these meetings, there are some examples of utilizing movies or slides, and of holding concerts.

(2) Another example is to collect photographs, compositions and pictures by school children, and other materials about water service and to hold an exhibition of these works. With this exhibition is set up an information corner on water facilities and a standing exhibition hall.

(3) There are many trips to supply information of water facilities to scholl children, groups of house wives and citizen in general in order to actually see water facilities and to deepen understanding of water service.

(4) There are other examples of broadcasting from a car equipped with a loud speaker through the town, of distributing leaflets with a souvenir, for example, a ball point pen, as publicity on a street corner, and of setting up guidance clinics temporarily in the street to give consultation about water service.

(5) There are also examples of utilizing the mass media, for example, advertisements, special articles in the newspaper and programs on television. These are effective means of appelaing to many peole at the same time.

The main events have been mentioned, but efforts are made to do this in every district, not only during this period, but also throughout the year.

Now, I will refer to the production of posters and movies.

(a) The aim of poster is, of course not explanation of detailed contents, but to be "Eye-Catching". Because of this aim, there is also a weak point in that it is difficult to pick up too many points. As a means of overcoming this weak poing, recently, calendars which have printed articles on a particular theme every month regarding water facilities and which naturally attract people's attention every day, are being distributed increasingly.

In regard to pamphlets too, there are ways to make people enjoy reading them by making sentences shorter and plainer, and by increasing the illustrations and photophraps.

For a movie, if the screening time is too long, the audience's attention diminishes so about twenty minutes is a suitable length.

In the case of undertaking to produce posters, pamphlets, movies or other public relations materials, it costs a considerable amount. So, for the occasion of this week's events, the Japan Water Works Association produces posters, pamphlets, movies, etc. and distributes them to each area, and as a result, it is effective in considerably reducing public relations expenditure by mass production and to standardize the nation wide public relations level, too. Each area then utilizes these materials and also adds its own unique methods to them.

(b) And, as I mentioned before, in order to get opportunities of direct contact with the inhabitants, of each district, we utilize not only various kinds of their meetings, but also plan to hold the meetings regarding water service which are organized by a few dozen members who are chosen from the general public by random sampling or from some kinds of groups by recommendation.

(c) We appealed to the education authorities to include water affairs in the grade school lessons and these began to be accepted gradually since about 1975, and have been included in the social studies curriculum formally since 1978. Through this, not only can we educate those who may be leaders in the next geneation, but it is possible that this will be used by them as a topic of conversation at home, and so even now we can expect big results.

Regarding this plan, school teachers are also very cooperative and the number of schools has been increasing annually, that apply to study by visiting water facilities.

(d). In addition, we must not forget that there are also public relations activities in the daily water service activities, for example, explanation to persons concerned in local water constructions, the efficient supply of information and emergency treatment in the case of accidents or suspension of water supply by explosion of water pipes and the like.

These are important public relations activities for gaining the confidence of inhabitants in relation to water service.

I have here reported an outline of public relations activities of water undertakings in Japan, and hope it will be useful.

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EFFECT OF EXTENSIVENESS ON THE DEVELOPMENT OF WATER SUPPLY

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4TH Asia Pacific Regional
Water Supply
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TIRTA DHARMA

INTERNATIONAL WATER SUPPLY ASSOCIATION
ASSOCIATION INTERNATIONALE DES DISTRIBUTIONS D'EAU

EFFECT OF EXTENSIVENESS ON THE DEVELOPMENT OF WATER SUPPLY

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1. Development of Water Supply in Japan

Since the year of 1887 when the first drinking water supply system was constructed in Yokohama City, the water supply systems of Japan was contructed in other big cities and then in small municipalities.

On the other hand, for some areas, extensive water supply systems was constructed which cover several municipalities.

In 1980, as a result of these efforts, Japan came to have 18,257 waterworks which consist of bulk waterworks (85), municipal (1,896), small–scale (12,148) and private (4,128). The ratio of population served drinking water (106,914,000) to Japaneae total population (116,860,000) amounts to 91.5%.

In Japan, there are two types of extensive water supply systems.

One is abig waterworks which intake raw water, purify it, convey, distribute and supply which intake raw water, to each home. The other is a bulk waterworks which intake raw water, purify it, convey and supply drinking water to each small waterworks. The number of bulk waterworks was only 7 in 1960. But, it showed a rapid increase as recent extensive water supply systems amounting to 17 in 1970 and 36 in 1980.

2. Promotion Policies of Water Supply Extensiveness in Japan.

1) National Policy

To promote the extensiveness of water supply in Japan, the Public Nulsance Committee, one of the advisory bodies of the Minister of Health and Welfare, issued a paper "Report on The Extensiveness of Water Supply and Management of Waterworks" on August 30, 1966",

In accordance with the report, a new national subsidiary system fo water source development facilites and water supply extensiveness facilities was established in 1967. Afterwards, subsidiary rate and the applied facilities were increased and the bulk waterworks were constructed one after another.

Waterworks Law was revised in 1977 that each prefectural government must makl an extensive water supply plan and construct facilities.

In 1981, 26 prefectural governments made extensive water supply plans in 34 regions and constructing water facilities accroding to the plan.

2) Policy of Local Government

On the other hand, Osaka Prefectural Waterworks, one of the oldest and largest extensive waterwokrs in Japan, started bulk water supply in 1951 to respond the urgent request of municipalities of Osaka Prefecture which has no other reliable water source except Yodo River Osaka Prefectural Waterworks extended its facilities successively and supplied 1,680,000 m/d for 35 municipalities of Osaka in 1980. But, until now, the facilities of Osaka Prefetural Waterworks were extended always to answer the request of municipalities.

3. Effects of Extensiveness of Water Supply until now.

Extensive waterworks made remakable contributions on the development and stability of water supply in Japan. The effects of extensiveness are as follows.

1) Getting water resource

We can neither construct new water facilities nor extend it without gitting water source. Extensive waterworks ensured water source for regions difficult to get water by conveying raw water and supplying bulk water.

2) Corresponding water demand increase

From 1960 to 1975, water demand showed a rapid increase in urban regions of Japan by high economic growth and urbanization. Municipal waterworks were albe to meet this rapid increase by getting dringking water from extensive water supply system.

3) Stable water supply

Extensive waterworks has been supplying water effectively by operating facilities according to the water demand. It is also effecfive for the stable water supply in case of intake restriction in abnormal dry year and accidents of water facilities by distributing water properly and supporting from another line.

4) Equalizing water supply services

Extensive waterworks for seversl municipalities can supply water on the same service level within its area and bulk waterworks can supply water to each municipal waterworks on the same water rates. Namely, extensive water supply system is effective for egualizing water supply services.

5) Research and studi projects.

Extensive waterworks have more form organization and finances than small waterworks. That is the reason whay extensive waterworks have been made big research and study projects on water quality, countermeasures for water pollution, stalbe water supply and effective operation of water facilities.

4. Extensiveness of Water Supply in the Future

1) Future environment of waterworks.

Environment of Japanese waterworks will be more severe in the different way from we met in rapid extension period. That is to say :

(1) Water demand is estimated to increase more.
(2) Raw water quality will be difficult to imporve.
(3) More stability for water supply is wanted because the ratio of population served drinking water exceeds 90%.
(4) Move efficient operation of facilities is wanted as the maintenance cost increases.
(5) It is necessary to improve old water facilities.
(6) We must supply water with fair service.

2) Functions necessary for the future extensive waterworks.

We have to cope with the environment surrounding waterworks in the future.

(1) Water Demand

The population of Japan is estimated to increase until 2009 and the water demand eill increase according to it. We have to secure water sources and construct water facilities to cope with the increase of water demand.

(2) Raw Water Quality

We can not expect the improvement of raw water wuality only by the preservation countermeasures until now. Water utility will have to introduce advanced treatment to supply clean water.

(3) Stability for Water Supply

In order to supply water steadily in case of abnormal dry year, water source pollution and water facility troubles, we have to construct clear water reservoirs, fair distribution facility, supporting facility from another line and water information system.

(4) Efficent Operation of Facilities.

We have to make an integrated information facility in order to operate water facilities more efficiently, as maintenance cost increases according to the scale and the complexity of water facility inreases according to the scale and the complexity of water facility.

(5) Improvement of water facilities

About 30 to 100 years have past since the facilities of Japanese waterworks were constructed. We have to imporve those facilities intentionally to keep the capacity.

(6) Fair Service

We eill have to make infomation facilities for small service blocks in order to equalize water supply services to supply water with care.

3) Subject for the extensiveness of water supply in future.

In order to cope with the future water demand increase and to supply water steadily, japanese waterworks have to keep on the extensiveness. Subjects for the extensiveness are as follows and the authorities concerned are taking countermeasures.

(1) Aims of Extensiveness

In Japan, the ratio of population served drinking water has exceeded 90% and the japanese waterworks are entering into the nature period from expansion. Though various ideas are proposed for the future aims of extensiveness, it must not be single but integrated reflecting water quality, Stability of water supply,[9] fairness of service, efficiency of facility operation, efficiency of management and the regional characteristics.

(2) Scale of Extensiveness

The scale of extensive waterworks has been decided by administration area, water source and so forth. But it is proposed to consider on the safety of water supply systems[10] and the unity of the supply area[14] in order to set the consensus of the citizen easily.

(3) Form of Extensive Waterworks

There are two forms of extensive waterworks, unity by merger and connection between bulk waterworks and municipal waterworks. Considering about the future circumstances surrounding waterworks, united extensive waterworks is not always the best. Extensive waterworks which connect major water source, water facilities and small service blocks organically by information facility[11] may be more suitable.

(4) Facilities for Extensiveness

Facilities necessary for the extensiveness are clear water reservoirs,[12] pipes connecting nearby waterworks, block, and loop system of service pipe and the water information system as well as conventional water source, purification plant, conveyance and distribution facilities.

5. Construction of the multi—center extensive waterworks.

To cope with the future encironments surrounding waterworks mentioned above, we need new policy for extensive waterworks as well as convetional unity by merger and connection between bulk waterworks and municipal waterworks.

I should like to propose "Mulit center Extensive Waterworks" as follows. "Multi—senter Extensive Waterworks" is an extensive waterworks connectiong many centers oganically by information facility.

We have ts make an integrated opeartion center for whole water facilities as well as operation centers of intake, purification and conveyance facilities for each water sources and operation centers for small blocks in the service area. We have to decide the alm of extensiveness and the service area of appropriate scale.

6. Policies we have to carry out are as follows.

1) Information system for water facilities.

In the future, it isnecessary to make an integrated information system from water source to faucet in order to operate extensively for water source and mainwater faceilities and to supply water fairly and with care for eachsmal service blocks.

2) Control system for each multi-center

As subsystems for the integrated information center mentionde adove, it is necessary to construct control centers to supply water stable, fair and effectively considering water demand and regional characteristics for each center such as water source, purivication plant, conveyance and service blocks.

3) Organic connection of water facilities

It is nécessary to coneectwhole extensive waterworks organically in order to control theinformation of water facilities.

We will have to construct control facilities such as reservoirs and valves, connecting pipes for different systems and small service block systems.

4) Promotion Policies of the Multi-center extensive waterworks.

Detail promotion policies of multi-center extensive waterworks by the connection between bulk waterworks and municipal waterworks are as follows.

(1) Organic connetion between both facilities.
(2) Construction of water information system (Fig – 1)
(3) Construction of small service block systems.

We will have to promote extensiveness according to the extensive water supply plan made for each prefecture.

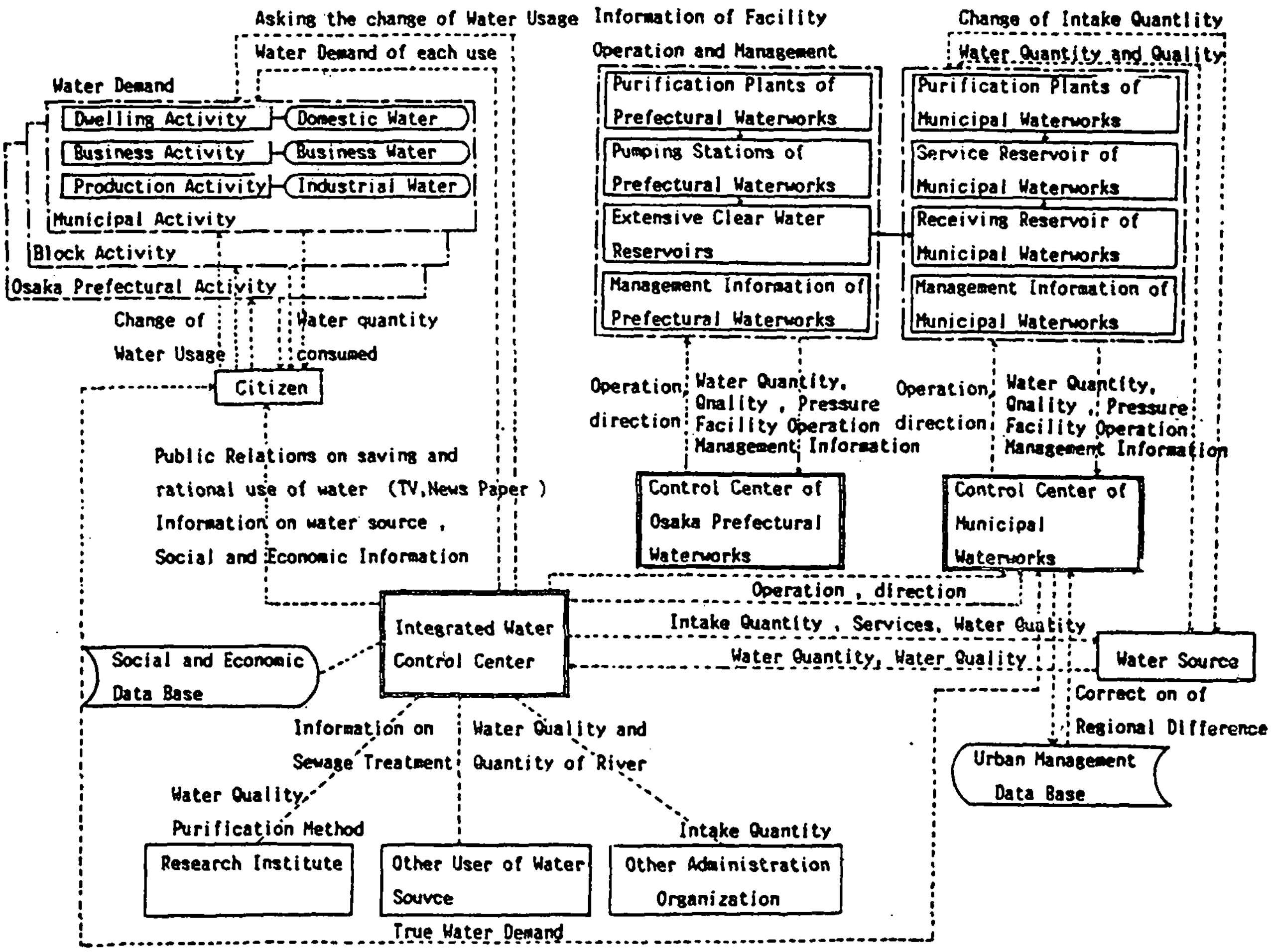

Fig .-1 " Integrated Water Control System " of Osaka Prefectural Government, an Example of Multi-center Extensive Waterworks

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GROUNDWATER WITHDRAWAL IN BANGKOK METROPOLITAN AREA WITH SPECIAL EMPHASIS ON LAND SUBSIDENCE PROBLEM

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Abstract

This article describes a historical development (period from 1957–1983) of groundwater pumpage from the several aquifers underlying Bangkok Metropolitan Area and illustrates the present state (year 1982) of land subsidence and deterioration in groundwater quality. Furthermore, the article emphasises the urgent need for a systematic collection of groundwater data and establishment of the Groundwater Data Bank which should be used for the control of groundwater withdrawal within the Bangkok Metropolitan Area. Finally, the proposal for reduction in groundwater withdrawal from 1,4 to 0.8 mill cum/d required to stop further subsidence and deterioration in water quality is given.

The data used for the preparation of this article are obtained from the Metropolitan Water Works Authority and Asian Development Bank to which the author extends sincere thanks. The oppinion and results presented in this article are solely the authors and do not necessarily represent the view of the above mentioned institutions.

Recharge to aquifers underlying Chao Praya River basin and estimation of sustainable yield from Bangkok Metropolitan Area

The volume of rainwater which is annually infiltrating into the aquifers underlying the whole Chao Praya River Basin (Fig. 1) has been estimated by various authors.

Generally, it could be said that the aquifers in the Upper Chao Praya River Basin (area 106,000 sq.km) receive up to two and half times more recharge (approx. 8% of 1200 mm/yr) per unit area than the aquifers in the Lower Basin (area 53,000 sq. km – recharge approx. 3% of 1,200 mm/year).

The volume of recharge to aquifers underlying the Lower Chao Praya River Basin, as estimated by different authors, is ranging from 1,400 x 10^6 cum/yr to 8.800 x 10^6 cum/yr which is equivalent to 3.8 x 10^6 and 24 x 10^6/d respectively.

The mechanism of recharge to the Lower Basin is via direct infiltration in the areas where sand layers appear on the surface (upper portions of the Lower Basin) and in the form of leakage (drainage of intercalted clay layers) due to difference in head (piezometric surface) among the different aquifers, in the lower portions of the Lower Basin. Furthermore, it is possible that a part of the rainwater recharged into the underground in the Upper Basin enters into the Lower Basin as an underflow. However, the magnitude of this underflow is not known but considering the higher recharge rate in the Upper Basin the groundwater volume entering into the Lower Basin as an underflow could be significant.

It should be mentioned here that the determination of recharge for an aquifer system such as this, which is subjected to a continuous increase in withdrawal, usually produces uncertain results which is clearly reflected in the above wide range of recharge figures calculated by different authors. Furthermore, the existence of several aquifers, which are all exploited in the Lower Chao Praya River Basin (Bangkok Metropolitan Area), also complicates determination of a correct figure of recharge to this groundwater system.

The best way to determine groundwater recharge in a groundwater system undergoing an intensive development is by means of a digital aquifer calibration technique.

The results of the water balance (bibl. 2.3) study made by AIT in connection with the groundwater model study indicate that the groundwater recharge to the Lower Chao Praya Basin is approximately 3.2% or 37.9 m/m of an average annual rainfall of 1191 m/m recorded in the bain's area. This infiltration rate produced groundwater recharge to aquifers of approx. 2 x 10^9 cum/yr which is equivalent to approx. 5.5 x 10^6 cum/d. It is considered that a part of the total groundwater recharge, entering into the aquifers in the Lower Basin, is recovered as a baseflow by rivers and streams within the Lower Chao Praya River Basin. The stream flow records of Chao Praya River at Ayuthaya indicate that approx. 4 x 10^6 cum/d is recovered as a base flow which gives at least 1.5 mill. cum/d of groundwater flow through the aquifers.

This is more or less the same volume of groundwater which is presently being withdrawn by wells in the Bangkok Metropolitan Area. As previously mentioned the underflow from the Upper Basin and the recharge from the Mae Klong River Basin are not considered in the above figure as their values are not known.

At the time when there was no significant groundwater pumpage in the Bangkok area (before 1955) all the above mentioned groundwater recharge has been discharged into the Gulf of Thailand via different aquifers underlying the Lower Chao Praya Basin. From the hydrogeologic conditions near the coast it can be concluded that the water, which entered annually into aquifer storage, has been discharged through a cross section with a length of about 120 km and an aquifer thickness of more than 300 m. This means that each km length of the aquifers cross section discharged about 12,500 cum/d of groundwater.

The results of different studies regarding sustainable yield from aquifers below the Bangkok Metropolitan Area, (which would result in a tolerable land subsidence) indicate that such a yield is in between 600,000 – 900,000 cum/d.

The following evidence supports the above estimates:

(a) a correlation of the decline rate of water level from the different aquifers indicates either decrease in slope or an upward movement of water level at a pumping rate which is below 700,000 cum/d (see also Fig. 6).

(b) the results of the groundwater model study by AIT indicate that in a calibrated model[2/], covering the entire diversion area created by groundwater withdrawal in Bangkok, the water level stabilises at a pumping rate of about 600,000 cum/d. It is also shown in the model that with this pumping rate a further land subsidence would be arrested.

Decreasing the pumping rate below the above rate would cause further recovery of the piezometric surface in the different aquifers but it is questionable if this could also cause any significant increase in the gound elevation in already subsided areas.

Consequences of withdrawal of groundwater from aquifers underlying Bangkok Metropolitan Area

Introduction

A historical development of groundwater withdrawal in Bangkok Metropolitan Area and the consequence of pumping from the different aquifers are clearly illustrated in the Figures 2-13.

It should be mentioned here that the consequence of an uncontrolled groundwater withdrawal from these aquifers would have been easier to assess (and prevent land subsidence) if Groundwater Data Bank (GDB), containing all well records from the Bangkok Metropolitan Area had been established about 10 years ago and had been continuously updated.

The compilation of available records into graphs as presented here, is an attempt to illustrate how advantageously such records can be used to depict a historical development of groundwater pumpage, to assess its consequence and to provide the background data for a rational decision regarding reduction of groundwater withdrawal in the Bangkok Metropolitan Area. Considering a value of GDB for the future control of groundwater pumpage in the Bangkok Area, it is strongly recommended that a systematic survey of all wells in the Metropolitan Area is undertaken and that collected data are shown on graphs and maps (similar to those presented here) which can be advantageously used for control, prediction and management of groundwater withdrawal from this area today and in the future.

The graphs presented below are self-explanatory however, the following should be noted.

Withdrawal, Water Level Decline, Cl-content, Subsidence Rate, Fig. 2, 3 and 4

As shown in Fig. 2, 3, 4 the present withdrawal is sustained primarily from the three aquifers namely, the Phra Pradaeng, Nakhon Luang and Nonthaburi aquifers contributing approx. 14%, 53% and 26% of the total withdrawal (1.4×10^6 cum/d), respectively.

As shown in Fig. 3 the rate of withdrawal from the Nakhon Luang aquifer has increased significantly during the last two years which is primarily due to a withdrawal by private users.

It should be noted from the graphs that the land subsidence, measured at station 8 in the period from 1977 to 1981, indicates that the subsidence is highest in the upper 27 m i.e. 2.5 m/m on average per m depth while at 197 m depth the subsidence is measured approx. 0.5 m/m on average per m depth. This is most likely due to a greater effect of withdrawal on the consolidation of the Bangkok clay by pumping from the Bangkok and the Phra Pradaeng aquifers (three upper aquifers). Consequently, a stop of withdrawal from these aquifers (in particular from the Phra Pradaeng aquifer) could produce an immediate reduction in the land subsidence rate. This is expected especially because the horizontal permeability in these aquifers would be able to provide a sufficient recharge to offset any groundwater losses due to leakage via underlying and overlying clay layers.

With regard to the increase in Cl-content it is possible to see from graphs that the highest increase is observed in a well situated in the Nonthaburi aquifer, which is attributed to the highest rate of pumpage from this aquifer. However, Fig. 9, 10 and 11 illustrating the isolines of 200 mg Cl/l in the three aquifers, indicate that the overall Cl-content, although increasing is still well below 500 mg Cl/l, which is the maximum permissible content specified by WHO standars. Consequently, the situation with regard to water quality is not yet critical (with exception of a few wells showing an excessive Cl-content probably due to upconing of fossil water), but due to its deteriorating treng the Cl-content should be closely monitored, if the present pumping continues unabbated.

Withdrawal and Number of Wells, status Febr. 1982, Fig. 5

It could be seen from this graph (last column to the right) that the MWWA is withdrawing approx. 440,000 cum/d from as few as 108 wells (average discharge rate approx. 170 cum/h per well) while the private users are withdrawing about 1,000,000 cum/d from as many as 9,500 wells (average discharge rate approx. 4 cum/h per well) [3] -

The above figures indicate that the overall efficiency of the MWWA production is much higher than that of the private users. However, as mentioned earlier the bulk of the private users, especially those in the urban areas, would most probably have to continue supplying themselves from groundwater. This is because the connection of private users to the central system would require a digging out of a great part of a highly urbanised area. Seen from the practical and economical points of view it is unlikely that this can be implemented. Furthermore, it should also be mentioned here that by having so many private wells concentrated in a small area it is difficult to impose an efficient control of the withdrawal and to protect the aquifers from an accidental pollution.

Increase in Total Withdrawal, Composite Water Level Decline and Land Subsidence for Period 1958 to 1982, Fig. 6

In can be seen from this graph that since 1967 there was a progressive increase in groundwater pumpage which in 1982 reached approx. 1.4 mill cum/d. The private users are withdrawing about 70% and the MWWA 30% of the above volume respectively. It should be also noted from the graph that during the last five years the MWWA withdrawal rate is kept almost constant while the withdrawal rate of private users has been increasing at a rate ranging from 50,000 to 200,000 cum/d for the last 4 years.

It is primarily the private withdrawal which is causing a higher rate of lowering of the piezometric surface as well as a higher rate of land subsidence observed since 1978.

It is interesting to note from the graph that in 1974/75, (during the oil crisis), the total pumpage was kept constant at a rate of about 700,000 cum/d for about 3 years. During this period the water level in all aquifers started to recover. This may indicate that such pumping rate is still below the annually recharged volume passing through this area.

Furthermore, it should be noted from the graph that the decline rate, shown by the depth to piezometric surface graph, decreases whenever a pumping rate smaller than 700,000 cum/d remained reasonably constant over some period (e.g. period from 1968 to 1970).

The above mentioned volume, at which there is a reduction in the decline rate of water level, should not be mistaken for a safe yield of aquifers underlying the Lower Chao Praya River Basin as this is several orders of magnitude higher. The above occurrence means only that whenever the pumpage is kept constant, the expansion of the cone of depression and water level decline rate show a tendency to stabilise. However, any pumping, regardless how small, from an aquifer system such as this would cause land subsidence. Increase in pumpage would increase the land subsidence rate and it is only a question of to which extent a land subsidence can be tolerated.

It appears from the graph that the land subsidence rate has accelerated when pumping rate increased above 700,000 cum/d. Consequently, the pumping rate must be immediately reduced to approx. half of the present withdrawal rate in order to arrest a further land subsidence in the Metropolitan Area.

Well Density Map, Fig. 7

It can be seen from this graph that the well density is the highest in the central (urban) area of Bangkok around the Chao Praya River where there are more than 20 wells per sq.km. Well density decreases in all directions from the central highly urbanised area.

Withdrawal Density Map, Fig. 8

IIt can be seem from this graph that the highest withdrawal takes place in the central (urban) area of Bangkok where is exceeds 2000 cum/d/cq.km. The areas with the highest withdrawal correspond roughly to the areas of the highest well density. The withdrawal density decreases in all directions from the central highly urbanised area.

The map also shows the rate of land subsidence as determined during the period from 1978 to 1980 and the total land subsidence measured for the period from 1957 to 1980. Generally, it can be concluded that the highest rate of land subsidence is closely associated with the areas of high withdrawal density and high well density.

It should be noted from the graph that the total subsidence is observed to increase eastward i.e. away from the centres of withdrawal. The reason for this anomally is most probably due to a decrease in T-value (aquifer yielding properties) towards the eastern part of the Lower Chao Praya Basin. Consequently, a relatively small pumpage (compared to the pumpage in the central area) would a create a comparatively big drawdown (a deep cone of depression) within a small area which in turn would cause a higher land subsidence rate.

Distribution of MWWA and Private Withdrawal/ Wells in 1982, Contours of Depth to Piezometric Level 1979, Isoline of 200 mg Cl/l 1982, Fig. 9, 10 and 11

It should be mentioned here that the available measurements of the water levels in 1981 could not provide for an adequate areal coverage required for a correct delineation of the contour lines in 1981.

However, despite the fact that the withdrawal from all aquifers has increased from 5 to 15% since 1979 (which caused further lowering of the water level in all aquifers) it is considered that the general configuration of water level contours as shown in above graphs did not, with exception of the depth to water level, change significantly. To obtain a depth to water level, corresponding to present pumpage, approximately 10 m on average should be added to a shown depth contours for the Phra Pradaeng and Nonthaburi aquifers fig. 9 and 11, respectively and approximately 15 m on average should be added to the depth contours for the Nakhon Luang aquifer fig. 10, which sustained a higher increase in pumpage that from the other two aquifers.

It should be pointed out that due to a very small variations of the ground surface in the Bangkok area and almost a horizontal extent of all aquifer layers over a great distance, the contour lines showing a depth to water level also show a true direction of the groundwater flow i.e. groundwater moves toward the areas with greater depth to the water level. Consequently, the contour lines shown more or less a true configuration of the cone of depression in all aquifers.

As shown in these figures, in the central part (highly urbanized area of the Bangkok Metropolitan), both the MWWA and the private users draw approximately the same volume of groundwater within a unit area. The abstaction by private users dominates in all areas outside of the central area and especially in the areas towards southwest and east which are outside the MWWA distribution system.

The depth of water level contour show that several deep cones of depression are created in each aquifer within the central area of the Bangkok Metropolis. The configuration of the cones of depression in the Phra Pradaeng and Nakhon Luang aquifers is similar, however, the depth to water level is higher in the Nakhon Luang aquifer due to a higher rate of pumpage from this aquifer. Under the present pumping conditions the depth to the deepest points in the Nakhon Luang aquifer is from 60–65 mbq, while in the Phra Pradaeng aquifer the depth is from 50–55 mbg. It should be noted from the graph that the cone of depression is deeper towards east in both aquifers although the abstaction decreases in the same direction. This is attributed to a general decrease in aquifer yield (T-value is smaller) in this direction which, for a comparatively small withdrawal, produces the deeper cone of depression than in the area with higher T-values.

While the depth to water level in the Nonthaburi aquifer is similar to that of the Phra Pradaeng aquifer is different than in the two previously mentioned aquifers. Namely, with exception of the local anomalies, the depth to peszometric surface decreases roughly equally in all directions from the centrally situated depression. An examination of the distribution of T-values in the Nonthaburi aquifer reveals that T-values also decrease in the same manner. This, together with a dissipation of the withdrawal rate in a similar manner produces a more uniform decrease in depth to water level than in the other aquifers.

All graphs indicate that the movement of saltwater edge (isoline of 200 mg Cl/l) is generally from west to east which is contrary to what it could be expected from a north-south alignment of the cone of depression and its distance from the coast. If the existance of large bodies of connate (fossil) water is excluded the explanation could be that the movement of saltwater edge inland is easier from the southwestern part than from the southern part of the area (probably due to direct-hydraulic contact between fresh and seawater).

Configuration of land surface at present and the possible extent of seawater intrusion into Bangkok Metropolis if present withdrawal continues, Fig. 12 and 13.

Fig. 12 showing present elevation of land surface around the Bangkok Metropolitan indicates that the lowering of ground surface is more pronounced towards the eastern areas where the highest total subsidence of 86 cm is recorded. This trend corresponds to the deep cones of depression developed in this area in the Phra Pradaeng and Nakhon Luang aquifers. It should be noted from Fig. 12 that the area of de deepest land subsidence is situated almost entirely in between the sea level and a ground surface contour of 1 m AMSL.

Fig. 13 shows that if the pumping rate from the aquifers remains the same as in 1982 (about 1.4 mil m^3/day) and the observed land subsidence rate of 10 cm/yr does not decrease, it would take approximately 10 years for the area situated now in between zero and 1 m above sea level to be entirely submerged below sea level.

Therefore, due to the special conditions i.e. low T-values prevailing in this area it is necessary to stop immediately all the pumpage from the aquifers in this particular area in order to stop further land subsidence.

C. Proposal for reduction of groundwater withdrawal in the Metropolitan Bangkok Area.

The plan for reduction in pumping rate from the aquifers is devised with a purpose to introduce the remedial measures first in the most endangered areas and then to proceed with stoping of withdrawal in other areas until the total abstraction from all aquifers is brought down to about 800,00 cum/d. As mentioned previously at this rate of abstraction it should be possible to arrest further land subsidence in the whole Metropolitan Area.

It should be mentioned here that in devising the plan for the phasing out of groundwater withdrawal, the availability of the alternative volume of the treated water from the Bhang Khaen treatment plant and the future plan for an extension of the MWWA distribution system have been taken into account.

As shown in Table 1 the plan for reeuction of groundwater withdrawal is divided into two phases. Phase I.a. and I.b. to be implemented by 1983 and 1984 respectively and Phase II to be implemented by 1986 at which time the total withdrawal from all aquifers is to be reduced to about 800,00 cum/d.

The details regarding areal distribution of MWWA and private withdrawal which should be reduced or phased out are illustrated in Fig. 14.

The figures indicates that approximately 400.000 cum/d of the MWWA groundwater withdrawal will be phased out as planned by 1986. It is assumed that it will be possible to maintain the above rate of withdrawal without causing further land subsidence and aggravating a water quality in the aquifers in the Metropolitan Area.

Before stopping the MWWA wells it is recommended to examine a discharge-drawdown relationship of each MWWA well with a purpose of determining their performance. The wells which exhibit a good performance should be conserbed to be used in an emergency situation and for apossible reactivation into service in the event that emergency situation and for a possible reactivation into service in the event that more of the private users in the central area will be able to connect to the central system.

It should be kept in mind that a groundwater withdrawal when properly managed will always represent a cheap and reliable water source.

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[1] *It should be mentioned here that the underground inflow from Mae Klong River Basin, is not taken into consideration in this analysis. This inflow which is due mainly to westward shifting of groundwater divide, due to pumping in the Metropolitan Area, should be considered as an additional recharge to aquifers underlying the Lower Basin.*

[2] *A model in which the past history of aquifer development i.e. piezometric surface contours and drawdown for the different rates of withdrawal represent the actual conditions.*

[3] *There is some doubt about the accuracy of the figure regarding the number of private wells. Field surveys of all existing wells should answer this question more precisely.*

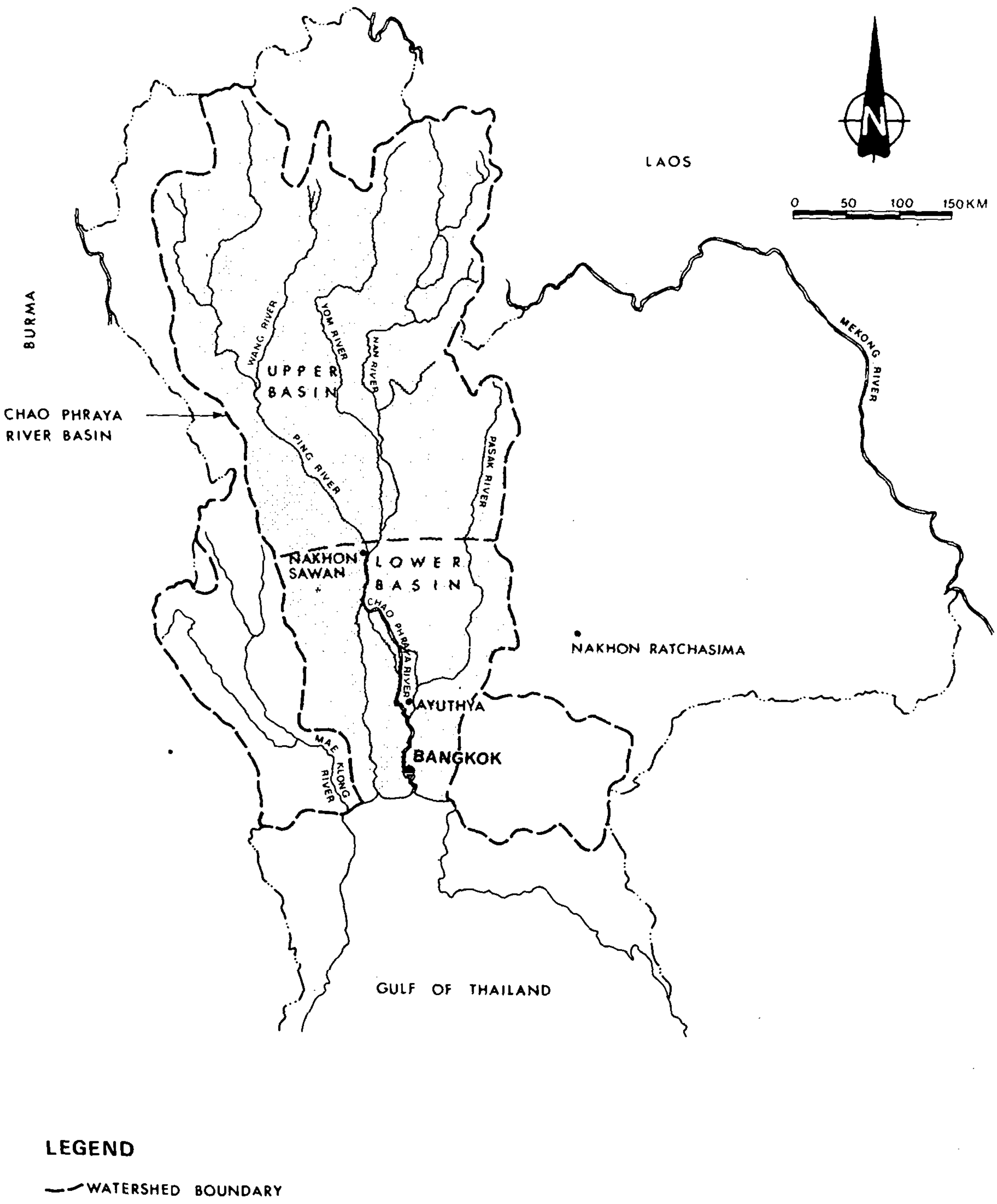
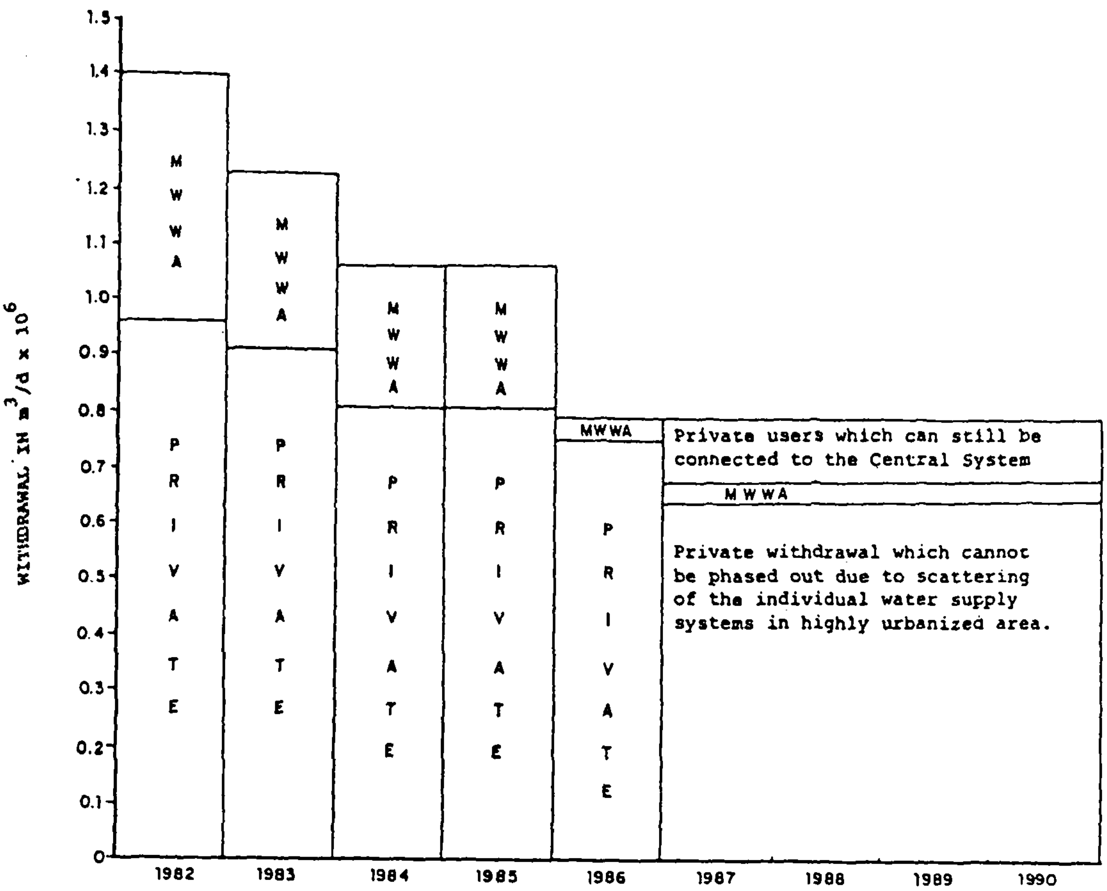


FIGURE 1 CATCHMENT AREA OF CHAO PHRAYA BASIN



Year	Phase	Total Withdrawal Phased out / Remaining m^3/d	MWWA Withdrawal Phased out / Remaining m^3/d	Private Withdrawal Phased out / Remaining m^3/d	Additional water from Bhang Khaen Treatment Plant m^3/d
1982		1,410,000	440,000	970,000*	0
1983	Phase Ia	183,000 / 1,227,000	128,000 / 312,000	55,000 (72,000)** / 915,000	200,000
1984	Phase Ib	167,000 / 1,060,000	58,000 / 254,000	109,000 (142,000)** / 806,000	200,000
1985		1,060,000	254,000	806,000	
1986	Phase II	265,000 / 795,000	215,000 / 39,000	50,000 (65,000)** / 756,000	400,000 / 120,000***

970,000* This figure includes 640,000 m^3/d pumped out in the central area and about 330,000 m^3/d pumped out in the outside areas.

(72,000)** Figure indicates required volume of water needed for replacement under assumption of 30% leakage losses.

120,000 ***Available volume to cover increase in demand in service area (equivalent to supplying of approx. 255,000 inhabitants with water demand of about 470 lcd).

TABLE 1. PLAN FOR REDUCTION OF GROUNDWATER WITHDRAWAL IN BANGKOK METROPOLITAN AREA

FIG. 2 PHRA PRADAENG (100 m bg) AQUIFER

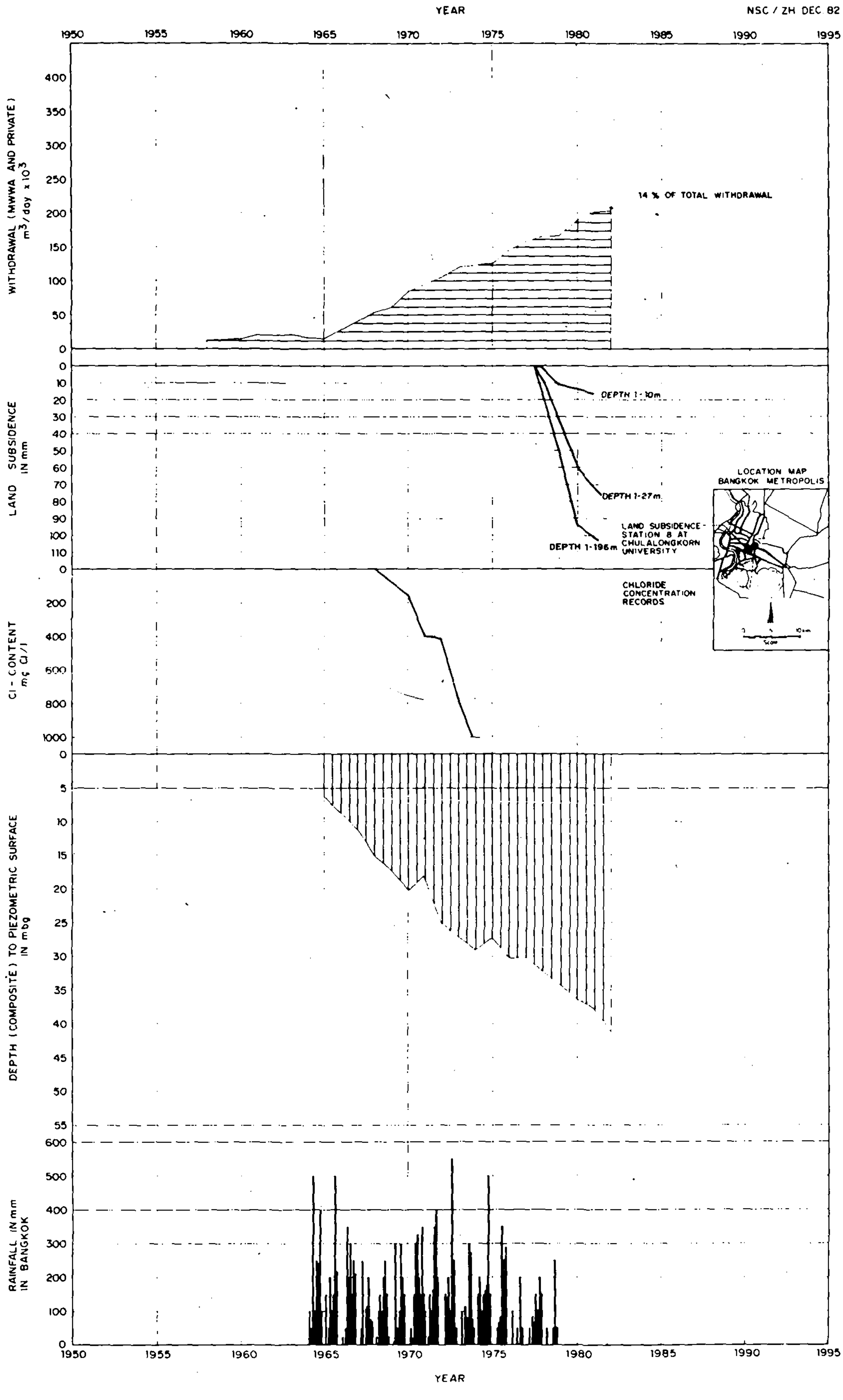


FIG. 3 NAKHON LUANG (150 m bg) AQUIFER

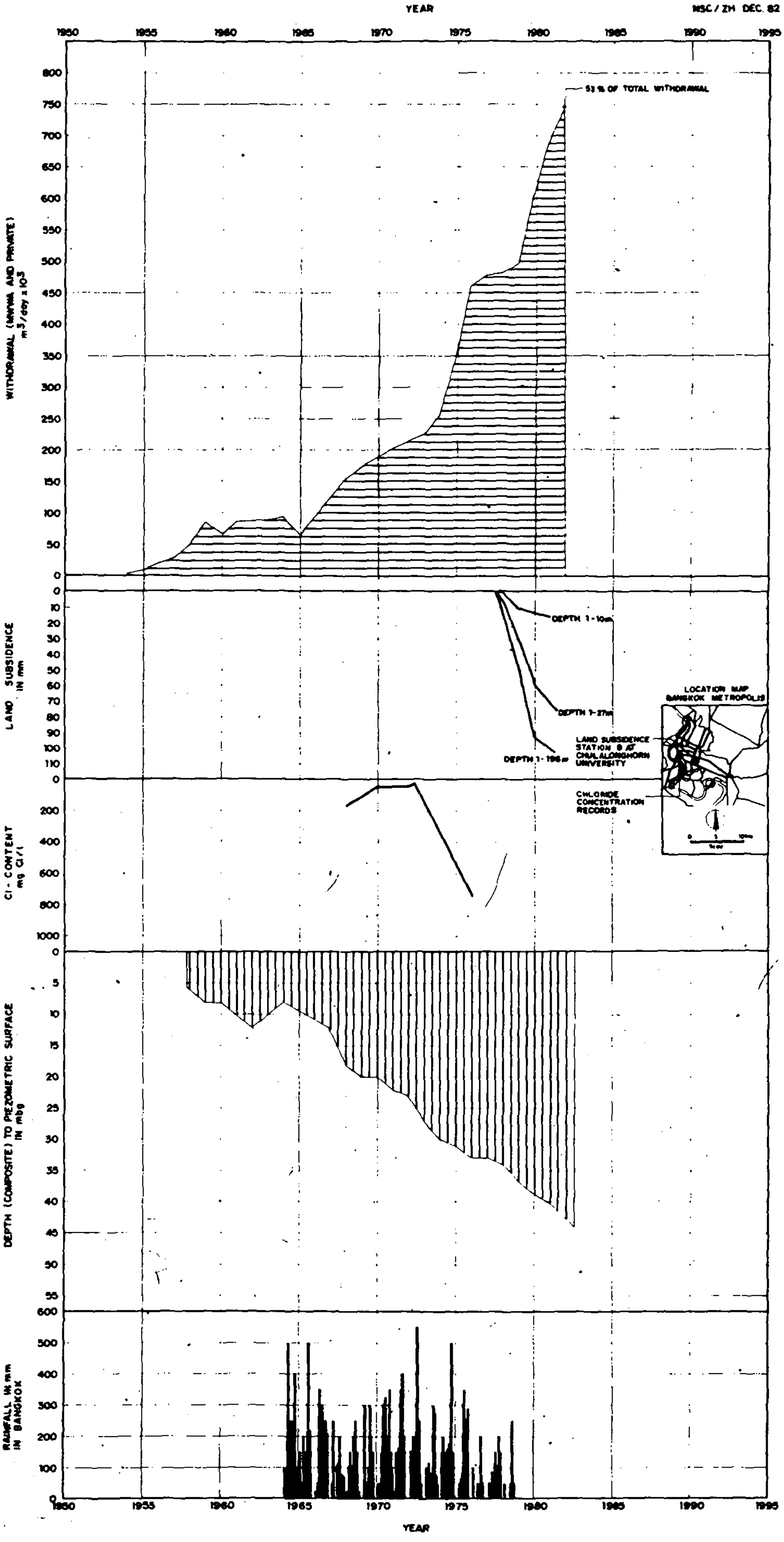


FIG. 4 NONTHABURI (200 m bg) AQUIFER

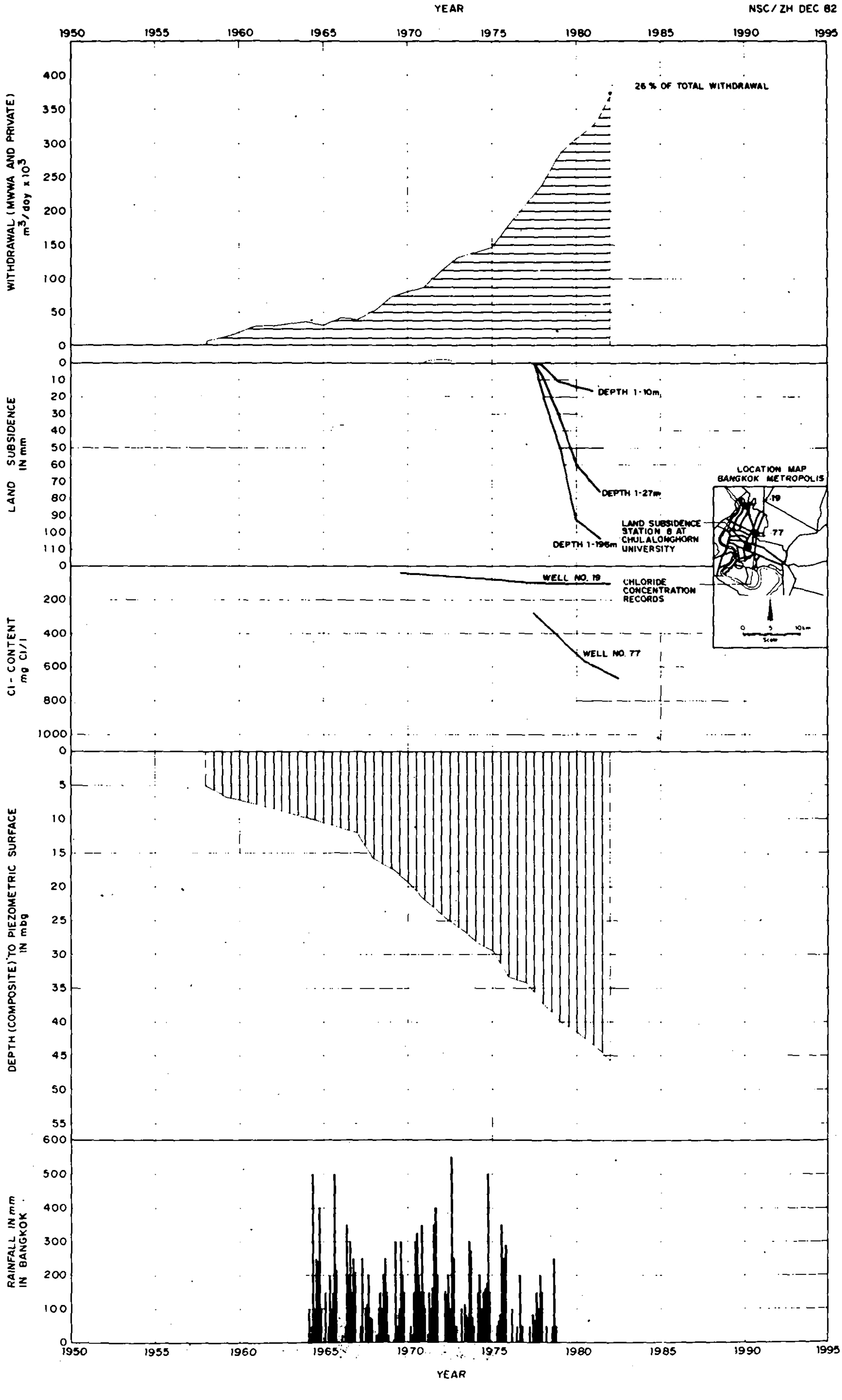


FIG. 5 GROUNDWATER WITHDRAWAL AND NUMBER OF WELLS INVOLVED IN WITHDRAWAL FROM AQUIFERS IN BANGKOK METROPOLITAN AREA

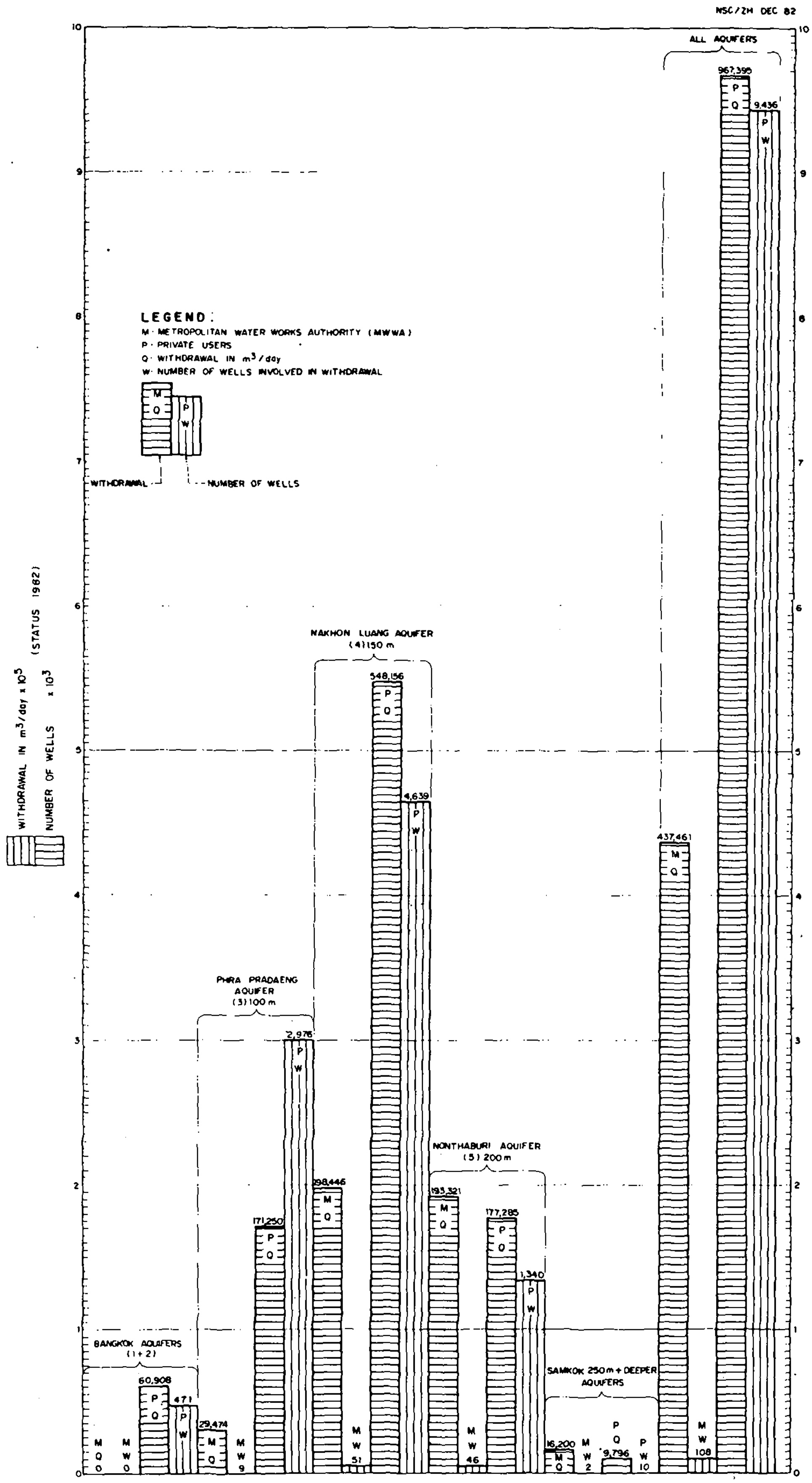


FIG. 6 WITHDRAWAL, DEPTH TO PIEZOMETRIC SURFACE; ALL AQUIFERS AND TOTAL LAND SUBSIDENCE

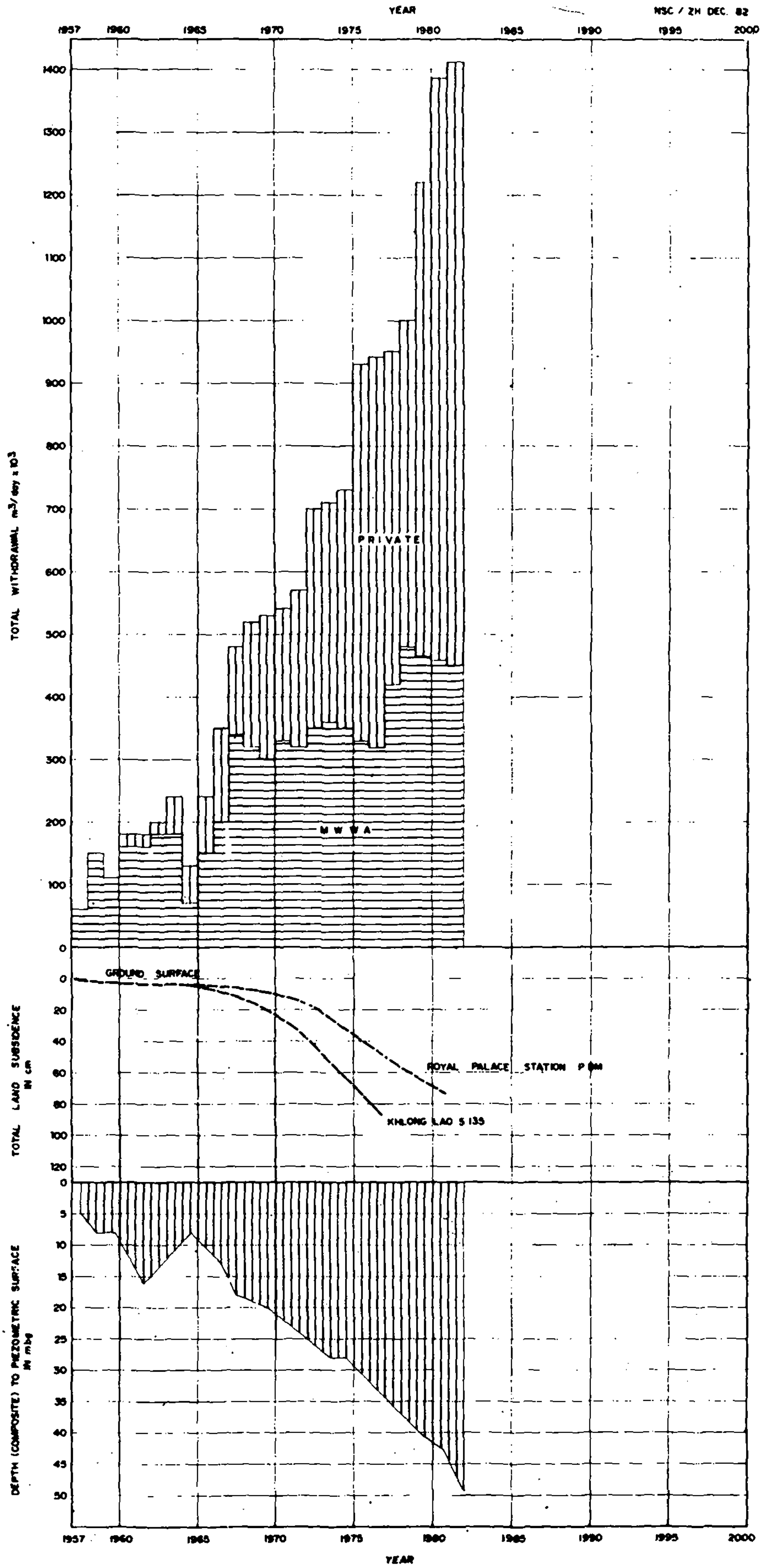


FIG. 7

WELL DENSITY MAP

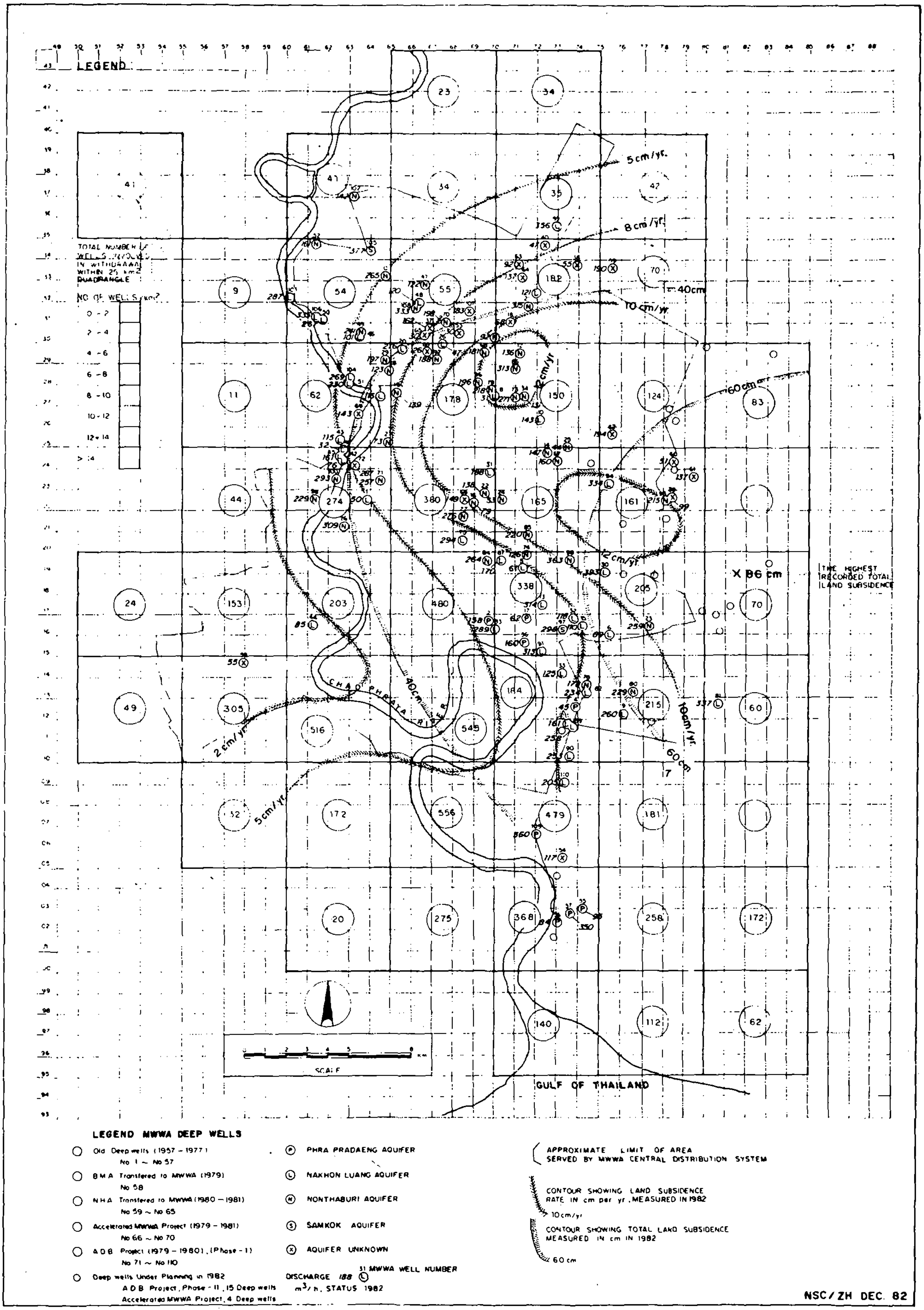


FIG. 8 WITHDRAWAL DENSITY MAP

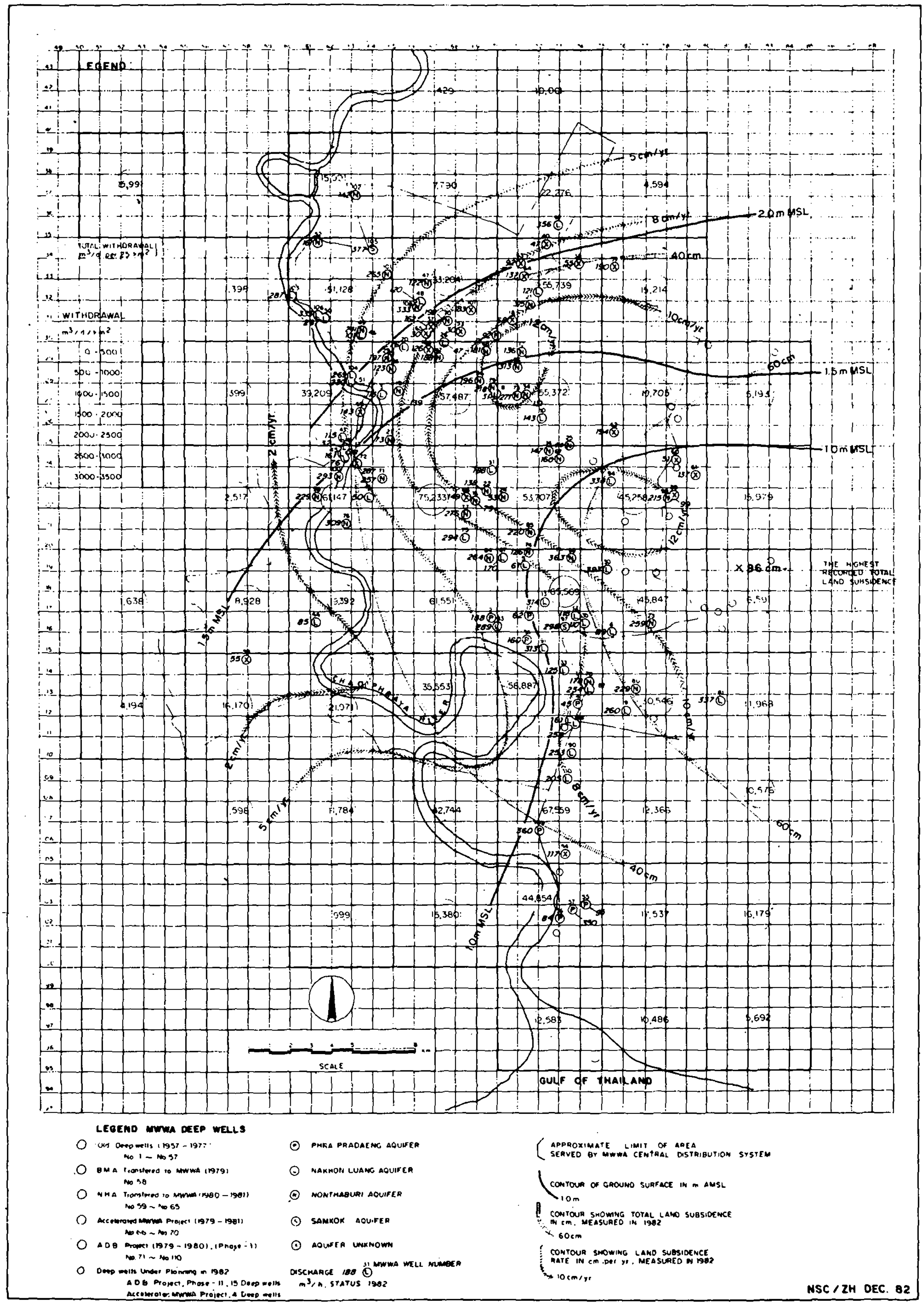


FIG. 9 DISTRIBUTION OF MWWA AND PRIVATE WITHDRAWAL / WELLS FROM ALL AQUIFERS AND PIEZOMETRIC SURFACE CONTOURS (YEAR 1979) PHRA PRADAENG (100 mbg) AQUIFER

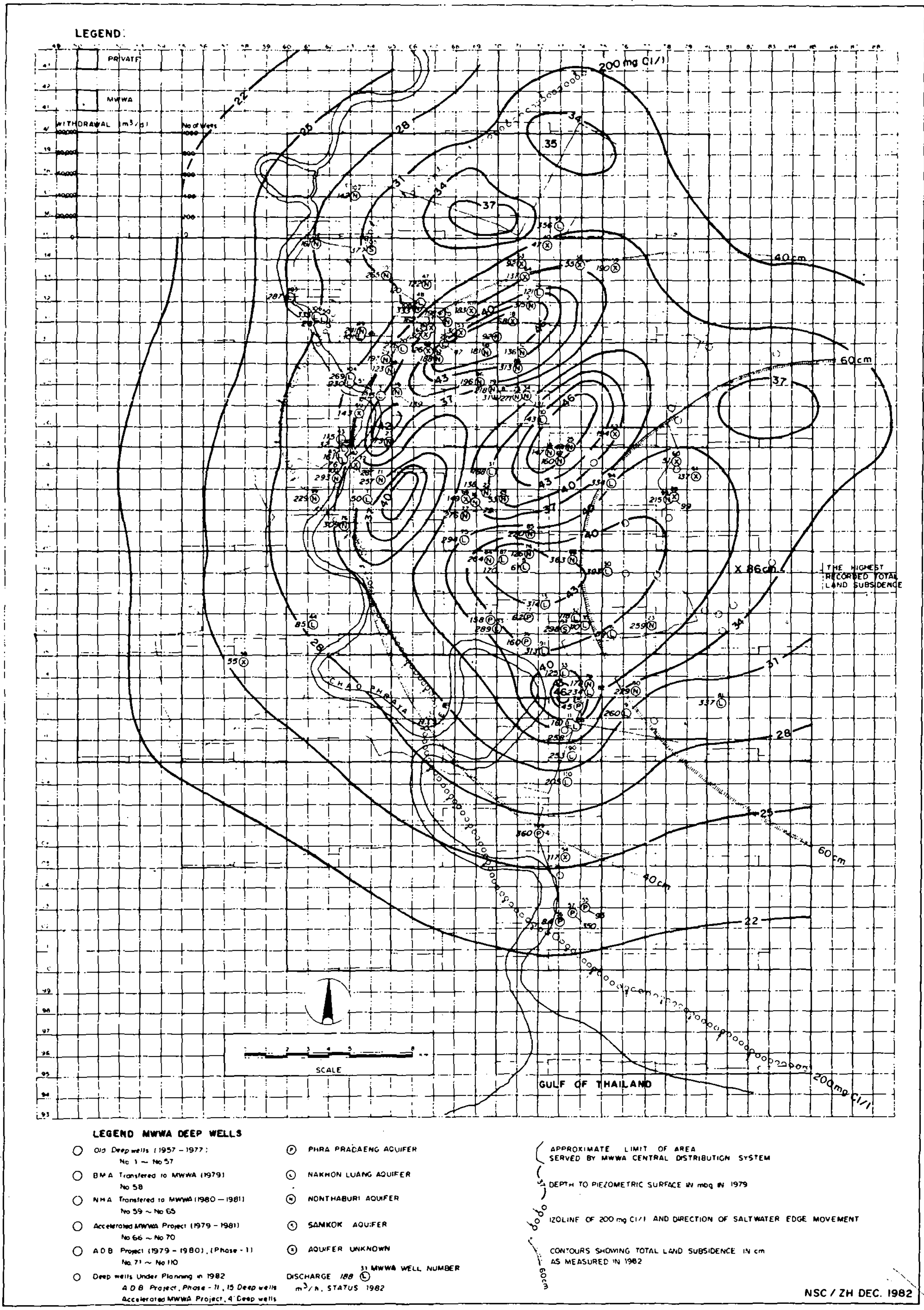


FIG. 10 DISTRIBUTION OF MWWA AND PRIVATE WITHDRAWAL / WELLS FROM ALL AQUIFERS AND PIEZOMETRIC SURFACE CONTOURS (YEAR 1979) NAKHON LUANG (150 m bg) AQUIFER

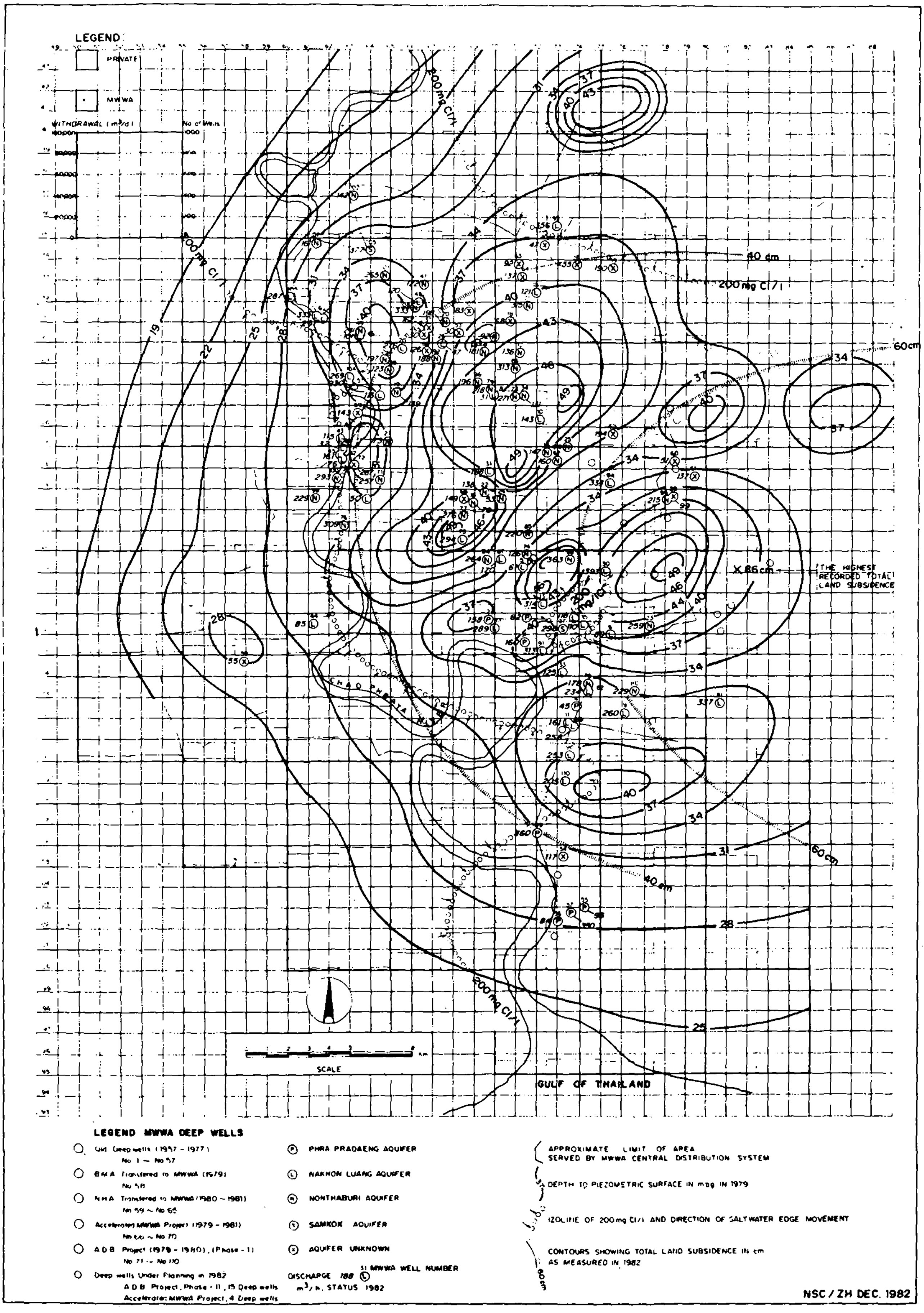


FIG. 11 DISTRIBUTION OF MWWA AND PRIVATE WITHDRAWAL / WELLS FROM ALL AQUIFERS AND PIEZOMETRIC SURFACE CONTOURS (YEAR 1979) NONTHABURI (200 mbg) AQUIFER

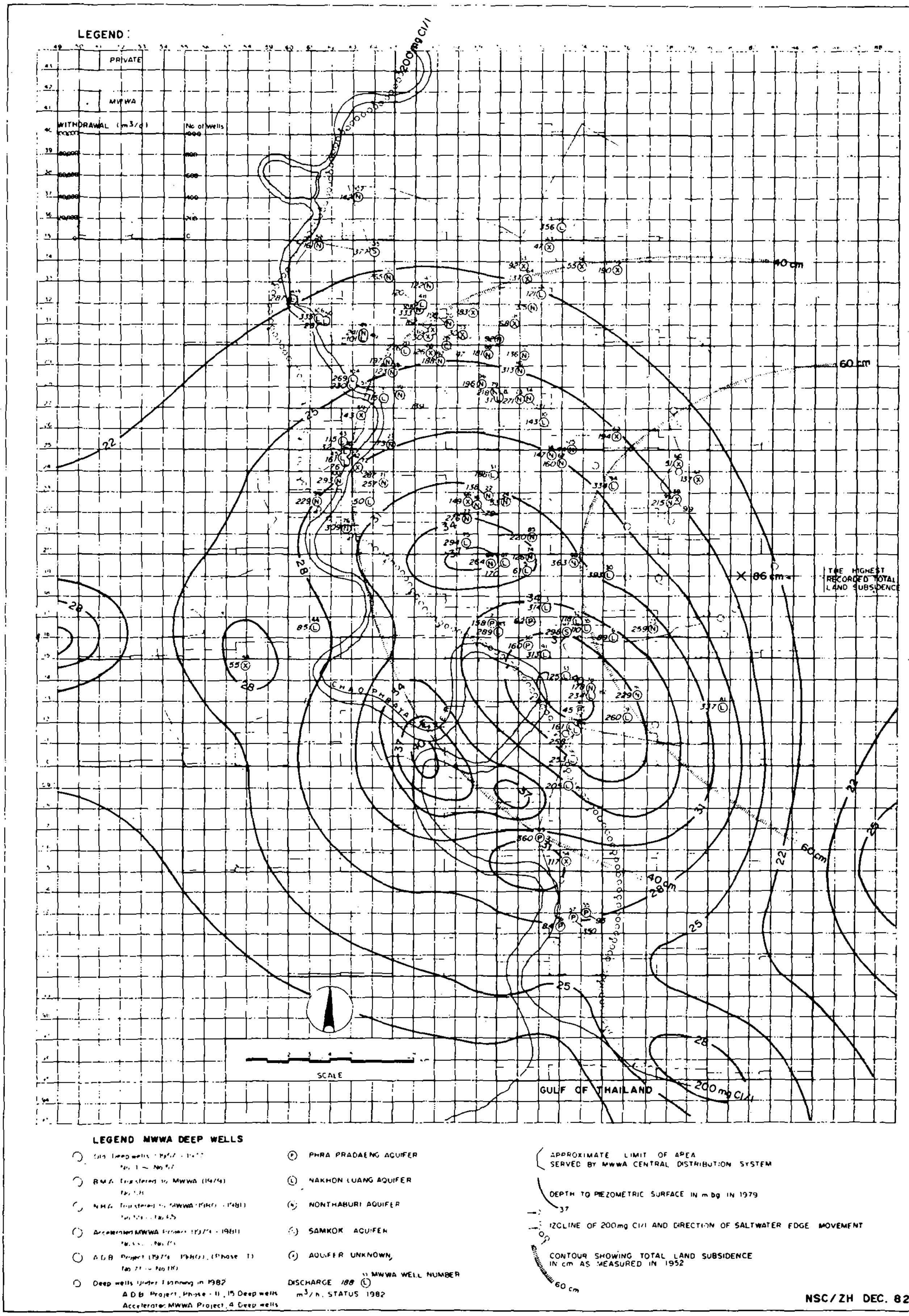


FIG. 12

BLOCK DIAGRAM SHOWING APPROXIMATE ELEVATION OF LAND SURFACE IN BANGKOK METROPOLITAN AREA AND RATE OF LAND SUBSIDENCE MEASURED IN 1982 (GROUNDWATER WITHDRAWAL 1,400,000 m^3/d)

(NSC/ ZH DEC. 82)

LOCATION MAP

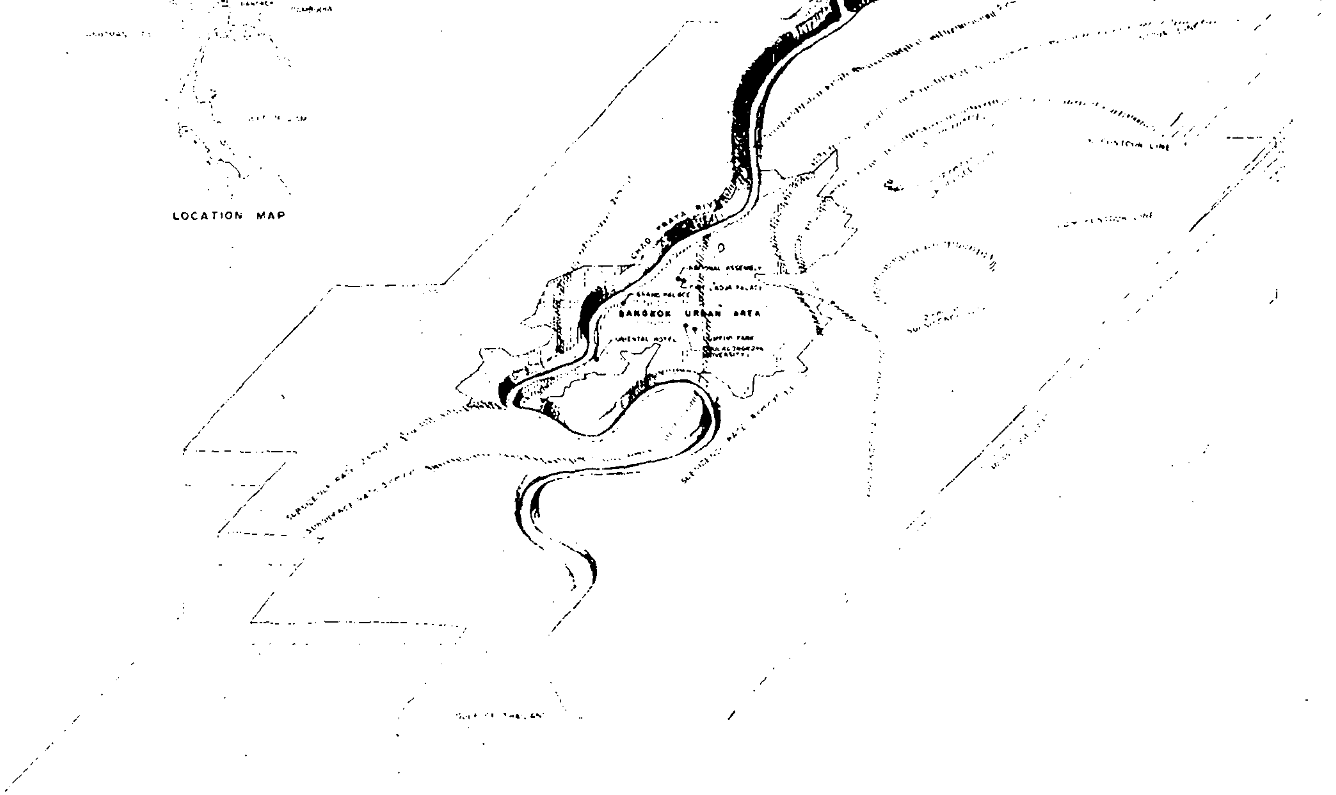


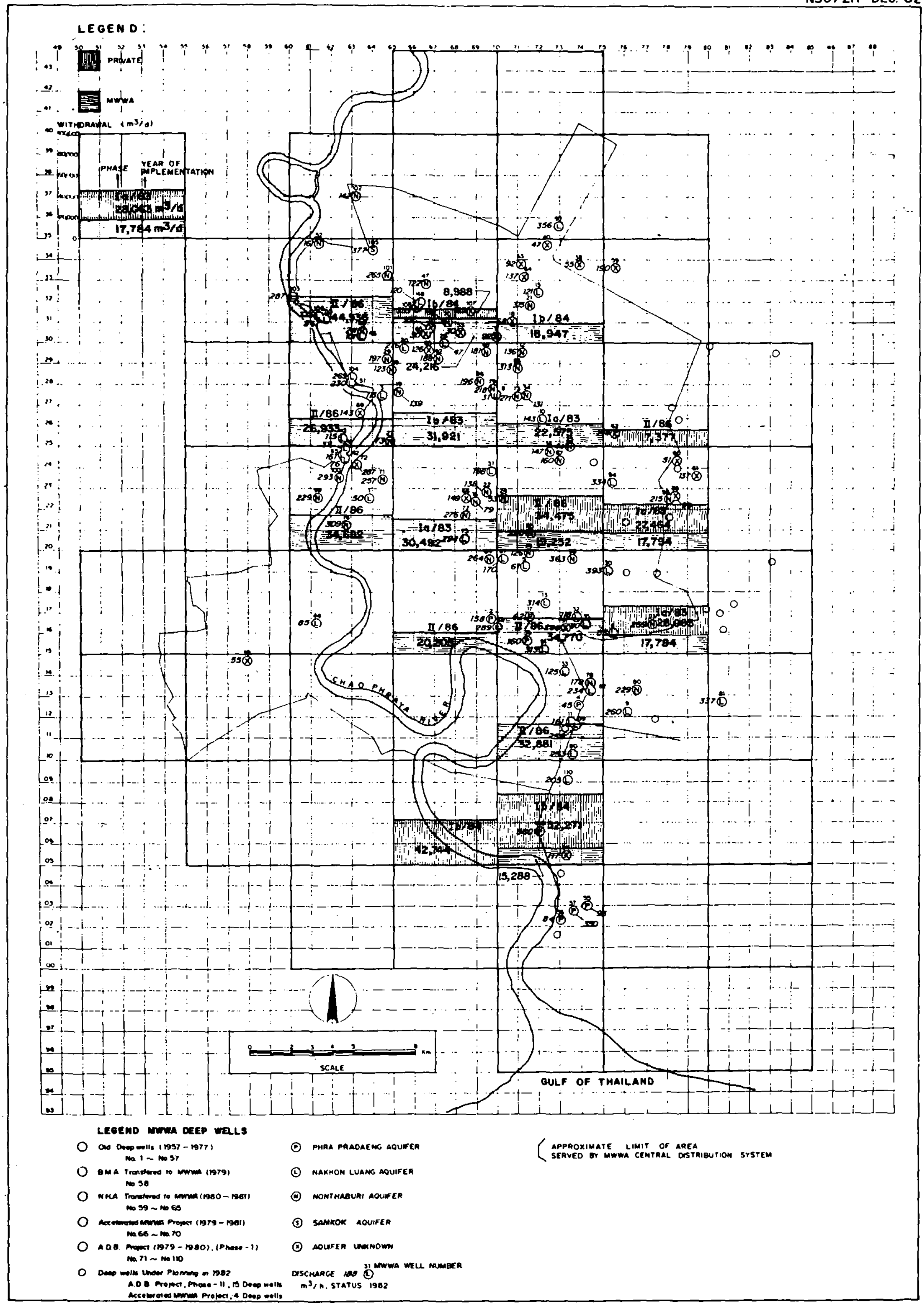
FIG. 13

BLOCK DIAGRAM SHOWING APPROXIMATE ELEVATION OF LAND SURFACE IN BANGKOK METROPOLITAN AREA IN 1992 IF GROUND-WATER WITHDRAWAL OF 1,400,000 m3/d CONTINUES UNRESTRICTED

(NSC/ZH DEC 82)

FIG. 14 DISTRIBUTION OF MWWA AND PRIVATE GROUNDWATER WITHDRAWAL IN BANGKOK METROPOLITAN AREA, TO BE PHASED OUT

NSC/ZH DEC. 82



APPROPRIATE METHOD OF DISTRIBUTION NETWORKS ANALYSIS FOR DEVELOPING COUNTRIES

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1. INTRODUCTION

The analysis of water distribution networks is an essential design procedure of water works. But the method of analysis is usually very complicated and requires a big computer which means it is a very expensive works. The available big computers are also concentrated in big cities. The engineers and technicians in developing countries can not easily access those machihe and have to design distribution networks without analysis or to rely on foreign consulting engineers.

However recent development of micro-computer technology and severe price competition in the market result in the development of very cheap and very capable micro-computers. Some of those recent machines are cheap enough to be purchased by local water offices and also capable for common engineering problems. But they are usually not good enough for the complicate networks analysis.

The main purpose of our research is to develop the methods of networks analysis which can be implemented to small computers which may be available even for small design offices of water works in developing countries. The methods should be run on a small stand alone machine, that means the programs should be written in common BASIC language and must require very small space of memory. Moreover the programs should be short and easy enough to be implemented to any small machine by any amateur programmer.

2. MINIMUM SYSTEM REQUIREMENTS

The fundamental requirement of the micro-computer system is a stand alone system with a CRI or another means of display. Some of them may have filing capability of data. The language must be provided with floating point arithmetic which is essential for engineering purposes. The system with disk drives are more desirable and may be amployed for tariff management or other purposes.

In our study, at least a popular computer with 8 bits CPU, user's memory of 16 K bite and a stand alone BASIC language should be used. It may not be difficult to obtain this kind of machine even in any developing country. If the analytical method proposed can be run on the machine, it will be very easy to transfer the software to any bigger one.

3. THEORY OF RELAXATION METHOD

There are two categories of analytical method of networks, the first is the flow rate correcting mathod represented by Hardy-Cross method, and the second is the pressure correcting method which is represented by Newton-Raphson method.1) The later may simply be called as NODAL METHOD.

Hardy-Cross method is the oldest method and can be calculated manually. It may be implemented to microcomputers and may not require large memory. There are various improved flow rate correcting methods developed in Japan. They belong to Newton-Raphson method which has to solve simultaneous linear equations and converge very fast. But if demands at nodes are the functions of pressure, those methods are difficult to apply. And the programming of automatic loop formation is also too comlicated to be implemented to small micros.

Nodal method does not require a loop formation and can deal with the problem of varying demands by pressure. It is more flexible than the flow rate correcting method. The original Newton-Raphson method has been modified by several researchers to improve its problem of slow convergence in case of remote initial estimation of value. Aya 2) did bench mark tests and proposed a few improved methods. The disadvantage of those modified Newton-Raphson methods is that they require large space of memory for Jacobian matrix which is very large and sparce for big networks. It is not suitable to implement to small micro-computers which have very small user's memory. The possible method which demands less memory space may be relaxation method based on nodal method.

First Order Relaxation

The nodal method is based on Kirchhoff's first law. If the sum of effleunts from node i is F_i, the nodal equation at each node holds as

$$(1) \quad F_i = \sum_j Q_{ij} + q_i, \quad (i = 1, \ldots,), \quad = 0$$

where Qij is the rate of effluent from node i to node j, q_i is the rate of supply from node i.

Let Fi be approximated with first order Taylor expansion by the dynamic water head H_i at node i as,

(2) $F_i(H_i + \Delta H_i) = F_i + \frac{dF_i}{dH_i} \Delta H_i.$

The correction value of the dynamic head is obtained by letting right side of equation (2) be zero.

(3) $\Delta H_i = - F_i / \frac{dF_i}{dH_i}$

The simplest method employs equation (3) for the correction value. Above method may be called as "Relaxation by First Order Expansion".

We developed another three sorts of relaxation methods different from the first one.

Relaxation by Second Order Expansion employs second order Taylor expansion. This method requires second derivatives of Fs. We do not think it is suitable for our purpose.

Alternate scheme is descent method to minimize the sum of squared Fs, which is employed in non-linear optimal problem. According to this method, unknown variable may be any of head, pipe element or amount of supply at a node, while in the methods presented so far, the unknown variables are limited only to the heads of nodes. But the known descent method requires second derivative and is too complicated for our paper. Our improved method to be presented does not use second derivative and is simple enough to be implemented to a micro-computer.

Descent Method by First Order Expansion, 3)

The objective function to be minimized holds as

(4) $f(X) = \Sigma_j [F_i (X)]^2, \quad (X = x_i, \ldots,).$

Substitute right member by first order expansion of F

(5) $f(x_i + \Delta x_i) = \Sigma_j [F_j (x_i + \Delta x_i)]^2$

$$= \Sigma_j (F_j + \frac{dF_j}{dx_i} \Delta x_i)^2$$

$$= \Sigma_j [F_j + 2F_j \frac{dF_j}{dx_i} \Delta x_i + (\frac{dF_j}{dx_i})^2 \Delta x_i^2]$$

A quadratic equation is obtained as putting the last part of (5) be zero.

(6) $\sum_j (\frac{dF_j}{dx_i})^2 \Delta x_i^2 + \sum_j \frac{dF_j}{dx_i} \Delta x_i + \sum_j F_j = 0$

If the roots of equation (6) are real number, choose the root of smaler absolute number as the correction.

If the roots are complex number, the following scheme gives the correction. The minimum of the last part of (5) is given by

(7) $\sum_j F_j \frac{dF_j}{dx_i} + \sum_j (\frac{dF_j}{dx_i})^2 \Delta x_i = 0.$

The correction holds as

(8) $\Delta x_i = - \sum_j F_j \frac{dF_j}{dx_i} / \sum_j (\frac{dF_j}{dx_i})^2.$

Flow rate and Derivative

Flow rate formula holds as

(9) $Q_{ij} = SGN(H_i - H_j) r_{ij} | H_i - H_j |^a.$

For Hazen-Williames formula, rij; $0.2785CD^{2.63} L^{-0.54}$, SGN( ); sign of ( ), a; 0.54, C; velocity coefficient, D; diameter (MM), L; length (M).

For Manning formula, rij; $031169^{n-1} D^{3/3} L^{-1/2}$, a: 0.5, n; roughness.

The derivative of (9) holds as

(10) $\frac{dQ_{ij}}{dH_i} = a r_{ij} |H_i - H_j|^{a-1}.$

q_i is water supply and leakage from node i. Leakage formula presented by Suishi et al 4) and Takakua 5) holds as

(11) leakage = $W_i P_i^w$

where Wi; leakage factor, w; coefficient (0.5–1.5)

Extended period simulation of service reservoir can be done by solving differential equations of reservoirs numerically using similar relaxation method. But it is omitted from this paper, because of available space of the paper.

4. NUMERICAL METHOD

Among the two correction formulas presented so far, the first method is the easiest one and is sufficient enough for common problems. We will present a few modified numerical methods for First Order Relaxation. But the other one may employ the same algorithm.

Numerical method of relaxation is as follows;

step 1, k=0

step 2, Give initial values of variables H_i^0

step 3, i=1

step 4, Calculate the value of F_i^k

step 5, Calculate ΔH_i^k

step 6, $H_i^{k+1} = \Delta H_i^k + \Delta H_i^k$.

step 7, If i < n, then i = i + 1 : go to step 4.

step 8, If all of F < e, then stop.

step 9, k = k + 1 : go to step 3.

where, n; number of variables, e; allowable error of F.

The relaxation methods presented so far are rather slow to converge, if the given initial values are very different from the solution. It is a common characteristics of Newton-Raphson method. So it is not practical to apply in the form of original algorism. It is necessary to find means of acceleration of convergence.

Condition of Convergence

The condition of convergence is that all of the value of F are smaller than that of the allowable error. That means it is not necessary to correct the head of the node which error is smaller than allowable error.

The following scheme saves a few times of iteration and a little time of execution.

step 1, Chek the error of the node.
step 2, If the value of F is over allowable error, corrected the head of node.
step 3, If within, pass correction and move to the next node.
step 4, If all of nodes are within allowable error, stop.
step 5, go to step 1.

note; The node has bypassed correction may over the allowable error at next iteration, affected by the correctioan of neighboring nodes.

SOR Method

Successive over relaxation method (SOR) which is a populer numerical method for linear simultaneous equations may also be applied to non-linear simultaneous equations.

Coreected value of variables are obtained by

$$(12)\ H_i^{k+1} = H_i^k + A\,\Delta H_i^k,$$

where, A; accelerator.

But we found that the accelerator should not be bigger than 1.3 and the result was not improved as expected.

Buffered SOR Method, 5)

The major reason of slow convergence of relaxation method with remote initial estimation is over correction. Over correction causes oscillation of corrected values. Too big accelerator also causes oscillation and divergence instead of convergence.

The simplest way to suppress oscillation is introduction of decelerator in place of accelerator, if there are indications of divergence. There are a few similar schemes proposed for linear simultaneous equations using variable ac- and de-celerator. But the rule of in and de-crease of them is empirical and is not easy to find that of non-linear equations.

Our method employs fixed ac- and de-celerator. It is very simple and also effective enough for our purpose.

The indicator is the sign of correction, as employed for modified Newton-Raphson method 5), 6).

The algorithm is as follows:

step 1, $k=0$

step 2, Set initial values of variables H_i^0.

step 3, $i=1$

step 4, If $F_i^k < e$ then $\Delta H_i^k = 0$: go to step 8

step 5, Calculate ΔH_i^k by equation (3)

step 6, If $\Delta H_i^k * \Delta H_i^{k-1} \geqslant 0$ then $A = A1$
If $\Delta H_i^k * \Delta H_i^{k-1} < 0$ then $A = A2$

step 7, $H_i^{k+1} = H_i^k + A\Delta H_i^K$.

step 8, If $i < n$, $i = i + 1$: go to step 4

step 9, If all of Fs are smaller than e, then stop

step 10, $k = k + 1$: go to step 3

where A1 ; accelerator, A2 ; decelerator.

The appropriate value of accelerator is between 1.3 and 1.4. That of decelerator is between 0.5 and 1.0. We recommend A1 = 1.4 and A2 = 0.8.
The values may be tried in the program presented in the paper.

Aya named the proposed method as Buffered Successive Over Relaxation or BSOR, because the work of the decelerator looks like that of a buffer against excessive over correction.

Symmetric SOR Method

It is apparent that the speed of execution is better as the given initial values are closer to the final solution. The modification of networks which have been analyzed should use the solution of the original ones as the initial data which may be near to the new solution.

Relaxation method only passes the corrected data from a node to the nodes connected by pipe elements. If the modified part of networks is remote from fixed water level nodes (service reservoirs), the influence of the change is slow to propagate via a group of nodes connected by pipes once every iteration. At the early stage of iterations, most of nodes may be left without correction, wasting execution time for the check of the nodes within allowable error.

The proper solution to the problem mentioned is the introduction of Symmetric SOR method which is one of the popular methods for linear equations. The algorithm is very simple. Reverse the order of correction at every iteration.

5. PROGRAMMING

A short program of Relaxation by First Order Expansion by BSOR method written in a popular BASIC is presented in Appendix. It is small enough to run on any small machine with 16K bite users area.

All of networks data should be written in DATA statements at the last part of the program. Formats of networks data are explained in the REM statements.

Every node and pipe must have unique number for its identity. Identical nodes or pipes number are not allowed. Direction of flow of each pipe is identified by the "from" node number and the "to" node number.

A fixed node is a reservoir with infinite surface area, the means the water head of the node will not change during iterations. There must at least be one fixed node among the nodes.

The leakage function (11) is not installed in the program.

The most probable values of ac- and de-celerator are yet to be determined. They may be entered from the console and be tried.

After minutes or hours, depending on the size of problem and given initial data, calculated water head of each node will be displayed on CRT. The influent into the networks at the fixed nodes will also be calculated.

Improvement

The program consists of routines for non-linear simultaneous equations and a very simple out put routine to the CRT. There is not any print out routine nor I/O routine of initial and final data in the program. If the machine has enough spare space of memory, that usually has, the following enhancements of the program may be favourable.

i) Data entry and editing from the console.
ii) Filing initial data and solution to a disk or cassette tape.
iii) Print out program of data of the networks:
    Node; water head, pressure and given data.
    Pipe; direction of flow, flow rate, velocity and given data.
iv) Installation of leakage function in the program.
v) Compile the program for faster execution.

If some of unknown variables are not water head of nodes, the correction formula of (6) and (8) should be employed. However the programming is not so simple as to be presented as stated before.

6. APPLICATIONS

The program has been checked on a lot of networks wih various initial water head. A few actual networks were analyzed.

Analysis of the networks with 38 nodes and 57 pipes by improved Hardy-Cross method required a week of intensive abacus calculation, even with a set of close estimation of flow rate of conduits 7). But the analysis of the same networks with random initial value spent only about 4 hours of execution time by a micro-computer of Z-80 CPU. If the initial given data are better, it will not take more than 1 hour.

An actual networks of Chiang Mai University water works with 48 nodes and 53 pipes had been analyzed. With randon initial values, the analysis took about three hours of execution time. It is believed that this tools can improve Chiang Mai University water works in the future. The program will latter be employed by traiing courses at Chiang Mai University for the engineers of provintial water works and rural water works. It will also be a design tool for water works in Northern Thailand.

The relaxation method has been employed in student exercise class of water supply at University of Tokyo, because it is very easy to program and suitable for the training of programming.

7. CONCLUSION

The theory of relaxation method for networks analysis was presented and implemented successfully to micro-computers.

Relaxation method has the following advantages:
i) Simple algorithm.
ii) Simple and short program.
iii) Small memory requirement.

Its only disadvantage is slow convergence.

Numerical methods and a few technics for acceleration of convergence were also presented. BSOR method and Symmetric SOR method were introduced for better performance. They were tested on actual networks and have been proven to be effective.

The new methods of networks analysis by microcomputers using relaxation method shall be powerful design tools for the mass provision of water supply in developing countries. They are very easy to program and will even be run on a small and cheap computer. With those strong tools, the domestic engineers and technicians will be able to train themselves, to accumulate experience and to be independent from the assistance of foreign engineers to meet the pressing demands of design of awaited water supply.

Acknowledgment

The research has been being done since Aya stayed at Chiang Mai University as a JICA expert in 1982 for the assistance of its Department of Environmental Engineering. The programs were developed on a micro-computer donated by JICA.

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```
10 '      APPENDIX
20 '
30  '  Water Distribution Networks Analysis,  ver-3
40  '     Relaxation Method          BY H.AYA, SUPORN K.', SEPT. 1982
50 '
60 DEFINT I-N
70 INPUT "Accelerator (1.0-1.5 MEAN 1.3) =";A1
80 INPUT "Decelerator (0.5-1.0 MEAN 0.8) =";A2
90
100 READ N,M
110 DIM S%(N,11),S1(N,2),P%(M,5),P1(M,2)
120 FOR I=1 TO N
130 READ S%(I,0),S%(I,11),S1(I,0),S1(I,2),S1(I,1)
140 NEXT I
150 FOR I=1 TO M
160 READ P%(I,0),P%(I,1),P%(I,2),P%(I,3),P1(I,2),P1(I,0),P1(I,1)
170 NEXT I
180 FOR I=1 TO M
190 FOR J=1 TO N
200 IF P%(I,1)=S%(J,0) THEN P%(I,4)=J ELSE IF P%(I,2)=S%(J,0) THEN P%(I,5)=J ELS
E 230
210 FOR K=1 TO 10
220 IF S%(J,K)=0 THEN S%(J,K)=I ELSE NEXT K
230 NEXT J
240 NEXT I
250 '
260 L1=0                                           '   COUNTER
270 L2=0                                           '   FLAG OF NODE ERROR
280 DIM B(N)                                       '   RECORD OF dH
290 ' SCRACH
300 FOR I=1 TO N
310   F=0                                          '   NODE FUNCTION
320   F1=0                                         '   dF/dH
330    FOR J=1 TO 10                               '   FLOW RATE OF PIPES
340      IF S%(I,J)=0 THEN 450
350       P%=S%(I,J)
360       H=S1(P%(P%,4),0)-S1(P%(P%,5),0)
370       XD=P1(P%,0)/1000
380       XL=P1(P%,1)
390       XC=P1(P%,2)
400        IF H=0 THEN H=.00001                      '   IF H=0, ERROR
410       ON P%(P%,3) GOSUB 650,700                '   IF 1, H-W. IF 2, MANNING.
420         IF P%(P%,2)=S%(I,0) THEN Q=-Q           '   DIRECTION  OF FLOW
430         F=F+Q
440         F1=F1+Q1                                '   dF/dH
450    NEXT J
460      IF S%(I,11)=1 THEN S1(I,1)=-F:PRINT "(";I;") Q=";-F;:GOTO 540 '  FIXED
470   F=S1(I,1)+F                                   '   NODE FUNCTION
480   DH=-F/F1                                      '   dH
490    IF ABS(F)>.0001 THEN L2=1 ELSE 530           '   CHECK OF ERROR OF NODE.
500    IF B(I)*DH<=0 THEN B=A2:PRINT "*"; ELSE B=A1    '   REDUCE SOR
510    PRINT "F(";I;")=";F;"dH=";B*DH;
520    S1(I,0)=S1(I,0)+B*DH                         '   CORRECTION OF LEVEL
530  B(I)=DH                                        '   RECORD OF dH
540 NEXT I
550 IF L2=0 THEN 610                   '   ALL NODES ARE WITHIN ALLOWABLE ERROR
560  IF L2=1 THEN L2=0                               '   INITIALIZE FLAG
```

```
570    L1=L1+1                                    '   INCREMENT COUNTER
580    PRINT '  n=';L1:PRINT
590 GOTO 290                                      '   RETURN TO SCRACH
600 '
610 PRINT ' End of Execution n= ';L1
620 GOTO 740                                    '   PRINT OF RESULTS
630 '  Subroutine
640 '** Hazen-Williams **
650 R=.27853*XC*XD^2.63*XL^(-.54)
660 Q=SGN(H)*R*ABS(H)^.54
670 Q1=.54*R*ABS(H)^(-.46)
680 RETURN
690 '*** Manning ***
700 R=.31169*XC^(-1)*XD^(8/3)*XL^(-.5)
710 Q=SGN(H)*R*ABS(H)^.5
720 Q1=.5*R*ABS(H)^(-.5)
730 RETURN
740 '  PRINT SOLUTION
750 FOR I=1 TO N
760   PRINT S%(I,1);'=';S1(I,1);'m',
770 NEXT I
780 END
790 ' DATA
800 ' number of nodes, number of pipes
810 DATA 10,12
820 '
830 ' Data of node
840 ' node no., node type, initial head (m), ground level (m), supply (m^3/s)
850 ' node type; 0 = unknown node, 1 = fixed level node
860 '
870 DATA 1,0,290,0,-2.00
880 DATA 3,0,200,0,0.347
890 DATA 4,0,240,0,0.463
900 '     continue
910 ' Data of pipe
920 ' pipe node, connected node no. from, to node no., type of pipe, coefficient
 C or n, diameter (mm), length (m)
930 ' type of pipe; 1 = Hazen-Williams, 2 = Manning
940 '
950 DATA 1,1,2,1,100,1200,800
960 DATA 3,1,3,1,90,1200,300
970 DATA 5,3,4,1,100,900,4000
980 '    continue to end.
```

MANAGEMENT, MANPOWER DEVELOPMENT & COMMUNITY PARTICIPATION

ST. II-2

THE WATER DECADE – THE NEED FOR AN INTEGRATED APPROACH TO TRAINING AND EDUCATION

Ian Vickridge and Rowena Vickridge
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4TH Asia Pacific Regional
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TIRTA DHARMA

INTERNATIONAL WATER SUPPLY ASSOCIATION

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THE WATER DECADE – THE NEED FOR AN INTEGRATED APPROACH TO TRAINING AND EDUCATION

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Nanyang Technological Institute, Singapore

1. Introduction

There is a need for skilled manpower at many different levels and in many different disciplines if the aims and objectives of the Water Decade are to be met. Traditionally, tertiary educational institutes in the developing countries have been modelled on well established institutes in the developed countries. This paper argues that not only are there limitations within the western model, but also that these deficiencies are accentuated in the developing world.

Although engineering expertise is of course required to plan and implement projects necessary to meet the objectives of the Water Decade, these plans may be inappropriate unless economic, social and cultural issues are also considered. Also, it may be impossible to implement any plans if political and educational issues are ignored. This paper therefore argues for much greater integration between those professional and institutional bodies responsible for planning and implementing projects as well as a more multi-disciplinary approach to training and education.

The problem with the western model of tertiary engineering education

The present theory & research oriented approach to engineering education in the developed countries often produces engineers with few practical skills and little understanding of how projects are planned and implemented. Most of the Professional Engineering Institutions recognise this and make it a requirement that engineering graduates work (sometimes under a training supervisor) for a minimum number of years (usually about three) before they are granted the status of a Professional Engineer and allowed to assume responsibility for engineering works. In many cases, Institutions require young engineers to sit exams, submit designs and/or attend professional interviews in addition to the minimum period of experience requirement.

The lack of practice skills results largely from the structure of standard undergraduate curricula which concentrate on the theoretical and analytical aspects of a wide range of technical and specialised disciplines at the expense of practical and non-technical aspects of engineering. This system not only meets western technology's need for specialists, but also allows maximum choice for the individual to pursue a career in a wide variety of specialist disciplines either as researcher teacher or practioner However, it must be reiterated that the onus for training graduate engineers in the skills necessary for practice is left with industry and the professional institutions, and that this fragmentary system of education is wasteful of resources, as much of the knowledge gained during the course is not used by the graduate in practice.

There are moves by many educational institutions throughout the world to produce a more able graduate by introducing elements of practical training to the curricula. This is normally in the form of 'co-op' or 'sandwich' programmes.

Although these programmes do indeed allow the student exposure to the actual practice of engineering, their shortcomings often include the failure to truly integrate theory and practice and the failure to tailor the theory input to the specific requirements of practice.

This problem is not exclusive to the education of engineers but is common to much professional training, since 'teaching" and "practice" fall increasingly into two exclusive categories or career structures, and few professionals bridge the two. The theory input in curricula is thus too often uniformed and more suited to preparing the student for further study, teaching or research, than equipping him with the skills appropriate for practice.

Ironically, professional career structures increasingly insist on academic qualifications as opposed to in-house "on the job" training, yet employers are, if anything, less satisfied with the quality and abilities of the graduates.

Inappropriateness of western model in Water Decade countries

One of the most obvious problems associated with the western model of engineering education is its wastefulness of resources since the graduate who becomes a water engineer will have aquired a mass of information and theory which is irrelevant to the specific task of planning, designing and constructing water supply and treatment facilities. Not only will he have acquired too much irrelevant knowledge, he may have undergone further graduate studies specifically related to water problems and, even then, will probably be deficient in many areas of knowledge. and skills required for his specific task as a water engineer (1). The argument here is that of generic versus specialist vocational training. Whereas generic education gives maximum freedom of choice to the individual, it is clearly wasteful and inefficient in countries whose educational resources are limited.

Secondly, the western system relies on the assumption that the average graduate will aquire practice skills after his education through supervision in industry. This whole relationship, which gives balance to the academic orientation of undergraduate courses, may be absent within developing countries leaving a greater onus on the educational programme itself to produce a competent professional.

Thirdly, because much of engineering curricula is "imported" from western universities, often for the purposes of accreditation, the content and bias is unrelated to indigenous circumstances and technolgy.

> " . . . . . too few civil engineers working in tropical climates have received any training in tropical sanitation. Expatriate engineers have been trained in their own temperate countries where sanitation is synonomous with conventional sewerage; and local engineers are either trained abroad where they receive the same prejudice, or at home where, because the engineering curriculum at most tropical universities is western-urban oriented, they are similarly indoctrinated. . . . Conventional training in sanitary engineering has thus provided tropical developing countries with many hundreds of engineers with severe tunnel vision' — the result has been unimaginative designers producing unimaginative designs which few communities can afford to implement". (2)

For these reasons, the education and training of the water engineer needs to be specific, comprehensive, technologically appropriate and practice oriented.

A further problem that surrounds the status and meaning of education in developing countries is what may be termed the 'mandarin syndrome', mandarins being the educated elite whose long fingernails symbolised a life removed from manual work. The economic rewards of a lucrative administrative post become, for many students, the promise and meaning of further education. This, coupled with the shortage of professionals at all levels, ensures that a large proportion of newly qualified graduates move immediately into managerial and administrative positions, thus becoming further removed from the actual practice and experience of engineering. Furthermore since administrative jobs are almost invariably based in large urban centres the young graduate engineer is rarely exposed to the overwhelming needs of rural areas. Far from investment in western style higher education programmes being able to meet some of the needs of the water decade, it could represent misdirected and inappropriate expenditure, contributing to the creation of an over educated but undertrained urban based professional elite.(3)

The place of professionalism

The relationship between education and status is often reflected in the debate surrounding professionalism. The expressed concern for the maintenance of standards in the interests of the community is an important one, but is not convincing when the prime motivation so often appears to be the monetary rewards accruing to the professional himself. The obsession with a professional identity becomes elitist and divisive by obscuring the more fundamental need to establish common goals and practices with co-workers, regardless of their level of training. This is specially important in those countries where resources are limited and needs are great. In these cases all available talent needs to be harnessed and directed in the most effective manner possible.

An example, which could possibly be a useful model for fulfilling water decade objectives, is that of the "barefoot" approach to medical services adopted in China. The great advantage of the approach is that it becomes possible to distribute and disseminate a normally scarce resource (i.e. medical knowledge — both preventive and curative) in the most effective and far reaching (in both the geographical and social sense) way.

The "barefoot" principle breaks away from the traditional and elitist concept of professionals maintaining strict control over essential but closely guarded knowledge and skills. Many professionals regard the barefoot principle as a treat to both their own personal interests or, more altruistically, to the quality of the service given. Others however recognise that overwhelming social needs militate in favour of radical strategies, and furthermore that rather than diminishing the responsibility of the professional, the barefoot approach to service delivery presents him with a challenge requiring versatility and imagination in his role as coordinator, administrator and teacher.

A further advantage of the 'barefoot' approach to the needs and problems highlighted by the Water Decade is that it allows maximum participation by those communities to which the efforts and aims of the Decade must be directed (4). Past experience has made it abundantly clear that the users themselves must be intimately involved in the planning, construction, operation and maintenance of water supply or waste disposal systems. This is not merely to economise on manpower but, more significantly, to ensure that the systems constructed are used appropriately and efficiently and maintained regularly and effectively (5). User participation to this extent requires professional engineers to 'hand over' some of their responsibilities to technicians and artisans as well as to cooperate with other community health workers.

An integrated approach to service delivery

To most effectively meet the aims of the water decade we need to adopt a "problem solving" approach which starts from the "unit of need" (eg house, village, community etc.) and which results in an "action system" at that level.

This requires, as we shall indicate, the united resources and skills, both within and between a variety of agencies and professions, and this structural interdependence must be emphasised.

The two dimensions of interdependence or integration can be defined as "vertical" and "horizontal", or intra-agency and inter-agency respectively

Vertical or intra-agency dimension

We can isolate three significant organisational aspects, i.e. structure, decision making, and communication.

Within any profession, a hierarchical structure encompassing different levels of training and areas of responsibility is apparent. An "unbalanced" or "top-heavy" system can result from too great an investment in the education of professional graduates at the expense of skilled or semi-skilled technicians. Though one professional engineer could produce the appropriate designs and plans, these would require several technicians and many artisans in their implementation. Too few artisans and technicians and an abundance of professional engineers would produce a lot of drawings but no water.

However a balanced organisational structure with artisans and technicians to support each engineer is not of itself sufficient to result in effective action at a local level, unless matched by a devolution of decision making *and supported by open communication between all* levels.

The importance of devolution becomes clear when we consider that organisational decentralization is coterminous with a geographical dimension, that is, the levels of community, locality, area and region relate to a corresponding level within an organizational structure (see Fig. 1).

For individuals working at local and community level it is essential that responsibility be given for making appropriate decisions. The devolution of effective decision making would be a new element for many developing countries where there is too often a bureaucratic stranglehold on individual and local initiative. Yet it is essential to avoid the interruptions to work, and undermining of local commitment and initiative that occur if all decisions have to be referred to a higher and remote authority.

On the other hand it is of equal importance that workers at local level have access to the advice and technical support from those at higher levels, and this means that communication needs to be two-way; downward to give guidelines and direction to local initiative and action; upward to convey information relating to local circumstances and needs and to provide "feedback" to policy and planning at a regional and national level.

Lastly, all workers at whatever standard of training and expertise and whether at village, regional or national level, need to be acquinted with the entire professional system at all levels, in order to identify common goals and concerns and to recognize each individual contribution to such goals.

Horizontal or inter - agency dimension

Few engineers are educated to an awareness of the socio-political dimensions of the technology they are employed to create or work with. However there is now a growing literature on the subject of "appropriate" technology which has induced many people to question, for the first time, the assumptions behind the ever increasing complexity of technological solutions in the name of progress. Much of this literature has arisen from the lessons learnt by the inappropriate application of these costly and sophisticated solutions in developing countries. Highly sophisticated equipment has either required costly expatriate maintenance personnel or, sometimes in the absence of this, has fallen into disrepair and disuse (6). Multinational companies have stood to gain by the sale of equipment and the provision of specialist personnel, and idigenous professional engineers have been mesmerised by the prestige and sophistication of this advanced technology, or have themselves benefitted by its deployment.

This situation is not unique to the engineering profession but is also true of other fields, where resources have been directed towards sophisticated technologies concentrated in major urban areas. For example, medical service in many developing countries are concentrated in a few prestigeous hospitals utilising very expensive high technology equipment and employing highly paid specialist doctors. Conversely, community medicine and health education are given low priority with the result that many preventible diseases are rife among the urban and rural poor who are largely ignorant of the causes and prevention of disease and have no easy access to health services (7).

The philosophy of the Water Decade, with its focus on those communities whose needs are greatest, runs *contrary to these trends of centralisation and sophistica*tion. Finding less broader awareness of the social, cultural and economic characteristics of the community. These will have a bearing on, for example, the cultural norms relating to waste and excreta disposal (8), social division of labour surrounding water carrying, the state of community knowledge of water borne and other diseases, the organisation and evaliability of labour, and the ability and commitment of the community to operate and maintain water supply and waste disposal systems (9, 10). All of these are now recognised as being of significance in the planning and implementation of water related projects. Yet here the water engineer must rely on the skills and expertise of other disciplines. Quratul Ain has described a classic example of the esential contribution of the community worker to the success of sanitary projects, concluding:

"My experience convinces me that technology and social work must be coordinated to have positive and long lasting results in programs of slum improvement". (11)

Likewise, Terry Murphy, speaking from Nigerian experience claims that:

"... water and waste enginners and adult educators must be conciuos allies" (4)

Raymann, with experience in West Cameroon emphasises the importance of community participation through:

"teachers, clergy, midwives and ... community leaders" as being essential "for construction but also for future functioning of the maintenance" (12).

To be most effective the engineer needs then to operate within a team (13) of community health co-workers consisting of representatives from the fields of education, medicine, economics, community and social work etc.

An organisational structure which may be appropriate to meeting the goals of the Water Decade, might consist of 'community health teams' at all levels — national, regional and local (as indicated in Figure 1 shown below). Each team (consisting of engineering, medical, social work etc. personnel) would be responsible for a particular geographical area. The responsibilities of the team could include general health education, the promotion of self help and initiative in improving water supply and sanitation systems, assisting in the planning, design and construction of such systems most appropriate to the community, co-ordinating the supply of materials and equipment, and helping to ensure that the systems are properly and adequately maintained. A further function of the team should be to act as a means of coordinating government directed and voluntary projects, and as such voluntary agencies and personnel would be represented at the appropriate team level (14). For this type of structure to be effective, it is essential that there be integration within each team at whatever level. As the engineer would be a key member of these teams, his ability to work in such interdisciplinary teams must be encouraged and therefore reflected in education and training programmes.

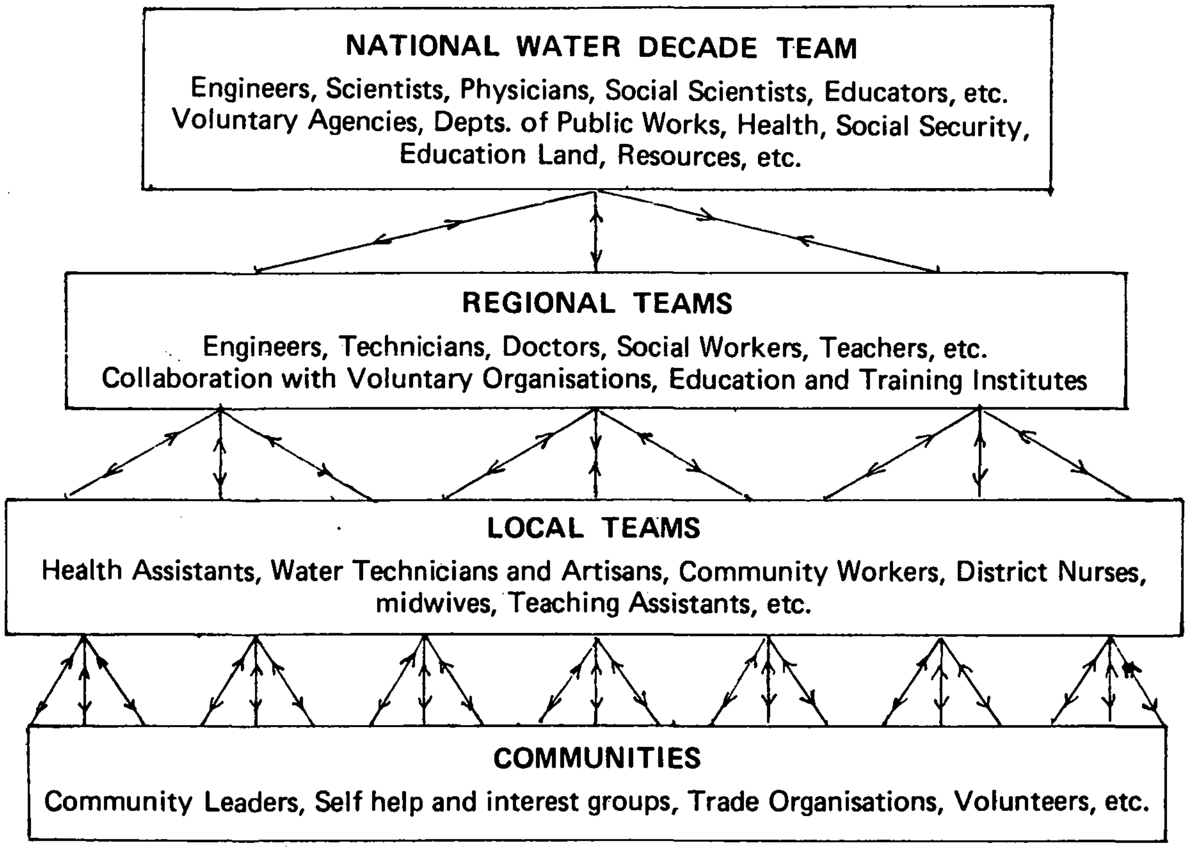

FIGURE 1

Implications for training and education

The preceding arguments imply four major strategies related to the educational and training requirements of the Water Decade.

1. Education and training needs to be specific as opposed to generic.
2. Education and training should prepare the engineer for "vertical" integration.
3. Education and training should prepare the engineer for "horizontal" integration.
4. Formal education and training of water personnel needs to be supplemented by public health education campaigns.

Ad.1 **Specific rather than generic**

> "The Decade technical manpower educational and training needs are likely to be best catered for within Environemental Technology Training and Research Institutes. Such Institutes which should be national or regional centres can be either constituent colleges of universities or they can be automonous institutes with statutory powers to award degrees, diplomas and certificates in environmental science and technology" (1).

Currently, universities can neither provide the specific theoritical nor the practical training input required for the Water Decade engineer. Institutions or Schools specially set up for the needs of the Decade would have more flexibility to run courses at all levels from crafts, technician to professional engineer which would be in line with manpower needs. These Institutes could provide curricula which would be more practice and problem oriented than those currently prevalent in most universities and should include a much greater emphasis on appropriate solutions to technical problems.

> "Most public health engineering teachers have received their specialist training in the industrialised countries and there is a very urgent need to increase the perception of the different nature of (indigenous) public health engineering problems...." (1).

It has been recommended (1) that the World Health Organisation should set up a standing committee on public health engineering education in order to formulate appropriate course syllabi. National governments should then establish training committees to formulate syllabi based on WHO guidelines but "tailored more appropriately to national needs" We strongly support these recommendations, however, in the absence of specific guidance, national governments should initiate training programmes on the basis of predetermined needs.

Ad.2 **Education for "Vertical" integration**

"Vertical" integration requires that the professional is familiar with the skills and expertise required by artisans and technicians to implement plans and designs and to operate and maintain the facilities once constructed
It the education and training of all levels of personeel were conducted 'under one roof' a certain measure of vertical integration could be achieved during the training period. Potential engineers would be studying in the same institute and possibly taking some common courses with those training to be artisans and technicians.

A development of this proposal could be a "step" system of education, whereby one level of training is a prerequisite for further levels. Thus professionals would have previously learnt artisan and technician skills. This would ensure a much more relevant knowledge background than the present system which produces engineering graduates with no practical skills or experience.

As far as possible, curricula should be practice and problem oriented and this can best be achieved by a much greater emphasis on projects which simulate 'real world' conditions. For example, ten weeks of the second year degree course in civil engineering at Nanyang Technological Institute in Singapore, are devoted to In-House Practical Training. The project carried out this year by 193 students was the construction of five hyperbolic – paraboloid shell roof structures each measuring 6 m by 6 m in plan and 4.25 m high. The students were divided into five construction 'companies' each of which was responsible for the construction of one structure. Apart from the excavation, the construction (including bar cutting, bar bending, formwork manufacture and erection, steel fixing, concrete mixing and placing and pipe laying) was all carried out by the students themselves. Each construction 'company' was responsible for planning and programming the work, designing the temporary works, ensuring safety and quality control, materials and cash flow as well as the actual construction. This project hash helped to instil in the students not only and awareness of the practical skills but also many of the non-technical facets of carrying out construction projects. Similar water reltated projects can be envisaged and in fact one is being planned for incorporation in the In-House Practical Training programme at NTI in 1984.

Approximately 25% of the students involved with the above project are Polytechnic diploma holders (technicians) and this points the way for projects which could be of even more benefit for students of water engineering. If major projects were carried out in each year of studies, it would be possible for project teams to include students from each level of study. Those students at higher levels would then have already completed several major projects and could be actively involved in teaching their less experienced colleagues. This would be of benefit to both parties and would also introduce students to the skills and techniques of educating and training. Engineers in the field would then be more ready and able to pass on their knowledge to others and this would in itself increase the possibility of realising the full potential of the 'barefoot' engineer.

In-house simulated projects can be very expensive to run and, although the products of the project may have some value (the structures at NTI will be used for additional laboratory and storage space), it is questionable whether institues with more limited resources could regularly afford to stage such projects. However, it is only a short step from well simulated rpojects to field projects and it is not difficult to imagine teams of trainee engineers, technicians and artisans being involved in real and meaningful water supply and sanitation projects. The greatest need for water is in the rural areas and villages where water supply schemes would be of the right scale for limited period student projects. This type of integrated training, involving students at varying levels of skills in much needed real projects, would be of great benefit to both the students themselves and the communities who would be served by the completed facility.

Ad.3 **Education for "Horizontal" integration**

Water engineers, at whatever level, need to recognise the socio-cultural context of design, construction and maintenance as well as the necessity for multi-disciplinary teamwork and community participation in project planning. Specific courses on these aspects of the water engineers work should therefore be included in curricula. Greater awareness of the problems and more effective cooperation between the professions could however be encouraged by joint seminars and, more significantly, joint field projects (e.g. Baldia Soak Pit Project) (11) with students of other disciplines. Clearly, such projects and seminars would be more easily arranged and implemented if the different professions were trained 'under one roof'. In this way, engineers could be made aware of community and health problems, and community workers could be introduced to some of the technical problems associated with planning and implementing water projects.

Ad.4 **General Public Health Education**

If community participation in water projects is to be encouraged and expected it is essential that the general public be made aware of the links between inadequate sanitation, polluted water and disease. Health education should therefore be seen as an important component in primary and secondary school curricula. This needs to be supplemented by campaigns directed at the adult population through national, regional and local media, the greatest effort being directed through the local and community workers, health workers and the 'barefoot' engineer as it is likely that these people will have the greates effect on the overall awareness of the general public.

> "Learning – by – discussion has been shown to be more likely to bring attitude change as participants do not simply **retain** knowledge, as tends to be a result of pedagogy, but are more likely to **believe** what they learn." (4).

Public health education should be an essential component of the community health team strategy, whether at national, regional or local level.

Conclusion

The need for an integrated approach to training and education for the Water Decade has been outlined and some suggestions for meeting this need have been made. However no strategy, however viable, can be implemented without political will.

It is the rural and urban poor who lack access to clean water and adequate sanitation and this is just one aspect of a more general inequitable distribution of resources and access to political power. Shourtages of food and water, low standards of living and high incidence of disease are endemic to the poorer communities of the world. The situation is worsening (15) due to present international economic forces, misdirection of expenditure and inappropriate national economic policies, which result in the concentration of scarce resources in visible, prestigeous, urban based and often under utilised facilities.

The redirection of resources towards the poor, deprofessionalisation to achieve a greater spread of useful knowledge, and community participation in projects can not be achieved simply through changing administrative procedures. Political will is necessary and it must be emphasised in conclusion that without this political will the aims of the Water Decade can not be met.

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SMALL WATER TREATMENT PLANTS USING ELECTROCOAGULATION

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INTRODUCTION

Approximately 95 percent of the Norwegian population use surface waters for drinking water, and 25 percent of the population are served by small water treatment plants. Surface waters in Norway are mostly coloured due to aquatic humus, and coagulation is the most important treatment method. The Norwegian Institute for Water Research (NIVA) decided in 1980 to concentrate the research activities on problems connected to small water treatment plants. Investigation of several small existing water treatment plants using coagulation showed that there are considerably operational difficulties involved in pH control, chemical mixing, and Al-sulphate dosing. Simplifying and optimizing this process has been the major objective when studying the electrocoagulation process using aluminium electrodes. A simplification of the conventional coagulation process will mean a great improvement to water supply technology in developing countries when water must be treated to render it potable. Avoiding handling of chemicals is of major importance.

Electrochemical processes have been used in water – and wastwwater treatment since 1887. The compact size and the easy operation make it very interesting in regard to small water treatment plants.

Extensive laboratory experiments of the electrocoagulation unit started in 1981. A joint project to develop a commercial unit started with the Norwegian company, Aqua Care, in 1982. The first prototype of a water treatment plant was completed in the autumn of 1982. The package plant includes the electrocoagulation process, granular media filtration, and ultraviolet (UV–) disinfection. The health authorities in Norway accept UV-disinfection as an effective disinfection process when treating water with fairly low turbidity and colour. The electrocoagulation process fillowed by granular media filtration is removing the impurities and ensuring an effective disinfection. The first full scale experiments are today being conducted at NIVA's research station, treating 15 m^3/day.

Electrochemical Processes in Water and Wastewater Treatment

The primary electrochemical sewage treatment process used was installed in London in 1889 and operated for 10 years (Marson, 1965). The process generated chlorine from seawater to deodorize and disinfect wastewater. Another plant for treating canal water was built the same year in Salford in England. J.T. Harries received a patent (U.S. Patent, 1909) in 1909 for purification of wastewater by electrolysis. Aluminium and iron electrodes were used together as anodes, which corroded during electrolysis. As early as in 1911 electrolytic sludge treatment plants were operated in California and Oklahoma (Collier, 1912). The demonstration plants using steel electrodes alternately connected to the positive and negative terminals of a D.C powersupply were all praised for their high quality effluent and lack of odour (Miller and Knipe, 1963). Operation costs were high since the sludge had to be hauled away, and thus all plants were abandoned in 1930.

Foyn (1963) described electrolytic treatment of wastewater using magnesium slat and alkalization in order to remove phosphorus at high pH. The chloride ions in seawater were oxidized to chlorine gas by the anode while hydrogen gas was formed by the cathode. The particles and colloids in water were adsorbed on the Mg(OH)2(s) and flotation occurred because of hydrogen gas formation. After a relatively short operational time, $CaCO_3$(s) deposited at the cathodes and rendered ineffective the flotation process. The process was very effective in regard to phosphorus, nitrogen, and organics removal, but was found to be expensive compared with biological treatment. The experimental work was never completed to a finished product.

Electrocoagulation has been studied for treatment of wastewater from food industry (Beck et al., 1974). The comparison was made between electrocoagulation and chemical treatment followed by dissolved air flotation. Floc formation for both processes was rapid. The electrocoagulation process surfaced a floc in 2–3 min and compacted it in 3–10 min, while the dissolved air flotation often required 10–20 min.

In the Soviet Union (Strokach, 1975), electrochemical water purification with a soluble iron anode was first used at the Shature Power Station in 1925. Stuart (1946) introduced the same process in USA in 1946 to remove colour from drinking water. In this case aluminium electrodes were used. Holden (1956) treated water from the River Severin, using iron electrodes. Two water treatment plants were run in parallel, the only difference being the chemical dosing system. Water quality measured as turbidity was the same in both systems. The electrolytic process was favoured as regards cleanliness and accuracy of dosing. The capital cost was difficult to estimate while the operational costs were found to be approximately the same.

The Effect of the Coagulation Process.

Coagulation is a process for combining small particles into larger aggregates. The process is an essential component of accepted water treatment practice in which coagulation, sedimentation, and filtration processes are combined in series to remove particulates from water. The water treatment for removal of particulates complishes removal of many harmful substances from water. Some examples follow (O'Melia, 1978):
Clays are a major portion of natural "turbidity" in raw water. Turbidity, including asbestos fibres, is easily removed by the coagulation process. Colour, organic macromolecules are effectively removed by coagulation. Large coagulation and filtraticon. Bacterial removals of 99 percent can be achieved. Several recent studies have shown that bacteria and viral agents are attached to organic and inorganic particulates (Britton and Mitchell, 1974 a,b). Hence, removal of these particulates by conventional coagulation and filtration processes is a major component of effective treatment for the removal of pathogens. Finally, many toxic organic substances, such as PCB and DDT, and also many inorganic toxic materials are adsorbed on naturally occuring inorganic and organic particulates. Removal of particulates will also provide removal of these hazardous substances.

Coagulation Conditions

Chemicals used for destabilization of colloids include salts of hydrolyzing metal ions such as aluminium sulfate and ferric chloride and synthetic and natural polyelectrolytes. Aluminium sulfate, Al2(SO4)3, is mainly used and will be discussed here. Alum acts as a coagulant in two ways. In most waters, enough alum is added to precipitate $Al(OH)_3(s)$. The mechanism occuring, enmeshment in the precipitate, means that the $Al(OH)_3(s)$ formed coats the colloids with a "sticky" layer. The second mechanism of coagulation by alum, adsorption to produce charge neutralization, includes adsorbing positively charges aluminium monomers on negative colloids so that aggregates are formed when contacts occur.

Turbidity in water is caused by the presence of suspended matter, such as clay, silt, nonliving organic particulates, plankton, and other microscopic organism. Turbid water can be classified as shown in Table-I.

EXPERIMENTS

The electrocoagulation process has been studied both in the laboratory and in pilot scales. In the electrochemical cell, raw water passes parallel aluminium electrodes connected to a battery. Aluminium dissolves from the anodes and hydrogen gas is developed at the cathodes. The basic principles involved in electrocoagulation are described in Figure 1, and cover:

1) **Coagulation**
The dissolution of aluminium from the anodes and the mixing into the water, created by the waterflow, results in coagulation of the pollutants to be removed.

2) **Alkalization**
The hydrogen gas formation at the cathodes results in pH increase of the water.

3) **Flotation**
The hydrogen gas formation results in flotation of the sludge found in the process.

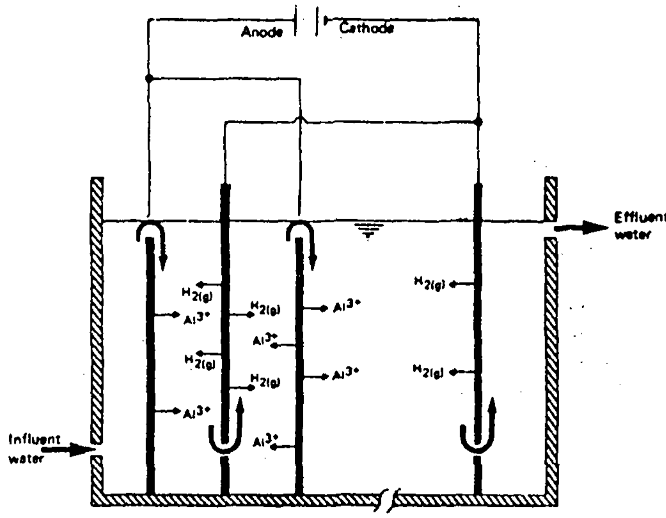

Figure-1. The principles involved in electrocoagulation.

A comparison of the electrocoagulation and the conventional coagulation process was done. Raw waters with various concentrations of organic matter (aquatic humus) have been studied. The laboratory scale experiments were performed using an electrochemical cell treating 10 1/h of water, having four aluminium electrodes, 3 mm apart giving a dentention time of 2½ min. A 12 V battery provided enough energy to the electrocoagulation unit. The xperimental set up is described in Figure 2.

The pilot scale experiments have been done with a unit treating 600 1/h water. The electrodes at the electrocoagulation unit were connected to a 24 V battery which created enough current treating water of various quality. The shape and design criteria of the unit has changed several times during the experimental period, from the first unit (Figure-3) till the present one (Figure-4) where most of the practical problems have been solved.

TABLE 1. Classification of water quality in relation to coagulation of turbidity (0' Melia, 1978).

Water quality characteristics / Effect of coagulatns	Alum Effect	pH	Ferric Effect	pH	Polymers
Type :					
1. High turbidity, high alkalinity	Easy, no need for additional chemic cals	6–7	Same as for alum	5–7	Cationic polymers are effective, even some anionic and aonionic.
2. High turbidity, low alkalinity	Important to measure/adjust pH (add base)	6–7	Same as for alum	5–7	Same as for type I
3. Low. turbidity, high alkalinity	Effective in large doses, $Al(OH)_3(s)$ precipitate, clay of activated silica may reduce the need for alum	6–7	Same as for alum $Fe(OH)_3(s)$ is formed	5–7	Cannot work alone, Clays are suitable targets.
3. Low turbidity, low alkalinity	Worst case; as type 3, but important to measure/adjust pH	6–7	Same as for alum	5–7	Cannot work alone, Clays are suitable targets.

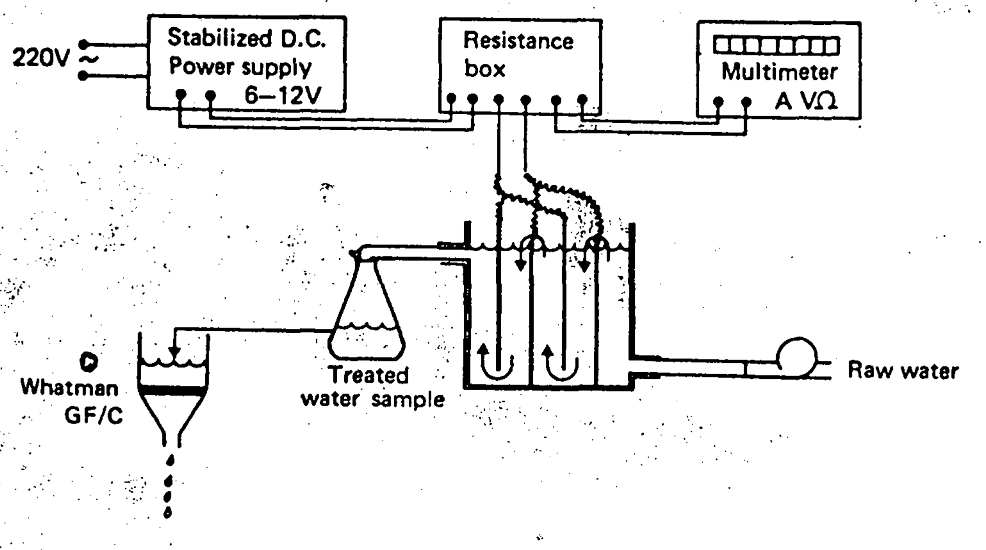

Figure-2. Equipment used for the laboratory scale electrocoagulation study.

The electrocoagulation process has been part of a package plant being studied. The Processes involved are electrocoagulation, filtration, and UV-disinfection. A sketch of the package plant being studied at one of NIVA's research stations is presented in Figure-5.

Water from several lakes in the vicinity at Oslo, Norway, has been used as the raw water sources. Important water quality characteristics from three of the lakes are presented in Table-2.

Table-2. Important water quality characteristics of water from lakes Tjernsmotjern, Hellerudmyra, and Smaputten.

Parameters / Lakes	Tjernsmotjern	Smaputten	Hellerudmyra
Turbidity (NTU)	0.9	0.95	0.9
Color (mg Pt/l)	110–140	44–78	105–110
UV-absorption (cm^{-1}) at 253.7 cm	0.63–0.65	0.26–0.35	0.50–0.52
TOC (mg C/1)	12.2–15.6	5.9–9.6	10.8–12.2
Spec. conductivity (uS/cm)	29–55	83–115	29–35
pH	6.0–6.5	6.2–7.3	4.3–4.9
Alkalinity (meq/1)	0.08–0.14	0.40	0

RESULTS AND DISCUSION

The Aluminium Dosage

The aluminium dosage, measured as mg A1/1, is proportional to the current across the electrodes (According to Faraday's law) and inversely proportional to the water flow through the system. Faraday's law can be used to describe the relationship between current density (A/cm^2) and the amount of aluminium which goes into solution (g Al/cm^2).

$$w = \frac{itM}{zF}$$

w = aluminium dissolving (g $A1/cm^2$)
i = current density (A/cm^2)
t = time (sec.)
M = molecular weight of Al (M = 27)
Z = number of electrones involved in the oxidation/reduction reaction (z = 3)
F = Faraday's constant, 96,500.

During the course of a series of experiments (Vik, 1982), the Al-electrodes were wighed. The theoretically calculated amount of Al dissolved was at various raw water temperatures compared with the weighed values of Al dissolved (Figure-6). The correlation found was very good (r^2 = 0.94) and was not depending on the temperature. In all further experiments the Al-dosage was calculated based on Faraday's law and the water flow through the system.

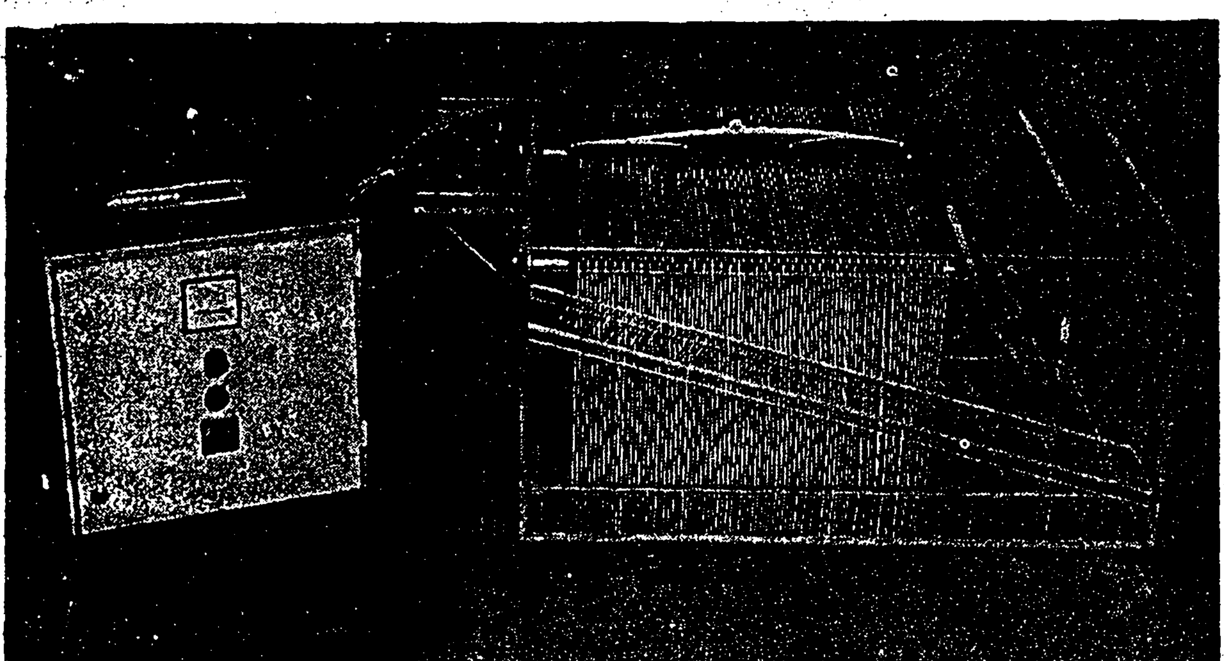

Figure-3. The first produced electrocoagulation unit.

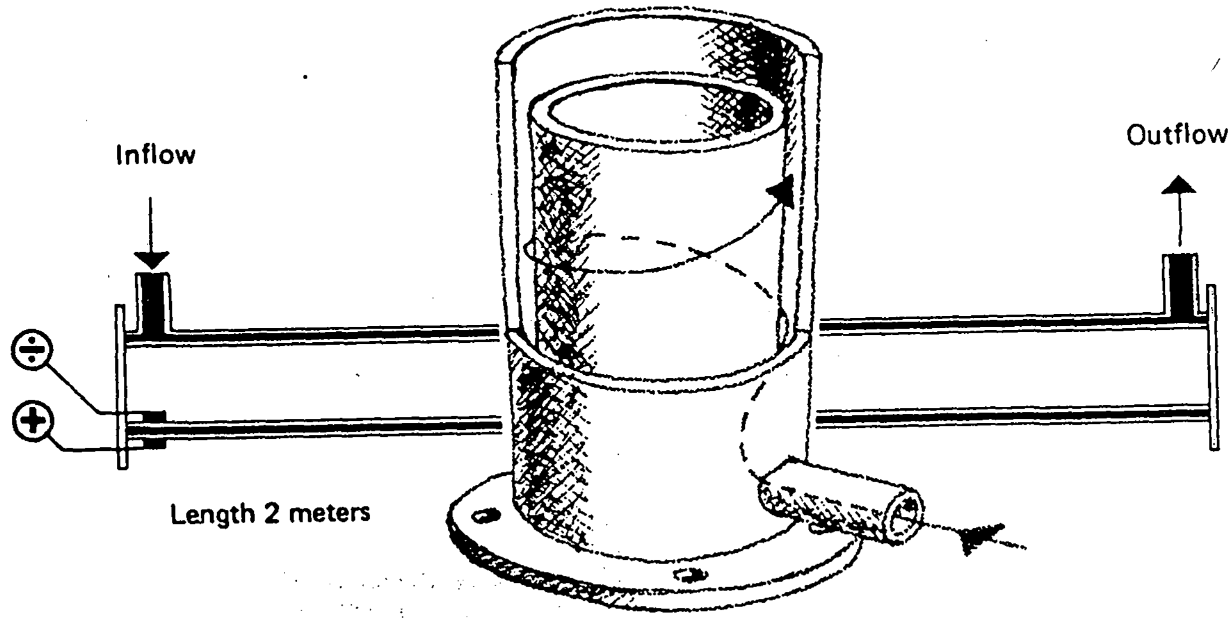

Figure-4. The present studied electrocoagulation unit.

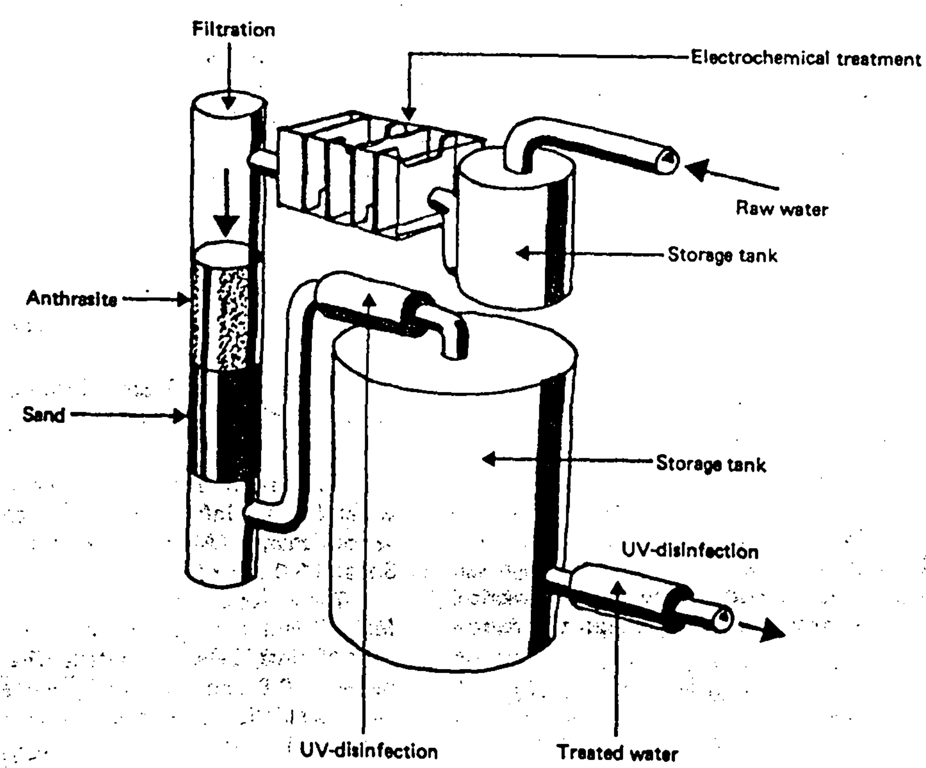

Figure-5. Principle sketch of the processes involved in the package water treatment plant being studied at NIVA's research station.

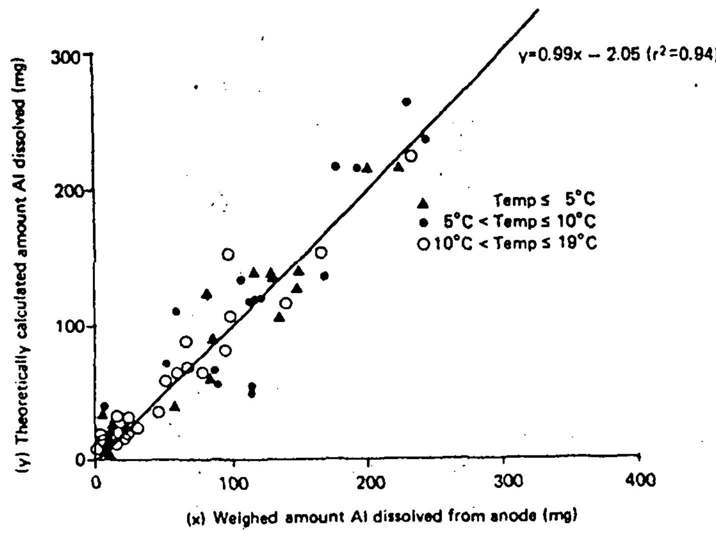

Figure-6. Relationship between theoretically calculated and practical dissolution of Al at different temperatures.

Necessary Electrical Potential

The necessary electrical potential to achieve the desired current density is in most practical cases depending on the potential caused by the solution resistance, the IR-drop. The IR-drop can be reduced by decreasing the distance between the electrodes and by increasing the surface of the anodes and by increasing the specific conductivity of the water:

$$\eta_{IR} = I \frac{d}{A.K}$$

where I = current (A)
d = distance between the electrodes (m)
A = active anode surface (m^2)
K = specific conductivity (10^3 mS/m)

The specific conductivity of the water is for a fixed design of the electrochemical unit determining the necessary electrical potential. For water with high salt content, the potential needed is very low. A practical example from the experiments illustrates the dependence:

Specific conductivity of water to be treated	Current needed for sufficient Al-dosage	Necessary electrical potential
(mS/m)	(A)	(V)
5	10	15.5
10	10	8.9
50	10	3.5

The Coagulation Process

The pH of the water to be treated increases during the electrocoagulation process due to the hydrogen gas formation at the cathodes. The importance of pH in regard to coagulation is well known, and a series of experiments adjusting the pH of the raw water have been performed. The increase of pH versus aluminium dosage is presented in Figure (7) A charge of 500 Coulombs is equal to an Al-dosage of 5 mg Al/l. (The coagulant dosage is calculated based on the water flow through the unit).

Residual Total Organic Carbon (TOC) concentration is presented as a function of the aluminium dosage in Figure-8.

The results shown that the pH-value of the raw water has no influence on the removal of organics at various charges (Al-dosage) as long as pH is kept between 3.9 and 6.0 (pH of the natural water in Figure-7).

The effect of raw water pH on the coagulant demand for efficient removal was further studied for another water source, Lake Smaputten. The raw water pH varied between 6.8 and 7.3 during the experimental period. One coagulation experiment was performed after adjusting the raw water pH from 7.3 to 4.8 Figure-9 illustrates the increase of the coagulant demand in order to achieve the same water quality with increasing raw water pH.

The results from the experiments using various water sources are presented in Figure-10 as residual total organic carbon (TOC) versus the aluminium dosage.

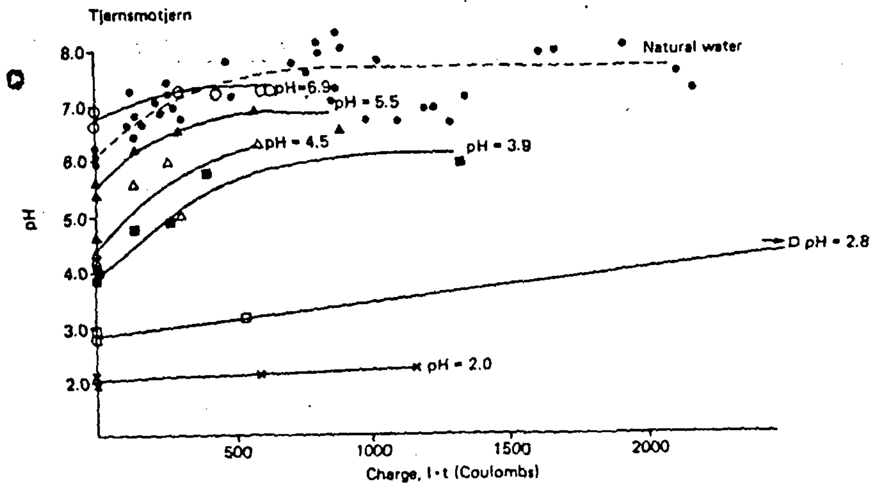

Figure-7. Increase of pH during electrocoagulation of raw water with different initial pH values. Water source: Lake Tjernsmotjern (pH 6.0).

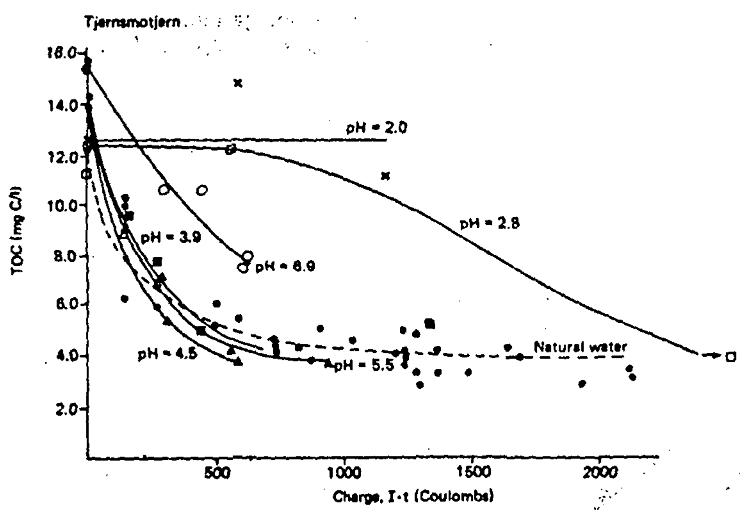

Figure-8. The efficiency of the coagulation processes for various pH-values on the raw water.

At optimum coagulation conditions for all water sources, the residual colour values have been lower than 5 mg Pt/l (WHO – Water Quality Standard).

Comparison of Electrocoagulation with Conventional Coagulation

Water from Lake Hellerudmyra was treated both with electrocoagulation and conventional alum. An aluminium dosage of 6 mg Al/l was added to both. The conventionally treated water was pH adjusted with NaOH to a pH of 6.0. The results are presented in Table-3. The residual colour is the same using both methods. The main differences between the two coagulation processes are the pH-values, residual Al-concentration, the sulfate concentration, and thus the specific conductivity. The simpler operation of the electrocoagulation process was noticed during the experiment.

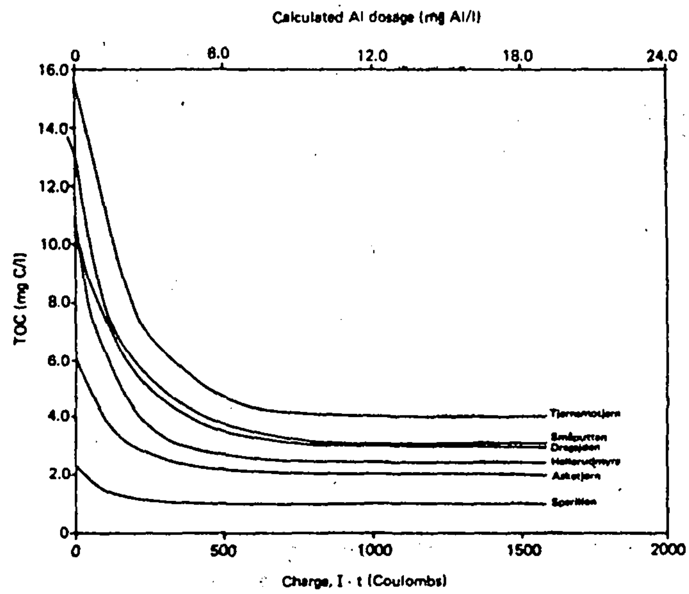

Figure-9. Residual UV-absorption (at 253.7 nm) as a function of the coagulant dosage (charge) for water from Lake Smaputten with various pH-values.

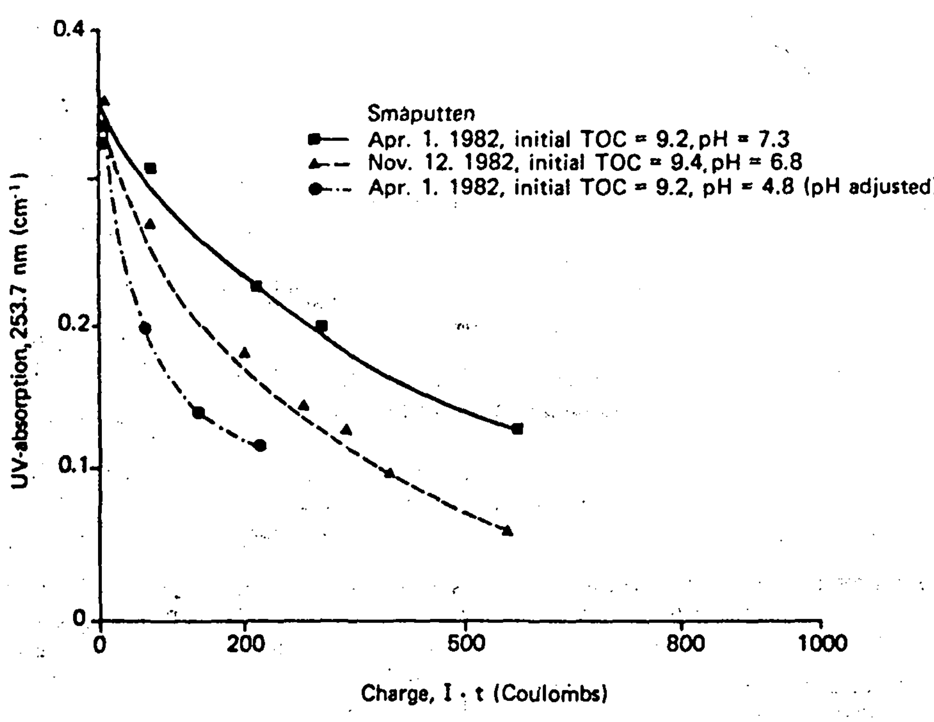

Figure-10. Residual total organic carbon (TOC) as a function of Al-dosage.

Table-3. Results from electrocoagulation of water from Lake Hellerudmyra compared with conventional coagulation of the same raw water.

Parameters	Process	Rawa water	Water Quality Electrochemically treated	Conventionally treated
Color	(mg Pt/1)	80	3	3
pH		4.8	7.0	5.9
Spec. Cond.	(uS/cm)	35	20	114
Ca	(mg/1)	1.08	0.76	1.09
Mg	(mg/1)	00.27	0.14	0.24
Fe	(ug/1)	130	10	20
Al	(µg/1)	290	330	40
Na	(mg/1)	1.05	1.63	1.49
K	(mg/1)	0.32	0.41	1.87
Mn	(µg/1)	34	20	32
Cu	(µg/1)	37	16	23
Pb	(ηg/1)	1.9	$<$0.5	0.5
NO_3	(µ/1)	$<$10	10	$<$10
SO_4	(mg/1)	4.6	2.4	32
Cl	(mg/1)	1.3	1.2	2.6
F	(mg/1)	$<$0.1	$<$ 0.1	$<$0.1

CONCLUSIONS

The experience so far makes the described package plant interesting on the following basis:

- Coagulation is an efective process removing various contaminations.
- The conventional coagulation process is complicated to operate as it requires chemicals to be transported, stored and dosed.
- The electrocoagulation process is found to simplify treatment in various ways.

Compared with conventional Al-addition, the electrocoagulation process has the following advantages:

- Transportation of chemicals is reduced to one tenth.
- Operation and maintenance of the plant is simple. No mixing of chemicals is needed. The electrodes must be changed only once a year.
- The necessary hydraulic detention time is lower than for conventional treatment (approximately 2 minutes).
- Naturally occurring organics can be effectively removed without pH adjustment when the raw water pH is between 4.0 and 6.0
- The electrocoagulation process removes part of the sludge formed by flotation. The sedimentation process is thus unnecessary, and rapid sand filtration is sufficient. This is especially important at locations with raw waters of high colour or high turbidity, i.e. needing large amount of chemicals.

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POTABLE WATER TREATMENT IN TROPICAL COUNTRIES : RECENT EXPERIENCES AND SOME TECHNOLOGICAL TRENDS.

KD 5017

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DEGREMONT.

A water specialist who handles worldwide contracts should learn all about the problems inherent to each type of climate and to each country. The field of water treatment, as many others, is in permanent evolution and the technique must be adapted to increasing pollutions, to the standards of potability in force, to improved new methods of analysis, to the creation of new synthetic products, to the increased scarcity of resources compelling man to treat waters unused up to now because of their unfavorable characteristics, to the qualification of labour(determined,among other things, by the size of the plants), and to the inenitable search for a compromise between economical factors and Public Health, etc.

We are giving below several recent examples of these principles taken from tropical countries; these examples are not at all exhoustive and they were so selected as to point out the variety of the problems so posed. The examples given below generally refer to surface waters (rivers, lakes, impounded waters) but the treatment of underground water will also be referred to.

The two chapters will be as follows :

- **Treatment problems** due to the quality of raw waters: high turbidities eutrophication in the impounding reservoirs (some of the preventive measures will be mentioned) entailing in particular the treatment of waters containing very large amounts of algae, toxics naturally present in the water like arsenic or fluorine, aggressive waters, etc. Most of these problems are due to the fact that under tropical weather conditions the differences between the dry season and the rainy season are very pronounced, there are areas of desert and areas with luxuriant fegetation and high temperatures favouring the vital phenomena (like growth of bacteria, algae or animals) etc.

  Besides, in these countries waters may sometimes have excessively low, or on the contrary excessively high mineral contents for either geological or pedological reasons.
- **Technological problems** inherent to the size of the plants, the space available, the search for an optimum efficiency, the origin and variability of the waters, the mode of running and all this according to the above mentionedtreatment problems, to the present state of techniques and even to the prevailing "fashion". These problems will be examined from the clarification, filtration and ozonization point of view.

CHAPTER I. EXAMPLES OF TREATMENT PROBLEMS INHERENT TO THE QUALITY OF RAW WATERS.

1. High turbidities

1.1. General

First of all we shall make the following comments on the main features of raw waters indispensable in this field for an adequate design :

- **Turbidity and/or suspended solids (S.S.)** ? Unfortunately these two indications are only rarely found simultaneously in the analysis reports on which any project or plant have been based; it is worth pointing out that **both indications** are always necessary since two different waters never have the same turbidity/S.S. ratio; besides, at a given place this ratio may change in the raw water according to the time of the year, and according to the treatment stage when following its evolution through the plant. Then, which of these two analysis is the most significant ? Generally, when the water has a very low turbidity, the determination of turbidity is the most significant, whereas when the water is very turbid it is far more significant to know the S.S. content ; in effect, beyond a certain maximum value the determination of turbidity no longer means anything (erroneous measures, false representation of the actual weight). For all the waters between these two extreme cases, the two analysis results should be available simultaneously.
- **Suspended solids grain size**: in each case, the S.S. grain size curve should also be determined since 100 g/m3 of fine sand require less coagulant and settle much more quickly than 30 g/m3 of colloidal clay. For example, a weight of 4 g/l may be removed according to the S.S. grain either by one static settling tank only, or by one grit removing tank or else one de-silting tank followed by one accelerated settling tank.
- **Suspended solids variability**: it is also necessary to know the extreme values (min. and max.) of S.S. contents during one year and above all to be sure that the maximum possible load of raw water was correctly estimated in order to adequately design

the plant: campaigns of analyses should therefore be conducted over yearly cycles.

— **Suspended solids treatability**: their ability to flocculation and settling should also have been tested (the concentration of the sludge obtained after settling should not be disregared since water losses at this stage of treatment depend on it).

The large range of results obtained for the above mentioned points, when taking into consideration the whole of the surface waters of the globe, shows that it is not possible to lay down any precise rule on the treatment procedure to be applied to waters according to their insoluble load (especially since other basic parameters such as colour, algae, etc. are to be taken into account for the selection of a treatment). For these reasons only orders of magnitude may be given for the various methods used to remove this load (expressed below as weight of S.S) :

— less than 20 — 40 mg/l : direct filtration with simple upstream coagulation-flocculation (provided the coagulant demand does not exceed 15 to 20 g/m3);
— from 20 —40 mg/l to 1.5—3 g/l : sludge contact—type accelerated clarifier (e.g. Pulsator, Accelator), or plate—type clarifier (e.g. Sedipac) or a combination of these two processes (e.g. Superpulsator); example of treatment application to a river water in Mozambique, treated in a Pulsator (lime + aluminium sulphate + activated silica):

S.S. in raw water	:	1 g/l
S.S. in sludge blanket	:	2.5 g/l
S.S. in clarified water	:	2 to 5 mg/l
S.S. in filtered water	:	0.3 mg/l
sludge from clarifier	:	

  — S.S. = 20 g/l
  — drawoff rate : 5%

— from 1.5—3 g/l to 5 g/l : according to the case, one static settling tank with sludge scraping system in one single stage, or one grit remover followed by one static or sludge contact—type settling tank ;
— above 5 g/l : in this range a two—stage settling is generally required and includes one preliminary settling and silt removing tank followed by one static or sludge contact—type settling tank; however, this range also includes an upper limit for S.S. content beyond which the reagent demand becomes prohibitive and the volume of formed sludge is far too large to be drawn off and to produce a sufficient flow of clear water : in para. 1.2. we show that it is generally very difficult to run a plant when the S.S. contents in the raw water exceed 40 to 50 g/l (some waters may contain up to 200 g/l of S.S.) ; still, in this case the flowrate of sludge to be drawn off should be precisely assessed and the subsequent flow of raw water required to obtain a certain treated water output should be properly determined : in effect, the concentration of the sludge produced by these waters with very high S.S. contents vary from less than 100 g/l to more than 400 g/l, depending on the nature of the S.S. and the treatment applied.

1.2. Special study of waters with very high S.S. contents

The latter type of clarification we have just mentioned (in two stages for waters with S.S. contents exceeding 5 g/l) is very interesting as far as treatment proper is concerned as it enables the use of the **double coagulation** technique, which may also be applied to waters having lower S.S. contents (as from 2 g/l approx).

In effect, we have beeen noting for several years now that with many types of water a two stage clarification provides significant coagulant savings ; in some exceptional cases, the total amount of chemical could even be reduced to 50—60% of the amount introduced in one single clarifier. However, this process would not be worth it for a water having a low S.S. content since it would then be difficult to compensate for the extra investment correspoinding to a second clarifier. This process, however, was considered for waters having moderate S.S. contents but containing a pollution both mineral (heavy metals) and organic, with a first sedimentation under alkaline pH (preferably in the presence of $FeCl_3$) to romove heavy metals, and a second sedimentation under acid pH to remove organics.

Double clarification is also applied to certain difficult cases of water softening with lime: the first clarifier works in clarification to remove the substances inhibiting cabonate removal, the latter taking place in the second sedimentation stage. This process becomes particularly interesting whenever very turbit waters are concerned: this is the case in the tropical countries where an extended dry season is suddenly followed by heavy rains and where forests are sparse or non-existent (as in Latin America, Africa, or the Middle-East, etc.); the resulting high turbidities are also very **variable** and make plant running operations even more difficult. Under such conditions, the double clarification of such waters must be performed according to methods adapted to each case and to the nature and the maximum aniticipated S.S. contents.

If the major part of the suspended solids is composed of grains of sand, carbonate or clay having and adequate size to settle naturally (for example of the order of 50 μ, or more) and if the colloidal fraction is relatively low, chemical treatment may then be applied only to the main clarification and, as regards reagents, the de-silting tank will works as a grit remover. In all the other cases, it is advised to perform a double coagulation.

Double coagulation process may be a mere **splitting of the dose of coagulant** between presedimentation and main clarification; the proportion of iron or aluminium salt to be introduced in presedimentation may vary as it depends on the proportion of colloids in the total S.S. content: generally, it ranges from 30 to 60% of the optimum dose as determined in the jar-test. Whenever jar-test is conducted with per-settled water, it often appears that the sum of the two treatment dosages respectively applied to each clarification stage is less than the dosage to be applied in one single clarification; an example of this is given in Table No. 1 : for the Kaduna river water (in Nigeria), with a 2 g/l S.S. content in the raw water, the aluminium sulphate dosage required in a two-stage treatment is 60 g/m3 when the total dosage required in a two-stage treatment is 50 g/m3; in the latter case the consumption of mineral coagulant mav thus be reduced by 15%.

This phenomenon may be explained by an increased adsoptive efficiency of impurities to the alum floc in case of insufficient dosing in pre-treatment. Splitting the dosage of mineral coagulant has indeed some advantages, but its limits quickly appear when it comes to the treatment of waters having variable turbidities: in such cases, the quick increase in S.S. content and the very high mineral coagulant demand generally evidenced in the jar-test show that another solution must be looked for; this solution may be the use of **poly-electrolytes.** When suspended solids contain large amounts of colloid and do not exceed maximum values of 5 g/l approx., the best results are generally obtained with **cationic** products. We had already noticed that in some cases of singlestage clarification these products made it possible, due to their double action as coagulant and flocculant, to reduce the alum dosage for slightly tubid waters and even to replace all of this reagent by them where turbid waters were concerned. Thus, during tests conducted in the Pulsator pilot unit at Manila, similar results were obtained with different treatments as follows:

– TABLE n°1 –

Example of a double coagulation
(jar-test).
KADUNA River, Nigeria

Raw water : Suspended solids : 2,000 mg/l
Turbidity : 850 NTU
pH : 7.25

Simulated treatment	Single clarification				Double clarification		
Presedimentation : * Dose of alum * Preclarified water : – pH – Turbidity	– – –				30 g/m^3 6.6 85 NTU		
Main clarification							
* Dose of alum (g/m^3)	40	50	60	70	10	20	30
* Turbidity (NTU)	12	7	3.8	3.5	7.2	3.9	3.5
Optimal alum dosage in main clarification	60 g/m^3				20 g/m^3		
Total alum dosage	60 g/m^3				50 g/m^3		

N.B. : Lime is added in all tests for pH adjustment to 6.6 (optimum)

S.S. in raw water	Treatment No. 1		Treatment No. 2		Treatment No.3
	Aluminium sulphate (g/m3)	Anjonic *or neutral polymer (g/m3)	Aluminium sulphate (g/m3)	Cationic ** polymer (g/m3)	Cationic ** polymer alone (g/m3)
7 to 15 mg/l	25 to 30	0.02 to 0.1	7.5. to 10	0.4 to 0.8	–
1 to 2 g/l	180	0.3	–	–	2 to 3

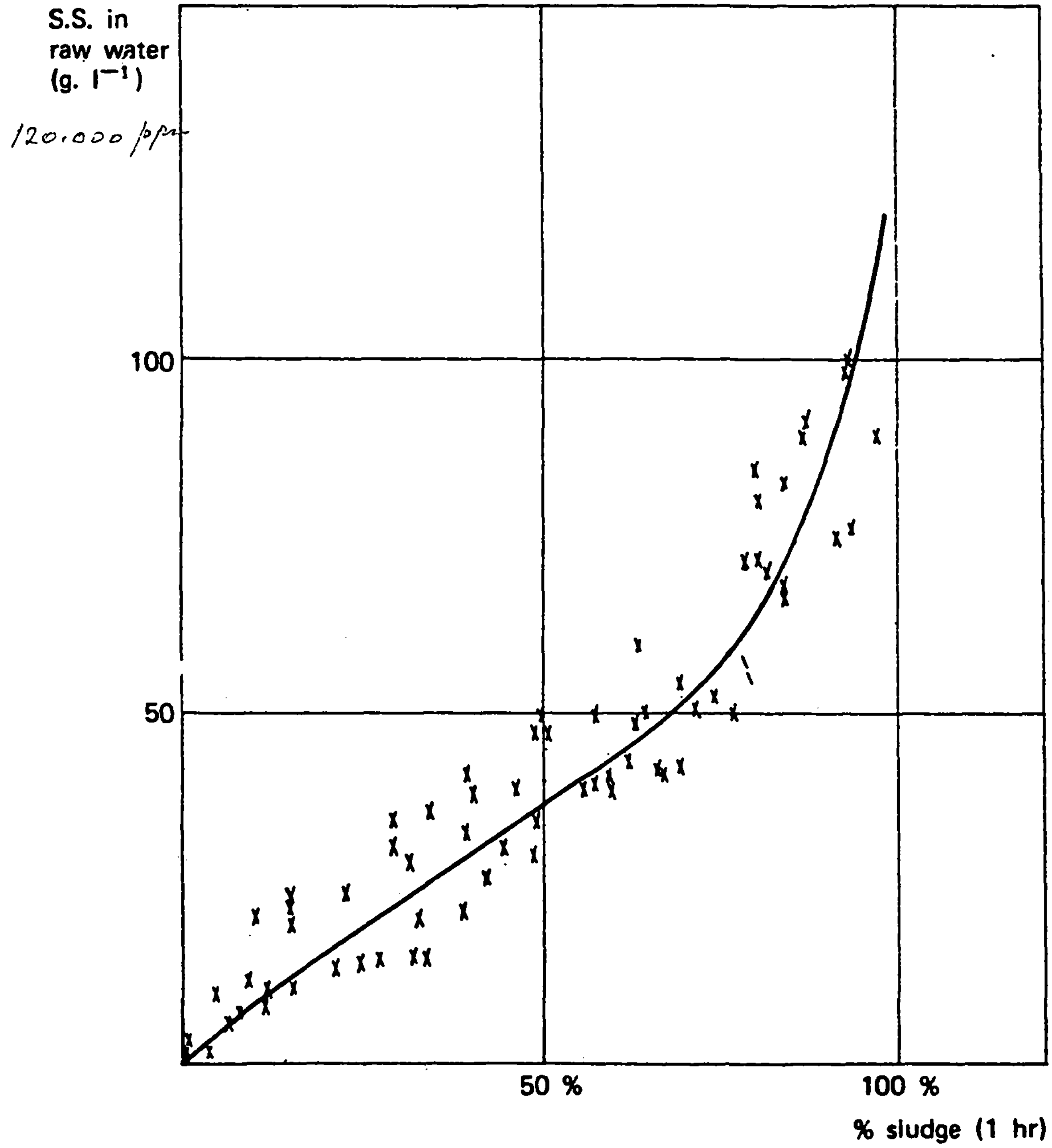
* ASP 6; N 100 (powdered products)
** Nalco 5 WP; Superfloc 575–C; Betz 1190 (liquid products)

Cationic polymers were thus applied in some cases of two-stage clarification. For example, at a plant in Costa Rica, the raw water was submitted to very sudden variations in turbidity and the S.S. content was frequently and very shortly increasing form 50 mg/l to 5 g/l, which made it very difficult to produce a treated water of good quality; this plant running problem was solved by adding on a permanent basis 1.5 g/m3 of a cationic polymer (Nalco 8103 or Catfloc T) into the pre-settling tank having a 3.5 m/hr working velocity:
regardless of the nature of the raw water, the quality of the pre-settled water was then more or less constant and the amount of aluminium sulphate applied in the main clarification varied only from 30 to 40 g/m3. Here again, such a treatment has its limits: whenever very high S.S. contents (10 g/l more) are concerned, a coagulating chemical is no longer adequate (should it be mineral, as aluminium sulphate, or organic and synthetic, as cationic polymers): a flocculating chemical should then be used. This means that when waters have *such a turbidity sludge treatment techniques* should be used: an **anionic** polymer must then be applied and the silt removing tank must be designed as a sludge thinckener.
An exampel of this is the study conducted with water from the wadi Cheliff (Algeria): *in flood period* the S.S. content varies from 10 to 120 g/l and it may be evaluated roughly by considering the volume of sludge settled after 1 hour rest (fig. 1). Silt removing was first tested and studied with waters containing 10 to 12 g/l S.S. by comparing the action of a mineral coagulant (aluminium sulphate) with that of various anionic or cationic polyelectrolytes. In all the cases, the resulting supernatant water contained no more than 1 g/l approx. suspended solids (obviously representing the S.S. colloidal fraction) and was easily clarified by the 30 to 40 g/m3 aluminium sulphate used in the following main clarification process; however, the resulting sludge settleability obtained in the de-silting process varied a lot according to the reagent used, as shown in the table below (where reagents are applied at the optimum *dosage specified in previous tests)*:

CHELIFF RIVER

Fig. 1

CORRELATION BETWEEN SLUDGE VOLUME AFTER SETTLING FOR 1 HOUR AND S.S. CONTENT IN RAW WATER



Test No.	1	2	3	4	5
Treatment (g/m^3) :					
– Aluminium sulphate	20	20	–	–	–
– Anionic polyelectrolytes :					
* Prosedim ASP 6	–	0.5	0.5	–	–
* Prosedium AS 23	–	–		0.5	–
– Cationic polyelectrolyte :					
* Prosedium CS 53	–	–	–	–	0.5
Sludge concentration obtained after 1 hour settling (g/l)	70	110	130	170	80

Without any treatment, and through natural settling this water produced after 1 hour a sludge whose concentration was already ranging from 80 to 90 g/l. This clearly shows that in such as case aluminium sulphate is not an aid to de-silting: on the contrary the floc of Al $(OH)_3$ becomes a useless bulk for the forming suldge and thus, reduces its concetration. A cationic polyelectrolyte does not give a better result (column 5); an anionic product should be used in this case, chosen after various comparative tests conducted in order to select the most efficient one: see the difference between columns 3 and 4; see also on fig. 2 the results of comparative tests conducted with a more turbid water (40 g/l).

On the other hand it apprears that for all the initial S.S. concentrations in raw water the concertration of the sludge produced depends on the dosage of polymer used; the variation zone of this rule is shown in fig. 3; the average value of this concertration after 1 hour settling and under the test conditions of this study, may be represented as follows:

$$C = 75 \times 10^{4r}$$

where r is the ratio of the dosage of AS 23 polymer (in mg/l) to the initial S.S. content in raw water (in g/l).

Fig. 3 shows that in this precise case a minimum of 0.1 g of polymer per kg of S.S. is necessary to obtain a sufficiently compact sludge. Since the use of powdered polymers is limited to a .1 g/m3 maximum dosage in potabilization treatments, these waters can be de-silted under optimum cconditions only when their S.S. content does not exceed 10 g/l; beyond this value, it must be taken for granted that there will be significant water losses in this per-treatment: for example, if the S.S. content in raw water is 40 g/l, a 1 g/m3 dosage of anionic polymer gives r a value of 0.025; according to fig. 3, the concetration of sludge obtained would then be about 100 g/J, hence a water loss through sludge drawoff of about 40% in the de-silting process: these figured examples show that it is hardly possible to produce drinking water by treating a raw water containing more than from 40 to 50 g/l S.S.

We have confirmed this with other waters, for example with water from a river in Peru where the test conducted have given slightly the same results as in the above case:

- it is impossible to use the aluminium sulphate in de-silting (maximum settling velocity equals 0.2 m/hr for 40 g/1 S.S. in the raw water);
- anionic polymers are superior to cationic polymers;
- the possible settling velocities with the most adequate products are as follows (Prosedim AS23 or AS37):

S.S. in raw water	dosage for "drinking water" (lppm)	high treatment rates (4 ppm)
10 g/l	7 m/hr	–
20 g/l	5.5 m/hr	–
40 g/l	2.5 m/hr	5 to 12 m/hr

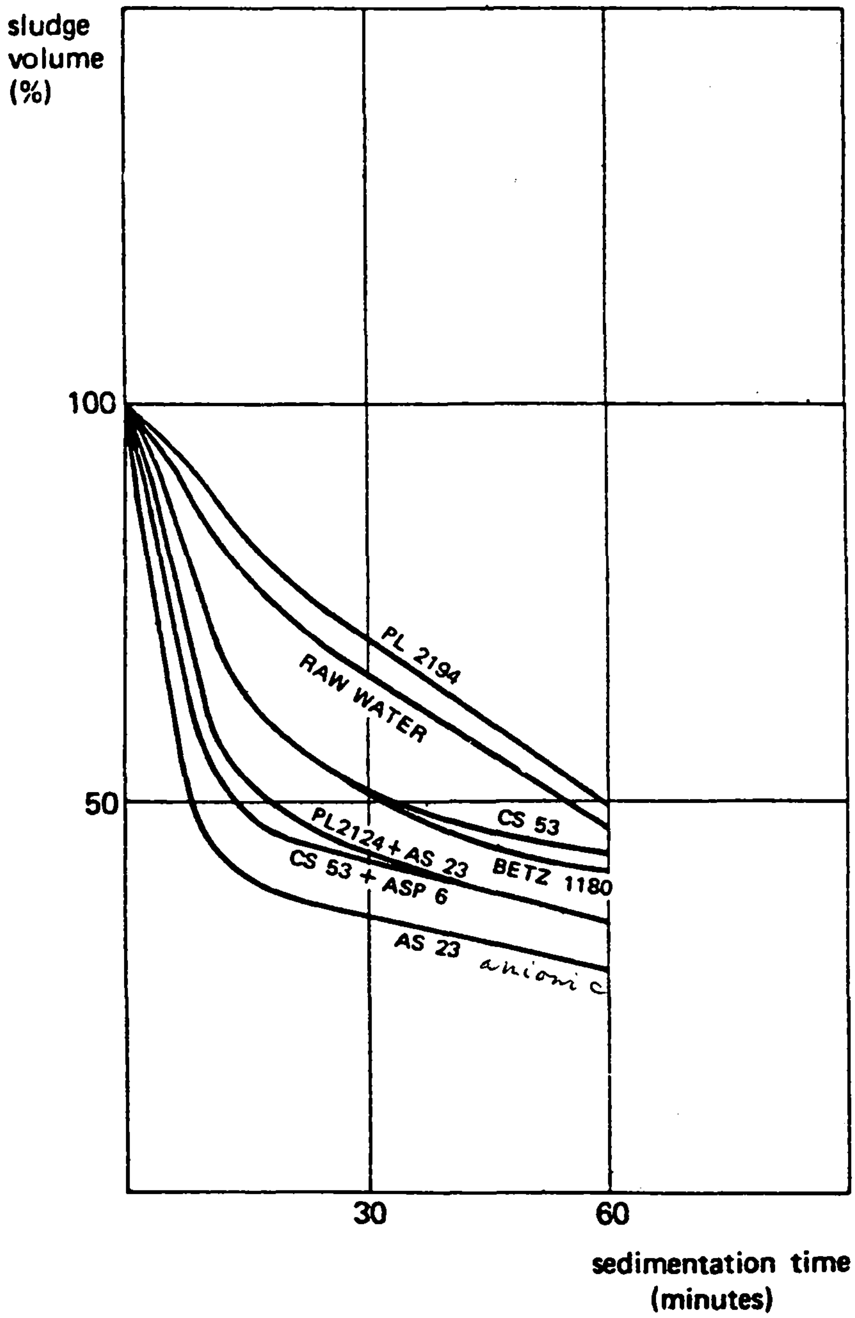
Fig. 2

CHELIFF RIVER

SEDIMENTATION TESTS WITH VARIOUS POLYELECTROLYTES

(1 mg l^{-1} OF EACH)

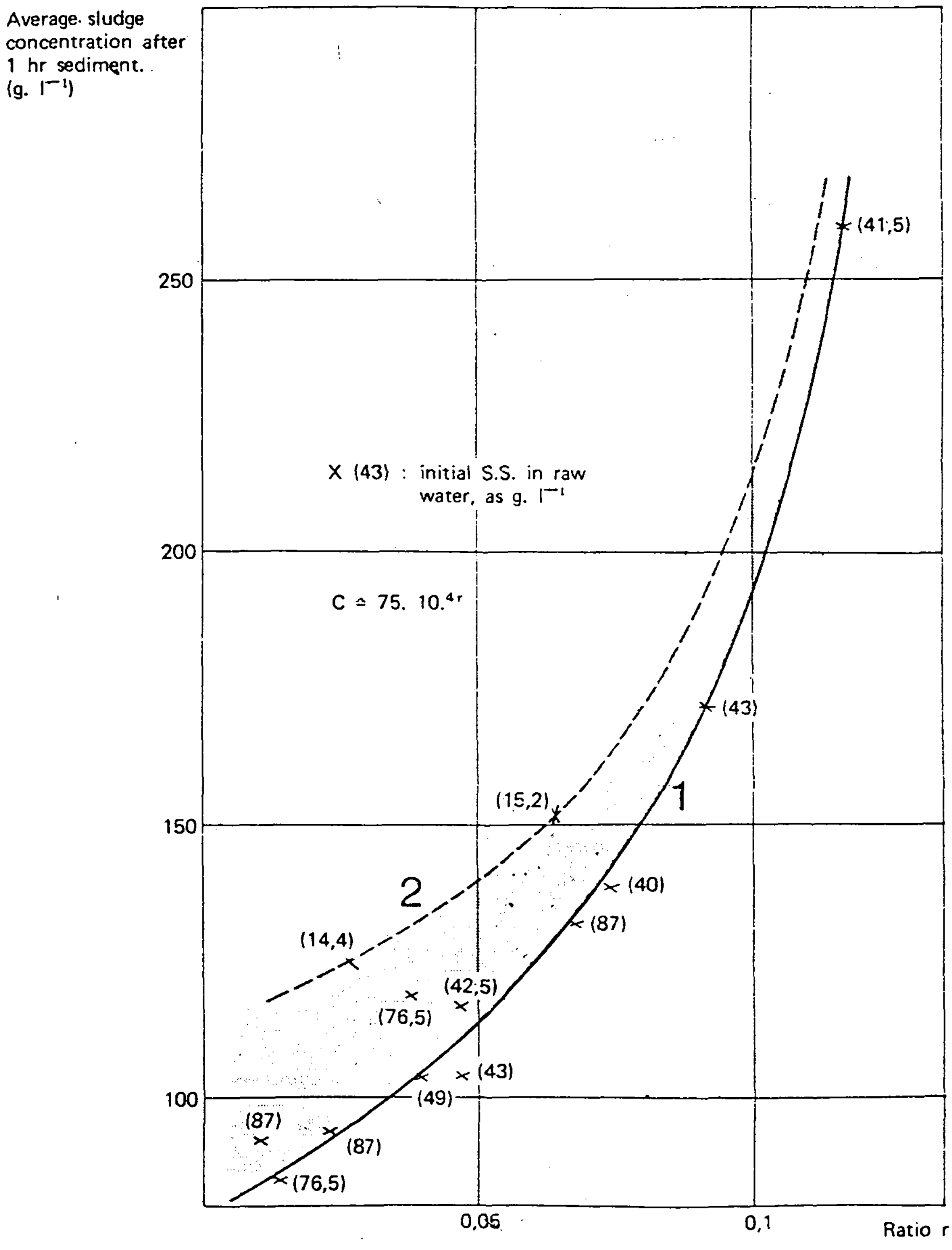
S.S. IN RAW WATER : 40 g l^{-1}



CHELIFF RIVER

SEDIMENTATION TESTS WITH AS 23

Fig. 3



$$r = \frac{\text{AS 23 dosage, as mg. } l^{-1}}{\text{S.S. content in raw water, as g. } l^{-1}}$$

Here again, and beyond 40 g/l it was hardly possible to run the de-silting tank properly; the same limit was also observed with a water in the Middle East except that in this occasion the best result was obtained by combining a cationic polymer (Nalco 5 WP or Superfloc 573) with an anionic polymer (Prosedim AS 34).

All these problems are thus specific and they should be studied individually. We can say, at the most, that whenever double coagulation can be applied, the optimum pre-treatment may often be designed according to the following basis (however, each particular case should always be verified either by jar-test or in pilot unit):

Suspended solids in raw water	Chemical treatment
not exceeding 1·2 g/l	Aluminium sulphate (or $FeCl_3$) alone or with cationic polymer, or cationic polymer alone.
From 2 to 5 g/l	Cationic polymer alone, generally.
From 5 to 40 g/l	Anionic polymer alone, generally.
more than 40 - 50 g/l	Treatment of such water not recomended; if water is absolutely required, production of very reduced quantities, with anionic polymer alone, generally.

2. Eutorphication on impoundments

In a increasing number of countries, the above problem (high S.S. peaks) now tends to disappear due to the creation of dam impoundments. Actually, it often means that the nature only of the difficulties met by the water specialist has changed since the phenomenon of euthophication in impoundments (and in any strech of water in general) is the second major problem in the tropical countries.

In fact, this has already been the subject of many conferences and publications; recently, the IWSA dedicated to this problem a wide-ranging international event*. Therefore, we shall not make a large development on this subject within the scope of this paper all the more so since it will be more detailed during the 15th IWSA Conference (in Tunisia, 1984, special subject No. 1). We shall only recall below some of the principle which are a particular concern to the water teratment specialist but are unfortunately often disregarded in the design of impoundment dams.

In effect, the water treatment plant must often be designed while the dam is still being designed or built: the only available basis is the quality of the running water which will be stored later on. It is generally understood that storing water improves its quality (1) (2)**, hence the characteristics of the raw water will be improved compared to those of the water stream(s) feeding the impoundment.

It is also known that this principle can be confirmed only when all the necessary measures have been taken to protect the impoundment against any type of pollution and when it has been checked that the yearly loads of phosphorus and nitrogen entrained by run-offs and water steams will not exceed certain values (3). However, one does not always bear in mind the tremendous consequences that may be due to a lack of clearing of the basin prior to filling it with water. When a dam has been built in a wooden or cultivated area, the land vegetation dies as soon as it gets drowned and decay starts immediately; this results in:

- the dissolving of a large quantity of organic carbon on the one hand, (first the leaves, grass and litter; then, at a slower rate, the bark and finally the very wood) which represents such an oxygen demand (1.3 to 1.5 g of oxygen per g of biodegradable dry matter) that the lower part of the water (also called hypolimnion) looses all of the dissolved O_2 it contained: in this area the medium becomes a reducing medium and many undesirable compounds appear: NH_4, H_2S, dissolved iron and manganese, aggressive CO_2; the treatment of this type of water is then more similar to that of underground waters and should include an open-type aeration at the head of the plant;
- on the other hand, the release of a large quantity of nitrogen and phosphorus contained in the vegetation — up to several hundreds of kg of N and P per ha —: the turn-over phenomena inside the impoundment will make these nutrients available to the algae which will thus be able to grow in the upper part of the water (also called epilimnion) and reach concentration sometimes very high (100,000 algae

* Specialised Conference on Eutrophication and Water Supply, 7th-9th October, 1981, Vienna (Austria).

** See References at the end of this paper.

per ml or even more); at the same time as this algal growth, the water gest supersaturated with dissolved O_2 (by-product of the photosynthesis activity).
We know many dams throughout the world where this phenomenon has occured:
we are giving 2 examples on fig. 4, both in Latin America, i.e. Poza Honda (Ecuador) and Valencia (Venezuela); in both cases the following has been observed:

– an eplimnion, 5 m thick max., with a very high algae content and super-saturated with dissolved O_2 (temperature exceeding 25° C).
  an hypolimnion laying from 10 m approx. deep to the bottom of the impoundment, in which there are large quantities of NH_4 (2-4 mg/l), Fe (4-5 mg/l), Mn (0.4-0.8 mg/l), H_2S (1.5–4.5 mg/l), etc. In the Poza Honda impoundment the maximum values observed even reached the following figures:
  . 1.2 mg/l of manganese,
  . 10 mg/l of NH_4,
  . 15 mg/l of H_2S,
– and a metalimnion (intermediate zone), a few meters thick, corresponding to a mixture of the above two zones.

In the same area of the Globe, other impoundments had been cleared before filling took place and they did not present these unfavourable characteristics. Besides, the water level variations over one year must be taken into account, and fig. 4 clearly shows that it is essential to have a water intake tower with several intake levels spaced by no more than 2 to 3 meters is order to be able at any time to select the intake level supplying the less unfavourable water to the treatment plant.

Finally, it is easy to understand why in such cases as those described in fig. 4, teratment methods are totally different according to wether waters from the epilimnion of from the hypolimnion are concerned.
It is therefore advisable (at least each time eutrophication is known to exist already or to be inevitable) to design the plant so that both types of water may be equally treated:
– clarification means capable of removing large quantities of algae;
– aeration and oxidation means capable of treating waters from the reducing hypolimnion.

To conclude this paragraph, we shall say that the preliminary clearing of the impoundments, the adequate design of water intake towers, and the agreement of the Employer on a treatment capable of facing any situation are the three main points on which we wanted to insist.
As far as the treatment of waters containing very large amounts of algae is more particularly concerned, this is a problem also concerning other types of water and about which we shall give below the most recent experiences.

3. Removal of algae

The phenomenon of excessive phytoplankton growth, which is commonly seen during the summer in the countries under temperate climate, becomes even more acute for obvious reasons in the countries under tropical climate. The causes of this phenomenon are varied: eutrophication in inadequately cleared and/or inadequately protected impoundments (the most frequent case as described in para. 2); town and/or industrial pollution in a river having a low flowrate; lower course of a river flowing out of a dam where the suspended solids – by which algal growth was hindered in the upstream course thus impeding light penetration – settle and where, on the other hand, nutrients dissolve in the water (a recent example of this is the Nile downstream from the Aswan High Dam).
In certain waters counts may evidence more than 100,000 algae per ml, even in river waters and even under temperate climate (e.g. the Vitstula in Warsaw).

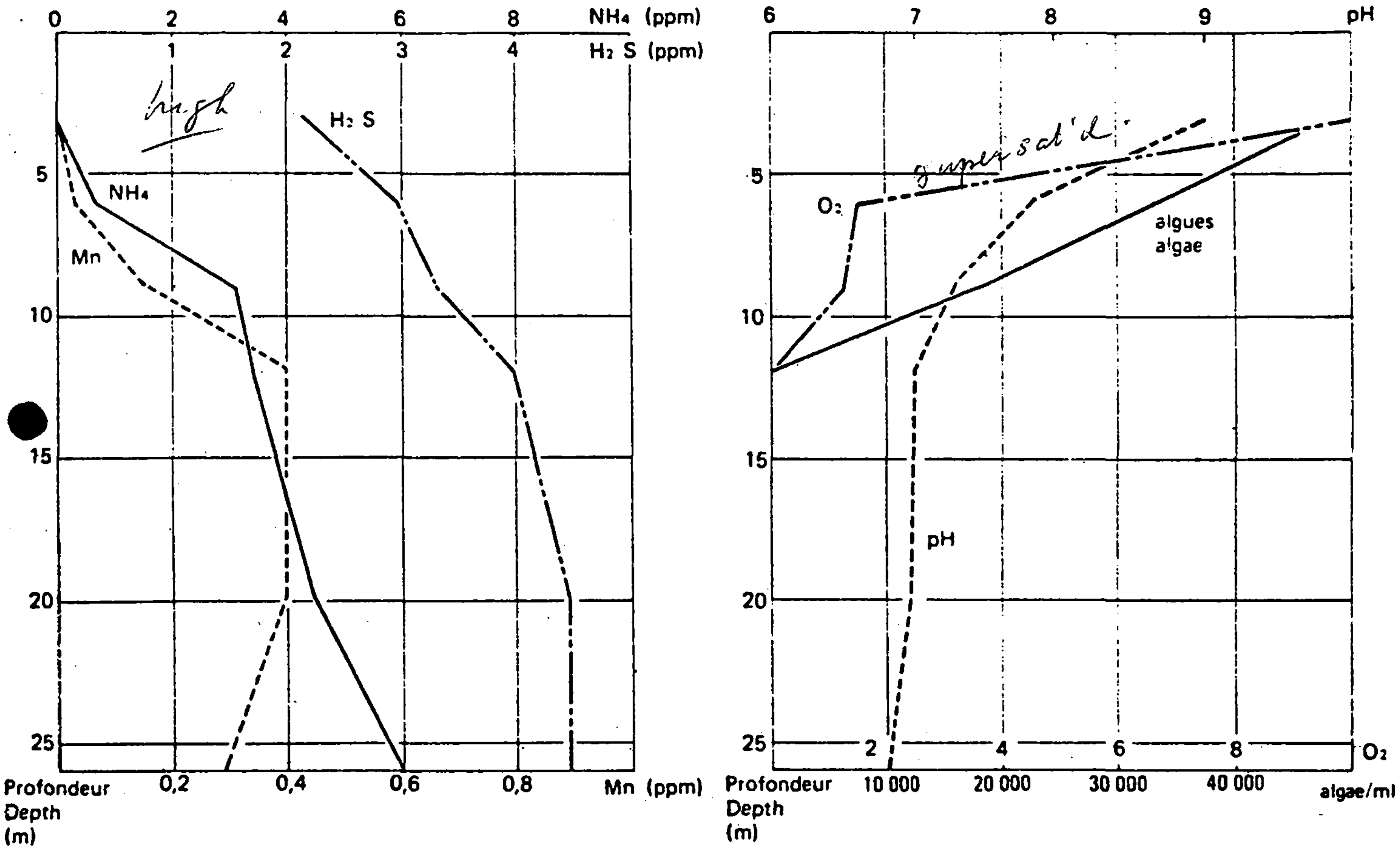
3.1. Thorough algae removal is a necessity

No international standard really exits concerning residual algae tolerances to be admitted in distributed water. Whenever it is specified that treated water should contain no algae, such requirement cannot be real istic; in effect, it is no more reasonable to quarantee an absolute zero for algae than for turbidity, colour, iron, organic matter, etc.
However, our major recommendation to any plant operator is to adjust treatment so that the removal of algae be as exhaustive as possible, for the following reasons:
– alge increase the organic matter content in treated water; once they have been destroyed by chlorine, they accelerate the disappearance of residual chlorine and, through decay, they use up dissolved oxygen and may generate unpleasant tastes and odors in the distributed water; besides, disappearance of dissolved O_2 is a corrosion generating factor;
– the entrainment of large quantities of algae in the treated water may indicate that other forms of aquatic life are also present: viruses, bacteria, free living or even parasitic animals (among which: the dysentery amoeba, Entamoeba histolytica; the **Giardia intestinalis** protozoon, agent of the giardiasis; the free swimming larvae or cercariae of the **Schistosoma sp** worm which is the agent of the bilharziosis); in the distribution network, algae become the food of small animals whose eggs or larvae have also passed through treatment (worms, crustacean, etc).) and thus favour their growth.

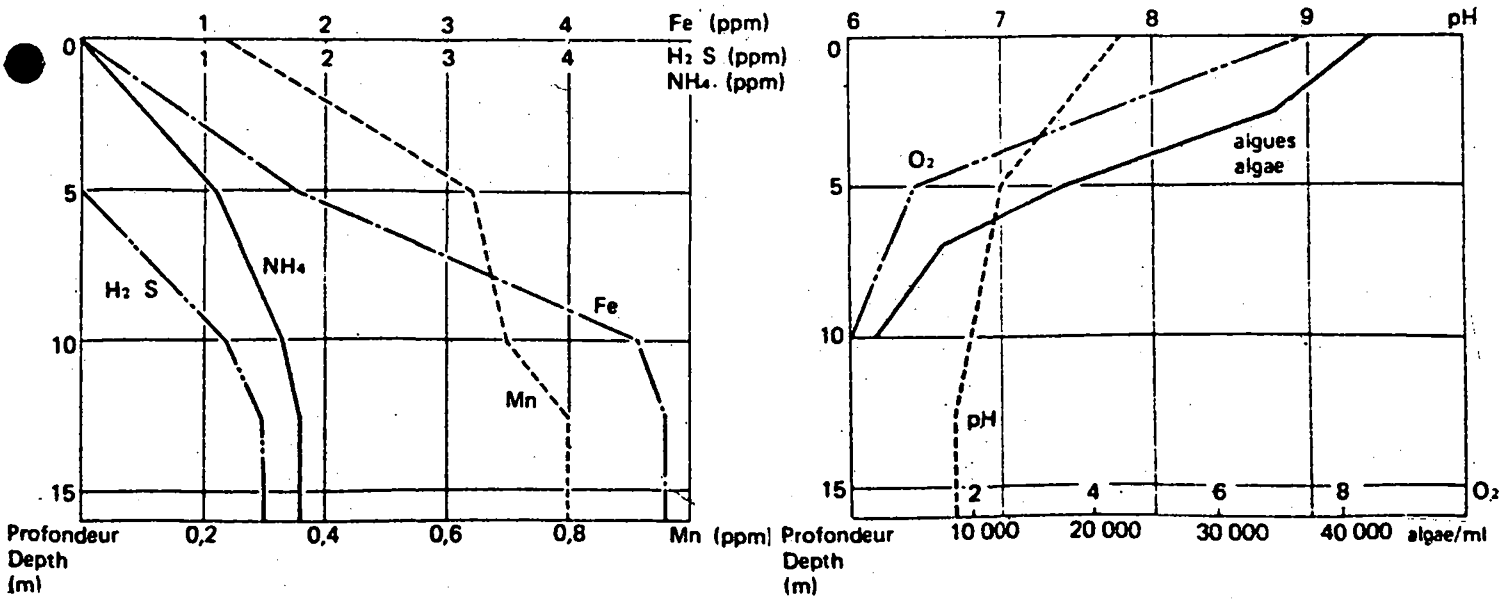
Practically, we have noticed that there were no major problems in the networks when the distributed water contained less than 100 small size algae per ml, i.e. approximatelly 100 algal standard units (20x20 μ), this unit being referred to later on as a.s.u. This figure may be considered as a provisional recommendation until an international standard or, even, wider studies be published on this subject.

STRATIFICATION CHIMIQUE DANS 2 RÉSERVOIRS EUTROPHES EN CLIMAT TROPICAL Fig. 4
(CHEMICAL STRATIFICATION IN 2 EUTROPHIC RESERVOIRS IN A TROPICAL CLIMATE)

1. POZA HONDA (ECUADOR)



2. VALENCIA (VENEZUELA)



3.2. Discussing the selection of a process to treat waters with high algae contents

3.2.1. Microstraining

This technique is sometime recommended for this type of problems. In fact we found data supplied in the literature by more than 10 authors about the use of microstrainers to remove phytoplankton. The mesh voids used vary from 15 to 45 microns (35 in most cases). The total algae removal percentages were gererally ranging from 50 to 70%; at the same time, turbidity was only reduced by 5 to 20%.

Tests conducted by us gave similar results: through cloths with mesh voids ranging from 25 to 35 μ, we have obtained average values of algae removal respectively equal to:

- 40% with river Nile water in Cairo,
- 55% with river Seine water in Paris,
- 50 to 65% with waters from various lakes and impounments.

It is worth adding that the percentages of algae removal are very scattered in consideration of the various species: the small lest are the most difficult to remove (sometimes only 10%), whereas they represent the major part of the coagulant demand (coagulation is indeed a phenomenon concerning surfaces and the smallest organisms represent the highest developed area/volume ratio); this' added to the low reduction in colloidal tubidity, makes microstraining almost incapable of reducing notably the coagulant consumption to come. Apart from certain particular cases (removal of organisms from zooplankton, like worms, larvae, crustaceans; pre-treatment before slow filtration), micro-straining is not for us a technique actually adapted to this problem.

3.2.2. Direct filtration

According to some authors (4) (5) and to our own tests, direct filtration without coagulation on either homogeneous sand type filter or on dual media type filter removes only 15 to 75% of algae, depending on the species.

When this method of treatment is applied under the best possible conditions: prechlorination, use of a coagulant or a flocculant, filtration through double layer (anthracite + sand) at low velocity (3.25 m/hr), the optimum removal percentage obtained is 95% on the average (6); besides, other experimenters have noticed even when dual media filtration is used, the filtration cycles become unacceptably shortened when the algae content in the raw water exceeds 1,000 asu/ml with 0.9 mm anthracite or 2,500 asu/ml with 1,5 mm anthracite (7).

We have also obtained similar results with a water from a Spanish river, near Madrid studied in a pilot plant: the precentages of algae removal were ranging from 63 to 98% according to the types of filters and treatment. The best results were obtained with 10 g/m3 aluminium sulphae and 0.5 g/m3 activated silica in a dual media filter, but under running conditions that would have become very difficult: the working life of the filters dropped below 6 hours when algal content in the raw water was exceeding 250 to 300 algae per ml, corresponding approximately to 2,500 asu/ml.

Therefore, direct filtration is not convenient for the treatment of waters with very high algae contents: a preliminary clarification stage is therefore necessary which has traditionally been up to now a settling process; we shall see, however, (para: 3.2.4.) that in some cases other processes may be used. Whatever be the treatment used at this stage, there will always remain in the water an algal residual of about one thousand per ml: a finishing treatment through sand filtration must always be applied to the treated water.

3.2.3. Selecting one type clarifier and adjusting treatment

If, once again, we refer to the data supplied in the literature, we notice that when it comes to the treatment of such waters static settling tanks have very variable efficiencies: the percentages given for the removal of algae in the clarified water from conventional units show an average of 59% as in the water from the river Thames at Staines (8), and range from 37% (coagulation with aluminium sulphate) to 97% (provided carbonate removal with lime is applied) with water from the river Iowa (9); on the other hand, wherever sludge blanket-type units were used the average removal efficiencies noted ranged from 85-86% (without prechlorianation) to 95-97% (with prechlorination) in a Polish river (10); in this latter case the zoopiankton content was at the same time reduced by from 93-96% (without prechlorination) to 99% (with prechlorination) and obviously the treated water produced by the following filtration unit was perfect.

Our own studies have always been in accordance with these bibliographical data. This is why we have been systematically using, for over 20 years now, the technique of the pulsated sludge blanket type clarification (in our patented apparatus, of worldwide reputation; the Pulsator clarifier) for the treatment of waters with high algae contents.

From 1960 we have been studying for several years running the efficiency of the Pulsator in removing algae from the river Seine water upstream from Paris. We have soon noticed that the reduction in the total phytoplankton population could be constantly maintained between 95 and 99% in the clarified water and virtually at 100% when the water was filtered through sand afterwards; as is the case for turbidity and colour removal, dual media filtration is not necessary provided clarification was performed under good conditions.

We have often been able to verify the superiority of the Pulsator clarifier over the static settling process not only as regards speed, but also as regards the quality of the clarified water and the reagent consumption. For example in the Philippines, with water from the

Laguna De Bay in which 50,000 to 100,000 algae per ml could be counted (90 to 95% being Cyanophyta: **Microcystis, Anabaena, Anabaenopsis, Osciallatoria, Lyngbya,** etc). the reduction in algae content that could be anticipated after flocculation test did not exceed 90% when static settling was applied; whereas with a Pulsator pilot unit a 95 to 98% reduction, which even reached 99.5% with a well adjusted teratment (7 g/m3 chlorine, 60 g/m3 aluminium sulphate and 0.1 g/m3 of powdered anionic polyelectrolyte) could be obtained.

Other comparative test were conducted in a lake in Tropical Africa where counts showed an average of 2,500 filaments of **Anabaena** and 2,500 colonies of **Microcystis** per ml of water, plus about one thousand of various Diatoms (in particular **Melosira** and **Cyclotella**): treating this this water required either either 60 to 70 g/m3 aluminium sulphate alone or 40 to 50 g/m3 of this coagulant together with the amount of sulphuric acid necessary to bring pH value to 6.2 approx. At the industrial plant, the Pulsator clarifier was compared with an "Upflow hopper bottom clarifier." *(UHBC) and the following results were obtained:*

Unit	Actual settling speed	Flocculant (activated silica)	pH adjustment (H_2SO_4)	Plankton % reduction
Pulsator	3.3 m/h	no	no	99.5
UHBC	1.35 m/h	yes (2 g/m^3)	yes	98.7
Pulastor	4.1 m/h	no	no	96.7
UHBC	1.1 m/h	yes (2 g/m^3)	yes	95.9

In Eqypt, numerous Pulsator clarifiers are now working at Cairo and at Alexandria to treat the water from the Nile which has been containing algae all the time since the Aswan High Dam was built. At Alexandria, a large proportion of these units corresponded in fact to a modernization of old settling tanks thus giving the Alexandria Water General Authority the opportunity to appreciate the advantages of this new technology:

- a production per unit of surface area multiplied by 2 to 2.5 (with an increased quality of clarified water);
- a reduction of 15 to 45% in coagulant consumption and of 15 to 35% in the chlorine consumption.

This efficiency of the Pulsator in removing algae may be explained both by the fluidized filter action of the sludge blanket and by the extended contact time between the upflow of water and the sludge blanket (about 3/5 of the total retention time inside the unit): this positive effect of an increased flocculation time had already been noted by AL-LAYLA & MIDDLEBROOKS, 1974 (11) and we have also verified it in various occasions, in particular with the river Nile water as indicated in the laboratory tests given in the table below:

Treatment : chlorine = 6 g/m^3; aluminium sulphate = 30 g/m^3; Nalco 600 SSI = 1 g/m^3					
Flocculation time (in minutes)	5	10	20	30	45
Algae residual (per ml)	1940	1600	1380	1150	960
% removal (raw water : 11,500 per ml)	83.1	86.1	88	90	91.6
Chlorine residual (free, in g/m^3)	1.4	1.15	1.1	0.95	0.9

However, optimum efficiency will be obtained only when treatment is properly adjusted; generally, this requires:

- a pre-oxidation (Cl_2, $C10_2$, O_3 , ...) for certain types of algae, like the chlorophyceae;
- a treatment with aluminium sulphate actually based on the the removal of algae and not only on that of turbidity; we shall illustrate this principle with, again, the example of the river Nile water: we have been studying this water for several consecutive years; all of the results of the laboratory tests are given on fig. 5, where it clearly appears that much more coagulant is required to obtain less than 1,000 algae per ml of clarified water than to obtain a turbidity not exceeding 5 NTU. This is due to the fact that the coagulation of clayey colloids is already almost complete as soon as the zeta potential (pZ) exceeds -5mV, whereas for the coagulation of algae the pZ has to be nullified: an illustration of this is given on fiq. 6 concerning an experiment in which the results of electrophoretic pZ measurement are compared with those of the jar-test (turbidity and agae counts);
- finally, an adequate flocculant, at least in certain cases; whenever a cationic flocculant is used, its coagulating action will often allow the amount of aluminium sulphate to be reduced.

It is also worth mentioning that removal of algae may be more or less easy depending on the nature of the prevailing group: removing Diatoms is not generally particularly difficult, even with aluminium sulphate alone; the removal of green algae (Chlorophеceae) generally requires a pre-oxidation; average reduction: 85% without prechlorination, from 95 to 98% with prechlorination (which should then be replaced by another type of pre-oxidation such as ozone or chlorine dioxide, when the problem of trihalomethanes prohibits the use of chlorine at the beginning of the treatment); as to blue-green algae (Cyanophyceae), they are the most sensitive to the optimum adjustment of the coagulant dosage, as evidenced in the upper part of fig. 6, concerning a jar-test conducted with the river Nile water. In fact, all the counts performed at the Cairo plants with various types of water (raw, clarified, filtered) by dicriminating the species of algae, have confirmed the results of our laboratory tests: in effect, both at the plant and in the jar-test the Cynophycea Anabaenopsis remaints when the dosage of coagulant is below the absolute optimum; compared to the whole phytoplanktonic population (in number of organisms per ml of water) it generally represents:

10 to 30% of the algae in the raw water,
75 to 90% of the algae in the clarified water,
85 to 100% of the algae in the filtered water.

Furthermore, if one remembers that the Cyanophyceae are well known to give unpleasant tastes and odors, to be occasionally toxic, to secrete mucilages causing post-floeculation in the networks, to elaborate THM precursors etc. (12), one may easily conclude that these are the most troublesome algae in the treatment of waters; let us just add that these are precisely the prevailing group in most of the eutrophication problems to bring an additional justification to the principles referred to in para. 2 (Preventing eutrophication).

3.2.4. Sedimentation or flotation ?

The situation has slightly evolved recently with the use of dissolved air flotation: this process which was at first applied to certain types of industrial waste waters (petroleum industry, paper mills, agri-food industries, etc.) and to naturally clear but very coloured waters, was gradually introduced to all the other fields of water treatment: town sewage, sludge thickening, and recently algae removal (both where effluents from lagooning and natual waters are concerned (13).

In this latter case, very interesting results were observed both as regards liquids/solids separation speed (5 to 8 m/hr) and in the resulting sludge concentration, and sometimes even in reagent consumption.

An example of this is given at Moulle, in France near Dunkirk: the treatment plant is supplied with raw water from a very eutrophic river cutoff and offers two points of interest (see fig. 7):

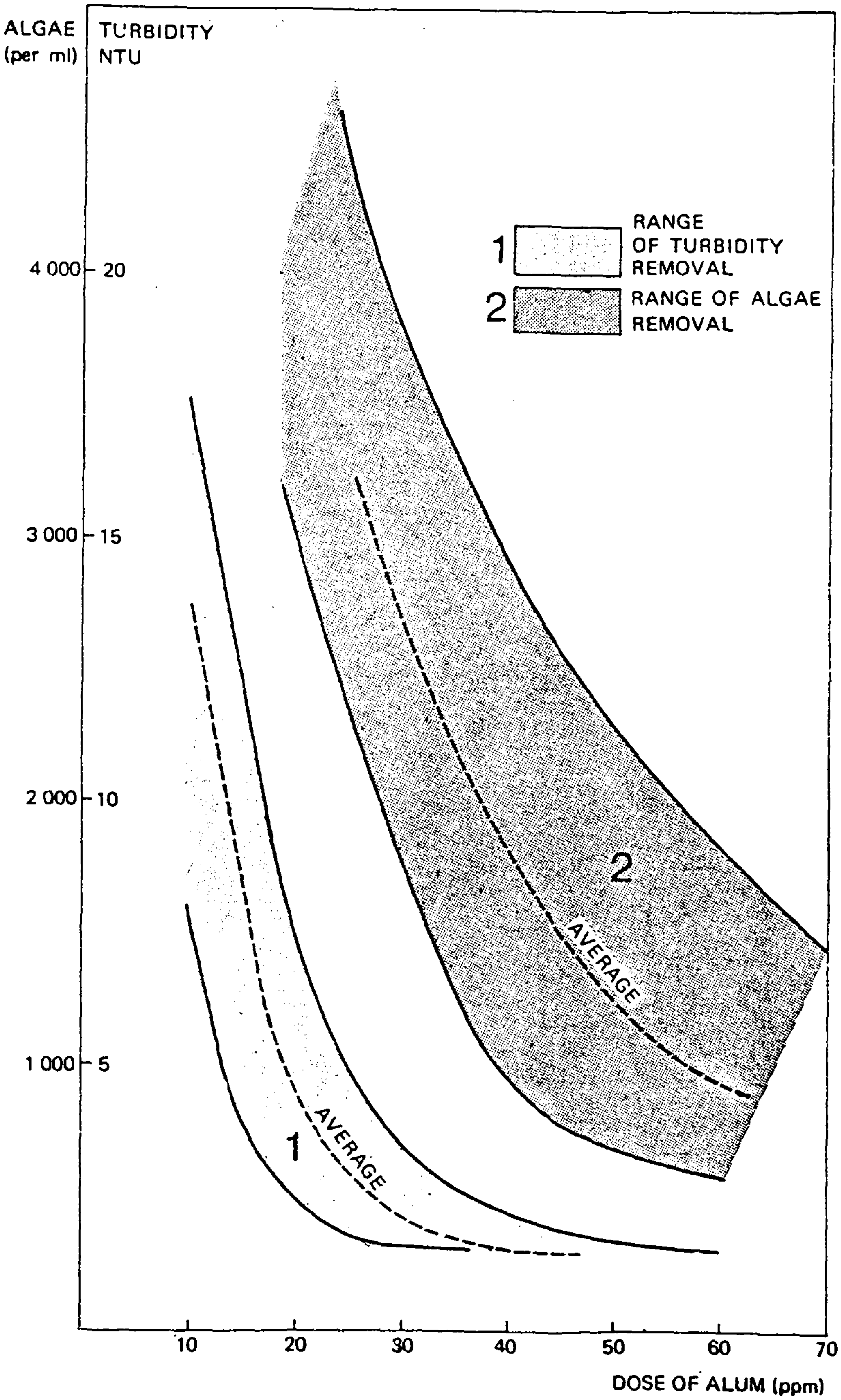
- a comparison between two lines including respectively a sedimentation process (1st stage) and a flotation process (2nd stage);
- an example of two possible uses of flotation:
  - . in water treatment (algae removal) in the 2nd stage,
  - . in thickening the sludge produced by the 1st stage clarification prior to its dewatering in filter-presses (whereas sludge from the main flotation process selected for the extension has a sufficient concentration to be pressed directly without intermediate thickening).

In this case flotation was found to have two main advantages over sedimentation:

- a coagulant dosage reduced by 20 to 40% (here, ferric chlorosulphate) giving the same result in both lines: before filtration 1,000 to 1,200 algae pr ml both in floated water and clarified water (30,000 to 50,000 algae per ml in the raw water);
- a very high ability to from concentrated sludage:
  - . water treatment: "floated" sludge has a 25 to 3C g/l concentration in dry solids whereas "clarified" sludge concentration is about 10 times lower: this explains why the floated sludge requires no intermediate thickening before the filter-press;
  - . thickening of sludge (from sedimentation) : concentration increases to 25 g/l on the average; with a static thickener the required surface area would have been 1o items larger.

Besides, a comparison between the running costs of boths treatment lines evidences that even if the two processes are almost equivalent when water treatment only is concerned, the use of flotation may reduce operating costs by 10 to 15%, sludge treatment included:

COMPARISON OF RESULTS OBTAINED IN JAR-TESTS Fig. 5
(ALGAE– VS TURBIDITY REMOVAL)



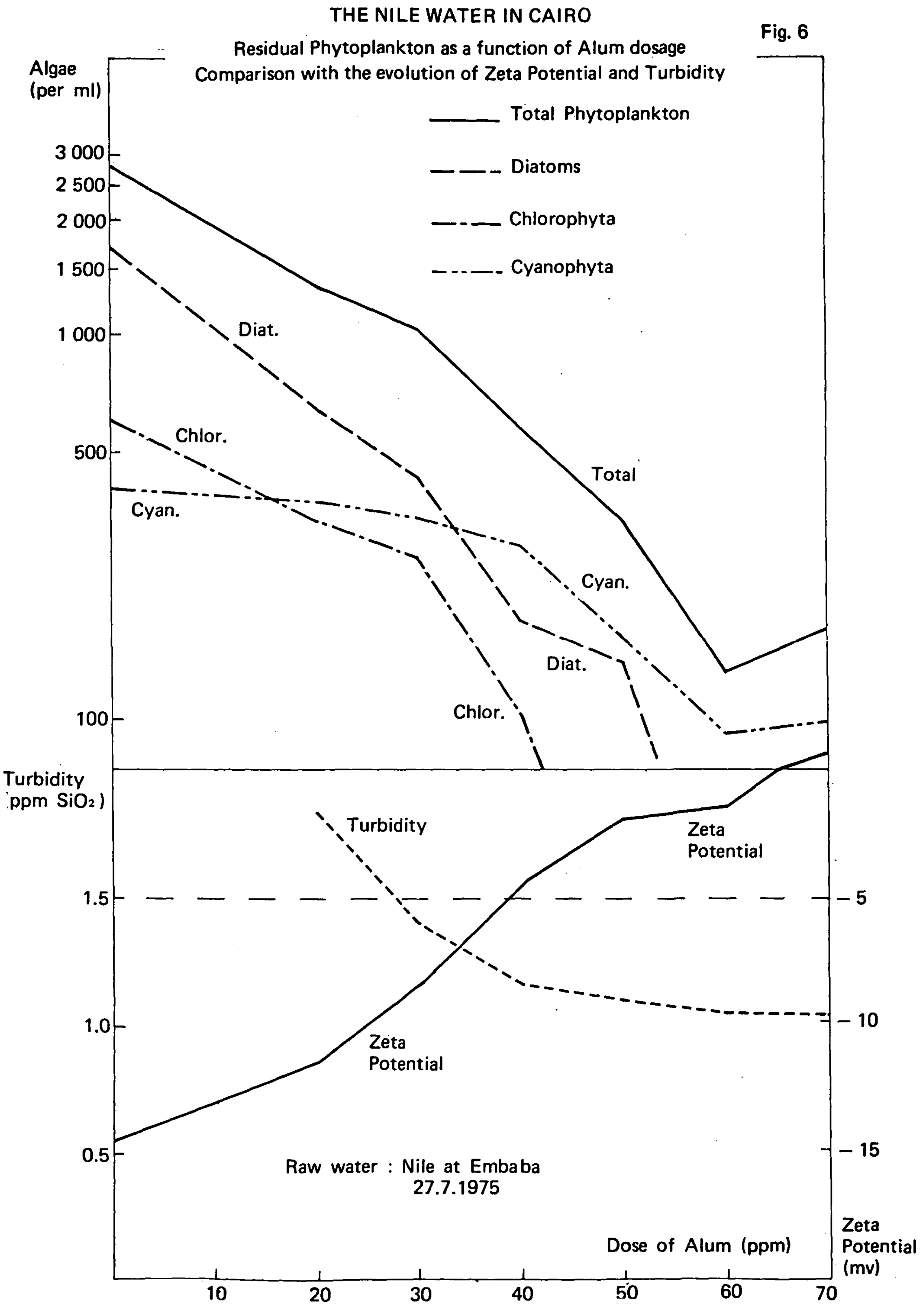
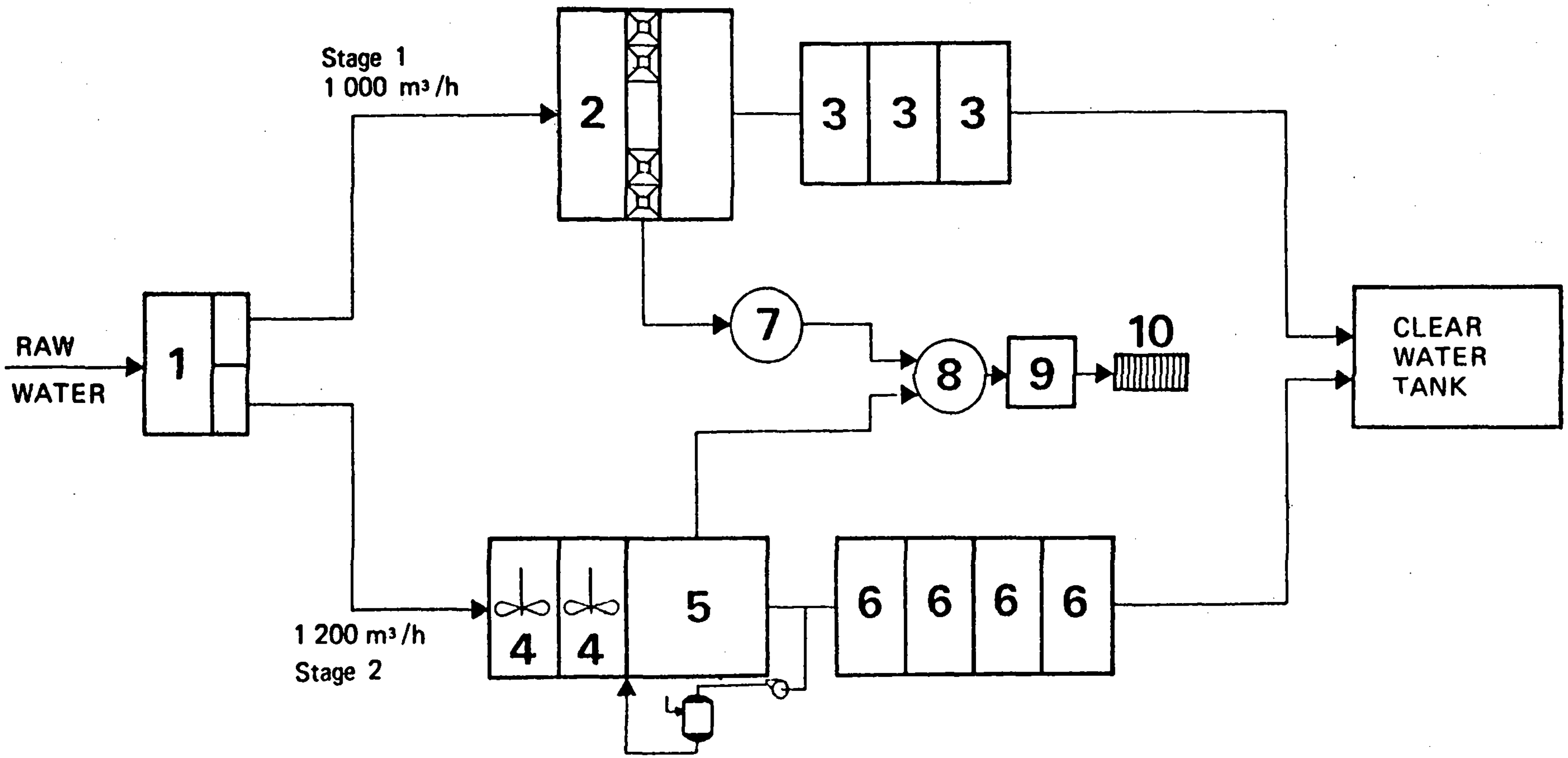

THE NILE WATER IN CAIRO
Fig. 6
Residual Phytoplankton as a function of Alum dosage
Comparison with the evolution of Zeta Potential and Turbidity
Algae (per ml)
Total Phytoplankton
Diatoms
Chlorophyta
Cyanophyta
3 000
2 500
2 000
1 500
1 000
500
100
Diat.
Chlor.
Cyan.
Total
Cyan.
Diat.
Chlor.
Turbidity (ppm SiO2)
Turbidity
Zeta Potential
1.5
1.0
0.5
5
10
15
Zeta Potential
Raw water : Nile at Embaba
27.7.1975
Dose of Alum (ppm)
Zeta Potential (mv)
10
20
30
40
50
60
70

Fig. 7 FLOW-SHEET OF THE MOULLE PLANT



		1	Raw water distributor	Sludge treatment :	7	Thickening of sludge from clarification by means of flotation
1 st stage	:	2	Pulsator Clarifier		8	Thickened sludge storage
		3	3 GAC Filters		9	Sludge conditioning
2 nd stage	:	4	2 Flocculators		10	Filter Press
		5	Flotation			
		6	4 GAC Filters			

we shall not insist on this computation already presented at the last I.W.S.A.'s International Conference in Zurich (14).

Thus, flotation has now become a solid competitor to sedimentation for the removel of algae, even when the most efficient clarification units are involved. In many cases it is now worth contemplating the choice between these two alternatives. With the present state of the technique, it may be considered that:

– flotation will be an interesting solution in a limited number of cases only because it requires:
  . a water never having significantly high S.S. content; reasonable S.S. scraper device, bottom and surface scraper (as shown on fig. 8: circular unit, and on fig. 9 : rectangular unit); but in this case, the upper admissible limit will not be very high;
  . all the means in equipment and labour for immediate repair of any breakdown should be available where the flotation unit is located: in effect, with a Pulsator a momentary stop of the chamber vacuum device, varying according to the case, may be tolerated without any modification in the quality of the treated water; consequences become more troublesome when there is a mechanical breakdown in units including flocculation tanks with either stirrers or recirculation by turbine; but when it comes to flotation units, any stop in the pressurization circuit makes treatmen immediately inefficient and the whole plant must be stopped;
– clarification in a Pulsator-type sludge blanket apparatus therefore remains the adequate solution for waters having variable turbidities and for countries where maintenance difficulties may be feared.

4. Toxic substances of natural origin

Even countries not yet industrialized have got certain natural plagues in their feed waters. We shall mention two cases which we have been studying more particularly during these last years.

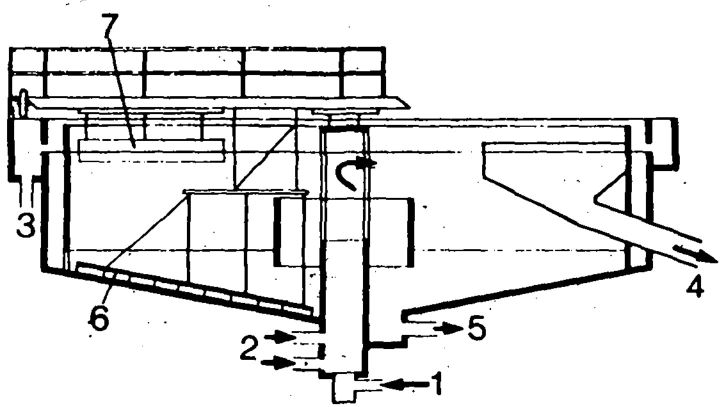
4.1. **Fluorine** (WHO's standard: 0.8 to 1.7 mg/l). This problem generally concerns underground waters: in certain cases fluorine content is up to 15 mg/l or more. A solution may be found through several types of specific treatments but with most of them (coagulation-flocculation with high dosage of aluminium sulphate; softening by lime with precipitation of magnesia; filtration through triculcium phosphates of natural or synthetic origin, etc). there are problems of either running costs, or reliability, or else resistance of the material to degradation with time. Presently there is only technique which seems to be applicable on an industrial scale and this is filtration through **activated alumina** beads, as it is commonly acknoledged by most of the Authors; the size of the material must be 0.3 mm approx., and speed of passage 10 m3/hr approx. per m3 of alumina; the retention capacity generally varies from 2.5 to 5 kg F /m3 of activated alumina depending on the operating conditions; when alumina is saturated it needs to be regenerated either with aluminium sulphate or with caustic soda and sulphuric acid. Our studies brought out the following points:

– the results of laboratory test obtained with waters artificially enriched with fluoride ion (as NaF) have confirmed those obtained on site with waters naturally having high fluorine contents;
– unlike what is advocated by many Authors, a preliminary acidification of water to a 5.5 pH value is rarely advisable: though this operation actually increases the ability of fluoridevion to be fixed by activated alumina, the amounts of acid required to lower pH value are so high, and so are those of the alkaline reagent required to correct the treated water carbonic aggressivity, that in most cases this operation is "anti-economical";
– the most economical process is a regeneration with caustic soda and sulphuric acid: reagent consumptions to be anticipated are: 8 to 9 g NaOH and 10 to 11 g H_2SO_4 per g of fixed F ion.

4.2 **Arsenic** (WHO's standard: 0.05 mg/l). Several areas of the Globe, some of them being under tropical climate, know this problem, Thus, in Taiwan the southwestern coastal regions were supplied with underground waters having high arsenic contents (0.6 to 2 mg/l) and many of the inhabitants consequently had "black foot" disease (15) (16). It is possible, in certain cases, to use other water sources to get rid of the disease; but, as with nitrates or fluorine, it is not always possible to find a substitue solution.

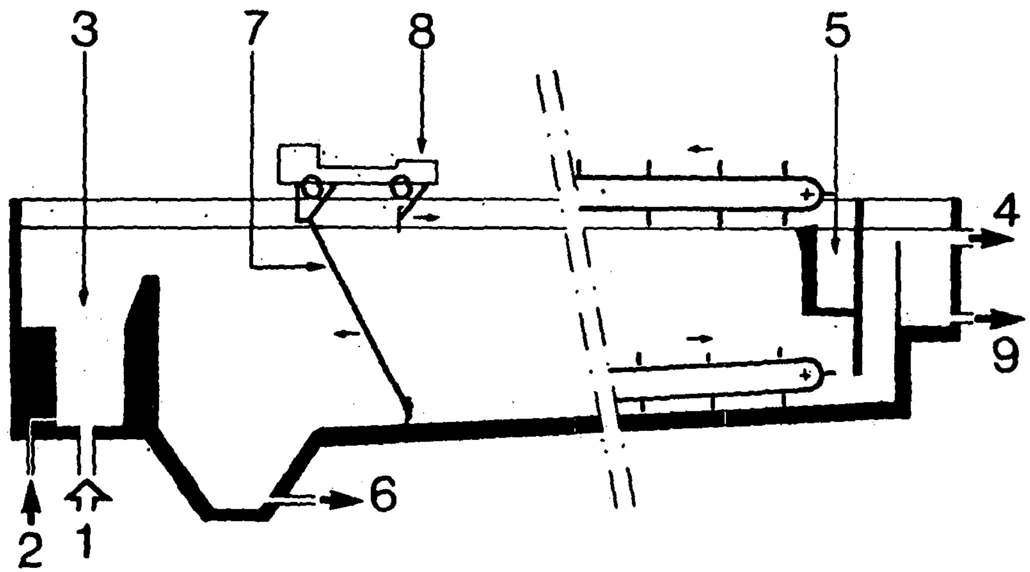
This is why we have studied possibilities or removing arsenic :

– from underground waters: by filtration through activated alumina, as for fluorine; however, the results of this process with arsenic are not so good as those with fluorine, and this was also verified by BELLACK (17);
– from surface waters: within the scope of a complete sedimentation filtration treatment, mainly when the water may have high turbidities; thus, at the plant built by us at Ilo (Peru) for a 0.5 l/sec. output, it is possible to remove arsenic (raw water with a 0.8 mg/l average content) both by means of the conventional coagulation-flocculation process and by carbonate removal with lime; as regards the first treatment our findings meet those by SHEN (15): on the hand iron salts (30 to 35 g/m3 $FeCl_3$ in the present case) are more efficient than aluminium salts (optimum pH



1. *Raw water inlet.*
2. *Pressurized water inlet.*
3. *Treated water outlet.*
4. *Scum discharge.*
5. *Sludge extraction.*
6. *Bottom scraper.*
7. *Surface scraper*

Fig. 8 – The SEDIFLOTAZUR



1. *Raw water inlet*
2. *Pressurised water inlet*
3. *Mixing zone*
4. *Treated water outlet*
5. *Outlet for floating material*
6. *Sludge extraction*
7. *Bottom scraping*
8. *Surface scraping*
9. *Recycled water to pressurisation*

Fig. 9 – Longitudinal FLOTAZUR

at 7 approx. in both cases); on the other hand, treatment results are improved after a prechlorination; finally the hazard of this process is that sand may get enriched with arsenic, thus requiring that the filter be washed from time to time with caustic soda. As regards carbonate removal using lime, it must be adjusted to a pH value close to 11 (requiring 300 to 400 g/m3 pure lime) in the presence of 10 to 20 g/m3 $FeCl_3$; under such conditions, the maximum reduction in arsenic content is obtained in the clarifier and the filter sand cannot get enriched with arsenic. These various results are shown in the table below:

Maximum permissible value (ppb)		Treatment conditions	pH 7		pH 11
W.H.O.	Peru		wihout prechlorination	with prechlorination	
		Residual arsenic (ppb):			
–	–	– Clarified water	100 to 180	50 to 70	5 to 15
50	100	– filtered water	25 to 35	10 to 20	3 to 10

5. Prevention of corrosion

The concern of the water treatment specialist must go beyond the standards of potability which protect only the consumer; he must also think in terms of pipe system protection which, moreover, is another wav of protecting the consumer by preventing the water from entraining any undesirable metallic elements in the distribution system. Under tropical climate, corrosion problems may be come particularly serious for several reasons:

- the water waters with high turbidity (see para. 1), with high colour or algae contents (see para. 3) require large amounts of mineral coagulant; its acidifying action (of both aluminium sulphate or ferric chloride) makes the treated water aggressive; besides, coincident to this, the water is enriched with Cl of SO_4 ions;
- in many countries, certain waters have extreme characteristics (for example: very low alkalinity and hardness, of about 10 ppm $CaCO_3$; high cloride content) which become so many factors of corrosion when measures are not taken;
- with a comparable chemical composition, corrosion phenomena will evalve faster in a warm water than in a cold water.

For the above reasons we wish to recall the following recommendations for the protection of metallic pipes, and particularly those made of cast iron or stell :

a) in almost all the cases, the final stage of water treatment should include not only a disinfection but also an injection of alkaline products to ensure conditions of calcium-carbonate equilibrium in the water;

b) moreover, when the alkalinity and calcium hardness of the water are very low (less than 60 to 70 ppm $CaCO_3$ when there are no other unfavourable elemnts; this limit should be increased in the presence of chlorides and sulphates), the formation of a protective film should be favored:
   - either by increasing artificially the alkalinity and harness of the treated water (necessary for the formation of a Tillmans 'protective layer); several solutions are then available (CO_2 + lime; CO_2 + $CaCO_3$; $NaHCO_3$ + $CaCl_2$; H_2SO_4 + $CaCO_3$; etc.);
   - or by applying film-forming treatment, such as the LTP (a zinc hexametaphosphate) developed by our Company;

c) the water must contain a minimum of 5 to 6 mg/l dissolved oxgyen;

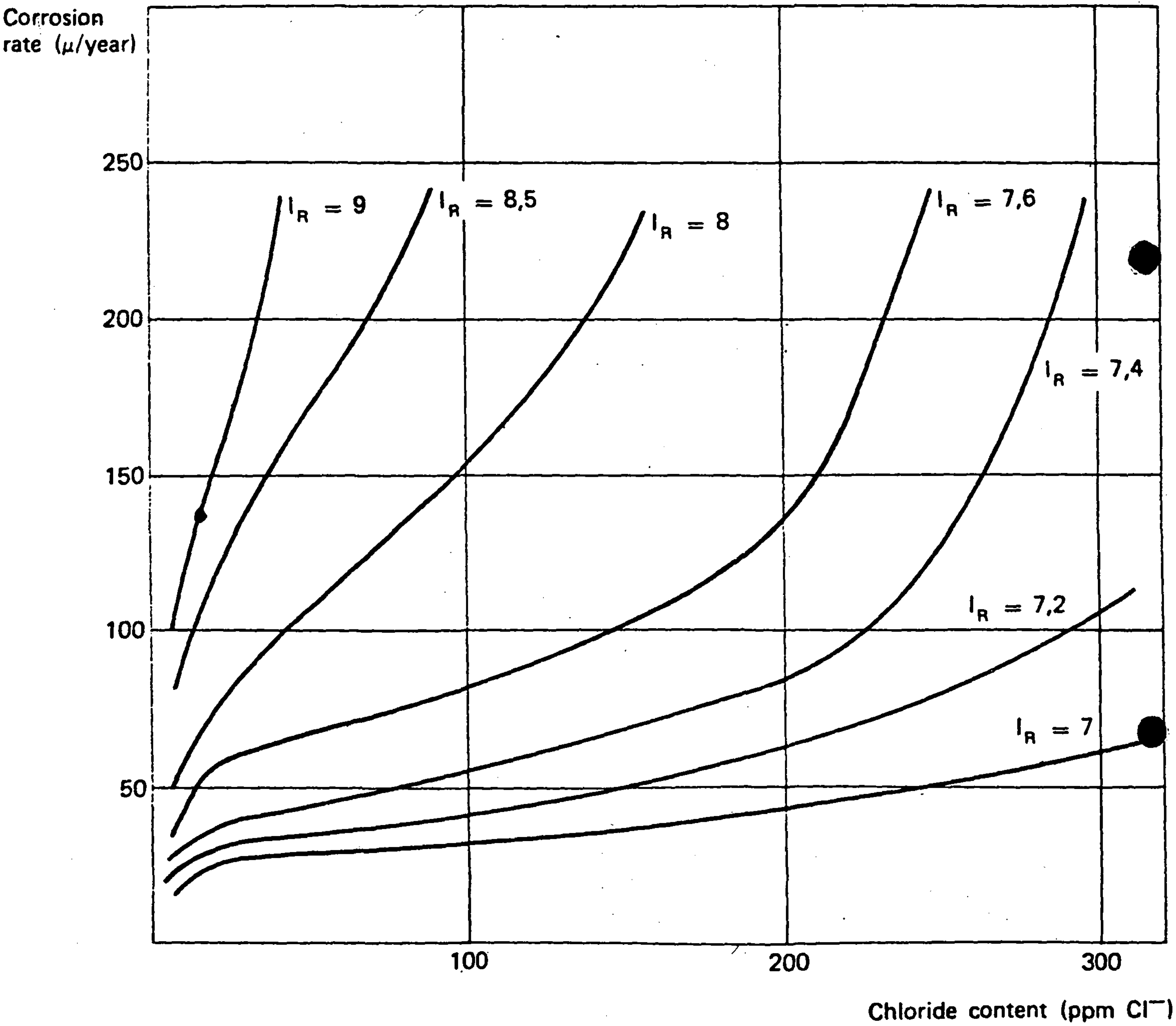
d). Whenever the water has particular characteristics, it is always advisable to conduct corrosion tests on site, for example with a series of ordinary steel rings over which water flows at a rate representing the actual operating conditions; rings are withdrawn one by one after increasing contact times (e.g. at the rate of one every month or every two months) and their loss in weight is measured after corrosion products have been removed: the results of a similar experiment are given on fig. 10 and concern a water in Peru whose chloride contect could exceed 300 mg/l Cl; within six months, it was possible to determine, under test conditions corresponding to this water, the value that should be given to the Ryznar index ($I_R = 2\ pH_s - pH$), i.e. water pH, according to chloride content in order to maintain the corrosion rate below a determined upper limit.

In the above described type of test. corrosion phenomena are reckoned to remain tolerable so long as the material lost by the rings corresponds to an attack not exceeding 70 to 80 μ/year: fig. 10 shows that this condition will be difficult to fulfil if chloride content exceeds 100 mg/l and/or if the Ryznar index exceeds a value which is less than or equal to 8. A simple computation shows that a corrosion rate of 130 μ/year (i.e. 28 MDD) represents already a metal loss of 1 kg/m2/year, i.e. 1 Tonne of metal per year and per km of a 300 mm dia. pipe. It is thus possible to realize the impact of these phenomena from a technical, economical and health point of view, and consequently to intensify prevention of corrosion.

RIO CHIRA (PERU)

Fig. 10

CORROSION RATE AS A FUNCTION OF THE CHLORIDE CONTENT FOR VARIOUS RYZNAR INDEX (I_R) VALUES



CHAPTER II. SOME EXAMPLES OF RECENT DEVELOPMENTS AS REGARDS TECHNOLOGY

1. Sedimentation

We have mentioned, earlier in this paper, the results obtained with the Pulsator in the removal of algae (see para. 3.2.3.) which are not yet widely known: they widen even more the field of application of this unit which has already proved its efficiency in the treatment of moderately turbid waters, in the optimization of powdered activated carbon use, etc.

At the same time, lamellar-type settling has known a significant development over these last years; it was then logical to combine the advantages of both processes resulting in the creation of two new units: the Superpulsator and the plate type Pulsator (see fig. 11). They have both been described in several conferences and publications (18) (19) (20) (21) (22) (23) and we shall not recall here their design and operating principles; within the scope of this paper we shall only mention some particular applications.

1.1. Superpulsator

This units wholly combines the two type of settling (plate-type and pulsated sludge blanke-type) and include plate inclined at 60^0 to the horizontal, spaced by 30 cm approx.,located inside the very sludge blanket (fig. 11 A). This design provides a significantly increased sludge blanket concentration and a resulting admissible speed about twice that of a conventional Pulsator to obtain the same quality of clarifeid water.

Many units of this type have already been built thoughout the world. Its advantages, that could be anticipated when it was being designed and during the first tests, have always been confirmed; another advantage was revealed when it was used in the treatment of waters with **variable turbidity.**

In effect, the inside of the plates located within the sludage blanket is fitted with angle irons acting as deflectors which place the thickened sludge back in suspension whilest it slides along the next plate : it produces a mixing of particles and a close contact between the upflow of water and the domnflow of sludge resulting in a excellent flocculation; thus, when the water is highly turbid the apparatus works as a combined flocculating-settling unit and when the water is relatively clear, it converts itself in a flocculating unit to optimize the direct filtration treatment.

There are several plants in France working on this principle: Huguenеuve, Montbeliard, Razac, etc. In the United States a plant operator published an article on this use of the Superpul sator with waters of low turbidity, with which the plant production capacity could almost be doubled (24); this solution may also be interesting when filter washwaters are recycled: however, it is then absolutely necessary to use a polyelectrolyte.

The only possible difficulty in this case may arise when the unit operating mode is switched over from a settling-filtration of turbid waters to a flocculation-filtration of relatively clear waters (the limits between these two fields being specified in Chapter I, para. 1.1.), since the sludge blanket may then loose its homogeneity: provisions can be made for a by-pass to feed the filtration unit while about half the volume of the tank is drained to discharge the sludge blanket to sewer, the diameter of the drain pipes and valves being so designed as to perform quickly this operation; for example, the characteristics of the Superpulsator at Razac (France) are as follows:

Output : 525 m3/hr
Total surface area : 160 m2
Drain diameter : vacuum chamber and raw water channel : 150 mm settling tank itself: 250 mm

1.2. Plate type Pulsator

In this case, the sludge blanket works in the same way as in the conventional Pulsator and the finishing modules are installed in the zone of clear water located above the sludge blanket; these modules may be either plates or tubes (fig. 11B); this is the actual "settling" part of the process thus separated from the "flocculation" part which takes place in the sludge blanket. The equal distribution of raw water at the base of the tank ensures at the same time an equal distribution between the modules and the floc suffers no deterioration when it passes from one zone to the other; moreover, the floc escaping from the sludge blanket undergoes thickening inside the modules: it is denser when it falls back into the sludge blanket and due to this phenomenon it is possible to reach upward velocities equal to, and even higher than, those admitted in a Superpulsator.

Another advantage of this device is that it enables the conversion of a conventional Pulsator into a plate type Pulsator and thus increases its production capacity and/or the quality of the clarifeid water, both with warm waters or with cold waters; experiments of interest on this point have been conducted in Canada and in Argentina and have already been the subject of several talks (20).

More than 40 units of this type are already in operation in various countries, and more particularly:

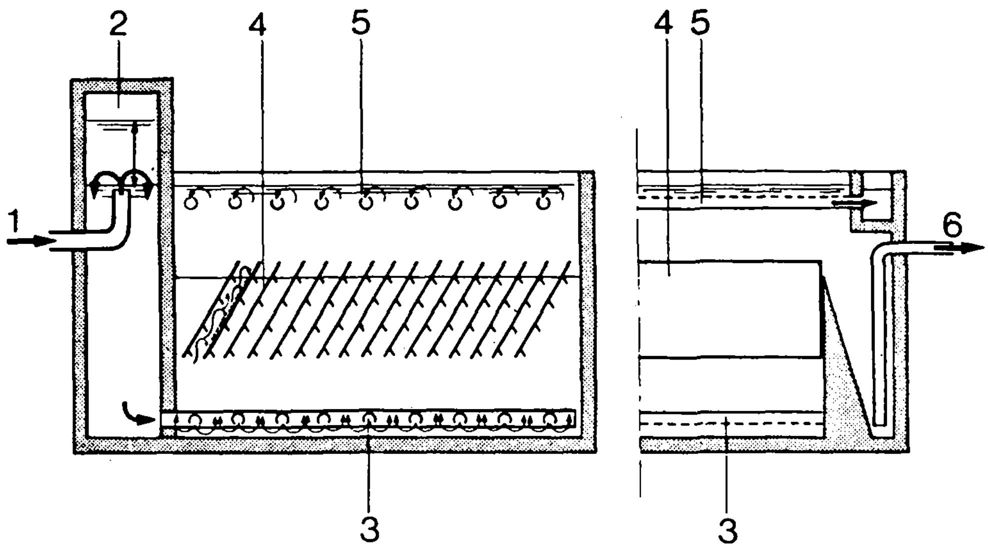
- in CANADA: over fifteen for plants whose output vary from 500 to 3,500 m3/hr;
- in THAILAND : at Egat-Sud (2 x 50 m3/hr), Egat-

- TABLE 2 -

Some examples of lamellar Pulsators in MEXICO
(with plates or tubes above sludge blanket)

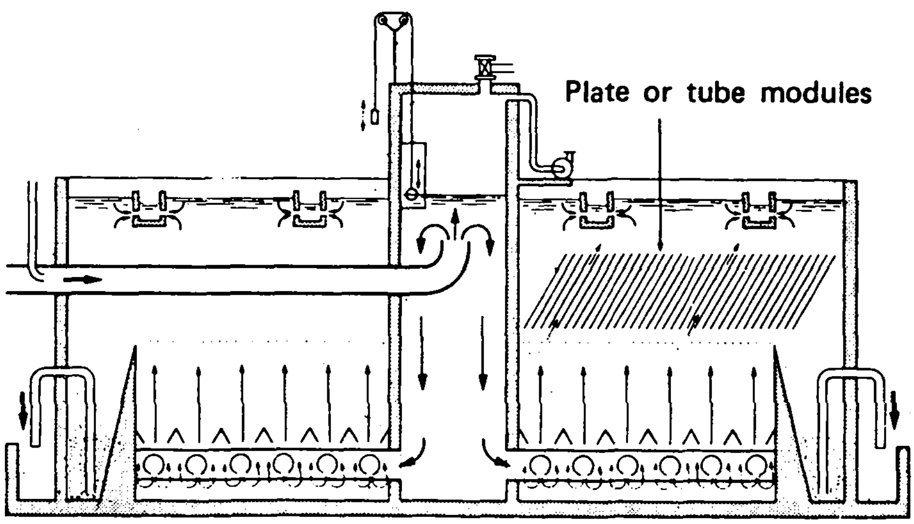
Location	Nr of units	Unit-flow (m^3/hr)	Rise rate (m/h) over totale surface area	Local conditions	Turbidity (or Iron if specified)		
					Raw Water	Clarified water	Filtered water
POZA RICA	1	2,520	5.9	Tropical climate : - Wet season: heavy rains over volcanic clays. - Dry season : algal blooms.	5 to 2,000 NTU	1 to 8 NTU	0.1 to 0.5 NTU
ACAPULCO	2	1,800	6		10 to 3,500 NTU	1 to 10 NTU	0.5 to 2.5 NTU
VILLAHERMOSA	1	1,800	5.9		10 to 4,000 NTU	1 to 10 NTU	0.5 to 4 NTU
CULIACAN	3	240	6.85		5 to 2,000 NTU	1 to 8 NTU	0.1 to 0.5 NTU
TIJUANA	2	1,800	6	Mediterranean climate : Impounded waters (+Eutrophication in ENSENADA Reservoir: presence of iron and manganese)	5 NTU	0.5 NTU	0.1 to 0.2 NTU
ENSENADA	1	540	8.45		⩽ 5 NTU	0.5 to 2 NTU	0.1 to 0.3 NTU
TECATE	1	450	8.85		5 to 10 NTU	0.5 to 1 NTU	0.1 to 0.2 NTU
RIO BRAVO	1	1,450	5.05	Continental climate: - air : 0-45°C - water : 12-30°C Water from irrigation canal	5 to 1,000 NTU	0.8 to 1.5 NTU	0.1 to 0.3 NTU
OAXACA	2	630	5	Ground water : Iron removal	3 to 8 ppm Fe	0.2 to 1 ppm Fe	0 to 0.25 ppm Fe

Fig. 11 A – THE SUPERPULSATOR CLARIFIER



1. Raw water inlet
2. Vacuum chamber
3. Perforated pipes for water distribution
4. Plate system
5. Perforated pipes for clarified water collection
6. Sludge discharge

Fig. 11 B – LAMELLAR (plates or tubes) Pulsator clarifier



Kanom (50 m3/hr), MWWA-Nong-Chok (50 m3/hr), Royal-Orchid-Hotel (2 x 65 m3/hr): the example of this country shows that this technique is also adequate for small and medium-size plants;

– in MEXICO : the main reference and results obtained with these units are given in Table No. 2 showing that in this country the plate type. Pulsator is used to treat waters of various different types: eutrophic waters from impoundments, river waters with very variable turbidities, etc., and even iron removal from underground waters.

Both with the Superpulsator and with the plate-type Pulsator the combination of a pulsated sludge blanket type sedimentation with a lamellar type sedimentation has the advantage of requiring only a limited space for settling while ensuring the production of a water having an excellent qualify. This was in particular the guiding factor in the choice of this unit for the above mentioned plants in Thailand. Another example of this is given by the Lagadadi extension plant at Addis Ababa (Ethiopia): the existing plant was supplying 50,000 m3/day of treated water with two Pulsator clarifiers, each having a 393 m2 surface area (rising velocity) in the sludge blanket: 3.45 m/hr) and six x 63 m2-filters (v=6 m/hr). The fast population growth (drift from the land) then imposed to increase the production of this plant to 150,000 m3/day; but, to treat these additional 100,000 m3/day, the space available was very limited as the site is very jagged and composed of very hard rock; on the other hand, the poor ability to flocculation of raw water made it impossible to increase notably rising velocities in a conventional settling. Lamellar type sedimentation tests were tehn conducted in the existing tank : the results (see Table No. 3) showed that the addition of modules above the sludge blanket could increase the rising velocity by 50 to 100%. This is why it was decided for the extension plant, presently being built, to build two plate type Pulsator clarifiers, each having a 519 m2 surface area (rising velocity through sludge blanket: 5.2 m/hr) and ten 63 m2-filters; the existing battery of six filters plus the new battery of ten filter altogether will provide in the future 16 filters operating at a 6.5 m/hr approx. speed. The layout of all these units is shown on fig. 12, together with the site undulations: it clearly appears that the increase in passage velocity through the units, made possible by an improved technology, brought a solution to a severe problem of reduced space.

2. Filtration

We have already had the opportunity of presenting the AQUAZUR-V type filter (21) (22) (23) with a high depth of water above sand layer (about 1.2 m for the constant level models). We shall only recall that this type of filters is particularly adapted to the treatment of tropical waters:

- such waters are often supersaturated in dissolved oxygen due to algal growths: a high depth of water above the sand layer ensures,inside the laters, a pressure sufficient to prevent outgasing which would create an artificial head loss in the filtration cycle thus resulting in too frequent filter washers;
- the hydropneumatic wash (as in Aquazur-T filter) with simultaneous use of water and air, together with surface sweeping ensures complete cleaning of the sand and in particular removes the living organisms that could develop in it (algae, Nematodes, Crustaceans, etc.) at the same time as mud-balls which are usually found in filter washed with water alone (or with separate air and water).
- the admissible rate may be high (up to more than 20 m/hr).

Fig. 13 shows the operation of this type of filter during filtration and during washing. Let us remind here that the Aquazur V type filter is generally designed to work with constant level and output. Filter level control was traditionally obtained by means of a purely hydraulic system (float-partialization box-siphon);

we have also dveloped a highly reliable electro-penumatic system (see fig. 14).

Besides, this type of filter may have alternative solutions adapted to certain local conditions of equipment availability, building principle, running method, etc. Three of them are given below:

- constant output, variable level filter without any level control system (fig. 15): the water to be filtered is distributed between the filters through weirs, the filtered water is collected in another weir whose position is such that the sand is always covered with water, and the water level rises as the filter gets clogged. The simplicity of this filter, however, is counter balanced by the increases in the building cost and by a risk of deterioration in the filtered water quality (due to a break in the floc when the feed water enters the filter).

  Example at Caterall (U.K.)
  - "Declining-rate filter" (fig. 16)

    Example at the Bandhupp plant supplying the City of Bombay (W. India).
  - Filter washed by gravity from the general filtered water collection trough (Fig. 17).

    Example at the Cutzamala plant supplying the City of Mexico.

3. Developing the treatment by ozone

3.1. Beneficial effects of ozone in the water treatment

3.1.1. General data – Methods of application under tropical climate

First reputed for its bactericidal, colour and odour removing properties, ozone gradually revealed its other

– TABLE n° 3 –

Addis-Abeba.

Tests with lamellar settling systems (installed in conventional Pulsators).

Rise rate inside the sludge blanket : 3.4 m/h

Rise rate above sludge blanket : 3 m/h

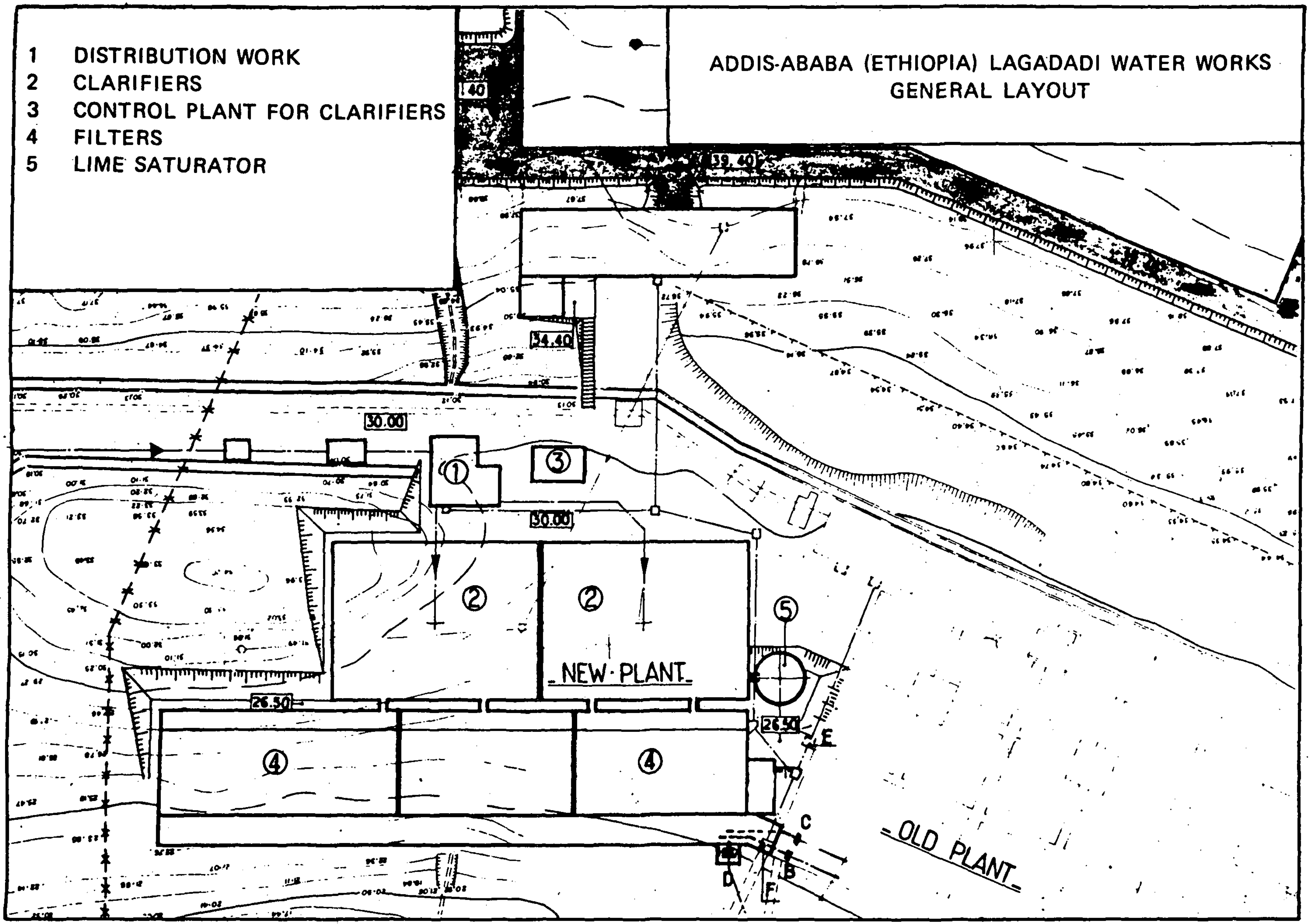
Turbidity (NTU)	Pulsator	Plates or tubes units
Rise rate in clarification zones :		
3 m/h	3 to 4.5	1.5 to 2.1
5 m/h	5 to 7.3	2.1 to 3.2
7 m/h	–	2.8 to 3.9

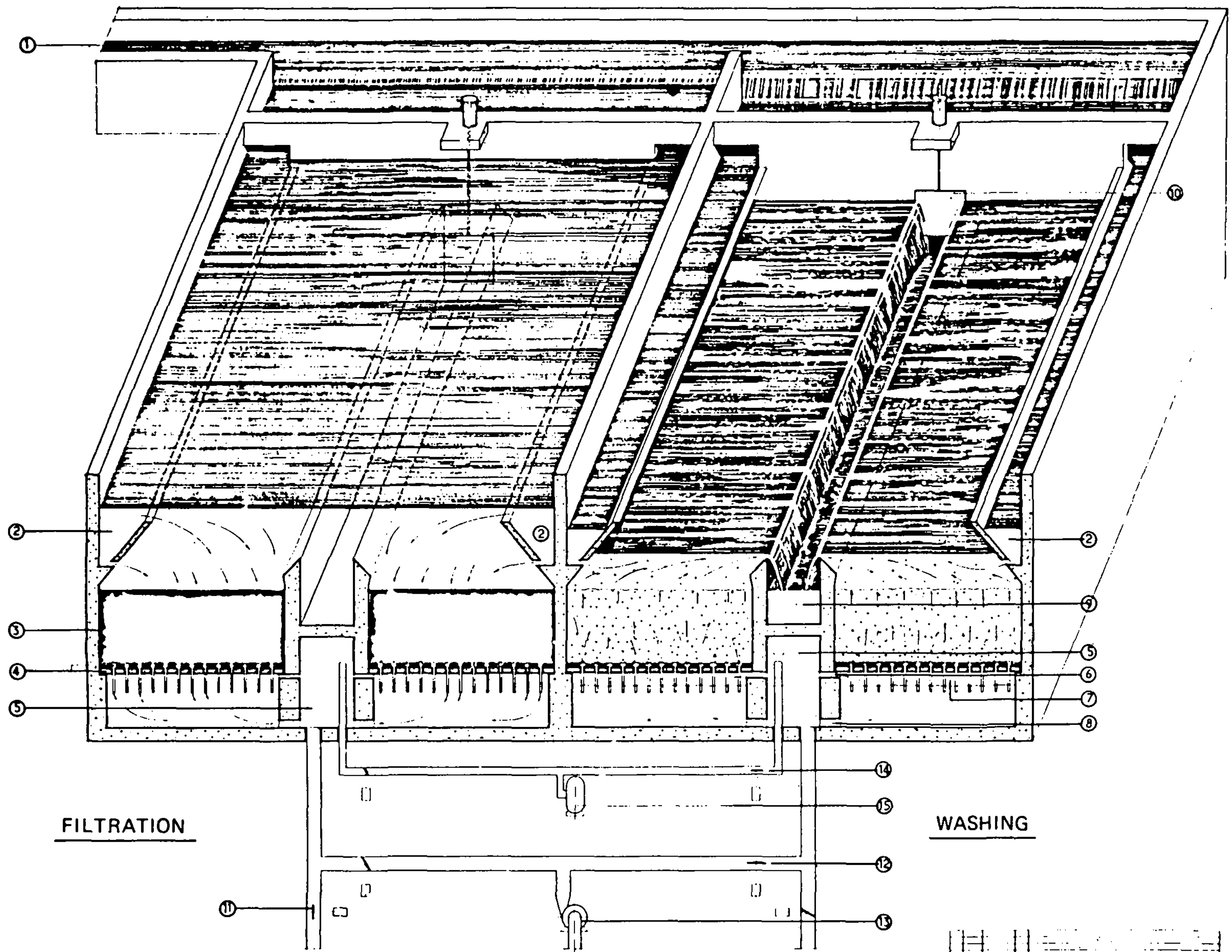
possibilities: removal of virus, action on organic micropollutants, oxidation of dissolved metals (iron and manganese), coagulating action (under certain conditions), factor of bacteria reviviscence useful in a further stage of filtration, etc. This is why, since the end of last century, it has been used in very different applications in 1978, over one thousand of drinking water treatment plants using ozone could be counted throughout the world, 57% in France.

Within the scope of this paper it is impossible to contemplate all the possible applicationsof ozone, like treatment of underground waters, a combined treatment using ozone and a filtration trough granular activated carbon to make a "biological activated carbon", etc. We shall only study here the addition of a complementary treatment with ozone in a conventional line treating surface water: we shall more particularly study the results obtained with tropical type waters, whenever needed.

In effect, in a tropical climate, some additional problems appear for this type of process: high water temperature leads to a reduced production of the unit when it is cooled by the water from the plant wihout any complentarycolling unit, and causes, on the other hand, a faster destruction of ozone dissolved in water. To get a better knowledge of the results of ozonization in warm waters, we have then conducted tests in a pilot-plant at Bangkok (Thailand) and, at a smaller scale, at Seoul (South Korea), at Singapore, in Australia, in Nigeria, etc. These tests, in particular, have enabled us to figure an order of magnitude for the the reduction in production of a ozonizer when the cooling water temperature increases: about 10% when temperature rises from 15–20°C to 30°C. They have also enabled us to determine the optimum parameters of ozone use under such conditions:

- **Ozonized air concertration:** ozone dissolving in the water should be fast enough to prevent its decomposition (favoured by high temperature) from becoming too significant; now, dissolving rapidity increases with the concentration of ozonized air from the production unit; as, on the other hand, the air flow should be sufficient to ensure a bubble denseness favourable to a good air/water ozone transfer, the best compromise between the above two requirements is within a concentration range from 15 to 18 mg O_3 per litre of air.
- **Contact time** between ozonized air and water: the tests conducted in Bangkok have evidenced a 6 to 8 minute optimum time for the removal of the main troublesome parameters: colour, organic matter, detergents, etc. Beyond this, the rapid destriction of ozone considerably increases the ozone consumption required to find a residual at the contact tower outlet, without any further improvement in the quality of the treated water.
- **Influence of preliminary treatment on ozone demand:** for an ozonization at the end of treatment, the amount of to be intriduced depends very much on the way the previous clarification was conduced, as we have noticed during the tests conducted in Bangkok: fig. 18 gives the observed residual O_3 contents according to the introduced amount for the various conditions of pre chlorination and coagulation used upsteram; in this case, to maintain a 0.4 mg/l residual O_3 content (usual value in disinfection) at the contact tower outlet, we can work out from fig. 18 the treatment rate to be applied according to the clarification treatment:


1 DISTRIBUTION WORK
2 CLARIFIERS
3 CONTROL PLANT FOR CLARIFIERS
4 FILTERS
5 LIME SATURATOR
ADDIS-ABABA (ETHIOPIA) LAGADADI WATER WORKS
GENERAL LAYOUT
39.40
34.40
30.00
30.00
26.50
26.50
NEW PLANT
OLD PLANT
A
B
C
D
E
F



1 - Raw water inlet
2 - Raw water and sweep-water channels
3 - Filter bed
4 - Filter floor and nozzles
5 - Channel for filtrate collection and for scour air and wash-water distribution
6 - Scour air distribution orifices
7 - Air-cushion
8 - Wash-water distribution orifices
9 - Wash-water discharge channel
10 - Wash-water discharge valve
11 - Filtrate outlet valve
12 - Wash-water inlet valve
13 - Wash-water
14 - Scour air inlet valve
15 - Blown air

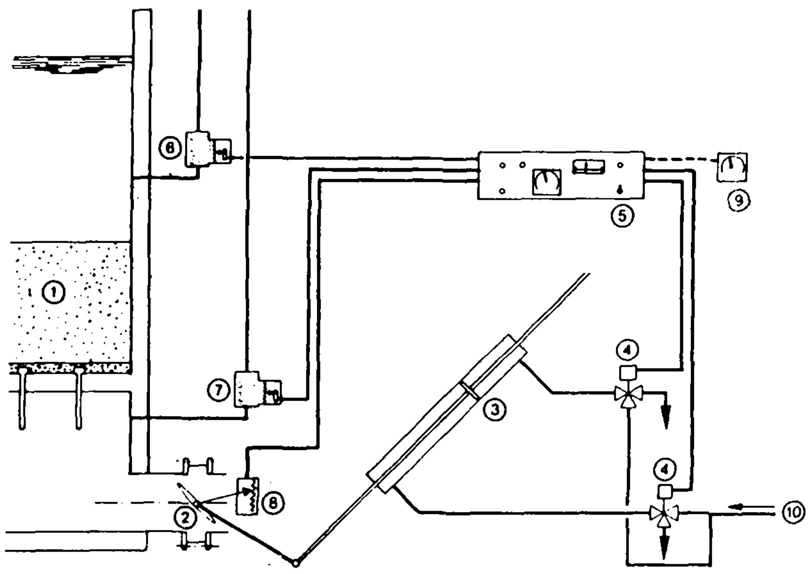
Fig. 13

THE AQUAZUR V FILTER

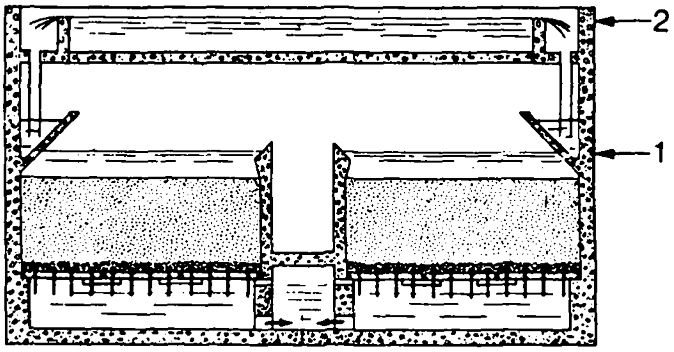
SP 1699 1

DIAGRAM OF AN ELECTRO-PNEUMATIC FILTER-CONTROL SYSTEM

Fig. 14

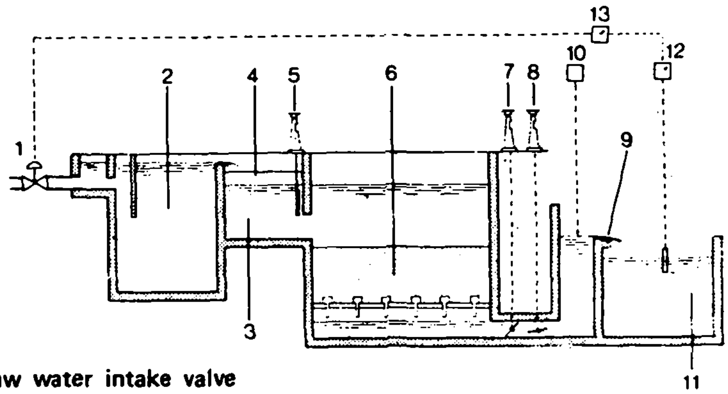


1. Filter
2. Regulating valve
3. Valve-actuating ram
4. Ram-operating solenoid valves
5. Electronic rack
6. Level sensor (RN)
7. Clogging sensor (IC)
8. Potentiometer
9. Remote dial registering degree of clogging (if required)
10. Compressed air or water



1. Low level, clean filter 2. High level, clogged filter

Fig. 15 – Variable-level constant-output AQUAZUR V filter



1. Raw water intake valve
2. Clarifier
3. Filter feed channel
4. Overflow weir
5. Intake yalve
6. Declining-rate filter
7. Filtrate outlet valve
8. Valve for controlling auxiliary head-loss
9. Individual filter outlet weir
10. Individual flow-meter
11. Joint filtrate tank
12. Measurement of level in tank
13. Raw water flow controller

Fig. 16 – Diagram of a general downstream control system for filters with declining flow-rate

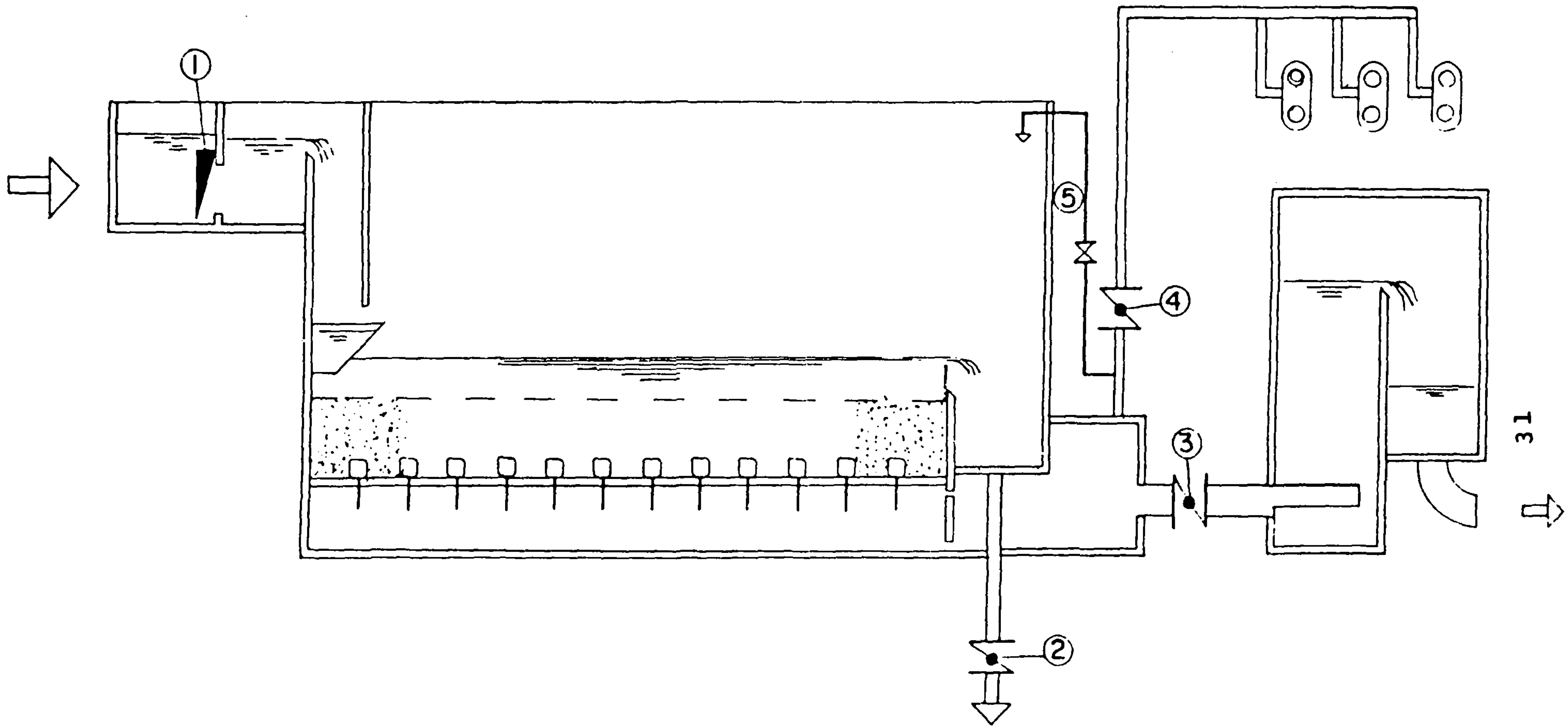


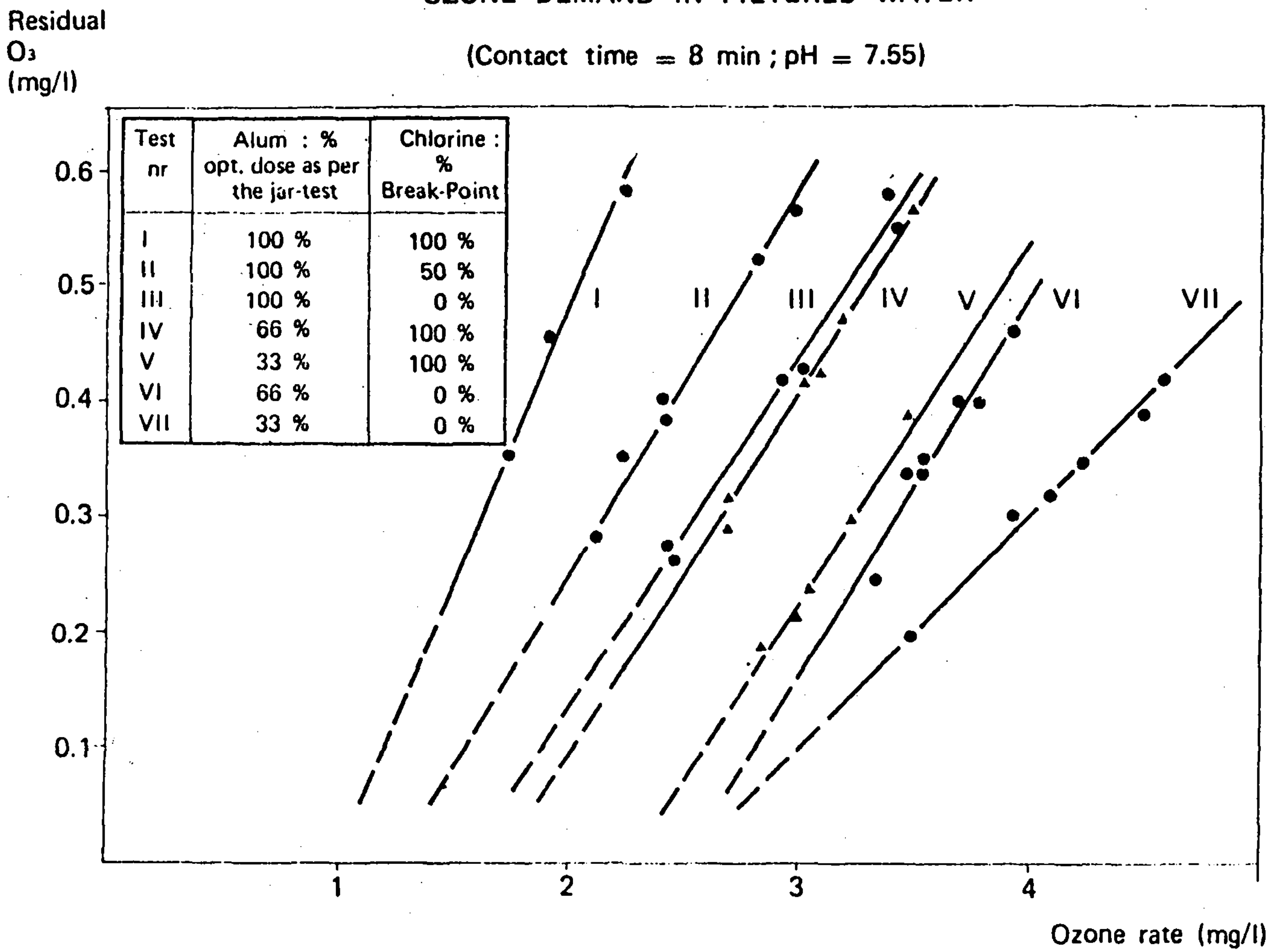
Fig. 17 AQUAZUR-V FILTER WITHOUT BACKWASH-WATER PUMP

1. Clarified water inlet
2. Washwater outlet
3. Filtered water outlet and washwater inlet
4. Air inlet
5. Air vent

INFLUENCE OF ALUM AND CHLORINE DOSES ON THE OZONE DEMAND IN FILTERED WATER

Fig. 18

(Contact time = 8 min ; pH = 7.55)



Test nr	Alum : % opt. dose as per the jar-test	Chlorine : % Break-Point
I	100 %	100 %
II	100 %	50 %
III	100 %	0 %
IV	66 %	100 %
V	33 %	100 %
VI	66 %	0 %
VII	33 %	0 %

these various results are gathered in Table No. 4, which shows that an economic use of ozone implies a previous treatment effected under good conditions. Fig. 19 also illustrates this principle.

- **Influence of pH:** as for temperature, an increase in pH value leads to a faster destruction of residual ozone. This well known phenomenon under temperate climate was confirmed with warm waters from tropical countries. Thus, in Bangkok ozone demand was 3.6 g/m3 in a filtered water whose 7.55 pH corresponded to the coagulation-flocculation conditions; when pH was increased to 7.95 (saturation pH), the ozone demand increased to 4.1 g/m3, i.e. a 14% increase without any imprivement in the *quality of the treated water. Besides, fig. 20 shows* all the results obtained in this field with tests conducted at Singapore. After all these observations we can only recommend that ozonization be applied at the lowest possible pH and, in any case, that final pH of water be adjusted to the conditions of calcium-carbonate equilibrium (prrvention of *corrosion) only after treatment by ozone.* Finally, it is worth recalling that treatment by ozone does not eliminate the need for a final chlorination as ozone does not leave any disinfectant residual in the water; the actual rapidity of ozone disappearance depends upon pH, temperature, etc. We have gathered on fig. 21 all the results corresponding to average conditions: it apprears that for the residual contents obtained in actual practice at the contact tower outlet (0.4 to 0.6 g/m3 at the maximum) the disinfectant has totally disappeared after 10 to 20 minutes. To protect the distribution *pipe system against any further increase in the* number of common bacteria or any secondary contamination it is necessary to add chlorine in order to still have at least traces of residual chlorine in the furthest point of distribution.

– TABLE 4 –

Influence of treatment rates in clarification on ozone demand in the filtered water (residual 0, in treated water : 0.4 mg/l)

Test nr	*Treatment rates in clarification*		Ozone rate (mg O_3/l	Increase in O_3 demand (%)
	Alum : % of the optim. dose as per jar-test	Chlorine : % Break - Point		
I	100%	100%	1.8	–
II	100%	50%	2.45	36%
III	100%	0%	2.9	61%
IV	66%	100%	3.0	67%
V	33%	100%	3.5	94%
VI	66%	0%	3.7	106%
VII	33%	0%	4.5	150%

3.1.2. Effects of ozone in filtered waters

3 1.2.1. **Disnfection:** it was already known about 100 years ago that ozone could destroy the bacteria of typhoid and cholera. On the other hand, its virucidal action has been known for over 50 years though it is only twenty years ago that a precise definition was given for the conditions under wihch ozonization should be applied to inactivate totally waterborne viruses, in particular that of poliomyelitis: 0.4 mg/l residual ozone during during 4 minutes (25), this rule being still applied presently for all of the viruses and pathogenic bacteria. This is why we usually use contact towers with two compartment: in the first one, the chemical ozone demand of the water is fulfilled until a 0.4 mg/l residual is obtained at the outlet; in the second compartment this residual rate is maintained for 4 minutes by adding no more than the amount of ozone required to compensate for that which is self-destroyed in the water during this contact time.

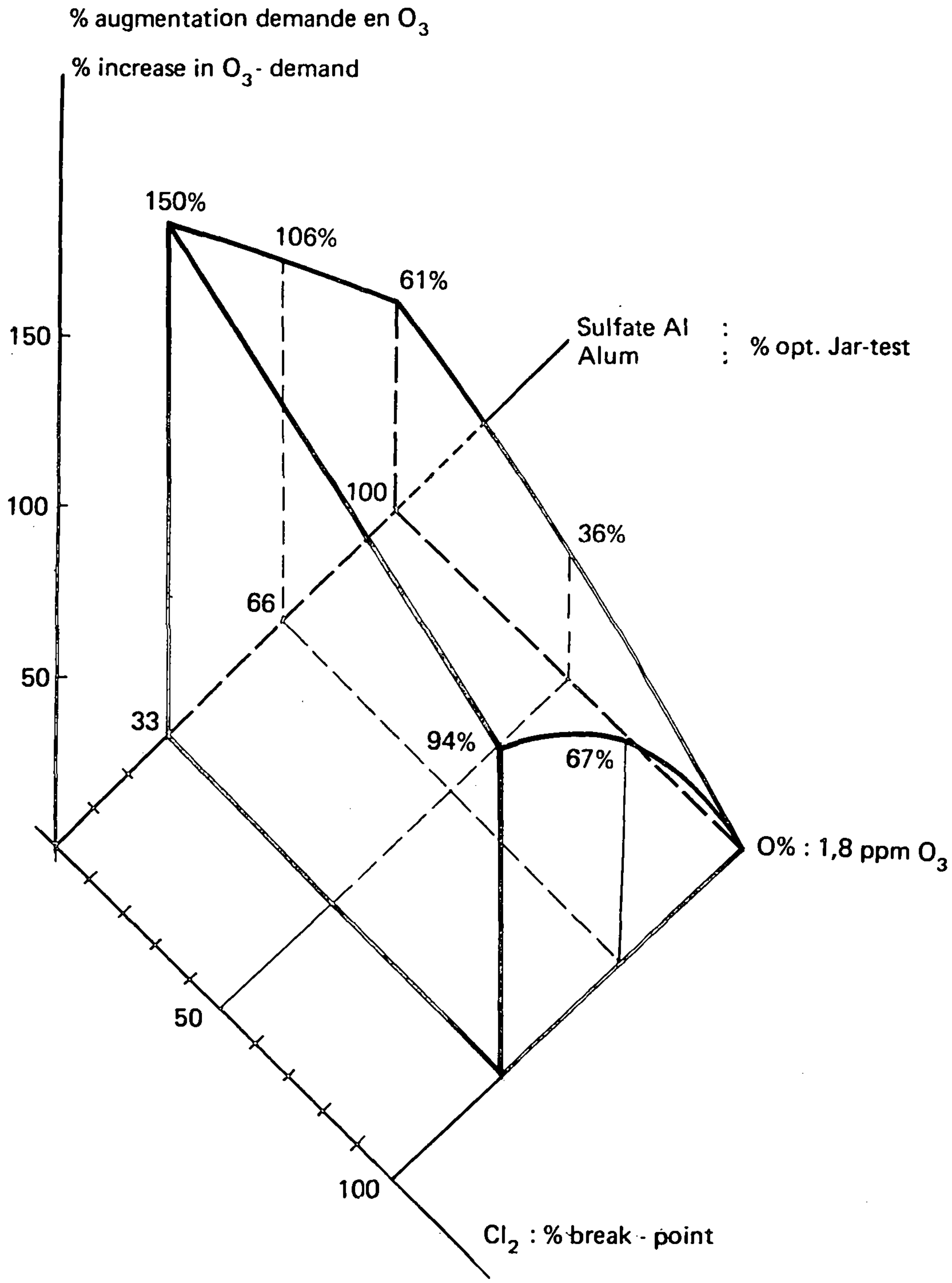
These virucidal conditions obviously ensure at the same time a virtually complete sterilization of the water as regards bacteria. This point was confirmed at Bangkok by tests conducted in a pilot plant :

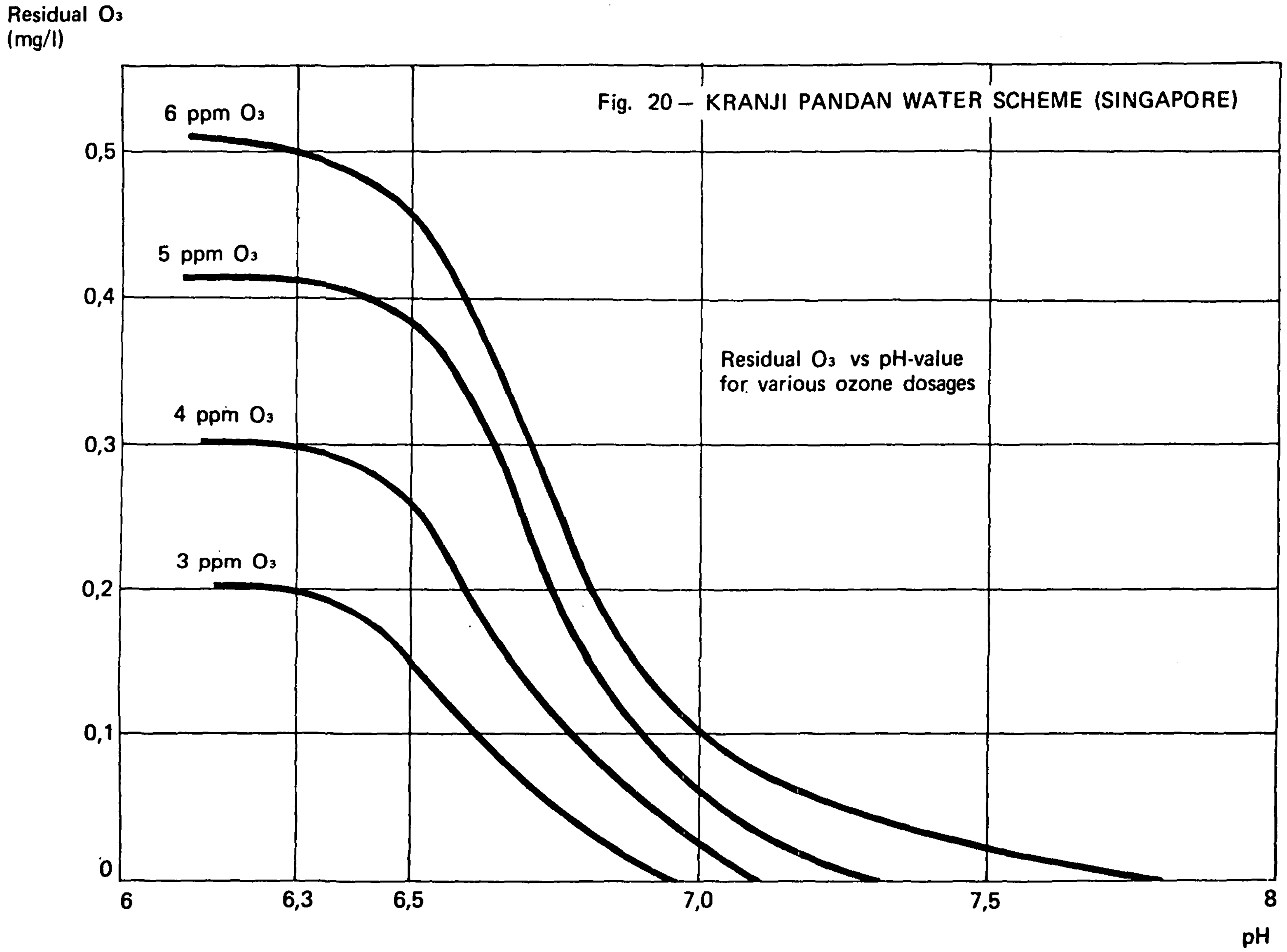
Fig. 19

BANGKOK : Tests O_3

Influence des taux de traitement appliqués en décantation sur la demande en O_3 de l'eau filtrée

Influence of treatment rates applied in clarification on O_3 - demand in filtered water




Residual O_3
(mg/l)
Fig. 20 – KRANJI PANDAN WATER SCHEME (SINGAPORE)
6 ppm O_3
5 ppm O_3
4 ppm O_3
3 ppm O_3
Residual O_3 vs pH-value
for various ozone dosages
0,5
0,4
0,3
0,2
0,1
0
6
6,3
6,5
7,0
7,5
8
pH

Total germ count (per ml)	Filtered water	Ozonated water
With prechlorination	3-35	0–1
Withhout prechlorination	65-350	0–1

3.1.2.2. **Total parameters (tastes, odors, colour, organic matter, etc.)**: all get impoved through ozonization; this treatment either removes or reduces most of the unpleasant tastes and odors (except when they are saturated organic compounds, without double bond, which may be removed only by activated carbon treatment, e.g. the metabolites of algae or Actynomycetes (26), like geosmin or 2-methylisoborneol);
on the other hand, it removes colour completely from most of the waters (except when they contain such elements as iron or manganese which must be previously removed) and it often provides a further and appreciable reduction in organic matter when compared to clarification.
Let us come back once again to the tests conducted in Bangkok where the following has been noted:

- a complete colour removal from a water which still had a 5° Hazen colour content at filter outlet;
- no taste and odor at all in the ozonized water;
- a further 30 to 40% reduction in organic matter (measured by permanganate value) content compared to that in the filtered water after addition of optimum dosages of chlorine and aluminium sulphate.

Other tests conducted in Singapore had the results shown in Table No. 5.
Besides, we have often noted that it is not necessary to reach the above mentioned vircidal conditions (0.4 mg/l during 4 minutes) to obtain these last results; we are given below a few examples:

- in **Nigeria**: with water from the Owo River at Lagos, residual ozone only appears when treatment rate exceeds 5 g/m3, while 2 g/m3 are sufficient to obtain a water of quite acceptable quality and 3 to 4 g/m3 are sufficient to reach the maximum removal of organic matter and above all of colour and unpleasant tastes (fig. 22);
- in the river Han water at **Seoul** (Korea): bad taste and organic matter removal starts well before the appearance of residual ozone, as shown on fig. 23' which also shows that in this case the improvement in organic matter removal due to ozone is noticeable mainly when the water is polluted;
- in **Australia**, the tests conducted with clarified water from the Advancetown plant, treating the Hinze Dan water, gave the results shown in the following table:

3.1.2.3. **Organic micropollutants**: besides, with the advances in analytic chemistry, it has been possible to define more accurately the beneficial effect of ozone on most of these substances, e.g.:

- **Detergents**: depending upon their nature and initial concertration in water, ozone may remove them either totally (as seen earlier in Table No. 5, concerning observations made in Singapore), or partially. In the tests conducted in Bangkok the raw water contained 0.35 mg/l detergents expressed as TPBS; this content was then artificially increased to 1.35, and to 1.65 mg/l; all the results are gathered on table No. 6, where it appears in particular that:
  - * detergent removal percentage through clarification is, in this case, no more

Ozone dosage (g/m^3)	0	1.1	1.8	2.35
Residual ozone (g/m^3)	–	0	0	0.3
Treated water :				
– turbidity (NTU)	0.23	0.23	0.2	0.18
– colour (°Hazen)	3	2	1.5	1.5
– taste threshold Nr	5	3.5	2.5	1.5

Fig. 21 RESIDUAL O_3 AS A FUNCTION OF TIME

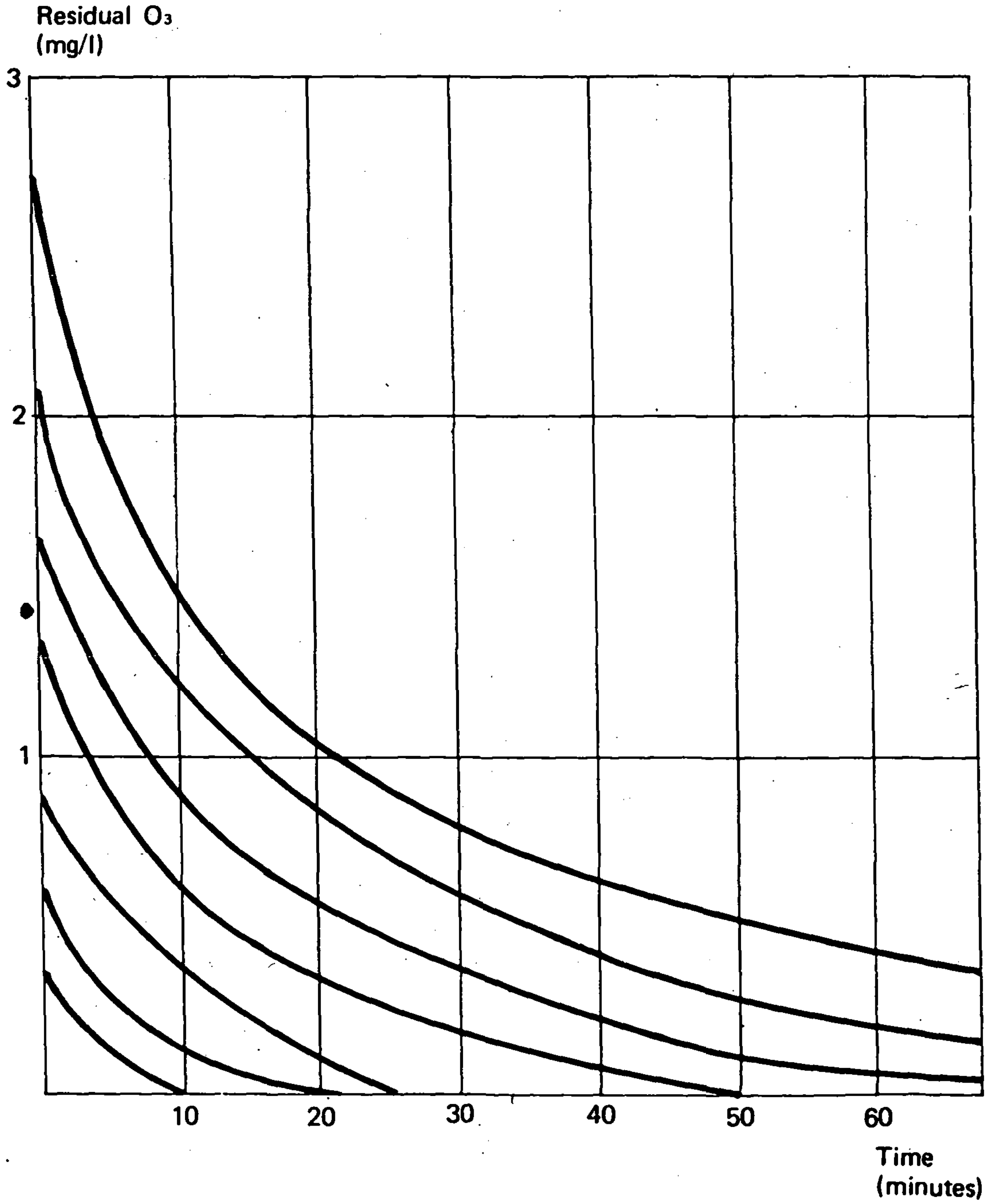


Fig. 22 LAGOS (NIGERIA) – OWO RIVER
OZONISATION TEST

PREVIOUS TREATMENT :
3,5 ppm Cl_2
12 ppm Lime
40 ppm Alum
+ Sedimentation – Sand Filtration

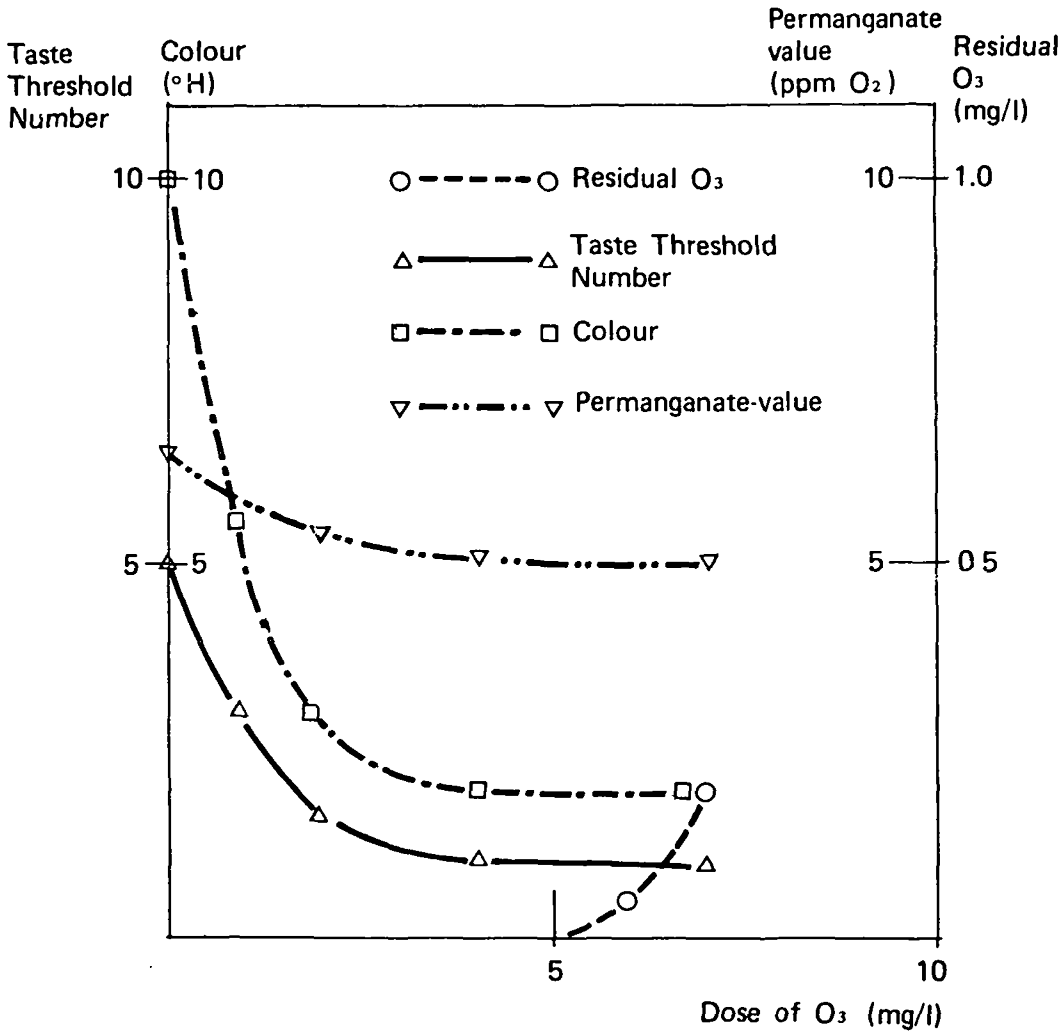
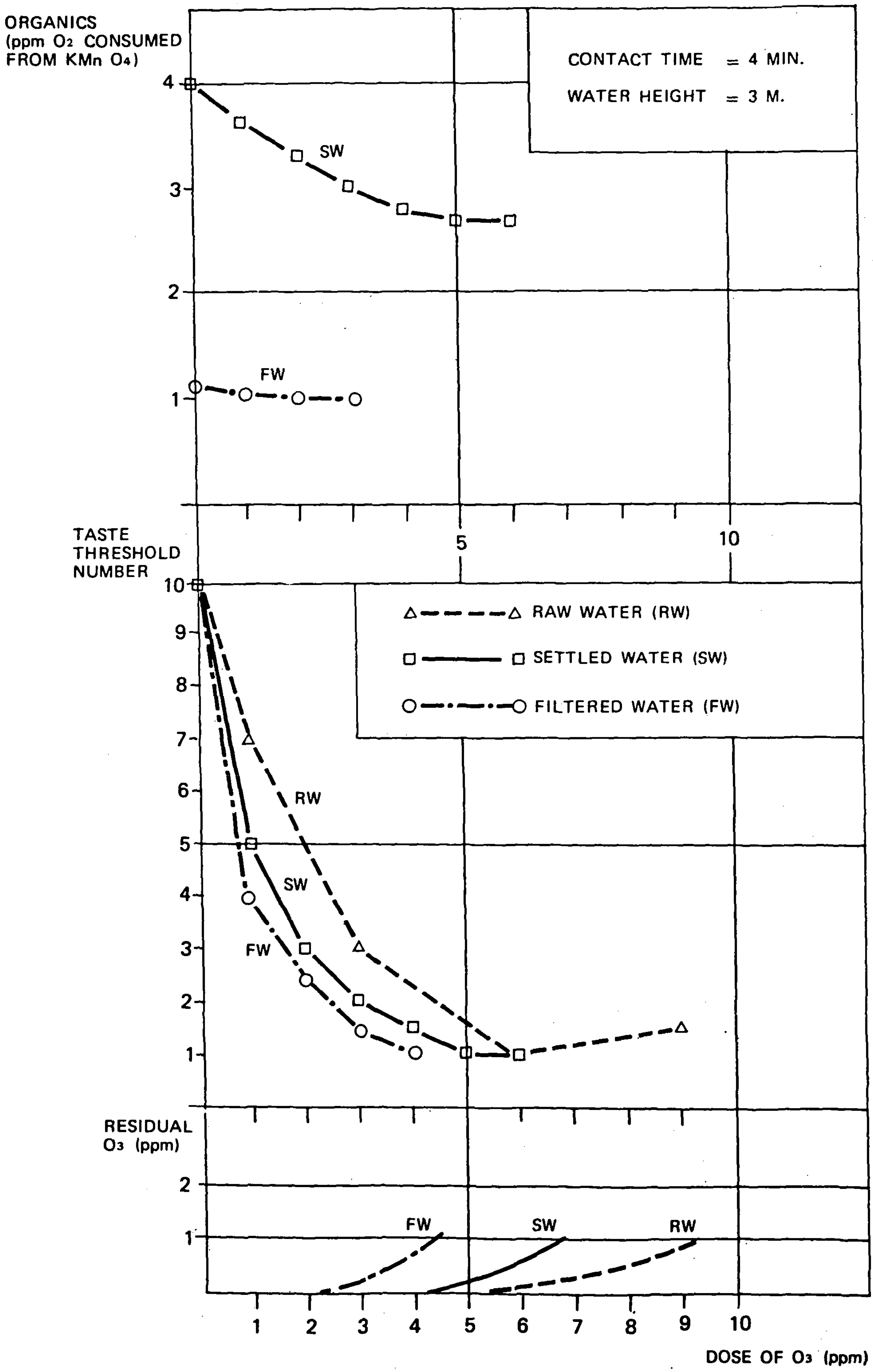


Fig. 23 SUMMARY OF OZONATION TESTS AT BOKWANG



than 20 to 30% max.;
* 5 mg approx. ozone per mg of detergent are required to reach 70% removal.

- **Cyanides:** ozone is very efficient on cyanides, even at a small dose: cyanates form which are 1,000 times less toxic.
- **Pesticides:** ozone destroys partially most of the organochlorinated pesticides (50% removal approx.): lindane, dieldrin, DDT, etc. and totally the organiphosphorus pesticides. In the case of an organophosphorus pesticide like parathion, there is first of all formation of a metabolite more toxic than the initial product: the paraoxon. Treatment must therefore continue to ensure its complete destruction.
- **Phenols:** here again intermediate products from degradation form and some of them are toxic (catechol, o-quinone, parabenzoquinone, etc.): treatment must go on until a significant amount of residual ozone is obtained to destroy them.

As to organic pollutants, it may therefore be noted that unlike the total parameters, earlier referred to (taste, odor, colour, organic matter), their removal requires treatment conditions similar to those specified above for virus removal, in particular the chemical ozone demand of the water must be met and an ozone residual be present at the contact tower outlet.

3.1.3. Pre-ozonation

Finally, it seemed interesting, in certain cases, to add a small amount of ozone in raw water, much lower than the total chemical demand, prior to clarification treatment. This results either in an improved quality of filtered water when dosages of the other reagents remain unchanged, or in a possible reduction in coagulant dosage to maintain the same guality of treated water. With the river Seine water in Paris (France), in particular, a marked improvement is obtained when a preliminary treatment with ozone, 0.5-1 g/m3, is aplied. Other tests, conducted with very polluted waters and having high algae contents, have evidenced a saving in coagulant that greatly made up for the additional cost of pre-ozonation.

– TABLE 5 –

Ozonisation test in CHOA-CHU-KANG water works, SINGAPORE

Type of water	Filtered	Ozonised with	
		2.5 ppm O_3	5 ppm O_3
Colour (Hazen Units)	8	5	3
Permanganate value (ppm O_2) :			
alkaline medium	4.4	4.0	3.4
acid medium	5.9	4.9	4.6
Taste threshold number	4	3	1
Detergents (as LAS)	0.12	ND*	ND*
Residual O_3 (mg/l)	–	0.1	0.3

*not detected

This advantageous effect was also found during the tests conducted at Bangkok, where after the injection of 0.2 to 1 g/m3 ozone in the raw water the coagulant dosage (aluminium sulphate) could be reduced from 40 to 30 g/m3, i.e. a 25% saving. However, in this case this preliminary treatment could not reduce the final ozone demand of the treated water.

This type of treatment is also interesting for impoundment waters which are in eutrophication and contain dissolved manganese, but the amount of ozone to be introduced is then generally higher: e.g. table No. 7 shows the results of a pre-ozonation test conducted with a water from the reducing hypolimion of an impoundment in Australia: after clarification, optimum

– TABLE 6 –

Study of Detergent removal by means of ozone in Bangkok

Detergents, as ppm TPBS, in following waters :				Average percentage of Removal, as compared with Raw Water
Raw Water	Filtered Water	Ozonised water		
		Ozone rate	Residual detergent	
0.35	0.25	3 ppm O_3	0.15	60%
1.35*	1.05	3 ppm O_3 4 ppm O_3 5 ppm O_3	0.8 to 0.85 0.5 to 0.55 0.3 to 0.35	40% 60% 75%
1.65*	1.35	7 ppm O_3	0.5 to 0.7	60 – 70%

* With artificial increase of detergent content in raw water.

turbidity removal is obtained as soon as 1 ppm O_3 has been injected, colour removal with 2 ppm O_3, but 4 ppm O_3 are necessary to remove completely manganese and bad tastes; however, with this last dosage the chemical ozone demand of raw water has not yet been met as there is still no ozone residual after preozonation treatment.

3.2. Examples of recent technological advances concerning ozone production.

3.2.1. Medium frequency production

Advances in the knowledge of the variety of ozone modes of action on the undesirable chemical bodies and living organisms in the water fayoured the multiplication of industrial plants and revealed new constraints concerning production capacity, available space, reliability and economical aspect of the process, etc. A consequence was the development of medium frequency production.

The main factor guiding this approach was the search for a further increase in the ozonizer power working at the industrial frequency usually available, i.e. 50 to 60 Hz, had already optimized to a maximum the other para-meters acting on power: apmlitude of supply voltage, optimized by placing a high dielectric strength material between the electrodes thus allowing high voltage operation; increase in the apparatus dielectric capacity through the use of thin dielectrics having high permittivity; optimized operating conditions (temperature, pressure, discharge gap) etc. Henceforrth, the only factor which still could be acted upon to obatin a significant technical improvement and tend towards "maximum specific power" was **frequency**, to which the power of the ozonizer is direactly proportional. This research had been carried out for over 20 years but the frequency generating apparatus were not yet perfected; this technique could not become competitive before the recent evolution in power semi-conductors which engendered the group of converters so-called "of the bridge, self-oscillating and natural turn-off type"; they can be mounted either in "series" or in "parallel"; we have selected the first type as it ensures more safety in case of a failure in the circuit: the converter then simply stops whereas in the other type of mounting the converter gets short-circuited and a elaborate protection device is required.

In practice, medium frequency production first of all consists in converting the 3-phase alternating current from the mains into direct current by means of a rectifier bridge (also called "GRAETZ bridge"), then in converting the direct current into medium frequency current by means of a thyristor bridge.

In order to optimize this process the main parameters which were then studied were as follows:

- **Frequency**: for any ozonizer there is a "maximum specific power" beyond which produced ozone self-destruction (due to temperature increase in the gas to be ozonized) becomes preponderant resulting in a production drop of the apparatus (fig. 24). This phenomenon also exists in medium frequency and this is why optimum frequency, which is in the present technique situation of about 400 to 600 Hz, should not be overrun.
- **Temperature**: since the existence of a "specific power" comes from the influence of temperature on the destruction of produced ozone, a further cooling of the apparatus should logically delay this negative effect and thus provide an increased production when power is slightly increased; this is what happens in practice as shown on fig. 24 giving the results obtained in a concrete case: maximum prodcution improved by 7% by reducing the cooling water temperature from + 20°C to + 5°C, and by about 15% by using a liquid coolant at – 10°C. Fig. 24 also shows that this improvement appreas only for the high production figures: the extra running cost corresponding to a clised circuit including a cooling unit will thus be compensated for only in the cases of medium frequency production (however, use of a closed circuit may be contemplated for conventional ozonizers in particular cases which also requie the protection of the unit against corrosion as referred to below about the Bedok plant at Singapore).
- **Voltage** : operating voltage drops when frequency increases; this means that for a frequency ten times as much as usual values and despite the fact that power is multiplied by a 2.5 approx. factor, the drop in operating voltage reaches alomost 50%. (see fig. 25).

Once it has been so designed, medium frequency production of ozone presents a certain in number of advantages both from the economical and electro-technical point of view:

- for a given apparatus, production may be increased by using medium frequency; for a given production the number of production elements may be reduced thus reducing investment and maintenance costs;
- due to the drop in voltage resulting from the increase in frequency the equipment works under better conditions (less risks for dielectric material of getting perforated);
- the plant power factor is improved and closer to 1;
- perfectly balanced phases feeding the apparatus due to the use of a Graets bridge which is a balanced receiver (whereas a convential single-phase ozonizer causes a certain ubalancing of phases);
- semi-conductors are components whose quality is always improving resulting in a constantly increasing reliability of this type of appliances.

As a whole, medium frequency production of ozone represents an interesting technical innovation; from and economical view point it starts being competitive with conventional low frequency processes from a production threshold of about 3 kg ozone per hour. The cooling closed circuit including a cooling unit is practically indispesable in this process when the

– TABLE 7 –

HINZE DAM (AUSTRALIA)
OZONISATION TEST OF RAW WATER

Samle n°	1	2	3	4	5
Ozone rate (ppm O_3)	0	1	2	3	4
Residual O_3 (ppm)	–	– 0	0	0	0
Clarification chemicals	20 mg/l hydrated lime 50 mg/l alum 0.1 mg/l LT 22				
10 min. settled water : – Turbidity (NTU)	0.72	0.41	0.43	0.40	0.41
Filtered water (through n° 2 Whatman paper) : – Colour (°Hazen) – Manganese (ppm Mn) – Taste Threshold Number	 4.5 1.4 7	 3 1.2 5	 2.5 0.6 3	 2.5 0.12 1.5	 2.5 0.02 1

Fig. 24 PRODUCTION AS A FUNCTION OF POWER IN AN OZONIZER
INFLUENCE OF TEMPERATURE

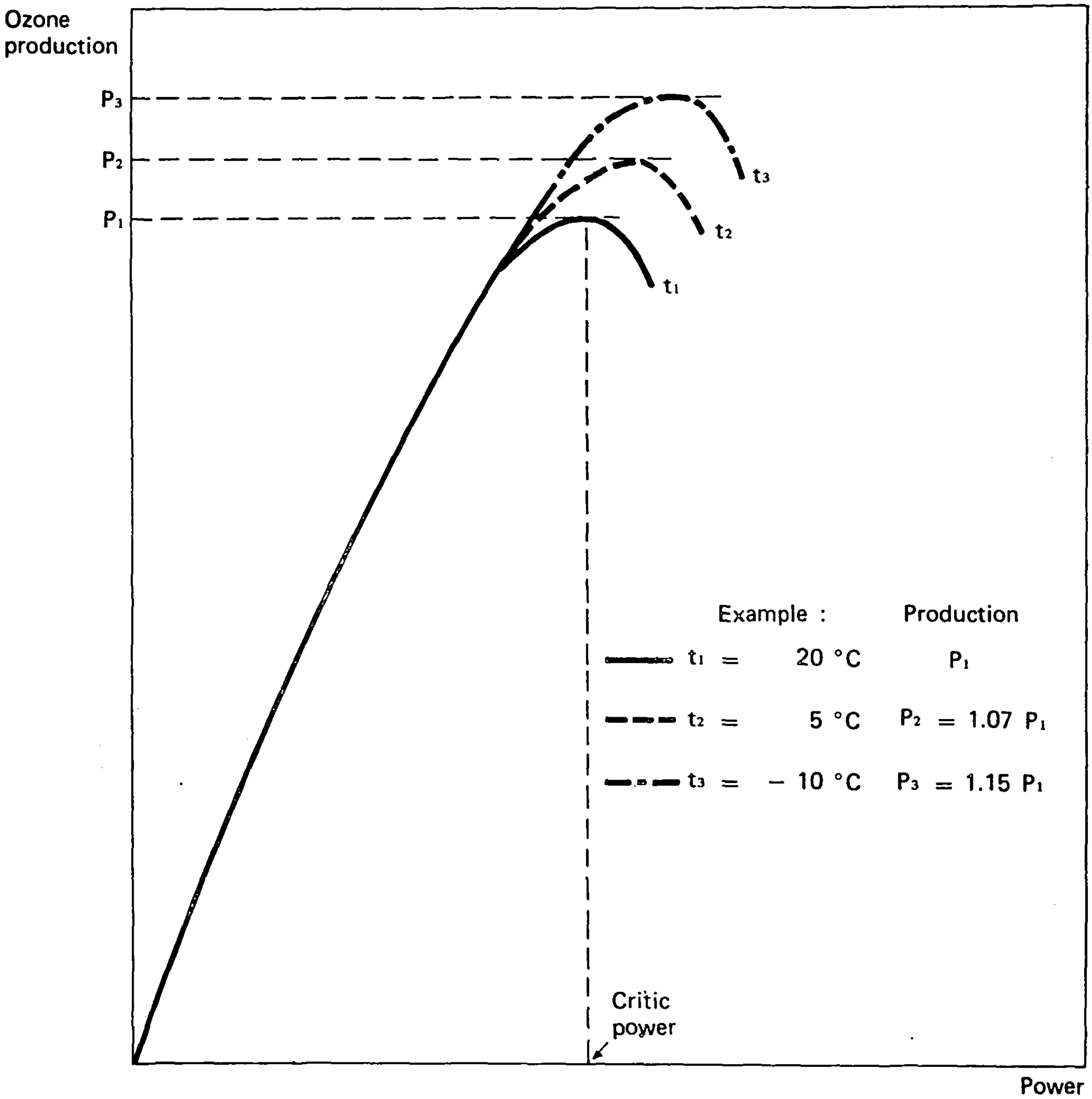
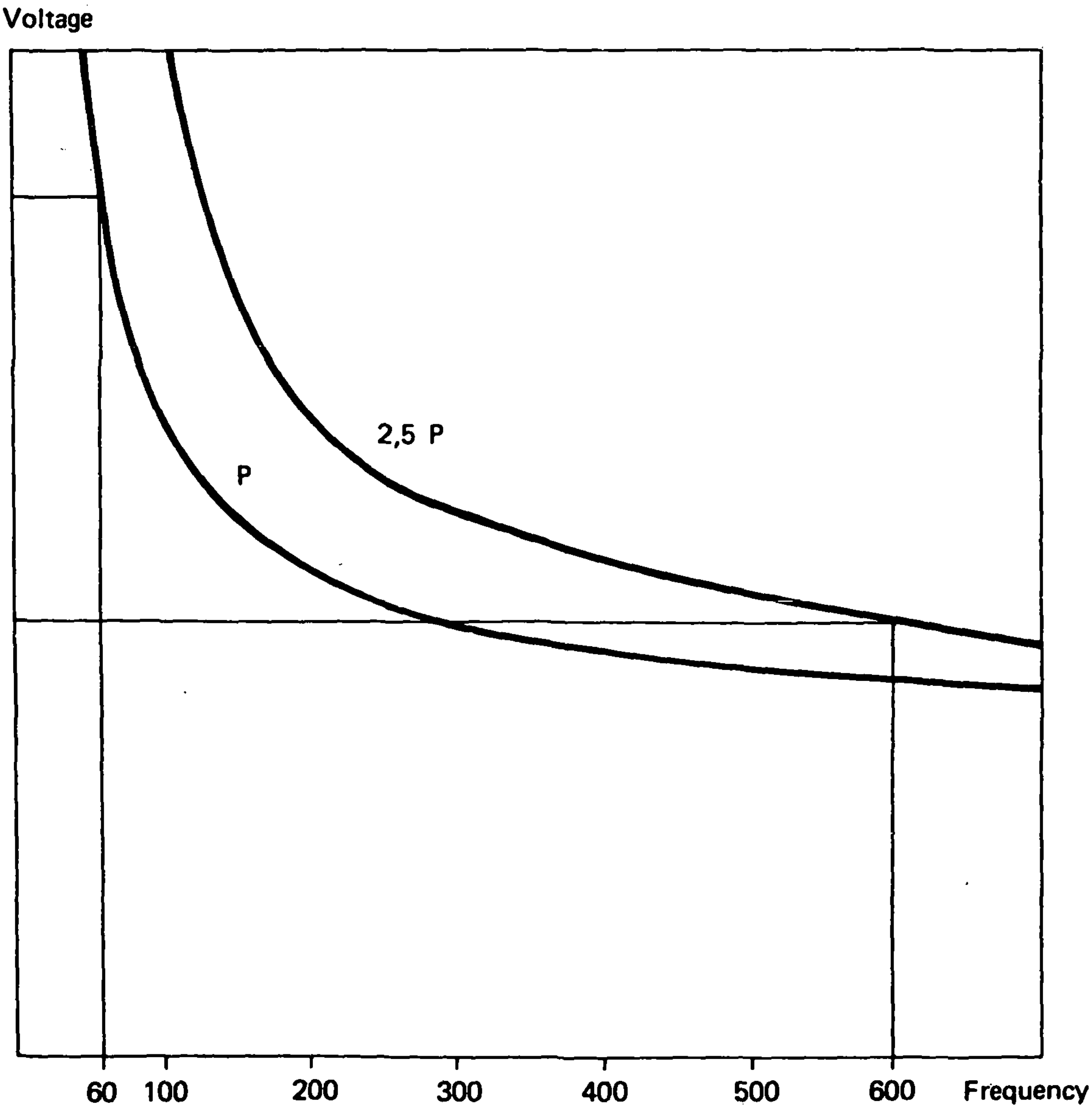


Fig. 25 VARIATION OF OPERATING VOLTAGE AS A FUNCTION OF FREQUENCY



temperature of cooling water exceeds 20°C during most of the year; this applies more particularly to the countries having tropical climate.

3.2.2. Sundry improvements (examples)

- **Elimination of spark phenomena on tubes:** formation of spark phenomena is due to parasitic discharges consecutive to a distortion in the distribution of electric field at the extremity of the inner metal layer of the glass tube; this phenomenon was studied by graphic method (Lehmann method) and could be eliminated by designing the shape of a metallic connector coupling the inner coating of the glass tube to the high voltage source which follows the shape of the equipotential areas of the electric field: this patented device is a stainless steel part to be inserted in the dielectric tube until it is in contact with the metal coating; this contact is obtained through a cylindrical part also including a truncated cone portion closed by a half-sphere fitted at the top with an element for electric connection to the alternating high voltage surce; the cylindrical and truncated-cone parts include slats whose flexibility provides correct centering inside the tube and good contact with the metal coating lining the glass tube. A detailed description of this device was recently given during a Conference of the International Ozone Association (27).
- **Control of the treatment by ozone:** the MIDES microprocessor type programable logic controller allows the control of both ozone production and distribution of ozonated air between the various towers of the contact chamber in order to assure a preset O_3 residual content at the outlet of each tower.

3.2.3. An example of large scale application in the Far-East

In this part of the world some plants already include a unit for treatment by ozone: an interesting example is the Royal-Orchid-Hotel treatment plant in Thailand, where ozonation of the water filtered through sand is effected before a filtration through granular activated carbon; this represents one of the most advanced treatment lines in the present state of this technique. However, the ozonation unit which is being presently built at the Bedok plant (Singapore) presents the interest of giving an example of application of the most recent improvements of the technique of medium frequency production to a large size plant.

This ozone production unit was designed to treat 6,000 m3/hr with a maximum 6 g/m3 amount of ozone, among which 2 g/m3 in preozonation (a technique whose advantageous effects were above referred to) and 4 g/m3 in disinfection and polishing of clarified water before sand filtration.

Production is ensure by four (4) double ozonizers, each unit being fitted with 710 tubes and producing 12.2 kg ozone per hour (design production is actually even higher but is limited by the cooling water temperature which may reach 30°C): as far as we know, these are the largest apparatus presently existing in the world. These ozonizers are used as follows (they are however made interchangeable by interconnections in the ozonated air circuits):

- one unit for pre-ozonation of raw water,
- two units for main disinfection (located between sedimentation and filtration,
- one unit on standby.

The main original features of this plant are its size and splitted up injection of ozone in water; besides, the following features also worth being mentioned:

- existence of a closed circuit for ozonizer cooling in order to protect the units against corrosion: in effect, chloride content in the water exceeds 150 mg/1 Cl, and conditioning is thus necessary; the water of this circuit is cooled by treated water in a heat exchanger;
- thermal destruction of excess ozone with an 85% recoverey of the applied power (air from the contractor tanks is pre-heated up to a temperature of about 240°C in a heat exchanger in which passes a counter-flow of air at 320°C from the destruction furnace);
- increase in the ozone dilution yield in water (over 90%) due to a water depth in the contractor tanks increased to 5 m.

4. Sundry problems

Space is obviously lacking here to exhaust this wide-ranging subject; however, we shall emphasize the following two points:

4.1. **Biological treatment of underground waters.** Over these last years, we have developed specific treatments for the biological removal of undesirable compounds such as ammonia, nitrates, iron and manganese (12). These treatments make use of bacteria naturally present in the medium. Their reliable and simple operation together with their (generally low investment cost, make them particularly appropriate to developing nations and more precisely to tropical countries where temperature is never a limiting factor.

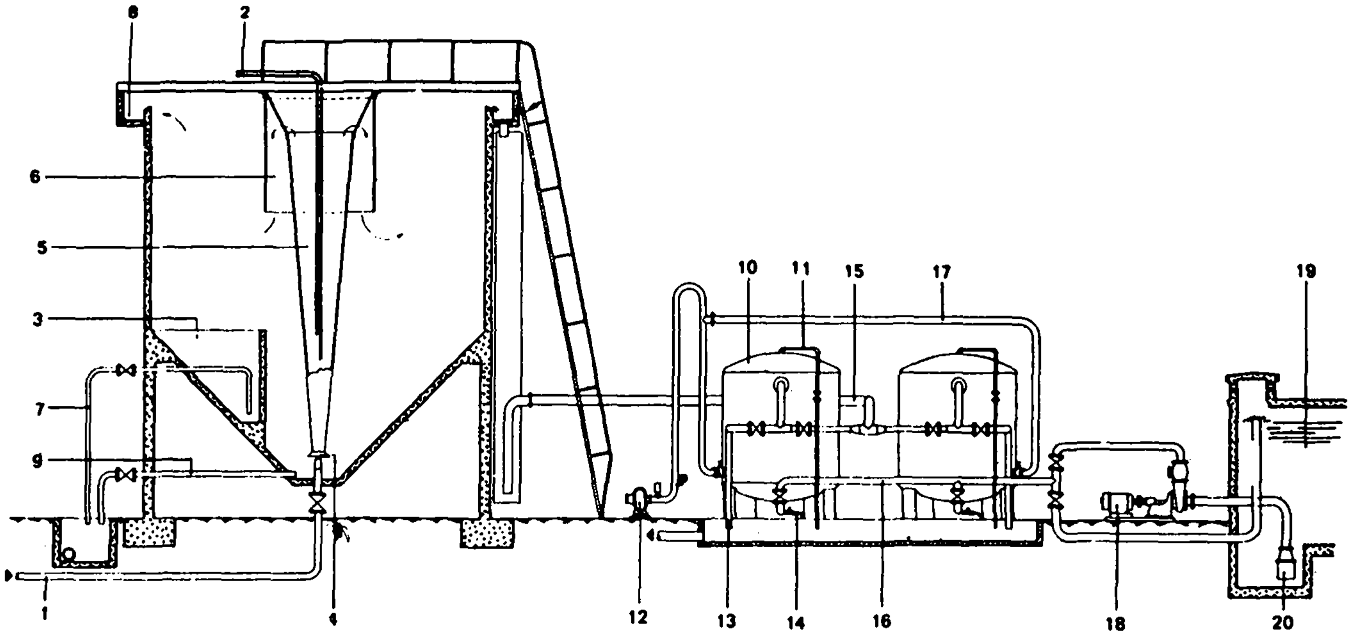
4.2. **Plants for small communities.** A water treatment specialist must be able to find a solution for any output between 1 litre and 10 m3 per second; however, whenever low outputs are concerned, plant running cannot obviously reach the same quality and the technology applied must be simplified. This is why there is a whole range of small plant units, made either of concrete or steel, with either open or pressure filters, conventional or package type, operating by gravity or under pressures etc., thus providing an equipment adapted to each particular case.

We have been installing such units for several years now in samll communities almost everywhere in the world, most frequently in tropical countries, and particularly in Africa. An example of these is given on fig. 26, where the use of a *ettling tank of the sludge contact Circulator type* (where power required for flocculation and recirculation is taken from a differential pressure system at the expense of a slight head-loss in the raw water inlet pipe) makes it possible to do without any mechanical elemnt in motion such as flocculating stirrer turbine, vacuum pump, etc., while producing a treated water of high quality.

Moreover, we believe that this question of water quality should always be present to mind, regardless of the size of the plant and the degree to which technology has been simplified, if only for sanitary reasons: many publications have shown that excessive turbidity could protect pathogenic bacteria against the action of chlorine and favour the entrainment with water of parasites such as cysts of *the protozoa causing amobi:* dysentery and giardiasis, or cercarieae of the worm causing bilharziosis, whose resistance to chlorine is higher than that of bacteria. As result, a water unproperly treatted from the clarification viewpoint may carry pathogenic *organisms even* when the results of tests conducted to detect etst-germs of fecal contamination are negative; in fact, in most cases' the result of treatment mainly depends upon the nature and dosages of the reagents used: this refers more to chemistry than to technology, and a simplification of the latter cannot allow a simplification of the former.

CONSULSION

With all the above we have seen some aspects of the improvement made over the last few years as regards the knowledge of tropical waters and the technological advance with a few to treatment; however, despite these improvements, we have noticed that it remains necessary to study each case separately in order to find a solution specific to each problem posed and corresponding to all the initial data: it is only at this expense that all the treatment plants will deliver a water of high quality which any human being has now a right to aspire to.



1. *Raw water inlet.*
2. *Reagent injector.*
3. *Sludge concentrator.*
4. *Nozzle.*
5. *Mixing chamber.*
6. *Flocculation chamber.*
7. *Sludge outlet.*
8. *Clarified water channel.*
9. *Clarifier drain.*
10. *Filters.*
11. *Air outlet.*
12. *Scour air blower.*
13. *Wash-water outlet.*
14. *Air vent and drain.*
15. *Clarified water inlet.*
16. *Filtered water pipe.*
17. *Blown air header.*
18. *Filtered-water and wash-water lift pump.*
19. *Filtered-water storage tank.*
20. *Filtered-water suction unit.*

Fig. 26 – Functional diagram of an AQUAZUR plant with CIRCULATOR clarifier

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THE NEED FOR STANDARDIZATION AND CENTRALIZATION OF TESTING

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TIRTA DHARMA

INTERNATIONAL WATER SUPPLY ASSOCIATION
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1. Introduction

In developed and developing countries there is a need for the use of standardized materials in many fields. Standards have to be based on the required quality for the purpose for which a material is applied. Once quality requirements are set up there is a need to appraise the quality by testing.
This paper deals with :
– the need for standardization (paragraph 3)
– quality appraisal and certification systems (paragraph 4)
– the need for centralization of testing (paragraph 5).
To introduce the subject paregraph 2 gives a philisophy about product and quality.
Finally in paragraph 6 a description is given concerning the certification system adopted in.
The Netherlands and applied by the Testing and Research Institute of The Netherlands Waterworks KIWA.

2. Product and quality

From times immemorial men has made goods. With his hands and with the aid of simple and self conceived tools. Those tools have been even more perfected resulting in the crafting of not only more refined products but also in greater series.
The handicraft developed to and industry; factories came to existance. They produced even better and finer, but also even more expensive products.
Gradually the question arose whether that was really necessary, whether there was really a need for the products as they were. Also, factories came to compete with with one another: manufacturing the finest product was not always of primary interest, but rather the question to offer the best at the lowest price.
What is the best ? To answer that question the consumer and the product's application are beginning to play an important role.
The consumer gets a need for standardization, especially in the application of mass products. It enables him to make use of products of different manufacture in combination and alongside one another.
But especiallly the question as to what is necessary for the purpose of application, is a relevant one or conversely : what is the needed quality ? And thus one arrives at the key question : "What is quality"?
Quality has objective and subjective facets.
Furthermore it is a dynamic concept : when changing a product's application, its quality must also be adjusted. Frequently therefore quality is defined as : **fitness for purpose.**
It is the extent to which the properties of the product are in accordance with the application requirements. As a consequence quality entails all kinds of aspects such as, effectiveness, safety, reliability, durability, purchase costs, maintenance costs etc. It has also something to do with the availability of raw materials, influences on the environment and energy consumption. The determination of the required quality level should be the concern of all parties involved, roughly implying the interests and responsibilities of government , producers and consumers. Each of those three groups will participate in the discussion from their own viewpoint. Apart from general aspects such as effectiveness and durability, the water supplying industry will have a special interest in such requirements as hygienic reliability, acceptable water consumption and the good functioning in the total system.

3. The need for standardization

In this paper a standard is defined as a technical document describing dimensions, tolerances, requirements for all physical, mechanical and chemical aspects for a certain product and finally it describes the testing methods to determine the conformity of the product with the standard. Thus, if a product meets the standard, it is fit for pupose.
In general this technical document is drawn up with the cooperation of all interests affected by it. It is based on the consolidated results of science, tehnology and experiences and aims at the promotion of optimum comm8nity benefits. The standard is available to the public.
The firs object of standardization has always been an economical one. It prevents uncontrolled differenthiation of products on the basis of uncoordinated specifications of individual consumers. The second object of standardization is a technical one, namely the determination of the fitness for the purpose for which the product is intended. It results in a guaranteed sufficient quality level for the use of products under known and evaluated circumstances.
Especially for the application of mass products the consumer has a definite need for standardization. Use of a product meeting the standard guarantees the quality

(fitness for pupose) and enables the consumer to make use of products of a different manufacture in combination and alongside one another.

The use of standardized products by the water supply industry is of great importance in the planning phase and the phase of operation and maintenance.

During the planning phase it allows for precise specifications of materials and gives a tool for an evaluation of procurement bids.

Successful testing and inspection of materials meeting the standard gives guarantees for the quality level of the materials.

Operation and maintenance are simplified if there is a unifomity in the application of materials.

The quality level guarantee, which inludes the result of standardization, testing and inspection, gives the manufacturer the assurance that the required guality level is fixed and valuable for all manufacturers. For the manufacturers basically there will be no competition on basic quality, falsification or trade barriers.

The choice of materials is based on quality and costs. Product selection on a price basis only—as the quality level has already been satisfied—directs to a more justified and competitive position for each manufacturer.

4. Quality assessment and certification systems

Quality assessment is testing the product as to the quality requirements : the standard of the product. The question is, to what extent should there be a certainty that the delivered product will satisfy the relevant quality reguirements. In any manufacturing process there will be a deviation within certain limits, but they need not always to be unacceptable. Through the manner of quality assessment it can be determined to a considerable degree what certainty with regard to the absence of unacceptable deviations is necessary. But the costs of that certainty must also be considered. In this area too consumers and producers will have a common interest as to the choice of the quality assessment system.

In the international centext the above mentioned quality assessment systems are called **certification systems.** Roughly—omitting a number of less relevant detailes there are three basic systems.

1. Batch testing;
2. Type testing and assess ment of factory quality control and its acceptance followed by surveillance;
3. Assess ment of factory quality control and its acceptance only.

Batch testing is asystem under which a batch of a product is sample tested and from which a verdict on the conformity with the specification is issued.

The second system is based on a sample testing of the product according to a prescribed test method in order to verify the compliance of a model with a specification, with assessment and approval of the manufacturer's wuality control arrangements, followed by regular surveillance through inspection of factory quality control and audit testing of samples from both the open market and the factory.

The third system concerns one under which the manufacturer's capability to produce a product in accordance with the required specification, including the manufacturing methods, quality control and type and routine testing facilities are assessed and approved, in respect of a discrete technology.

These three systems offer a variety of possibilities, and partly they have also certain limitations, advantages and disadvantages. It would lead too far to dwell on these. Yet each of them is indispensable in itself and they provide in certain needs, depending on among others the nature of the product or the production method, the availabi lity of generally accepted quality requirements and the nature of the application. However it might be, it is clear that for the development of any system the willingness to cooperate and mutual trust are a primary precondition. Whatever choice will be made, there will be a need for qualified personnel, measuring and testing equipment and an organization within which all that is going to function, in order to render the system opera—tional. But not only that. One should also realize that the manufacturer is bound for a lot of developmental work within his company. The establishment of a quality assurance system – of which quality control so necessary for certification forms a part—will require investments. He would want to evaluate these burdens against the advantages such a system could yield to his Company in the long term. Certification is a menas of improving industrial perfomance. It can be used as a tool to develop the quality of indigenously manufactured products as a means to substitute imports by giving the consumer a confidence into such suc products. Especially for the manufacturer, a quality assurance system is a better way to improve industrial perfomance. Because only then it will be possible to substitute an otherwise imperfect testing of the final product for a system enabling corrections and adjustments to be made on any moment during production.

Furthermore the results thus obtained may considerably contribute to the improvement of product design and of the production process itself.

5. The need for centralization of testing

After the conclusion that testing and inspection can be very helpful and recommendable it will be clear that the operation of testing and inspection by each water supp company itself is undesirable.

The number, size and irregularity of testing and inspection acitivities make it uneconomical, not to mention the impossibility of permanent availability of testing equipment and laboratories.

The availability on the right moment and in the right place of the right expertise is almost impossible.

The continuity of testing and inspection is also important for the evaluation of the internal quality control of the manufacturer. A regular surveillance gives more than an instantaneous insight.

Centralization offers obviously the principal advantages

as saving of expenses, the availability of specialised expertness, more contineous infomation and the exchange of knowledge and experience in the testing and inspection and in the application.
Summarized one can say that individual testing and inspection has remarkable restrictions which makes it too expensive or organizationally and technically impossible.
These limitations may be avoided in case a centralized system is chosen.

6. Certification and testing by KIWA

In The Netherlands nowadays, there are about a hundred waterworks, which are in hands of the lower governments (provinces and municipalities). They established KIWA in 1948.
During World War II the water industry in The Netherlands considered the possibilities to centralize the testing and inspection of materials purchased by them.
The post war period formed a reconstructional period for the water indsutry regarding the water supply systems and for the building industry regarding the water systems or house installations. After this period reconstruction and development have been permanently present until now with urban and rural developments. Now we can speak about consolidation although because of operation and maintenance especially regarding water systems a substantial quantity of products causes a constant flow on the market.
The quality rating systems chosen by KIWA in 1948 were
- batch inspection
- type testing and quality control assessment.

As far as batch inspection is cenderned, this only relates to the products purchased by the water industry for its own specific use.
In batch inspection the KIWA inspector judges the guality of a batch of products on the basis of the specifications agreed beforehand between the buyer and the manufacturer.
The inspection takes place in the factory, or on the building–site if the products are made there. The request for batch inspection is given in writing for each particular case, the buyer supplying to KIWA all the specifications, details, drawings etc.
The inspector acts upon these directives and does all that is necessary to get a proper insight into the quality of the batch which the manufacturer presents to him for testing.
The inspector gives the accepted products the "KIWA Batch Inpection Mark". Generally an inspection report is submitted to the buyer after each inspection. It is, vien one hand, a confirmation of acceptance (the essential point being that the materals are provided with the mark), on the other hand it gives an insight into the basic quality level of the product.
The cost of the batch inpection are charged to the buyer after the work has been completed.

The centralization of batch inspection activities has sound advantages, such as largely reduced costs and availability of centralized expertise of materials and testing on its own.
However, in spite of centralization, batch inpection was labour intensive from the point of testing technique and organization. Also the agreements on technical specifications, differing from case to case, ask for a continuously lot of efforts.
It was therefore questionnable if in the long run a well balanced relation between costs of inspection and the value of the material could be maintained.
Moreover: could a very flexible organzation required for batch inspection in conformity with the specifition not be used more efficiently in another way.
So KIWA has adopted as an additional method: type testing and quality control assessment.
This certification by KIWA is bases on standards and a set of regulations, stating all the procedure involved. The certification comprises the following elements :

- Application by the manufacturer for certification for a defined product in relation to a particular technical specification or standard.
  Type testing by KIWA, mostly in its own laboratories.
- Assessment of factory quality control by KIWA experts intended to investigate whether the quality control system is sufficient to guarantee that all future products will fulfil the standard.
- On positive results of type testing and quality control assessment KIWA agrees with the manufacturer on the basis of a standard contract in which all rights and duties of both parties are psecified.
- In the contract it will be stated that the manufacturer has the right to put on the "KIWA Quality Mark" on the said produdts.
- The manufacturer is obliged to pay to KIWA a certain fee which amounts to about 0.5 to 1 % of the value ot he products with the mark.
- KIWA is obliged to aregular surveillance on the quality control system of the manufacturer and the conformity of the certified products.

The certification system has been in operation for over 30 years and embraces about 100 different product–bound schemes. The products involved are those purchased by the water industry (pipes, chemicals, valves, hydrants, water meters, check valves etc.) as well as those purchased by plumbers for water systems (pipes, fittings, couplings, flushing cisterns, W.C.–pans, anti–backsiphonage valves etc.).
For this KIWA has concluded contracts with about 200 manufacturers in all countries of Europe.
At the present stage this is a unique situation in the world, where the water industry, by its own Institute, certifies the products for which it has a legal or moral reponsibility.

ANNEXE

QUALITY APPRAISAL BY KIWA

System	Requipments	Relation between	Mark
KIWA Quality Mark	Standards	KIWA and Manufacturer	KIWA Quality mark and Factory mark
KIWA Assessment	KIWA Criteria	KIWA and Manufacturer	KIWA Assessment mark and Factory mark
KIWA Batch inspection	Consumers Specifications	KIWA and Consumer	KIWA Batch inspection mark

QUALITY OF PIPELINES

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QUALITY OF PIPELINES

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1. INTRODUCTION

The pipelines in our modern society are the functional arteries to that society as the normal arteries are to the human body. Pipelines represent an important system of **silent** *transport – mostly underground–, who's importance* may be demonstrated by a simple comparison. In The Netherlands, all the owners of private cars tgether, are responsible for a rather noisy transport of 5 billion ton-kilometer per year; public water supply only, represents a transport of about 30 billion ton-kilometer in the same period. Next to pipelines for water supply, we have pipelines for gas, for oil, for sewerage, for district-heating, for demineralized water and even for milk. The density of pipelines in a society indicates the level of development of that society. In developping countries the density of pipelines is mostly quite small and their transport capacity (in ton-kilometer; or m^3-kilometer for gasses) rather poor. On the other hand, in the modern society of developped countries there is a high density of pipelines with an enormous transport capacity. Taken again The Netherlands as an example: the natural gas transport system (not the distribution system) comprises more than ten thousand kilometer of pipelines with a transport capacity of about 18 trillion m^3-kilometer per year.
If such pipelines or pipeline systems stop their functtioning the result looks like the effect of the stopping of the blood circulation in a human body. Although the latter stopping is directly fatal, also the stopping of a pipeline system represents a severe effect on the modern society: no potable water or energy, or heat or sewage disposal; a complete disorganization of the total society will be the effect.
This paper deals with the measurements which could be taken to reduce the risks of failure of pipelines; in particular attention will be given to the quality systems (as operated by manufacturers or contractors) and to the third-party certification of the compliance to specifications.

2. MEASUREMENTS AGAINST DISTURBANCE

The measurements aqainst disturbance of the society due to the effects of failures of pipelines may be of two different natures, i.c.:
– reduction of risk to fail;
– reducction of effect of failure.

Examples of measurements of the latter nature are:
– the use of parallel pipelines (in particular for water supply in urban areas);
– the storage of the transported medium at the end of the system (example: the storange cisterns for potable water in the U.K.-domestic water systems);
– the planning of repair programmes on the basis of the determination of risks of failure (with special stocks of pipes, joints etc. for immediate repair).

Although these measurements could largely reduce the annoying effects of disturbance in pipelines, there are still negative effects to be considered, such as the annoyance for the noisy, above-ground transport system (traffic jams, diversions), the reduction of retail selling when streets in the city are blocked, and last but not least the stop in production when the transported medium is directly supplied into the production process as is sometimes the case in small factories where no storage capacity before the production process is avaliable.
The reduction of the effect of failures does, by the effect of its measurements, not interfere with the origin of the failure.
This is only the case when the risk of failure is reduced by appropriate measurements.
The aim of such measurements could be described as the improvement of the **"fitness for purpose"** or the **quality.**

3. QUALITY

In the everyday life the word **quality** *is mostly misused,* in particular in advertising, witness of expressions, such as "export quality", "super quality", "honest quality", yes even "fantastic quality".
In our context quality indicates the fitness for purpose. This is a rather short indication of what quality means. A more detailed definition of quality is: the extent to which the properties of a product (or a service of a process) comply with the specifications derived from the aimed use. And as quality is the basis of successful business entreprise, "quality" could also be defined as "the whole of the properties of a product that satifies customer expectations at a price he is willing to pay". In these definitions, on a more or less direct way, indication is given of the specification to which the product (or the service) has to comply. It seems therefore

necessary to consider the subject of these specifications more in detail.
Before that, it might have been noticed that the word quality is not only used in relation to a product (from a manufacturer) but also in relation to a service, such as delivered by the contractor of pipelines. The word even applies to a process such as the (technical) management of a pipeline system, as performed by or on behalf of the owner of the system.

4. SPECIFICATIONS

In the previous chapter it has been outlined that the word "qualuty" should not be regarded only in relation to the product of a factory but also in relation to the service, as delivered by the contractor of the pipeline system or to the process, as performaed by the maintenance-manager of the pipeline system.
It is obvious chat the specifications for the product differ largely from those for the contracting service and from those for the maintenance process.
In the following considerations a restriction of approach will be made, i.e. that only the specifications for the product will be considered.
In contrast wit all private consumer markets, the pipeline market is characterized by a high level of direct and frequent contact between the supplier and the customer. This characteristic aspect finds his origin in the rather important (financial) value of such projects and in the more unique aspects which differ from project to project.
In spite of the direct and frequent contact between the parties concerned, the following questions always arise:
– has the customer fully and accurately defined his requirements/specifications;
– has the manufacturer fully understood the requirements/specifications;
– can the manufacturer satisfy these requirements/ specifications.
As said before, the technical aspects of a pipeline project may differ largely from project to project. This could even lead to rather unique specifications for the materials to be used.
Nevertheless, it is evident that the use of standardized materials/products manufactured on the basis of general specifications could offer several advantages to manufacturers, contractors and customers.
The advantages for the manufacturer are :
– standardized production;
– more efficiency;
– no "over-asking" clients;
– rather simple stockholding.
Although other manufacturers, making the same produts should be regarded as competitors, these others offer him at the same time the possiblility to compare his products with those from the others.
For the contractor the advantages of standardized materials are found in more experience and knowledge in the actual construction work.
Finally, the cutomer will find his advantages demontrated by
– a larger market to purchase the products;
– an easy comparison of prices;
– mostly lower prices due to the more effective competition of manufacturers;
– a better insight in the behaviour of the products under practical conditions.
– the possibility to work with a rather reduced stock of spare parts.
The central point in most countries, to define the specifications for such standardized products/materials, is formed by the nastional standards institute in their national standardization committees.
In order to obtain good standards two basic conditions have to be fulfilled, i.e. :
– the standarization committee shall be formed by all parties concerned, thus manufacturer, users, constructors, dealers etc.;
– the level of the standard to be written shall fully reflect the good experiences with the products in practice.
In both conditions fulfilled lie the basis for the aforesaid advantages for manufacturers, constructors and customers.

5. QUALITY MAKERS

The quality of a pipeline (thus in short; the fitness for purpose) is the final result of different steps, which could be defined as quality steps. These steps are taken by the following bodies:
o the **customer** or client who orders for the pipeline; on his own or with the help of his consultant he translates the practical conditions into the complete specification; on this level he defines the answers to all aspects such as mechanical and chemical properties of the soil, aggressivity of the fluid to be transported, rate of flow, working pressure etc.
o the **manufacturer** whi answers the complete specification by the specifications of the different elements for the pipelines such as pipes, flanges, joints, coatings etc. In case the specifications for the elemnts are laid down in national or international standards he may refer to these documents.
o the **contractor** who, on the same way as the manufacturer has done for the different elemnts, offers the service of contruction on the basis of the complete specification.
o the **maintenance body** (the customer himself or a body on his instruction) who, also on the same way as the manufacturer has done, offers the service of maintenance as specified in the complete specification.
Since there is no fundamental difference in the quality steps to be taken by the manufacturer or by the other bodies (contractor or maintenance body), an outline of the manufacturers' quality steps could demonstrate

very well the level and the impact of the steps of the other bodies.

6. QUALITY STEPS BY MANUFACTURERS

Taken into account the "business definition" of quality (see § 3 : "the whole of the properties of a product that satisfies customer expectations at a price he is willing to pay"), the manufacturer has to arrange the whole of his manufacturingactivities, i.e. from purchasing raw materials until delivery of the product to his customer, with the primary objective to satisfy the customer of his product.

From this objective, within the whole of the manufacturing process, the manufacturer will arrange for a **quality system** in which the different steps together aim at that final target: to accomplish satisfaction from the customer. All the operational techniques and activities performed by the manufacturer, necessary for achieving and maintaining the required quality are known as the **quality control**. Within this framework, keeping the quality system at the required level, including the demonstration of that system being in conformity with the required conditions is called **quality assurance**. This quality assurance extends over the whole of the manufacturers' activities. Examples are :

- purchasing procedure;
- inspection procedures on purchased goods, such as raw materials, semi-manufactured products, accessories, etc.;
- storage of purchased accessories (to prevent contamination of degradation of properties; e.g. influence of storage conditions on rubber joints);
- manufacturing process (maintenance of equipment, instruction to personnel);
- procedures of inspection and control during production (e.g. sampling frequency and subsequent investigation);
- equipment for measurement and inspection (e.g. accuracy, calibration, reproducibility, maintenance and management);
- storage of finished products;
- transport to customer (e.g. risks of damage, environmental conditions, packing);
- instructions for installation, use and maintenance.

From all these aspects it may be seen that not only the quality department of the factory is involved, but all the members of the personnel. This indicates that quality is everybody's concern and responsibility.

Taken the quality of the products to be delivered as the starting point, the costs of quality control have to be considered in connection with a series of related costs.

Roughly speaking these related costs could be indicated as follows:

- the costs from external failures (thus after delivery on complaint of the customer);
- the costs from internal selection before delivery;
- the costs from internal failures on the basis of inspection and subsequent appraisal during production;
- the prevention costs related to the inspection procedures on purchased materials and foods.

Taken as basis the essential elements of the the "business definition" of quality, i.e. satisfaction and price, it may be obvious that all these costs of quality control should be related to these elemnts of satiscaftion and price.

Practice of modern quality control has demonstrated in the past decades that an equilibrium of costs may be obtained with finanlly a total of costs on a lower level than in case no reasobable quality assurance was performed.

Main point in this is the demonstration of quality (or of the presence of quality assurance).

7. DEMONSTRATION OF QUALITY

In the same context as the misuse of the word quality (see S 3) stands also the demonstration of the quality by those responsible for the quality, witness of expressions such as "we deliver the best quality", "under electronic quality control" and "every product checked before delivery".

Taken the demonstration of quality as a basic point the question arises in whose interest quality have to be demonstrated. On the first sight it is obvious that the main interest lies with the customer of the product of which the quality have to be demonstrated.

Further consideration may lead to the opinion that also the manufacturer may have an interest in an impartial demonstration of the quality of his products. For he, in such cases, will find himself in fair and equal position with this competitors.

Since World War II, the impartial and independent KIWA-institute in The Netherlands has worked for over 35 years in this field of demontration of quality for materials for all types of pipelines (water, gas, oil, sewerage) and products for water systems. There are several ways to demonstrate the quality or, effectively, appraise the quality or materials of which two have found a large application and that not only in The Netherlands.

These two appraisal systems are :

- batch inspection (by a testing and inspection agency);
- certification (by a certification body);

for which the testing and inspection agency (TIA) and the certification body (CB) may be incorporated in the same institute.

In batch inspection the TIA inspects the batch of a product on the basis of specifications which have been agreed upon between customer and manufacturer. The batch inspection report defines the properties of the sampled products of that batch in terms of compliance with the specification; it has no value for other batches of that product from the same manufacturer and this for two reasons :

- only for the inspected batch the agreed specification apply;

the sampling took only place from that particular batch.

Although batch inspection is a well known and largely used system for quality appraisal, some disadvantages of that system should be montioned:

- batch inspection only applies to properties which may be determined on finished products on an easy way; properties which may only be determined during production (e.g. the prestressing of the steel in prestressed concrete pipes) or which require long term testing (e.g. endurance testing of plastic pipes) can not be covered by batch inspection;
- batch inspection practices do not stimulate in the direction of drafting standarized materials specifications;
- batch inspection may be a rather expensive method for quality appraisal.

It was a logical follow-up of batch inspection that (third party) certification was developed.

Basic elemnts of third party certification are :

- the impartial and independent status of the certification body;
- the conformity for the certified products to national (or even international) standards;
- the evaluation and approval of an acceptable quality system with the manufacturer;
- the regular control on product conformity and level of quality system through surveillance by the certification body.

As may be concluded from these elemnts of certification some of the disadvantages of batch inspection are elimenated by certification since all the properties of the products are covered and also the use of standardized products is promoted.

In the situation in The Netherlands certification has become well known and appreciated by both customers and manufacturers; it is an effective and rather cheap system to confirm, in an impartial and independent way, that a manufacturers' quality assurance is performed on the required level and that his products meets the harmonised (through standards) specifications.

8. CONSULTANCY WITH BATCH INSPECTION.

In spite of all efforts from standards institutes, manufacturers and users, there will always be fields in which no standards will be available and, consequently, no certification will be possible.

These fields may be identified in two different ways:

- cases in which newly developed products are marketed and for which products no standards could be drafted since the good experience in practice is missing;
- cases in which products have been designed and constructed or manufactured in a direct, conditional relation with the particular use of these products.

As has been the experience in The Netherlands, these two fields are making a good profit of the batch inspection services.

This good profit could be achived by the KIWA practice not to accept orders for batch inspection in case the quality system of the factory concerned was not evaluated or even not known. A second point favourable for this good profit has been the consultancy service offered to customers in view of the drafting of their specifications and of the main objectives in relation to the evaluation of the quality control during production. The combination of consultancy service and batch inspection service is applied for several materials and products; aprticular examples to demonstrate the possibilities of a good profit of this combination of services may be found at prestressed concrete pipes and pipes of glass fibre reinforced plastics (GFR).

A final remark in relation to batch inspection is the following. With the batch inspection service, and in particular when this service is performed in combination with the consultancy service, a good start is given in the direction of drafting standards for that product, since harmonisation of specifications and coordination of the collection of practical experience is of basic imprtance for standardization.

9. SUMMARY

This paper, dealing in a general way with the quality of pipelines, has given on outline of all the different aspects and functions which relate to that quality. Within this, not only the quality of the goods supplied by the manufacturer have been discussed, but also the quality of the services performed by the contractor and the maintenance body of the pipeline system.

Within this field of interest, quality is not the task only of the quality department of the manufacturer but the task of everybody on the total line from raw materials, over the production of pipeline elements, to the complete installation and subsequent maintenance of pipeline systems.

As a demonstration of delivered quality a third party certification system or a batch inspection service may be required for that demonstration. It has been indicated that a batch inspection service, in combination with a consultancy service, might bring an advantage to the customer who has required such services.

In both cases, certification system of batch inspection, the obtained experience with material properties is of great value to the standardization of these materials.

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NEW MATERIALS FOR SAFE AND ECONOMICAL DRINKING–WATER PIPELINES

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1. GENERAL INTRODUCTION

Pipelines, which carry water to people's homes, greatly improve living conditions, with regard to both hygiene and convenience. The water consumption figures in highly industrialised countries–200–300 1 drinking–water per inhabitant per day–speak for themselves. Futhermore, in order to establish industrial plants it is essential to have a sufficient supply of water, thereby completing the cycle.

High demands are placed on drinking–water pipelinces: as far as possible the planning and operation must gurantee troble-free running for decades. The quality of the water should not be affected either by the pipes or by their component parts. It must be possible to construct permanent leakproof pipe joints under building site conditions. These were the aims aspired to 2000 years ago, when water transport pipelines were built in stone or wood. Due to the limited technical possibilities at that time, not all these wishes could be fulfilled by such constructions. It was only as technology developed further that new basic condiotions were provided. Thus, for example, metal pipes are lined with cement to prevent undesirable interaction between water and iron. Such measures, in some cases augmented by external corrosion protection on a large scale, have no small influence on price and weight. So it is no wonder that a material was sought which would, to the greatest possible extent, possess the properties desired in a water pipe. Today it is justified to state that this alternative has been found: pressure pipes in the thermoplastic mateials unplasticised Polyvinyl Chloride (abbreviated to uPVC), and Polyethylene (abreviated to Pe). Pipes in this material offer technical and commercial advantages. The pipes are light in weight. They can easily be laid by hand, without mechanical equipment being required. Illustration 1 shows the comparative weights of pipes in customary, standaridised materials. Plastic pipes do not require any corrosion protection, either internally or externally. The material is not attacked or influenced either by soil or by water, irrespective of their characteristics. On the other hand, the water is not affected by the pipe material either, and the significance of this fact sould not be understimated. No changes occur in the pH value, which can happen in the case of materials combined with cement.

Jointing techniques have been perfected. Pipe joints can easily be made under site conditions. The joints are, on the other hand, completely leakproof during the leakage test and in operation. A complete range of pipes, fittings and valves makes it possible to construct pipelines consisting largely of the same material. The pipes have excellent hydraulic properties. They are not only smooth on the outside, but on the inside too, thus considerably reducing rectional losses in the pipe. Due to the smooth surface and the chemical resistance there is no tendency towards the formation of deposits.

There is also a commercial benefit in addition to the technical advantages : pressure pipes in thermoplastic materials are moderately priced, and this has a favourable influence on investment costs.

Viewed as a whole, these aspects must be considered advantageous. Some of them will be dealt wiht in detail as follows. Furthermore, advice will be given on the planning and execution of such installations.

2. STANDARDISATION AND WIDESPREAD APPLICATION OF PLASTIC DRINKING WATER PIPES.

Standardisation is a basic requirement for interchangeability, and this in turn is a pre-requisite for rationalised stock–keeping and trouble–free operation of the pipe system. The standardisation of plastic pipes was, therefore brought in to being at avery early date. The first Standards for pipes in uPVC appeared in 1941, stipulating dimensions and quality. That was around 5 years after installation of the first PVC pipes in drinking–water pipelines.

Today, all the important data for pipes, fittings and valves in uPVC an PE are laid down in numerous national Standards, and also in the ISO Standards. Thus, within the same sizing system, world–wide interchangeability is guaranteed.

In many countries the proportion of plastic drinking–water pipes in the total mains network exceeds 25%. With regard to this figure, it must be taken into consideration that in many areas the plastic pipe has only been integrated into existing mains networks during the last two decades. As a comparison, the proportion of plastic mains pipes in new installations is in many places well'over 50% annually. For service connections, both PVC pipes and–in many countries–PE pipes are used.

3. CHOICE OF MATERIAL AND SIZING PRINCIPLES

As mentioned previously, two thermoplastic materials are given preference in this field of application, uPVC and PE. Varying from region to region, PE is in some cases divided into highdensity PE (HDPE) and low–density PE (LDPE). The latter is preferred for use in northern latitudes, as the flexibility of LDPE pipes is superior to that of HDPE pipes at low temperatures. The material stresses permissible for uPVC, HDPE and LDPE are in the ratio 4 : 2 : 1. The wall thicknesses of the pipes are determined by means of the following formula :

$$s = \frac{p \cdot d_e}{2 \cdot Q + p}$$

whereby s = pipe wall thickness
d_e = pipe outside diameter
Q = permissible material stress
p = nominal pressure, i.e. max. working pressure at 20^{o} C

From this it can be seen that the wall thickness of a PVC pipe is much less than that of a PE pipe. The ratio of PVC to HDPE is 1 : 2. The inside diameter of a PVC pipe, and, therefore, its transport capacity, is around 18% larger than that of a HDPE pipe with the same outside diameter and nominal pressure rating. The price and weight per metre are also influenced (illustration 2). As a result of this, the following practice has evolved : PVC pipes are used predominantly for mains, i.e. for pipelines with a nominal bore of 80 mm and above. The pipes are supplied in straight lengths between 5 and 15 m long. Each pipe has a socket formed at one end to accommodate the sealing ring and the end of the connecting pipe. Pipes which are plain at both ends are used less frequently. In this case, jointing is carried out with the aid of double sockets.
Today the use of PVC pressure pipes is advantageous up to DN 500.
For the smaller diameter range, i.e. for service connections up to an outside diameter of 63 mm, it is of advantage to use PE pipes. The pipes are delivered in coils up to several hundred metres in length. The actual length required can easily be cut off the coil. The connections at both pipe ends are carried out by means of suitable jointing elements.

Illustration 3 is a diargram showing the concept of a drinking water supply system in plastic : the mains are in PVC and the service connections in PE. PVC is preferable to PE for cold–water pipes inside buildings. The material is predestinated for use in domestic installations, due to the large assortment of fittings and the simple solvent cement jointing method.
What lifespan can be expected for PVC or PE drinking water pipelines ? The wall thicknesses of standardised pipes are so dimentsioned that, even after a working life of 50 years at the nominal pressure and at the nominal temperature of 20^{o}C, there is a sufficient safety margin against fracture. The safety factors vary sligthly, depending upon the material properties of PVC and PE, and lie between 2.5 for PVC and 1.6 for HDPE. The safety factor is calculated, by the way, from the quotint of the long –term be haviour over 50 years and the per missible pipe stread Q perm.

This is shown in illustration 4, a diagram of the long–term behaviour, using PVC as an example. As the long–term behaviour graph represents a minimal curve with the minimum requirements placed on the material, and in practice the actual working pressures usually lie below the nominal pressure, as a rule the safety factor is, in effect, greater. For working pressures above 10 bar, the Standard also includes pipes of pressure rating PN 16. These are normally only required in special cases.

4. PIPE JOINTS AND FITTINGS

Various jointing methods are used, depending upon the pipe material. Site conditions also influence the choice; faultless pipe joints must be guaranteed even under difficult local conditions, or in cases where the personnel are less specialised. The jointing methods for PVC and PE pipes are different, which is why they are described separately as follows :

4.1 PIPE JOINTS, FITTINGS AND VALVES FOR PVC PRESSURE PIPELINES.

For buried PVC pipelines, the rubber–sealed push–fit joint has prevailed. The solvent cement joint used in the 1950's is today reserved for applications where load–taking joints are required, in other words where the axial force resulting from the internal pressure must be taken up by the pipeline. It must be taken into consideration that under the often difficult trench conditions sovent cement joints place high demands on the installation personnel. In comparison, rubber–sealed push–fit joints are uncomplicated and less sensitive to dampness or misalignment.
Sockets are provided at the pipe ends and on the fittings. The pipe wall thickness in the socket area is greater than that of the pipe, to ensure the same stress conditions. As the fittings are provided with socktes on all sides, a certain surplus of sockets occurs during installation, so that the cut–off pieces of pipes which have been shortened can generally be utilised without requiring special double sockets. Pipes with the socket formed at the pipe end have an advantage over pipes with plain ends, in that there are practically only half the number of pipe joints to be mode the basic risk of a leaky joint is thus reduced.
The sealing ring which fits in the seal groove may have a round section (illustration 5) or a ribbed section. Both systems have proved satisfactory. The ribbed section sealing ring has the advantage that the joints are much easier to construct, as less pressure is required to compress the seal during jointing.
Both sealing systems are leakproof both in the case of overpressure or a vacuum. Thus, in the case of a vacuum accurring during abreakdown, the suction of impurities into the drinking–water pipeline can be avoided. The

sealing rings are either delivered separately from the pipe or fitting, or already assembled by the manufacturer. In the latter case it is of advantage to use caps to close the socket openings in order to prevent the seal area from becoming soiled.

Fittings are available in cast iron and in PVC. Metal fittings are preferred for nominal bores above 200, as injection moulded PVC fittings are not yet available in these sizes. PVC fittings offer the advantage, which should not be underestimated, that the entire pipeline can be constructed in one material. Components prone to corrosion are thus eliminated, the fisks reduced. Fittings, which have also been standardised, are available in the appropriate designs. There are tees with 3 sockets, or tees with flange outlets, in models with 3 equally large or with reducing outlets (illustration 6). Also available are flange adaptors either with a socket or a spigot end as well as reducers. Bends from 11^o to 90^o are formed from pipe. The radius of curve lies at $3.5 \times d_e$.

Special tapping saddles consisting entirely of PVC have been developed for the construction of service connections (illustration 7). Only the integral cutter in the tapping saddle is made of brass. Mounting is extremely simple ; only a hammer is required and a tool to operate the cutter. It makes no difference whether the pipeline is dry or under internal pressure. The tapping procedure is just as simple to carry out in both cases. The disc out from the pipe and the shavings are retained permantly in the cutter. They cannat possibly well out (illustration 8).

The cutter remains in the saddle after tapping. In case of emergency it is possible to screw down the cutter at a later date to shut off the service connection. A PE pipe can be connected directly to the tapping saddle, once again avoiding metal components, by means of a special compression joint. A simpler and more technically perfect solution can hadly be imagined.

If a shut–off valve is to be built into the mains pipe, a some–what different design is required, enabling the valve to be screwed directly into the pipe saddle.
A gate valve has veen developed to shut off the mains, the body and gate of which are also completely in PVC. Only the stem and the stem nut are made of rust–proof steel. The only metal part projecting on th outside is the square to connect the operating rod. The upper section is connected to the actual gate valve body by means of a so–called shell coupling. After removal of the shell coupling, the complete upper section of the gate valve, including the gate, can be removed in an upward direction : an ideal solution for maintenance or revision work. The gate valve is supplied with push–fit sockets or with adaptors for flange connections * at both ends (illustration 9). ** The aim of constructing a drinking–water pipeline completely in plastic has thus virtually been achieved.

4.2. PIPE JOINTS AND FITTINGS FOR PE PRESSURE PIPELINES.

For reasons of economy and installation technology, the use of PE pressure pipes with diameters above 63 mm is generally restricted to special applications. Such cases will not be treated in detail at this point. The domain of PE pressure pipes is the service connection, i.e. the link between the mains and the building to be connected. The diameter range in question for this purpose lies between 20 and 63 mm.
For PE pipes there are, basically, two customary jointing methods : fusion joints and mechanical joints. Whilst fusion jointing plays an indispensable part in PE gas lines, it has not prevailed in the case of water pipelines. Here the mechanical joint is predominant.

* or for shell coupling connections at both ends
** if shell couplingsare used, there will be no need to use screws or other metallic parts.

This is certainly partly due to the fact that normally only two joints have to be made per service connection: one to the tapping saddle and the second at the point of entry into the building to be supplied. Here too, the site conditions have an influence on the choice : the mehcanical joint is easily constructed, without requiring fusion apparatus and a power supply.
Mechanical joints are available in both metal and in plastic. The metal ones are predominantly in brass. They are mainly in the form of adaptor fittings : at one end the connection for the PE pipe and at the other end a female or male thread for connection to a valve. Plastic joints are made of uPVC or another suitable plastic. One model, in PVC, ensures uniformity with the tapping saddle described and illustrated above. This fitting does not only allow jointing to PE pipe but also to pipes of other materials, such as PVC, steel of copper for example. Various types of transition joint can be carried out easily in this way. It is merely necessary to select the appropriate connecting elements for the PVC fitting body (illustration 10).
There are many types of mechanical joint for PE pipes. It would go too far, and is not the pupose of this article, to go into every detail.
When selcting such joints, it is important to ensure that they are leakproof in the event of both overpressure or a vacuum. They should also be sufficiently save against the pipe being pulled out of the joint, to prevent leakage as a result of earth movement.

4.3. FITTINGS FOR PIPES OF VARIOUS MATERIALS.

When building plastic pipelinces it is time and again necessary to make connections to existing buried pipelines in other materials. These can have flange connections or plain pipe ends. For both situations, a special range of fittings offers ideal jointing possibilities : fittings in ductile cast iron, clad inside and outside with a special synthetic resin, allow connection to pipes of steel, cast iron, asbestos cement and plastic. Pipe of such different materials which have been, and still are, used in water supply systems, have varying pipe outside diameters. The fittings mentioned here make it possible to take up the different diameters. In this way, for example, a PVC pipe can be connected to one end of a double socket, whilst at the other end a connection can be made to a pipe in cast iron, steel, or asbestos cement. When ordering, the outside diameters of the pipes to be connected should be given. Tees with socket or flange outlets, flanged sockets, double sockets and reducing fittings are only some of the types available. The range of nominal bores extends from 50 – 400 mm. Thick trapezoidal sealing rings make it possible to take up greater tolerances as well as angular deflection of the connected pipe (illustration 11).

5. STORAGE, TRANSPORT AND INSTALLATION.

Due to the relatively low module of elasticity of PVC and PE it is necessary to limit the height of the pipe stacks during storage. The weight of the pipes can otherwise cause permanent deformation resulting in ovality. In the case of PVC piping in straight lengths, the height of the stacks should as arule not exceed 1.5 m. If PE piping in straight lengths is employed, the height of the stacks should not exceed 1.0 m. Coiled PE pipes are best stored on a flat surface. It is of advantage to fit the coil on a reel in order to unroll the required lengths tidily.

During transport the whole length of the pipes should be supported. As a rule, loading and unloading can be carried out by hand, but the pipes must not be thrown. Only in the case of palleted pipe budles is it necessary to use a mechanical lifter.

Where the ground conditions are suitable, plastic pipes can be laid very cheaply. The trench can be narrow. Care must be taken, however, to ensure that the trench–bottom is free from stones.

Individual stones can cause local stresses in the pipe, thus giving rise to stress peaks.

When constructing push–fit joints, the pipe is normally pushed in to the complete depth of the socket. Transvere contraction of the pipe when put under pressure, or caused by a drop in temperature when the pipeline is filled, has the effect that the pipe retracts slightly from the base of the socket. The light weight of push-fit fittings in PVC helps to facilitate installation work (illustration 12). The incorporation of PVC gate valves is also extremely simple (illustration 13). No construction machinery is required to transport the components. It goes without saying that it is necessary to weight the PVC pipes with soil between the push–fit joints before carrying out the leakage test, to prevent the joints from sliding apart. It is of advantage to leave the joints uncovered during the leakage test, so that a visual examination is possible. Tees, bends and end–pieces must be given sufficient support, unless the joints are load–taking. The test pressure may not exceed the maximum permissible working pressure – this corresponds to the nominal pressure – by more than 1.5 times. As a general rule : test pressure = nominal pressure + 5 bar.

It is not advisable to construct the service connection until after the leakage test has been carried out. This causes the least hindrance to the progress of the installation. Using PVC tapping saddles with built–in cutter (illustration 14) it is very simple to tap the pipe. A tapping tool is not required. A simple key is sufficient. A loss of pressure can be observed during leakage testing of the PE service connection, which is caused by transverse contraction of the pipe. This is due to the material. It is generally sufficient to carry out a visual examination, as there are normally only a few joints to be checked.

6. SUMMARY

Today, plastic pipes are used extensively all over the world for the construction of drinking–water pipelines. The cost/profit ratio is convincing. The investment costs are moderate in comparison with other types of execution. The life expectancy of a plastic pipeline is high, whereas maintenance costs are low. Neither soil nor water corrode PVC or PE components.

Protective measures against corrosion are, therefore, unnecessary. The material meets all the hygienic and toxicological demands which are placed on a construction material to be used in drinking–water pipelines. The low roughness value of the material – k = 0.007 mm–has a positive influence on the amount of energy required to transport the water, and thus on the level of the running costs.

Processing and installation are easy due to the simple jointing methods and the light weight of the material. It is, however, essential to make the installation personnel familiar with the special features of the installation techniques for plastic pipelines, before installation commences. Suitable training courses are offered by the appropiate quarters.

The expert has been handed a new material for pipeline construction in the form of plastic pipes. The material offers a considerable number of advantages. The complete range of system components makes it possible to construct pipelines which, almost without exception, consist entirely of plastic. The proportion of well over 50% plastic pipelines in new constructions in many countries is the best proof that with this material a new chapter has begun in the construction of drinking–water pipelines.

COATED CARBON STEEL PIPE – AN ATTEMPT AT MAXIMUM UTILIZATION OF DOMESTIC PRODUCT FOR WATER SUPPLY PIPING

Ir. Aburizal Bakrie

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INTRODUCTION

The impact of the world economic recession has been enormous. Most of the western nations are confronted with the declining output and rising unemployment. The debts of developing nations (aside from a few oil producers) continue to mount. A new specter of rising prices is brought forcibly to some of the third world's attention in what becomes known as "double digit inflation".

As one of the major oil producers, Indonesia must nevertheless fasten her belt in the face of international economic stagnation, instability and uncertainty. The acceleration of development of water supply and sanitation must, therefore, reconsider measures which will more efficiently use available resources. Within this framework, this working paper is presented. It places greater emphasis product, especially coated carbon steel pipe for the development of water supply systems.

It is my sincere hope that this working paper will prove helpful to those who have the well-being and health of the Indonesian people at heart.

WATER SUPPLY AND SANITATION PROGRAM

Recent Health Progress

Water supply and sanitation program is closely related to Government efforts to inprove health conditions. The period 1940-1955 was marked by a sharp deterioration of health conditions. Smallpox, plague and cholera were epidemic; malaria, yaws and tuberculosis were widespread; malnutrition was ubiquitous. The Government mobilized efforts to combat the spread of specific deseases, but it was not until 1968 that any overall startegy of health development was formulated as part of Repelita I (first five-year development plan). The policy of the Indonesian Government since that time of wide coverage of basic health services in both rural and urban areas. By and large, Indonesia has avoided the development of an elite, urban-oriented health service. For example, large modern hospitals, which typically receive most attention in other developing countries, have not been overexpanded or over-equipped.

By almost every measure, the provision of health care facilities has dramatically improved in recent years. For example the total number of health centers has risen form 1,050 at the beginning of Repelita I to about 5,000 at the end of 1981. Every kabupaten (regency) will soon have a hospital and every kecamatan (sub-regency) has at least one health center (Puskesmas), and often more. In addition, there are now about 10,400 sub-health centers and health posts, and about 1,200 hospitals with about 100,000 beds.

The development of health manpower has paralled the pace and direction of infrastructural growth. During Repelita II, there was a remarkable increase in the number of health workers, with an approximate doubling in almost all categories. Since then, emphasis has been placed on improvement in the quality of training and rationalization of numerous categories of para-medical workers. Health sector growth is also reflected in the consumption of drugs, which has grown by 15 - 20 % annualy since 1969.

Total drug consumption was estimated at US$. 450 million in 1980. Of this amount, about 15% was financed by the public sector and 98% of all drugs were produced in Indonesia.

Although a detailed assessment of changes in health status in Indonesai is hampered by data problems, there is no doubt that over the last decade improvements in the most comprehensive measures - life expectancy and infant mortality - have been dramatic. Reductions in infant mortality and increased in life expectancy compare very favourably with other countries over the same period. Each year in the 1970's, infant could on average expect to live over eight months longer than infants born in the previous year. This progress was probably over 50% greater than the average for all low-income countries.

Water Supply and Sanitation

In the 1970's, urban water supply development was concentrated in the large cities, mostly those with 100,000 or more inhabitants. Projects were undertaken in 38 such cities. During the decade, production capacity in urban areas rose from 9,000 to over 21,000 liters per second. Water supply programs in rural areas, financed principally under INPRES programs, brought water to an additional 10 million people in the 1970's. During the same period, however the rural population rose by 20 million. By 1981, 40% of the urban population and 18% of the rural population had access to safe water.

The pace of development of services had to be accelerated. In mid-1981 the Government set targets for the decade ahead, and the improvement in the level of urban services in 150 small towns, 40 medium sized cities, and 10 large cities.

The needs in rural areas are immense. If targets are to be met, an additional 60 million people in over 30,000 villages will be supplied with clean water by 1990.

A dramatically expanded program would require simple technical standards. The needs of smaller cities and rural areas are different and often technically simpler than those of major cities. Urban water supply systems, which have been criticized for being "over-engineered", are gradually simplified. For the expansion of the programs to smaller towns, Cipta Karya has produced manuals. Experiments are also undertaken in rural areas with the aim of simplifying technical standards. In fact, accuracy can, to a certain extent, be sacrificed as long as it is still tolerable, the goal being to give people access to safe water.

" COATED CARBON PIPE - AN ATTEMPT AT MAXIMUM UTILIZATION OF DOMESTIC PRODUCT FOR WATER SUPPLY PIPING "

Capability of domestic pipe industry

Large-scale development of water supply systems will be successful if sustained by ample availability of pipe, to mention one of the items of equipment required.

An illustration of the size and scope of the water supply program has been given. Let us now glance at the capability of the domestic pipe industry.

The history of pipe manufacturing in Indonesia dates back to 1959 when the first plant producing mainly pipes of small diameters was established. They were pipes for electric insulation, furniture, bicycle frame and the like. As time went by and in line with the technological development, the industry is today capable or producing larger diameter pipes for various applications in accordance with international standards such as BS 1387/1967, ASTM A53/A120/A252, JIS Q3444/STK 41, API 5L and 5 LX. The American Petroleum Institute in Houston, Texas, has granted two major Indonesian manufacturers licenses to use API monogram on their line pipes. The manufacturers authorized by the API are PT .Bakrie & Brothers and PT. Krakatau Steel. The ability of the pipe industry here to produce quality pipes is, in fact, beyond doubt.

With 19 carbon steel pipe plants in operation, Indonesia has a total production capacity of 531,000 tons per annum, 60% or which is earmarked for water pipe. Unfortunately, the maximum capacity has not been attained so far. This is largely due to insufficient market.

Large-scale water supply program will, no doubt, create an adequate market and ensure that production of water pipes in Indonesia will be in full swing. Modification in design criteria and preference to the utilization of domestic product will help serve the purpose.

Some socio-economic advantages

The maximum utilization of pipe produced in Indonesia, especially coated carbon steel pipe which will ensure its longer life time or technical durability, is strongly recommended. The advantages are obvious among them :

a). The saving of foreign exchange by restricting imports or producing import substituting pipe at home;

b). Processing substantial quantity of raw material available at home PT. Krakatau Steel has, in fact, been able to produce hot and cold rolled steel sheets;

c). creating more job opportunities.

The lull or slowdown brought about by a prolonged recession to the industry is national problem. Large-scale water supply program would bring one segment of the industry back to activity with the socio-economic advantages that entail. It may keep a balance between expansion, inflation and employment.

Pipe Manufacture

Many different processes are used in the manufacture of pipe. They are grouped by definition into several classifications such as ;

- Wrought Seamless Pipe
- Forged Pipe
- Cast Pipe
- Welded Pipe

- Wrought Seamless Pipe is not commonly used in water supply piping. This pipe manufacturing method has not been adopted by Indonesian pipe manufacturers. It is planned by one of our member of Steel Pipe Manufacturers Association to start the production of wrought seamless pipe at the end of 1986.

- Forged Pipe is made primarily in pipe sizes of larger diameters and heavier wall thickness, where other seamless grades are not readily available because of costs or equipment limitation. As well as wrought seamless pipe, this pipe is not meant to be used in water supply piping.

- Cast Pipe - wrought iron pipe, is a two component ferrous metal consisting of high purity and a glass like iron silicate slag ammounting to about 3% by weight of the material. The iron silicate is distributed evenly throughout the base metal in the form of elongated fibers as many as 250,000 per cross sectional square inch. The uniformly distributed networks of iron silicate are considered primarily responsible for the corrosion resistance of wrought iron.
  - Cast steel pipe is not commonly used in water supply piping.
  - Cast iron pipe has a relatively long life because of its heavy wall and inherently good resistance to internal and external corrosion. This pipe is used extensively for water and gas distribution systems and sewage lines in cities and towns. Unfortunately due to the complication of the manufacturing process, this pipe is not manufactured in Indonesia.

- Welded Pipe - Fusion welding of pipe is done by resistance welding, by induction welding or by arc welding methods.
  Methods adopted by Pipe manufacturers in Indonesia are :

  - Electric Resistance Welding - Four methods of resistance welding are extensively used. These are flash welding, low frequency resistance welding, high frequency induction welding, and high frequency resistance welding. In every process, the strip or plate is initially formed by rolling or ring forming into a circular shape.
    Seventeen out of nineteen carbon steel pipe manufacturing plants in Indonesia have adopted this methods used in their production lines. These nineteen carbon steel pipe manufacturing plants have a total production capacity of 531,000 metric ton per year. 60% of this total production capacity, i.e. 318,600 metric ton, is meant to produce water pipe according to Brithis Standard and ASTM, either Black Steel pipe or galvanized. This capacity of producing water pipe has never been reached and utilized in total, due to insufficient market availability.

  - Arc Welding Process - Spiral Welded Pipe.
    Spiral welding generally is applied to lightweight pipe for dredging pipe, irrigation systems and other services. In Indonesia, spiral welded pipe is mainly manufacture for the purpose of pipe pile and water/gas supply piping. Two of nineteen members of carbon steel pipe manufacturers association produced this type of pipe.

  - Other type of pipe extensively used in watersupply piping and manufactured locally in Indonesia are :

    - Asbestos Cement Pipe
      The manufacture and usage of Asbestos Cement Pipe started in Italy approximately in 1913. Production in the United States started in 1929 and Indonesia started in 1976. Rapid recognition of its

usefulness due to its strength, corrosion resistance and maintained high flow characteristics has resulted in its becoming one of the most used pipings for carrying water and sewage.

- Clay pipe
- Polyvinyl chloride (PVC) Pipe

Corrosion

Corrosion is the mechanism by means of which metals and oxygen strive to reach equilibrium. It would be well to think of the "Corroded" condition as the normal and the "Noncorroded" condition as the transitory phase in the never ending battle between the engineer and environment. All require and ionizing medium.

Corrosion has been abscribed to the absence of sunlight, to the presence of dust, to bacteria, and to numerous other factors. It has been shown that such influences can, indeed, affect the rate of corrosion in special cases but that they are not primary causes.

All chemical reactions require the presence of an ionizing medium. The most ionizing medium is water. No corrosion will occur in the total absence of water. It is to be noted that this does not mean the "apparent" absence of water. It is well known that iron (which naturally included steel) corrodes, or "rusts", very slightly in desert areas, yet some corrosion does occur, as the humidity is extremely low, but not non existent, in desert areas.

Carbon dioxide is the most important gas in terms of corrosive power. It is always present in the atmosphere in small quantities and is encountered in nearly all natural waters in the free or chemically combined form. In industrial districts and heavy automobile traffic areas, the carbon dioxide content of air is greatly increased. Carbon dioxide in solution will attack ferous metals. The attack on iron or steel piping usually occurs along with and as an adjunct to oxygen corrosion, although the attack will occur in the absence of oxygen.

Many other factors of water contents such as, calcium, magnesium, carbonates, bicarbonates will affect the rate of corrosion.

However, iron and steel pipe can be and is being used. Looking back at the untold thousands of miles of steel pipe that are in service, one is impressed by the fact that most of it is in good operating condition. This inescapable fact illustrates that corrosion is due more to environmental factors than those which are inherent to the material. The pipe mills turn out a uniform product of carbon steel. If its weakness are known (as they are), it can be safely assumed that these have been minimized. It is therefore up to the engineer to adjust to the environment in the most economical manner.
There are always special cases requiring expensive coatings. Good engineering consists of selecting the least expensive of the acceptable alternates and designing a system that requires the minimum quantity of costly materials.

Protective Coatings

Since corrosion of metal is a surface reaction, it is obvious that, if a protective coating which is continuous, impervious, chemically inert, and electrically insulating can be bonded to the interior and exterior of the piping corrosion can not take place in the pipe wall as long as the protective coating remains in place undamaged and with out cracks or pinholes.

There are various protective coating such as galvanizing, coal tar enamel, hot applied coal tar tapes, cold applied plastic tapes, cement mortar and asphalt coating.

The well known and common application of Internal coating for water supply piping in Indonesia are :

- Galvanizing : The zinc used for galvanizing is on the anodic (wasting) or electrochemical protective side of steel, and it is wasted or changed to zinc compounds before the steel pipe will be attacked.

- Cement Mortar : Cement mortar is used extensively as a protective interior lining for steel pipe in new construction and it has also been used in rehabilitating old pipe lines.

However, H.M. Howarth stated ;

The corrosion allowance may be zero if internal and exterior corrosion or errosion are not expected. If a corrosive fluid is to be transported, or if soil conditions are condusive to corrosion, no corrosion allowance is necessary if suitable means are taken to mitigate such corrosion.

Cement Lined Steel and Cast Iron Pipe

Manufacture. The cement lining is generally applied to steel and cast-iron piping by the centrifugal casting process. The metal is first immersed in a cleansing solution to remove all traces of oil or grease so that an adherent bond can be formed between the interior wall of the pipe and the cement lining. The pipe is then placed in a slightly inclined position, with the higher end at the mouth of the cement mixer. A measuring device, adjustable to measure the exact amount of cement for each size of pipe, allows the proper amount of lining material to flow into the pipe.

The pipe is sealed with stoppers at each end and then rotatea in a horizontal position at high speed from abount 30 sec to 1 min, depending upon the size of the pipe. The centrifugal force and vibration set up by this operation brings a small amount of water to the surface of the mixture, so that the cement sets into a dense adherent layer with a smooth surface. The cement-lined pipe is cured in a moisture-and-temperature-controlled atmosphere in about 72 hr.

Temperature changes have no effect on the pipe or lining as the coefficient of expansion of the cement and the metal is about the same. The added support given by the lining enables the pipe to withstand high working pressures. Cement-lined pipe can be cut to length and fitted just as ordinary pipe. The lining is able to withstand, without chipping, any blow on the exterior of the pipe which does not actually dent the pipe.

Standards. Cement-lined steel and cast-iron pipe is covered by the following spesification:

AWWA C205 - Standard for Cement-mortar Protective Lining and Coating for Steel Water Pipe.

AWWA C104 - Cement Mortar Lining for Cast Iron Pipe and Fittings for Water (also ASA Standard A21.4).

Application. Cement-lined pipe is well established for use in cold-water lines. Substantial quantities of cement-lined steel pipe are used for other applications where corrosion is more of a problem. The largest user, by far, is the petroleum industry for use in oil-field flow lines, pipe lines, tubing and casing. Cement-lined pipe is particularly suitable for these applications because of the presence in the oil fields of salt water, hydrogen sulfide, carbon dioxide, and other corrosive material. Other applications include lines in salt works for handling brine, discharge lines in coal mines for carrying highly corrosive sulfur water, lines in paper and pulp mills for handling diluted acids and corrosive waste liquids, and lines in process plants where water or other liquids must be kept free from iron contaminations or rust.

Jointing. Cement-lined pipe is generally joined with screwed seal rings which prevent the corrosive liquid from coming in contact with steel. Flanged joints are also extensively used. Some prefabrication is done of piping assemblies involving welding of the steel joints. Field joining of the preassembled welded assemblies is then done with flanged ends. Cement of course must not be at the pipe ends being welded. After welding, these are filled with mortar.

Market Share of Carbon Steel Pipe for Water Supply Piping in Indonesia

It is obvious that a replacement of the cement mortar lined cast iron pipe by cement mortar lined carbon steel pipe will encourage the effort of local. or domestic pipe manufacturers to improve their production capability and capacity. Market share of carbon steel pipe for water supply and gas piping will be improved. A new field of job is created i.e. cement mortar lining job, to support the carbon steel pipe manufacturers in fulfilling the demands of cement mortar lined pipe. There is no dought that cement lined carbon steel pipe has no weakness as compared to cement lined cast iron pipe.
Carbon Steel pipe manufacturing plants have a sufficient production capacity to subtitute the usage of cement mortar lined cast iron pipes which are so far imported. An absolute substitution with similar quality materials, less cost and more added value.

INTERNATIONALIZATION OF THE STANDARDS OF MACHINERY, TOOLS AND MATERIALS FOR WATERWORKS

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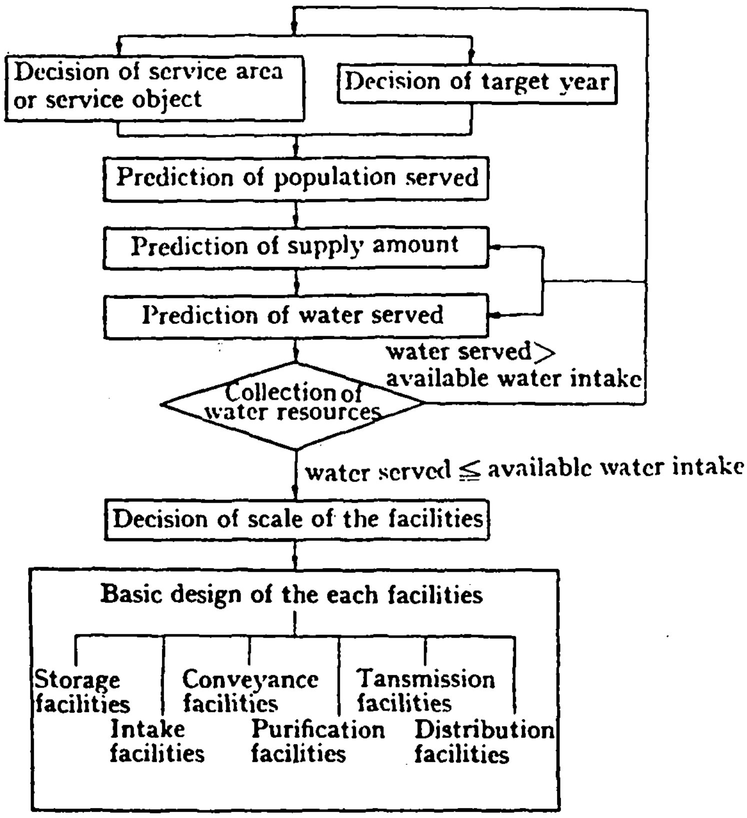
1. Introduction

Nowadays the following procedure is generally arranged at the basic planning stage of modern waterworks projects.



Among these waterworks facilities, industrial products are employed to a great extent, primarily in the facilities of water conveyance, water transimission and water distribution, and secondarily in the water purification facilities.

A great variety of industrial products – machinery, tools and materials – are employed in these waterworks facilities, so that it is difficult to make sweeping generalizations about them.

Nevertheless, the properties that these products should have are :

1. Endurabilty
2. Safety in quality in contact with supplied water for

communities.
3. Facility in maintenance and management.
4. Adaptability to the environment in which they are installed.

These are the minimum requirements. At the selection stage, it is necessary to make a comprehensive judgement that takes into account their function, performance, economical efficiency and durability.

Table-1 lists the machinery, tools and materials used in wateworks for general purposes. (Japanese Industrial Standards and Japan Water Works Association Standards).

2. Standardization of Machinery, Tools and Materials for Waterworks.

Almost all of the machinery, tools and materials used in waterworks are on the whole, manufactured and supplied as industrial products and are supplied as tandardized products.

The levels of standardization are :

(1) Manufacturer's standards,
(2) manufacturer's association standards,
(3) national standards and
(4) international standards.

Table-1

1. Japanese Industrial Standards (JIS)	2. Japan Water Works Association Standard (JWWA)
Asbestos Cement Water Pipes	Test Methods of Filter Sand for Water Works
Reinforced Concrete Pipes	Concrete Box for Stops for Water Works
Centrifugal Reinforced Concrete Pipes	Mortar Lining of Steel Pipes for Water Works
Mortar Lining Ductile Iron Pipes Centrifugally Cast for Water Works	Asbestos Cement Water Pipes Reinforced by Steel Sheet.
Asbestos Cement Joints for Asbestos Cement Water Pipes	Subterranean Fireplugs for Water Works
Rolled Reinforced Concrete Pipes	Iron Covers of Fireplugs for Water Works
Steel Joints and Fittings for Asbestos Cement Water Pipes	Iron Covers of Sluice Valves for Water Works
Castiron and Fittings for Asbestos Cement Water Pipes	Snap Tap for Water Works
Faucets	Stop for Water Works
Sluice Valves for Water Works	Vane Wheel Double Jet Wet Dial Type Water Meters
Air Valves for Water Works	Valve Keys of Screwed Type Sluice Valves for Water Works
Screwed Type Malleable Cast Iron Pipe Fittings	Valve Keys of Cast Iron Stop
Screwed Type Steel Pipe Fittings	Iron Covers of Air Valves for Water Works
Steel But-Welding Pipe Fittings for Ordinary Use	Two-Stage Box of Stop
Steel Plate But-Welding Pipe Fittings	Butterfly Valves for Water Works
Bellows Type Expansion Pipe Joints	Snap Tap with Saddle for Water Works
Vane Wheel Single Jet Wet Dial Type 13 mm Water Meters	High Speed Air Valves for Water Works
Construction of Pressure Vessels	Boating Methods of Cast Iron Pipes for Water Supply
Measurement Methods of Pump Discharge	Centrifugal Cast Iron Pipes for Water Supply
End Suction Centrifugal Pumps	Cast Iron Fittings for Water Pipes
Small Size Multi-Stage Centrifugal Pumps	T-Type Centrifugal Ductile Iron Pipes for Water Works
Double Suction Volute Pumps	T-Type Ductile Iron Fittings for Water Works
Water Ring Vacuum Pumps	Epoxy Powder Coatings for Interior of Ductile Iron Pipes and Fittings for Water Works
Multi-Blade Fans	Stainless Steel Pipes for Water Works
Pressure Reducing Valves for Pneumatic Use	Copper Pipes for Water Works
Electric Overhead Travelling Cranes	Copper Pipe Fittings for Water Works
600V Grade Polyvinyl Chloride Insulated Wires (IV)	Sodium Alginate for Water Works
600V Polyethylene Insulated Cables and 600V Cross Linked Polyethylene Insulated Cables	Calcium Hydroxide for Water Works
Low Voltage Three-Phase induction Motors (for general purpose)	Soda Ash for Water Works
High Voltage Power Capacitors	Sodium Metaphosphate for Water Works
Busway	Test Methods of Bentonite for Water Works
	Liquid Sodium Aluminate for Water Works
	Test Methods of Powder Activated Charcoal for water Works

Unplasticized Polyvinyl Chloride (UPVC) conduits
Sealed Nickel-Cadmium Cylindrical Rechargeable Single Calles
Galvanized Steel Pipes for water Service
Coating Steel Pipes for Water Service
Fittings of Coating Steel Pipes for Water Service
Asphalt Protective Coatings for Steel Water Pipe
Coal-Tar Enamel Protective Coatings for Seetl Water Pipe
Coal-Iron Pit-Cast Pipe for Water Works
Cast-Iron pipe Centrifugally Cast in Sand-Lined Moulds for Water Works
Cast-Iron pipe Centrifugally Cast in Metal Moulds for Water Works
Cast Iron Pressure Fittings for Water Works
Ductile Iron Pipes
Ductile Iron Fittings
Lead Pipes for Water Supply
Alminum Sulfate for Water Works
Ruber Goods for Water Works
Unplasticized Polyvinyl Chloride Pipes for Water Works
Unplasticized Polyvinyl Chloride Pipe Fittings for Water Works
Polyethylene Pipes for Water Works
Polyethylene Pipe Fittings for Water Works
Polychlorinated Alminum for Water Works
Tar Epoxy Resin Paints for Water Works and Method of Coating
Rigid Vinyl Chloride Lining Steel Pipes for Water Works
Plastic Coated Pipe Fittings for water Works
High Impact Unplasticized Polyvinyl Chloride Pipes for Water Works
High Impact Unplasticized Polyvinyl Chloride Pipe Fittings for Water Works
Sodium Hypochloride for Water Works
Solution of Sodium Silicate for Water Works
Liquid Calcined Soda for Water Works
Adhesives for Rigid Vinyl Chlorides Pipes for Water Works
Caps of Sluice Valves for Water Works

The machinery, tools and materials for Waterworksgo through various stages of development, practical application and generalization, pass the above-mentioned levels of standards succesively to be filed and integrated into the upper standards.

However, at the stages of filing and integration, many problems arise such as complicatedly entagled interests, of the parties concerned and so forth.

In this text, I would like to explain the last stage of the standardization, that is, the compatibility and unification of national standards and ISO standards, by citing some examples.

Standardizing activities in most nations in the world are advancing, thanks to the stanardizing bodies of each country and these are shown in Table-2.

In the industrialized countries, approximately 10,000 national standards have already been established; on the other hand, in the developing countries, the number is 1,000. There exists a great disparity between the two sides.

Table 3 shows the tendency of standards applied to the products in these countries.

3. ISO Standards and Their Positioning

From a global point of view, if each country persists in adhering to only its own national standards, this interferes with industrialization, standardization and the expansion of free trade.

Therefore, four items on 'standards and certification systems' were established in the GATT Standard Code which came into effect in 1980:

(1) compatibility of national standards and international standards,
(2) non-discrimination application of the certification system,
(3) furnishing information about and public priornotices of standard certification system,
(4) assistance to developing countries.

Under these circumstance, the ISO, which formerly had a comparatively voluntary position, has come to have, so to speak, compulsory significance.

The history of the ISO originates from the field of electric technology. The International Electrotechnical Commission (IEC) was established in 1906, and the International Organization for Standardization or the ISO was duly inaugurated on February 23, 1947.

The Member Bodies of the ISO are the organizations which primarily represent the standardizing activities of their countries. From each country only one organization can be entitled to membership. As of 1981, it consisted of 72 Member Bodies and 16 Corresponding Members representing a total 88 countries.

In the eyes of the law, the ISO is not made up of organizations that are governmental bodies, however, more than half of the Member Bodies are government

Table-2. Standardizing Body of Each Country and Comparison of the Number of Standards and Employees

Member Body		Number of Standards	Number of employees	Member body		Number of Stds.	No. of Empl.
Nation	Member Body			Nation	Member Body		
USSR	GOST	22,120	500	Colombia	ICONTEC	1,607	° 61
Cermany, R.F.	DIN	18,000	610	Egypt	EOS	1,600	500
Czechoslovakia	CSN	13,507	1,841	Portugal	DGQ	1,582	127
Bulgaria	BDS	12,817	1,850	Venezuela	COVENIN	1,317	135
France	AFNOR	10,465	393	New Zealand	SANZ	1,258	48
Romania	IRS	10,206	–	Chile	INN	1,193	53
Hungary	MSZH	9,893	400	Israel	SII	1,171	500
India	ISI	9,710	1,622	Iraq	COSQC	782	105
Poland	PKNIM	9,664	800	Pakistan	PSI	687	73
Yugoslavia	SZS	9,419	114	Malaysia	SIRIM	584	443
USA	ANSI	9,092	115	Bangladesh	BDSI	468	70
UK	BSI	7,800	1,009	Sri Lanka	BCS	425	146
Japan	JISC	7,720	94	Cuba	NC	405	–
Korea, Rep. of	KBS	6,186	84	Philippines	PSA	354	223
Korea, Dem. P Rep. of	CSK	5,595	–	Thailand	TISI	290	159
Italy	UNI	5,491	44	Singapore	SISIR	222	–
Spain	IRANOR	5,280	40	Canada	SCC	213	60
Brazil	ABNT	3,570	149	Ireland	IRRS	200	–
Belgium	IBN	3,557	43	Greece	ELOT	164	28
Turkey	TSE	3,244	169	Libya	LYSSO	138	10
Mexico	DGN	3,068	280	Lebanon	LSI	134	4
Netherland	NNI	2,944	117	Jamaica	JBS	29	152
Australia	SAA	2,921	210	Nigerai	NSO	120	120
Viet Nam	TCVN	2,816	120	Ethipoia	ESI	108	137
Switzerland	SNV	2,780	16	Saudi Arabai	SASO	106	86
Mongolia	MSC	2,593	–	Cyprus	CYS	56	10
Austria	ON	2,148	210	Morocco	SNIMA	49	3
Norway	NSF	2,015	27	Kenya	KEBS	40	84
Peru	ITITEC	2,001	219	Algeria	INAPI	–	73
South Africa	SABS	1,998	1,188	Sudan	SSD	31	17
Finland	SFS	1,995	35	Ivory Coast	DINT	–	9
Iran	ISIRI	1,922	1,180				
China	CAS	1,750	–				
Denmark	DS	1,633	49				

The source : ISO/Member Bodies, 1979.

Table 3 FOREIGN STANDARDS ADOPTED BY VARIOUS NATIONS (examples)

		Iron & Steel	Materials & Chemicals	Machinery	Electro-technical	Others
Southeast Asia	China	JIS(JPN) GOST(USSR)		JIS(JPN) GB	JIS CCITT(INT)	
	Rep. of China			JIS MSS(USA) ANSI(")	NTTPC	
	Rep. of Korea		FSUSA) BS(UK) MIL(USA)			
	Hong Kong		FS(USA)	ASTM(USA) BS(UK)		
	Philippines	ASTM(USA)		ASME(USA)	IEEE(USA)	
	Indonesia	ASTM(USA)		UIC(INT) BS(UK) SSPC(USA)	ANSI(USA) BS(UK) NEMA(USA) DIN(FRG) DVE(FRG)	
	Brunei			IIW(ITN)		
	Thailand				NEMA(USA) DIN(FRG)	
	Malaysia		FS(USA)	ASME(USA) MS JIS(JPN) API(USA) BS(UK) PU	JIS(JPN) BS(UK)	
	Singapore		FS(USA)	ASME(USA)	BS(UK)	BS(UK)
	Sri Lanka				BS(UK)	
	Pakistan				MIL(USA)	
	Bangladesh	PRSS(PAKISTAN)				
	India	IS	BS(UK)	IS GOST(USSR) IBR	JIS(JPN) BS(UK) IS	
	Burma				BS(UK)	
	Portugal			DIN(FRG)		
	Turkey			ANSI(USA) DIN(FRG) ASTM(USA) TS SAE(USA)		

		Iron & Steel	Materials & Chemicals	Machinery	Electro-technical	Others
Africa	Ethiopia	API(USA)				
	Algeria	AWWA(USA)		JIS(JPN) NF(FRANCE)	IEC(INT)	
	Nigeria			BS(UK)		
	Rep. of South Africa			DIN(FRG)	IEC(INT) DIN(FRG) NEMA(USA) VDE(FRG)	
Latin America	Mexico			AOSI(USA) ASME(USA)	IEEE(USA)	
	Brazil			ISO(INT) TEME(USA) ASME(USA) NEMA(USA) API(USA) ABS(USA) JIC(USA)	IEC(INT) DIN(FRG) ANSI(USA) VDE(FRG) NEMA(USA)	ANSI(USA) ASME(USA) ASTM(USA) ABNT
	Algentina				IRAM	ASTM(USA) AISI-SAE (USA)
	Trinidad & Tobago	EIA(USA)				
Eastern Europe	USSR	JIS(JPN) GOST	GOST	GOST	GOST	GOST
	Poland			ASME(USA) PN NEMA(USA)	CEE(INT) GOST(USSR) PN	TSC
	Romania			JIS(JPN) DIN(FRG) ANSI(USA)	VDE(FRG)	
	Yugoslavia			DIN(FRG)	VDE(FRG)	
	Czechoslovakia				CEE(INT) DVE(FRG)	
	German Democratic Republic	DIN(FRG) UST(SWISS)				
the Middle & Near East	Egypt			BS(UK)		
	Saudi Arabia			ANSI(USA) AISC(USA) ASTM(USA)	BS(UK)	
	Iraq	NF(FRANCE)		BS(UK)	BS(UK)	
	Iran		HMOW	API(USA) NEMA(USA)	BS(UK)	
	United Arab Emirates					BS(UK)
	Libya	API(USA)			NF(FRANCE)	
	Kuwait	API(USA) UL(USA)			BS(UK)	

agencies or body corporates operating under public law. Table-5 shows the progress of Member Bodies since 1947.

4. Process of Establishment of ISO Standards

ISO standards are, of course, established by the ISO. Actually, Technical Committees (TCs) and their substructures, Sub-Committees (SCs) and Working Groups (WGs) are fundamentally in charge of operation.

Technical Committees from TC-1 to TC-181, are in operation at present. Among them, the following are related to machinery, tools and materials for waterworks. (Table 4). All the ISO member Bodies have the right to participate in all these committee such as TCs, SCs and WGs; the ones who express the intention of positive participation are enrolled as P-members; the ones who request information on a constant basis according to the progress of the operation, are O-members.

In a committee, P-members nominate the Secretariat, who has the responsibility and obligation to execute the duty of the committee concerned. A chariman is nominated by ISO Council or by the attendance of the meeting. The chairman presides over the meeting to reach an agreement of international standard drafts.

To begin with, a Working Documents (WD) is prepared and deliberated on at the WG and SC level. This WD has to be approved by the Secretariat of TC or SC to become a Draft Proposal (DP) and is then sent to the ISO Central Committee for registration. When SC or WG completes the deliberations of the DP, it is regarded as a Draft International Standrds (DIS). After the approval by the majority of P-members of TC, the DIS is then transferred to the next stage, that is, approval of Member Bodies. This can be obtained with the approval of over 75% of all of the Member Bodies. Thereafter, the Central Secretariat prepares a Council Book on the basis of the above-mentioned vote, and ISO standards is finally established by the voting of Council (Proof).

This is the procedure of establishment of ISO standards. Something can be done with the case when each country has no national standards up until then, but in a case where each country has a particular standard with a long history and when the matter differs, it is necessary to make many adjustments to prepare an unified ISO standard, needless to say, these exist as formidable difficulties.

It is not too much to say that the preparation and completion of ISO standards becomes more and more important in consideration of worldwide trade libralization and the significance of interchangeability and compatibility of facilities, machinery, tools and materials for technical assistance from the developed countries to the developing countries.

Originally these had been a tendency that the ISO put emphasis on basic fields such as the definition of terminology, testing methods, parts and so on. But since the execution of the GATT Standard Code, there is a movement to complete products standards in compliance with the demands.

5. Case Studies of National Standards and ISO Standardisation of Cast Iron Pipes.

Here I would like to take a look at the relations of standards of each country and ISO standards on Cast Iron Pipes, which are the most important and generally used material for waterworks, as a case study of international standardization of the Cast Iron Pipe standard.

Cast Iron Pipe is a typical pipe material which has been used for years in pipelines for water conveyance, water transmission and water distribution of modern waterworks.

As Cast Iron Pipes have a long history, each country has fairly old national standards of its own. On the other hand, ISO/R13 Grey Iron Pipes, Special Castings and Grey Iron Parts for Pressure Mainlines was established in 1955 as the result of efforts made toward the comatibility of these standards.

However, since the latter half of the 1950s, the improvement of the reliability of pipelines has been advocated, and tough, almost indestructible, Ductile Iron Pipes started to be adopted for use and accordingly, began to replace former brittle Grey Iron Pipes in countries such as the United States, the United Kingdom, France, Germany and Japan, where national standards were established from manufacturer's standards. For example,

ASA A21 51-1965	Ductile Iron Pipe, Centrifugally Cast in Metal or Sand-Lined Mold, for Water or other Liquids.
DIN 28600-1977	Ductile Cast Iron Pipe and Fittings for Water and Gas Supply, Technical Terms of Delivery.
NF A38-012-1962	Ductile Iron Pipe, Technical Specification.
JIS G5526, 5527-1974	Spheroidal Graphite Cast Iron Pipes (and Fittings) for Water Supply (JWWA G105, 106-1961 Ductile Cast Iron Pipes and Fittings for Water).

At this stage, every standard in each country followed the standards for Grey Iron Pipes: the dimension of external diameter of Ductile Iron Pipes was the same with that of Grey Iron Pipes. As for mechanical strength, values of tensile strength, elongation etc. were stipulated as Ductile Iron Pipes as a reflection of technical levels at the time of standard establishment.

Tehrefore, there was no compatibility in technical matters as each country prescribes different standards for these national standards of Ductile Iron Pipes.

Therefore, a Sub-Committee of ISO/TC 5/SC 2 on Cast Iron Pipes and Fittings was held by various countries, mainly from Europe. The members were France, Germany, the United Kingdom, Switzerland, Italia, TABEL 4

TC	SC	Secretariat	
TC 5		SNV	Metal Pipes and Fittings
	SC 1	SNV	Steel Pipes
	2	AFNOR	Cast Iron Pipes
	5	SNV	Pipe Fittings
	10	BSI	Pipe Flanges
TC 21		BSI	Equipment for Fire Protection and Fire Fighting
TC 30		AFNOR	Measurement of Fluid Flow in Closed Conduits
	SC 7	AFNOR	Water Meters
TC 45		BSI	Rubber and Rubber Products
TC 59		AFNOR	Building Constructions
	SC 7	SIS	Equipment for Water Supply and Drainage
TC 67		IRS	Materials and Equipment for Petroleum and Natural Gas Industries
	SC 1	IBN	Pipes
TC 71		ON	Concrete, Reinforced Concrete and Prestressed Concrete
TC 77		SNV	Products in Fiber Reinforced Cement
TC 25		BSI	Cast Iron and Pig Iron
	SC 2	AFNOR	Spheroidal Graphite Cast Iron
	SC 3	DIN	Malleable Cast Iron
TC 17		JISC	Steel
TC 26		DIN	Copper and Copper Alloys
TC115		AFNOR	Pumps
TC138		NNI	Plastic Pipes, Fittings and Valves for the Transportation of Fluids
TC147		ANSI	Water Quality
TC153		BSI	Valves

Table 5 YEARLY PROGRESS OF ISO MEMBER BODIES

Christian Era	1947	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
total of Member Bodies	26	26	27	29	33	34	33	34	36	38	40	40	41	44	44	46	50	50	51	53	54	55	55	54	54	56	58	62	62	63	65	68	71	73	72
total of Councils	11	11	11	10	10	10	10	11	11	11	11	11	11	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	18	18	18	18	18
Chairman	U.S.A.			France			Sweden			U.K			Finland			U.S.S.R			India			Turkey			U.S.A.			Sweden			U.S.S.R.			France	
Vice-Chairman	Belgium		India						Italy			U.S.A.			France			U.K.						Iran			Germany			Canada					

Austria and others. After a long-term discussion, a standard amissible to each country was established to unify the standard of pipes and fittings in terms of diameter ϕ 80 mm – ϕ 1200 mm.

ISO 2531 (the first edition: 1974) Ductile Iron Pipes, Fittings and Accessories for Pressure Pipeline

In this standard, values was unified which had formerly been disunified among the national standards. Concerning pipe material strength, a reasonable value was organized from standards values of each country.

Thereafter, Japan, the United States, Canada and Australia and others participated in ISO/TC 5/SC 2, the range of applicable diameter was broadened to ϕ 40 mm – ϕ 2,000 mm. (in the third edition, to ϕ 2,600 mm). The second edition was published on September 1, 1979, where flange pipes PN16, 25 and 40 were newly added. In this way this standard came to be adopted all over the world.

On the other hand at the ISO/TC 5/SC 2 committee, the same members deliberated on not only the body of Ductile Iron Pipes but also additional corrosion preventive measures and Ductile Iron Pipes for non-Pressure pipelines. And now the following have already been completed.

ISO 4179 (1980)	Ductile Iron Pipes for Pressure pipelines – Centrifugal Cement Mortar Lining – General Requirements.
ISO 6600 (1980)	Ductile Iron Pipes – Centrifugal Cement Mortar Lining – Composition Control of Freshly Applied Mortar.
DIS 8179	Ductile Iron Pipes–External Zinc Coating
DIS 8180	Ductile Iron Pipes – Polyethylene Sleeving
ISO 7186	Ductile Iron Pipes and Accessories for Non-Pressure Pipelines.

Very useful systems for construction and maintenance of pipelines for water pipes are originated in line with the ISO standards which are the worldly common basis for the construction and maintenance of pipelines for waterworks. It can be said that this is a very effective back up from the point of view of economical efficiency, standardization, easy and prompt availability, reliability of efficiency etc.

In addition, full scale standardization of the ISO started in the 1980s, so it is not necessarily true that ISO standards have been established on machinery, tools and materials for water that are widely used in all the nations of the world.

Great hopes are entertained of the vigorous effort made by TCs, SCs and WGs. In this context, Ductile Iron Pipes can be considered as an advanced case.

6. Ending

Finally, the following is a list of ISO standards in terms of machinery, tools and materials for waterworks.

ISO 13	Grey Iron Pipes, Special Castings and Grey Iron Parts for Pressure Mainlines.
ISO/R49	Malleable Cast Iron Pipe Fittings Screwed in Accordance with ISO Recommendation R7.
ISO 559	Welded or Seamless Steel Tubes for Water, Sewage and Gas.
ISO 7084	Pipeline Flanges for General Use – Metric Series Mating Dimensions.
ISO 2441	Pipeline Flanges for General Use – Shapes and Dimensions of Pressure Tight Surfaces.
ISO 7531	Ductile Iron Pipes, Fittings and Accessories for Pressure Pipelines
ISO 4179	Ductile Iron Pipes for Pressure Pipelines Centrifugal Cement Mortar Lining–General requirements.
ISO 6600	Ductile Iron Pipes – Centrifugal Cement Mortar Lining – Composition Control of Freshly Applied Mortar.
ISO 4064/1	Measurement of Water Flow in Closed Conduits Meters for Cold Portable Water – Part I: Specification.
ISO 4064/2	Measurement of Water Flow in Closed Conduits Meters for Cold Portable Water – Part II: Installation Requirements.
ISO/R1398	Rubber Sealing Rings for Joints in Asbestos Cement Water Piping.
ISO 4633	Rubber Vulcanized Materials for Joint Rings for Water Supply and Drainage Pipelines Specifications
ISO 160	Asbestos Cement Pressure Pipes and Joints.
DIS 4422	Unplastinized Polyvinyl Chloride (PVC) Pipes and Fittings for Water Supply – Specification.

NECESSITY & STANDARDIZATION OF METERS FOR COLD POTABLE WATER IN WATERWORKS

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Japan Waterworks Association

4[TH] Asia Pacific Regional
Water Supply
Conference & Exhibition
Jakarta, Indonesia
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1. Introduction

Water Supply is generally accepted to be one of the social fundamentals absolutely necessary for our modern everyday life. However the situation in connection with the water supply project are becoming diversified and lots of problems have to be worked out for the water supply to fulfill its social role.

In such background, measurement is one of essential procedures for supplying potable water economically and reasonably. About measuring water, much discussion has been made so far in various countries with the change of times and the latest tendency is that all suplied water is to be measured for collecting water charges.

In any case, an industrial standardization should of course perform a vital function for smooth development and reasobable management of the water supply.

The industrial standardization in each country has a long history with much achievements, and lately, an international standarization has been rapidly materialized and expanded in many fields.

2. Situation of water supply in Japan

The first modern water supply in Japan was completed in Yokohama in 1887 and in 100 years thereafter, water supply in Japan made great stides and the rate of extension has reached 91.5%. Meantime, the water supply administration was also reformed many time in step with the development in the water supply, e.g., revision of the water supply law made several times, expansion achieved introducing the government subsidy system and to combat a considerable change in various situations around the water supply.

The existing situation of waterworks in Japan are classified as follows.

Description	Large-scale waterworks	Small-scale waterworks	Private waterworks	Total
No of waterworks	1.896	12,148	4,128	18,172
No. of waterworks/ total No. of waterworks (%)	10	67	23	100
Total population in the area (persons)	101,636,000	8,990,000	1,113,000	111,739,000
Population served water/ total population served water (%)	91 3	7.7	1.0	100
Population served water/ total population (%)	83.5	7.0	1.0	91.5

(Total population : 116,860,000 persens)

The rate of extension 91.5% is classified by city, town and village as below.

Description	City	Town	Village	Total
Total population (persons)	88,890,000	24,910,000	3,060,000	116,860,000
Population served water (persons (%)	84,680,000	20,000 000	2,230,000	106,910,000
Rate of extension (%)	95.3	80.3	73.0	91.5

From the above, difference in the rate of extension is still noticeable and there are quire a great number of districts where about ten million persons, equivalent to 8.5% of total population of Japan, are still out of benefit of water supply in the towns and villages.

Today, the living basis of the people has been strengthened and enormous investment in water supply construction has also been made. Nevertheless, there are some districts with no water supply.

The reasons are ;

(1) topographical difficulty in installing pipelines.
(2) no water source is assured.
(3) high construction costs because the scale of community is very small.

Thus, a system which can afford to supply clean water stably in future has to be made more complete, including the districts with no water supply.

However, the surrounding circumstances of the water supply are becoming more complicated and diversified increasingly, i.e., gradual deterioration in water quality of water source, existance of organic compound, unstability of water source due to water shortage, increase in possibility of big earthquake, etc. The present waterworks in Japan have to solve these problems painstakingly.

3. Changes in water-supply system in Japan

(1) Period of fixed rate system or combination of fixed and metering system for water charges.

Until 1915 or thereabout, water supply fixed rate system was adopted, at the initial stage in all waterworks, but metering system was adopted only for big consumers and special consumers. The reason why fixed rate system was approved at that time is that there was some surplus capacity in water feed and there was no need to save the water so eagerly.

In line with the advancement of modern water supply, said fixed rate system has gradually been switched over to metering system to assure effective income with a factual understanding of the situations in each waterworks.

(2) Period of transfer to complete metering system.

The employment of fixed rate system for the majority, brought an increase in the quantity of daily water-supply per head.

Consequently, it was quite natural that waste of water and increase in city population and the resultant water shortage caused inevitably atransfer to the metering system. Moreover, there have hitherto been many examples that the metering system was adopted in a period of expanding supply areas with recognition of necessity of water supply in daily living.

The reasons for adoption of metering system are as follows :

1) Settlement of water shortage caused by increasing consumer.
2) Extension of water supply to areas where the water supply is not installed yet by making effective use of water saved by metering.
3) Tamporary expedient till completion of expansion work.
4) Fair collection of water charges.
5) Necessity to stop raising of water charges. The metering system contributes to the saving of water and also allows the expansion work to keep at a required minimum.
6) Establishment of economical foundation of waterworks.

(3) Period of revival and completion of metering system

The principle of metering system was introduced in many cities generally in 1915 to 1930; but it substantially retrograded due to destruction by Kanto Earthquake in 1923 and the World War II. However, the principle remains unchanged and in 1950 or therebout, the metering system was revived and at persent, the system has pervailed throughout the nation.

(4) Economical merit of metering system

Decrease in daily water consumption per head by metering system can be said to be the reduction in waste of water in fixed rate system. The metering system can rather make the waterworks in an appropriate scale and pervenr the wasteful installation of water supply facilities, therefore the system will pay off the cost due to adoption of metering system. The employment of metering system pervent waste of water and increase the income by collecting charges for water wasted so far. Even viewed from the relationship between water supply system and running expenses, metering system becomes in no way a big burden compared with fixed rate system in the respects of the purchase of meters, maintenance & repair, etc.

For the above reasons, metering system is very common jn Japan, and in the circumstances where balance between the capaity of water supply facilities and required quantity of water-supply is liable to be lost due to increase in water consumption, the significance of metering system is re-appreciated in the following respects :

1) Fixing an usage in water saving way in modern living developing more and more with recognition that water is a limited resource.
2) Finding out an underground water leak which is a major leakage.
3) Reasonable control of water supply in repidly developping modern living and data collection for drawing up future plan.
4) Sound management or waterworks and security of smooth water supply.

In this way, at persent, water meters are an apparatus indispensable for both water supplier and consumers, abd serve as the base for fixing water consumption and computing water charges.

4. Water meters and industrial standardization in Japan

Water meters necessary for measuring cold potable water have all been imported from foreign countries in the beginning of installation of water supply. In 1898, the first meter was imported from Germany. Until the import was interrupted due to an outbreak of the World War I in 1914 and before a domestic products was put on the market, foreign-produced meters had all been used.

As a result, the number of types increased remarkably together with the domestic products.

Some metes were different not only in construction but also connecting screw threads and the overall length.

Though a dry dial, multi-jet, vane wheel type meter used conventionally was in a main stream from 1926 on, dry dial, wet dial, multi-jet, single-jet and further a disc type also joined the variety of types made by Japanese manufacturers.

Thus, waterworks had much trouble in maintenance and repair of these meters. It is reported that in 1932, there were 53 types of domestic water meter used in the Bureau of Tokyo Metropolitan Waterworks. This was because that the meters had not been standardlized at that time, and up to now, each bureau of waterworks has been endeavoring to coordinate the meters with the domestic standard at an enormous cost.

However, there are still some bureau of waterworks whose meters do not meet with the standard, in overall length and/or screw threads.

In such situation and in 1936, the standardization of water meters was advocated and the corporate standard prepared mainly by the manufacturers them selves was established. This standard was limited only to 13mm domestic water meter mainly used, and it became the basis for JIS Standard described later.

In respect of industrial standardization in Japan, on the one hand, understanding of the people with the standardization was poor since the development of modern industries was behind western countries. And, the procedures began with the establishment of the purchase standards of products by the government and the test standards necessary for purchase.

However, industrial standarization project was initiated as a formal system in 1921, in which the standardization Investigation Committee of Industrial Products was established by the government to lay down overall standard of industrial products and commence standardizing work, and then the Japanese Engineering Standards (JES) were set up.

In 1949 after the World War II, a great took place even in the industrial standardization project.

And, the industrial standardization law was enacted based on a new idea in order to secure and develop national unification about the industrial standardization. Based on this law, Japanese Industrial Standards Committee (JISC) was established and through the delibration, it was decided to lay down the Japanese Industrial Standards (JIS).

In such background, the national standards of water meter (JIS). "vane wheel single-jet, wet dial type 13mm water meter" was provided in 1951, and thereafter in 1982, the JIS was revised taking account of coordination with ISO 4064 PART I "Meters for cold potable water-Specifications". However actually, an overall coordination is quite difficult because of the customs or legal regulations in our country.

Also as the corporate standard, in 1965, the standard "vane wheel multi-jet, wet dial type meters, 13mm to 40mm" was provided by the Japan Waterworks Association (JWWA) and through the revision in 1968, another revision is under preparation in order to coordinate with ISO standard as with the foregoing JIS.

Initiated by these standards, the standardization of water meters as a general also made progress gradually, and the types of water meter have also been integrated to rationalization.

Now, the importance of industrial standardization is fully recognized.

Thinking about the necessity of standardization, recent industrial standarization is under way at the following 5 levels :

(1) Company standardization,
(2) Corporate standardization,
(3) National standardization,
(4) Regional standarization,
(5) International standardization.

These procedures for standarization are promoted keeping close connection and harmony with each other, especially, the national standaridization plays quite a important role in development of the nation's industry, economy, better living. Therefore, the advanced countries positively promoted national standardization from old times and recently, the developing countries have also started to tackle this problem seriously.

Nowadays, the work of international standardization is very active and as a typical international organization for industrial standardization, there are ISO (International Organization for Standardization) and IEC (International Electrotechnical Commission).

ISO was established in 1947 and at present, 89 countries are participating in setting up the international standards in all industrial fields excluding electricity.

On the other hand, IEC has a longer history than ISO and 44 countries are engaged in unification of the international standards over the whole eletrical industry. It is a principal object of the international standardization project to set up an internationally unified standard by adjusting the interests of the countries concerned on mutual understanding and to assure international trade by promoting enforcement of the standards in each country and at the same time, to give an impetus to the international cooperation extending over such departments as scoence, economy, etc.

As the organizations of ISO and IEC, General Assembly, Council, Technical Committee (TC) and Sub-Committee (SC) are organized.

ISO and IEC are now putting big efforts on the preparation and issuenace of ISO International Standard (ISO-IS) and IEC-IS which applicable internationally.

Membership countries of ISO and IEC are quite active to conform their national standards to ISO-IS and/or IEC-IS, and there are some western or developing countries which have already legally adopted the international standards.

Participation in the activities of the international standardization is vitally important to promote an internationalization, i.e., each nation's ideas and technologies can be reflected on the international standard by mutual discussion, national standard of each country can be prepared and revised from the international view point, by collecting worldwide tendency for standardization and technical information. Thus the participating countries are well consious of the importance of the international standardization project and their participating activities are impressively positive. They are sending off many respresentatives to attend the meetings and directing efforts to promote the international standardization.

The activities on the water meters are going on at ISO/TC30/SC7.

The work territory of ISO/TC30 lies in aiming at standardizing the rules and methods regarding "Measurement of fuild flow in closed conduits" and details of the work are the standardizarion of the following; (1) definition of terms, (2) test methods, (3) structural requirements of measuring intruments, (4) measurement conditions, and (5) correction and evaluation of measurement data.

TC30/SC7 is a sub-committee concerning the water meters and its work territory lies in aiming at standardizing the water meters taking the following into consideration;

(1) hydrodynamic definitions and test methods, (2) installation and operational requirements of water meters, (3) assembly and interchangiability in use and so on.

A present subject of TC30/SC7 work is a preparation of the international standard covering the following fields about water and hot water meters :

(1) hydraulic characteristics, (2) construction characteristics, (3) test methods and (4) conditions of placing, installation and use.

The standards set up until now and standards already discussed or under work in the above fieleds are as follows. (refer to Table 1).

Table I

Work progress conditions at ISO/TC30/SC7 (as of August 1983)

Standard of Draft Nos.	Titles of standrds	Progress conditions
ISO 4064/1	Meters for cold potable water Part 1 : Specification	Already established
ISO–4064/2	Meters for cold potable water- Part 2 : Installation requirements	Already established
ISO/DIS–4064/3	Meters for cold potable water Part 3 : Test methods and equipment	Already voted
ISO/DIS–4064/2/DAD	Part 2 : Installation requirements ADDENDUM 1 : Multiple group operation	Already voted
ISO/DP**–7858/1	Meters for cold potable water – Combination meters – Part 1 : Specification	Already voted
ISO/TC30/SC7 N141 ISO/TC30/SC7 N155	– Combination meters – Part 2 : Installation requirements Part 3 : Test methods	Under work
ISO/TC30/SC7 N147	Hot water meters Part 1 : Specification	Under work
ISO/TC30/SC N143	Checking ISO 4064/1 in every 5 years	Under work

* Draft International Standard

** Draft proposal

5. Harmonization with OIML

Concerned with the above mentioned activities of international standrdization, Organisation Internationale de Metrologie Legale (OIML) has been organized and in activity by the Government of each counties to resolve international problems in construction, usage, allowable error etc. in the fields of measuring instruments.

One of purposes of OIML is "to standardize essential and enough characteristics and perfomances on measuring instruments which is to be internationally approved and remommended to use by member countries.

This organization has prepared drafts on many classified subjects from its working groups to make international recommendation or document.

In the field of water meter, the working group OIML/SP5/SR16 has already established International Recommendation No. 49 – Water Meter intended for the Metering of Cold Water. However, specification of water meters in OIML and ISO is not yet harmonized but confused because the work for standardization has been so far processed separately in each organization.

For example, in designation for water meter, Qmax. has been recommended by OIML while Qn (½ of Qmax.) has been specified by ISO with no harmonization achieved up to now. In addition, Japan has proposed Qc (flow rate at 5m Aq head loss = theoretical value based on actual condition of use) since its attendance to the committee. Recently, liaison meeting of OIML and ISO was established, and it has been in study to achieve a common system of water meter designation up to 1955 under collaboration with wach other.

6. Conclusion

Starting from that an agreement including GATT standard code was signed in December 1969, the international standardization of weighing and measurement has become realistic at a rapid pace. In the industrial fields of various countries, too, revising work to coordinate their national standards with ISO is under way and even in regard to the apparatus and materials used for waterworks, it is not an exceptional case. In such background, Japanese representatives attended the international conference relating to the water meters of ISO/TC30/SC7 for the first time in 1977 and since then, they have been appreciated as regular member.

However, since Japan was the first participating nation in Asia and the time of participation was late, the most significant standards, ISO 4064/I "specification of water meters" were established without any consideration for our actual situation and customs. As a result, a grave inconvenience was experienced to coordinate Japanese standards with the international standard because we couldn't ignore our tradition and customs.

From varied experiences described above, when setting up new international standards, it is essential to attend the meetings successively, clarify the opinion to be reflected on the standard, and make efforts to get understanding from other countries.

However as a matter of fact, the history and environmental conditions of the individual countries in the world differ from each other and there are also the circumstances inherent in each country. Therefore, although the standards which are advantageous to their own countries can not always be establihsed. But the international standard is to be prepared thorugh discussion between the representatives of the participating at the existing worldwide technical level.

Thus, it is a basic rule of the international standardization to coordinate the national standards or elevate the technical level of their own countries with the international standard as a target.

For dealing steadily with the international technical exchange which will be brisk more and more in future, national standards should be energetically coordinated with the international standard as easly as possible. Otherwise, it is obvious that not only be thier own tehcnologies isolated in the international arena but also they will be left behind the technologies making progress at a worldwide level.

For reflecting each opinions on the international standard even slightly, it is hoped that the represetatives from various countries in Asia will attend the international conference as much as possible.

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ECONOMICAL APPROACHES OF WATER UTILITY MANAGEMENT IN OSAKA CITY, JAPAN

ENERGY SAVINGS FOR WATER–CONVEYANCE SYSTEMS

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4[TH] Asia Pacific Regional
Water Supply
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Jakarta, Indonesia
5-11 November 1983

TIRTA DHARMA

INTERNATIONAL WATER SUPPLY ASSOCIATION
ASSOCIATION INTERNATIONALE DES DISTRIBUTIONS D'EAU

ECONOMICAL APPROACHES OF WATER UTILITY MANAGEMENT IN OSAKA CITY, JAPAN

ENERGY SAVINGS FOR WATER–CONVEYANCE SYSTEMS

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1. Introduction

As well known, energy costs have risen sharply since the ban on petroleum export laid by the OPEC in 1973. Since then international interests have resulted in the escalation of the energy control among many people concerned.

In contrast with this, developments of alternative energies were accelerated to break away from conventional petroleum dependent social economic structure, and energy savings were also promoted figorously.

Japan was not an exception in those tendencies. A governmental project called "Sun Shine Plan" was executed in the nation–wide scale as a national project, and the Law Relating to Rationalization in Use of Energy was enforced to make the first step toward formation of energy savings social structure in 1979. Since Japan is largely dependent on foreign contries for supply of natural resources and energy sources the scope on energy savings is a great deal more.

The water supply system is one of the enterprises that consumers much fundamental natural resoureces such as electric power, chemicals and so on. Therefore the resources and energy savings measures to meet the social demands should make the water supply management.

In order to meet such social demands, Osaka Municipal Water Works Bureau has investigated about and executed various energy savings measures.

2. Electricity Consumption.

Founded in 1895, the water supply service of the Municipality has a histroy of 87 years. According to the statistics of 1981, we were pumped 552 million cubic meters per year for supplying 2.63 million inhabitants.

Our utility has now 7 intake pumping stations, 3 purification plants, 2 transmission pumping stations, 10 distribution pumping statiions and two booster pumping stations, a total capacity of 2.43 million m^3/day and a total length of 4,800 Km of pipelines (of rawwater, transmission and distribution mains rangeing in size from 75 mm to 2,200mm).

The pumping stations of the water works facilities are operated by power supplied from electric power plant. The total elecricity consumption was 175 million kwh per year and the basic unit of electricity 0.317 kWh/m3, they show as consuming 86,6% for pumping, 5.49% for purification treatment, 1.56% for draining and 6.37% for other miscellaneous usages of all elecricity.

The pumping stations were consumed 152 million kWh per year. In fact, most of the electricity consumption is used for the pumping station.

In the case of our Bureau, the elecricity consumption of the pumping operation is somewhat higher, because we have intake and purification facilities outside the city boundary, and water delivery pumping systems, as well, necessary to deliver water by pumps from the purivication plants to the city.

3. Approaches to Energy Savings Methods

It is convenient to consider energy saving methods under the headings direct and indirect. Into the former category fall means such as the use of more efficient pumps based on actual condition of energy consumption while examples in the second category are waste reduction and application of tariffs which encourage water saving. The measures thus also set up are required to cope flexibly with changes in surrounding conditons. In a paper restricted in length as is this one, it is not possible to deal complehensively with every means of saving; what follows is a selection of those which, is the author's view are most important and which are singular to the operations of the water works.

1) Intruduction of Latest Technology:

This is a method to introduce the some of new technologies that have been obtained by technical innovation and which offered high efficiency. Therefore before introduction of a new technology it is necessary to investigate economical effects of the investments made not only for building new facilities, but also for the existing facilities. Recent control–technologies–development is very remakrkable and good examples of the savings availabel from such control technologies are variable–speed–control for pumps.

2) Optimization of the Facilities Management

After the facilities have been installed for many years, in many cases some of old facilities do not always meet the present actual conditons of the systems. For example, the design capasicy or condtions of equipment is met satisfy the present requirements due to degradation. Therefore, it is necessary to remodel them so that they can cope with the present, and also for the future situation. For this, many concrete measures can be picked up, such as optimization of pump–head and the water canveyance systems.

3) Improvement of Management Method.

Besides measures directly relating to energy consumption, energy savings can be realized through imporvement of facility management methods including byelaw enforcement and change of purification treatment systems. In this case, direct estimate of economical effects may sometimes be difficult. However, establishment and execution of better energy savings policies are also very important for imporvement of water works management efficiency.

4. Energy Savings Measures.

1) The Choice of Variable–Speed–Control for Pumps.

So far discharge pressure and quantity of water have been controlled mainly by adjustment of the pump discharge valve opening degree (valve control method) or by increase or derease of number of running pumps (running pum number control method).

The valve control method is very simple. But it causes useless comsumption of energy in proportion to the valve throttling degree.

For more efficient operation and maintenance of the distribution system, we are aiming at still more improvement of energy savings. To achive there purpose, we are going to adopt the "variable–speed–arives" of pumps to control pumping water at various points in the distribution systems to maintain sufficient pressures and flows to meet the systems with the quantitative demands, owing to the innovation of electronic technology.

For the variable speed control, many methods have veen developed so far. However, generally speaking, the methods with favorable speed change efficiency cost high. Therefore, the variable speed control method must be selected after thorough and careful examination about the variable speed control range, economy, and cost for maintenance and control.

Since distribution system of osaka City is controled through disharge presure of distribution pumps which are coneected directly with the distributing pipes, the systems are not installed the stand–pipe. Threfore it is necessary to control the pressure carefully, depending upon time fluctuation with the quantitative demands.

Such installations have been executed since 1967 for the existing facilities where investment effects could be made clear, including construction of new pumping stations according to the operating conditions of the repective pumping stations. At present, 32 sets of the intake, transmission and distribution pump among 123 sets (total) are controlled by the revolutional speed control method, and several sets are planned to be remodelled for the speed control.

The accumulated investiment required for adoption of the speed control method is 642.1 million yen. However, oweing to the remodellling, the electricity could be saved by 31.9 million kWh per year, i e, saving of 590.1 million yen per year in terms of the electricity power charge. This is equivalent to 18.2% reduction of the total electricity consumption of our Bureau.

2) Optimization of the Pump–head

Upon installation of a new pumping plant, pump rating and number of pumps to be installed are usually chosen carefully for ensuring the maximum design capacity with prospect of future inrease in water demand. However, operating changes of pumping station and other relating conditions are unavoidable. Therefore, for rational operation of the pumping stations, we should be capable of coping with such changes flexibly. From a view point of the energy savings, measures to cope with changes in required pump–head are very important. Meanwhile, for large fluctuation of water demand by seasons or years, change of rated pump–head is k nown as effective.

In Osaka City, optimization of the pump–head has been executed by replacing pump impller with that of lower–head for pumps that area operated at a load below the rated capacity. In the case of the water intake and transmission pumps, time fluctuation of the water is comparatively low and the supply water transmission pipe–line are fixed. So, impeller of those pumps was replaced with that of the optimum–head on the occasion.

Since 1965 low head imperllars were fabricated for 6 sets of the pump in total, and at present, several sets of the water delivery pump are planned to have replacealbe low head impeller.

By the optimization of the pump head, energy saving of 7.7 million kWh per year – the reduction 130.1 million yen per year in electricity power charge, could be achieved with investment of 42.8 million yen for fabrication of the impellers. The power savings percentage by this method is 4.3%.

3) Practical uses for the existing Facilities.

Direct Water Delivery In Nighttime

In the distribution system of Osaka City, the secondary distributing plants serve to store water led from the primary distributing plants for delivery of water in accordance with the quantitative demands by pumps. However, one of them, the required head can be often obtained only by remaining head of water delivered from the primary distributing plants, particularly in night time, oweing to change in allocated secondary water delivery area or other similar reasons. Taking this into consideration, we adopted direct water delivery system for such secondary distributing plants to delivery by use of bypass pipeline between the reservoirs for the purpose to save pumping power.

Installation of Pumps for Specific Use

The purification plants need various kinds of in–site water such as washing of filters and feeding of chmicals. In our systems those waters have obtained from the transmission pipe lines.
However, since water pressure in the lines is higher than that necessary for the in–site water feeding, reducing valves are used to obtain the necessary water pressure. The electric power loss caused by such presure reductions is considerably large because significant amount of in-site feeding water is used in each purification plants. The electricity savings effect obtainable by elimination of such pressure reduction was examined through comparison with the necessary investment, and based on the examination result which turned out to be favorable, pumps with required capacity for the specific use were installed.

Direct Delivery of Sludge from Sedimentation Basins

As part of water pollution control and emvironmental conservation, sedimentation and filtration facilities (10,000 m3/day or more) have been used as "specific facility" to treat waster-water to the discharged under th Water Pollution Control Act.
Therefore, in the design of sludge facilities, we have adopted the methdos of delivering the sludge into thickners by pump directly from sedimentation, instead of going by way of sump.
Successful delivery of high concentration sludge into drain treating plant could be realized togehter with electric power saving for sludge pump owing to use of effective head between the sedimentation basin and the slude pump.

As a result, needed facilicty investment of 189.4 million yen, electric power saving of 1.8 million kWh per year corresponding to elecricity power charge reduction of 30.6 million yen per year could be ensured. The electric power saving perentage of those pimprovement is 1.0%.

4) Miscellaneous

Power Factor Improvement by Use of Condensor.

Since the water work facilities use numerous number of motors, the power factor of the whole electric system is to be low. It causes increase of power loss and consequential decrease of the operation efficincy of the sequential decrease of the operation efficincy of the whole electric system. In light of this, electric power plants provide charge system including rebate for power factor improvement made by consumers for promoting it. In order to improve the power factor, many condensors had been installed in our facilities.

Drying–Bed for Alum

Usually, sludge from the sedimentation basins is dehydrated mechanically. However, if site with sufficient area is available, natural air drying of the sludge contributes largely to saving of resources and energy, because it does not need chemicals, electric power and mechanical facilities and equipment.

Reuse of Filter Washing Water.

In our system, pumps and piping were remodelled partially for allowing reuse of the washed water from filters. Reuse of it as the raw water allows saving in raw water intake pump power and coagulant consumption.

Bypassing of Upstream and Downstream in Flock Formation Basins.

In our bureau, mechanical apparatus for the coagulation basins is replaced through partial adaption of the series of baffles.

Thus, by virtue of the abovementioned measures which include those not relating to the energy saving directly, electric power saving of 2.1 million kWh per year, i.e. electric cost reduction of 190.3 million yen per year, was achieved as against the required investment of 569.2 million yen. The electric power saving percentage of those measures is 1.1%.

5. Conclusions

The efforts for improvement of operation efficiency are generally very important factors for water works management irrespective of current energy price. In this respect, development of continual energy saving measures is very desirable. Besides, it is very imprtant to introduce new energy saving tehcnology into the water service facilities on every opportunity of construction of new facilities, renewal and remodellling of the facilities and equipment.

Table 1. Energy Conservation Potential in Osaka City (1981)

Energy Conservation Opportunities	Aggregate of Capital Cost (till March '81)	Projected Annual Electricity Energy & cost savings (April 1981 – March 1982)		Saved Ratio
		Amount	Cost	
	Million yen	Million kWh/year	Million yen	%
(1) The choice of variable-speed control for pums	642.1	31.9	590.0	18.2
(2) Optimization of the delivery pump head	42.8	7.6	130.2	4.3
(3) Practical uses for the existing facilities	189.4	1.8	30.6	1.0
(4) Others	569.2	2.0	190.3	1.1
Total	1,443.5	43.3	941.1	24.6

SOME ECONOMICAL EFFECTS AND PRACTICES OF WATER LEAKAGE CONTROL IN JAPAN

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INTERNATIONAL WATER SUPPLY ASSOCIATION

ASSOCIATION INTERNATIONALE DES DISTRIBUTIONS D'EAU

SOME ECONOMICAL EFFECTS AND PRACTICES OF WATER LEAKAGE CONTROL IN JAPAN

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1. Introduction

It is a matter of great account for water facilities, which aim at supplying water effectively and safely, to endeavor achieving thoroughly control and prevention of water leakage. Water leakage does not only cause the loss of precious water and decrease of effectiveness ratio, public accidents by shortage of supplied water and pollution, but also secondary accidents such as traffic damages by overflows, damage in basement of houses by submergence.

This paper is to refer to first, the change of the amount of delivered water and leakage ratio, mainly based upon the practical experiences in the Bureau of Waterworks, Tokyo Metropolitan Government (TMW) since 1945, and some useful elemnts employed aiming at reducing leakage ratio.

In the second part, some measures, to be advised to employ by insufficiently prepared waterworks in basic matters relating to leakage detection and control works, are referred.

2. Some effects of leakage detection in waterworks.

2.1. The increase of the amount of delivered water and the change of the leakage ratio in TMW.

In Tokyo, concertration of population made a remarkable increase of water demand since late in the 1940. The maximum daily water supply shows as the index 1.0 point in 1950, 1.7 points in 1960, 3.4 points in 1970 and 3.7 points in 1982. (Figure–1)

(2) The leakage ratio

The waterworks of Tokyo, inaugurated its modern water supply in 1898, has also started a survey program for the leakage deterction and control works since 1923. Its water suplly networks suffered from serious damages caused by the Great Kanto Earthquake in 1923 and further World War II.

Consequently, the works were some time interupted, and the leakage was supposed more than 80% just after World War II. (Figure–2)

– The leakage detection and control works in the confused period–

During the time from 1945 to 1948 was confused period caused by after World War II. Especially, the service and distribution facilities destructively suffered. Then the first rehabilitation works were started by the leakage detection and control works positively.

At first, rather primitive works, such as crashing lead pipes and shutting stop valves were mostly employed. As a result, the leakage ratio had been reduced to 56%. The next step, mainly a detection of underground leakage and repairing, has advanced.

Consequently, the leakage ratio dropped to 30% in 1948.

The present leakage works –

Subsequently, the works plan has been strengthened, based upon the detailed investigation in the test area. Nowadays, the underground leakage are detected in two ways, one way is the patrolling survey which aiming at quick finding and repairing. The other is the selective survey which grasping the amount of leakage in the respective 3,690 blocks. Actually, the deliberate and gradual efforts for leakage detection and control have been made continuosly without been discouraged by the desperative war damages. The leakage ratio was reduced to 15.0% in 1982.

2-2 Some elements for reducing leakage and outline of measures

Even in case of newly constructed water facilities, the leakage can not be avoieded with the passing years, if the struggle for a leakage detection and control should be neglected. Therefore, it is not an easy task to support a certain leakage ratio through a detection and control works, and besides the leakage reduction requires much and continuous efforts and expenses.

The leakage consists in several complicated causes as follows; deteriorioration of old distribution pipes, corrosion (pipe-in-pipe, soil and electrolytic), increasing vehicle's load and some sorts of pavements, water hammer and external pressure, joint looseness of uneven settlement and eathquake, accidents caused by other construction works, poor construction of pipe joint, the groundworks and laying, unproper design and selection or materials, etc. Hence, to determine a deliberate plan which covers basic works, leakage detection works and perventive works is the most important matter for the leakage reduction.

The leakage prevention and control works employed by TMW are shown in Table–1.

In this table, an emphasis is placed in the replacement of old distribution pipes and introduction of stainless-steel pipes for service pipes. As to the pipe replacement, the old pipe-lines which were laid before 1945 count about 2,000 KM in Tokyo, but 1,600 KM of them have been replaced with the new ones since 1981 at the pace of 160 KM a year.

The leaks from service pipe are estimated to be more than 90% out of total leakages. Therefore, TMW had been researching for the materials, structures, anti-corrosion and anti-earthquake quality of pipes since 1973.

As a result, an excellent work-system for the service pipeline was adopted in 1980 which consist of a saddle type ferrule, stainless-steel pipe and flexible joint. This measure has been effective in jointing of service pipes from leakage.

– The expenditures of leakage prevention at TMW in 1982 are shown as follows;

Basic works	220 million yen
Leakage control works	10,110 million
Preventive works	17,670 million
Total	28,000 million yen

– The result;

Leakage ratio (Table–2)	15.0%
Effectiveness ratio (Table-2)	80.1%
Investigated length	Approximately 4,700 KM
Repairs	Approximately 5,700 cases
Amount of water pervented	Approximately 180,000 cub.m/day
Replacement of old pipes	Approximately 232 KM
Replacement of stainless pipe	Approximately 27,000 cases

2-3 Some econimical effects of leakage detection

Generally speaking, the reduction of the amount of leakage water makes an effectiveness ratio which includes an unaccounted-for ratio increases, but the less the leakage ratio becomes, the more the expenditures for the leakage control works will be. If a leakage ratio drops below a marginal point, the effects of investment for leakage control will sure be decreased.

In this regards, the Ministry of Public Health and Welfare, the central authority concerned with water supply in Japan, has been actively encouraging the water suppliers with giving a guideline of the effectiveness ratio, which is more definetely comprehensible than the leakage ratio, at 90% or more. However, Tokyo has had such a unique circumstance as great destruction by the earthquake of 1923 and the World War II, the city expansion on the soft soil foundation, increase of traffic and long history since its start. Therefore, it requires a great effort to get to 90%.

The following is the cost analysis of leakage detection and control works at TMW in 1982.

(1) Total leakage detection and control cost against total amount of supplied water is about 16 yen per cub. m and against unit cost of water supply is about 9.9%.

(2) The preventive cost against total amount of supplied water is about 10 yen per cub.m and against unit cost is about 6.2%.

(3) Total leakage detection and control cost against current expenditure is about 10.8%.

(4) The preventive cost against current expenditure is about 6.8%.

(5) The ratio of total leakage detection and control cost to the unit cost is about 22 yen per cub. m (about 13.2%).

(6) The unit cost is 164 yen per cub.m.

The raw water cost of the Fourth Tone River Water Works Expansion Project which has been launching since 1972, is 100 yen per cub.m or more. Consequently, at present, due to difficult situations in promoting water resources development, the leakage detection and control works must be carried out positively.

3. Leakage detection and control practices

In case of such waterworks, which have leakage ratio more than 50% or so and where pipelines maps are incompleted and water quantity measurement is unfinished, the following practices of the leakage pervention works, mainly based upon the experiences in TMW, would be advisable.

3-1 The measurement of the amount of water supply

The first step of preparatory work of leakage protection is to grasp the amount of water quantitatively.

(1) The outflow from a water treatment plant.

One of the measuring methods of a water treatment plant outflow without a flow meter is to measure the water level of the clear water reservoir: The valves of inlet pipe to clear water reservoir is shut at first, and then the quantity of outflow is extimated by measuring of unit time and the decline of the water level. At the same time, the flow in each trunk main is measured by proper value control. In this regards, the following conditions are necessary.

(i) the measuring time should be at least more than one hour.

(ii) It is possible to stop partially water, which might be possible to cause water suspension in some of its supply area, for the flow measuring of each trunk mains.

(iii) The sufficient previous arrangement between the staffs and the related offices before the practice of measuring works and the careful management of the measuring work by use of wireless communication are necessary.

(2) The flow measurement of water mains.

There are two kinds of handy flow measuring methods of water mains. The one is a heat film-probe type flow meter and the other is a supersonic wave flow meter.

(i) A heat film-probe type flow meter.
A small hammer-like sensor is attached at the top of cylindrical shaped appratus, with a diamater of 55 mm.
This meter is inserted into pipeline through hydrant or so, and flow velocity is measured by the thermal difference between the top and the end of heat film. This method is simple and trobule free, and useful for a long time. Working time for measuring including installing and removing of apparatuses is about 30 minutes by a crew consist of one operator and two assistants.

(ii) A supersonic wave flow meter.
The supersonic wave flow measuring method is applicable for such a pipeline of which inside is not rusty.
The principle of this method is as follows; When the supersonic wave pulse is projected into the fluid, there occurs a difference of pulse arrival time between appointed two points of the pipeline according to the direction of flow and pulse. This time difference is measured in a special way and converged to the flow in the pipeline. The flow meter is usually installed in the flow meter box.
Recently, a handy type supersonic flow meter has been developed, and with which flow measuring would become easily possible with high accuracy without injuring pipe body.

3-2 Pipe locating techniques.

Location of underground pipes is an important preliminary process of leakage detection and maintenance of a pipeline. There are two systems: one for metallic pipe, and the other for non-metallic pipe. The results of pipe location, including the position of hydrant, sluice valve, etc., should be plotted on a map so that accurate management map of distribution facilities is able to be made. The efficiensy of leakage prevention work will be remarkably improved by effective use of the map.

(1) Metallic pipe locating device

The buried metallic pipe are located by a conventional electromagnetic metal detector. There are two location methods: induction and direct method. In any way, the change of electric-wave from transmitter is caught by a receiver' In this way, pipe laying site, pipe direction and buried pipe depth are located. The detectable distance, in large cities where buried pipelines are congested like Tokyo Metropolitan area, is 100 m by the direct method but the induction method is in the ratio of 1 : 3 or 1 : 4 to the direct one and detectable depth is about 3 meters. But in local cities the detectable distance is 1,000 meters by the direct method and 500 meters by the induction method. The error in measurement is 3 to 4 centi-meters per 100 meters. Only one week training course for detection work is necessary for the detection crew.

(2) Non-metallic pipe locating device

One of these kinds, improved under TMW's guidance, is based upon a sonic method. A vibrator is aatached to a hydrant or a service meter, which emits a sound signal sent from the oscillator, into pipeline..
While, a pick-up (a geophone) and a receiver unit (an amplifier), placed within a range of 150 meters, catches the sound signal, and can search the pipe location.

Another method which is simplest but rather accurate and applicable to all kinds of pipe materials, is the hearing-on-road survey method.
This method is as follows:
One of the crew is listening to the sound trhough a rod-detector, the end of which touching the valve of hydrant, etc,, the other, which is standing from 20 to 50 meters apart from the former and go across the street tapping the road surface with the end of the pick. When the ground surface of the buried pipe location is tapped, the sound quality from rod detectir changes dry that is quite different from that of the another place, thus they can find the pipe location. This method is fairly effective where traffic noise and other urban noises are not so much.

3-3 Leakage detection technics

The are usually three steps in leakage detection work. The first step is investigation of the road conditions, the second one is leakage detection by audient method and the final step is the confirmation work of the results of the second step.

(1) Investigation of the road conditions

At the first step, the condition of the road such as depression, a wet spot, puddles and the condition of the flow in underground man-holes of every utilities, sewerage pit or storm drain pit should be carefully investigated. The quality of drinking water is different from that of underground water. Using this, the examination of the sample water, taken at possible leakage site is made with handy examination kit for the items such as residual chlorine, pH and electric conductivity after filtration through a filter paper same as coffee percolator. It is especially possible to be leakage water when it is flowing into these pits at midnight.

(2) Audient method

Mainly, leakage sound is detected with stethoscope directly from the sluice valves, hydrants, curb stops or ser service meters. Usually, rod detector (stethoscope) which attached vibration cell on the rod, is used. If leakage detection by rod detector is impossible, the electronic stethoscope is applied. The sound oscillation caused by leakage is cought with a sensor, converted to electric wave, amplified and then transmitted to receiver or recorder. There are two ways of detection, one is to set sensor on the road and detect the leakage sound which propagate through the ground, the other is to set the pick up on the valves or hydrants and detect the leakage sound directly through pipe-body.

In TMW, leakage detection crew, each consist of 4 members, is usually working at midnight when the noise influences caused by heavy traffic and other urban noise are less than that of daytime.

The other method is the Leak Zone Tester which is fit for the grasp of the distribution of leakage in water supplied area. It is equipped with a submergible microphone, and attached to all of the hydrants in the surveying networkd to show numerically the noise levels. It is possible to measure about 7 kilo-meter per day by a pair of crew member. Three days training courses is necessary for a new crew member.

(3) Confirmation work of detection results.

This work is to confirm the possible leakage site which is detected by audient detection works. Conventionally, it has done by open and shut of stop valves, boring with electric hammer drill, boring-bar or detection bar. For this, the correlation method developed by TMW together with an electronics company, has been applied since 1983. This method is to catch the leakage sounds at two points above the pipeline, where the leakage site is between these two points. The distance to leakage site is calculated by using the difference of arrival times of leakage sound, the distance between these two points and leakage sound wave propagation velocity in the pipelines. According to the result of a field test, the percentage of possible leakage detection is 72% that is fairly high.

Correlation method has the following advantages:

(i) Leakage is able to be detected in the daytime without suspending water supply, avoiding the influences of urban noises and distribution flows to some extent.
(ii) More sensible than ordinary audient method.
(iii) Operation is simple and independent upon operator's skill.
(iv) The result values are directly displayed on CRT and confirmed visually.

3-4 Repairing techniques

This description is not to refer to the general considerations of repairing techniques which is applied according to the pipe-diamater, pipe-materials, condition of pipe-damage, construction wokrs, etc.
Hereupon, the consideration of repair works for branch pipeline which has been more than 90% of total leakage accidents, and other two repairing techniques, the is recognized in TMW, would be referred:

(1) The consideration of repair works for branch pipes

On the occasion of a branched pipe repair work, the condition of leakage site, aged pipelines, locating of parallel pipe, the aged pipelines laid, etc. should be thoroughly investigated. As a result, if necessary, branch pipes and distribution pipelines is to be renewed.
In case of that, strength, corrosion resistance and flexibility of pipeline that are related to kinds of the pipe materials and joints should be taken into account of. Furthermore, preventive precaution such as reduction of branch pipeline length and number of joints, should be in consideration at the stage of planning and deisgning.

(2) Freezing method

To repair leakage in a service pipe, a relevant portion at its upstream is frozen by artificial liquefied air, a mixture of liquefied nitrogen and oxygen whose temperature is around − 180 centigrades, thus avoiding an excavation and operating the curb-stop. This method was born in TMW and is now used conveniently in their daily work. At the planning of this method, it is necessary to investigate the local conditions such as possiblity of procurement and keeping of the artificial liquid air and the climate of the area.

(3) Inside repairing method for large pipe

A leakage in a large pipe, which diameter is more than 600 mm, especially at the joint, is repaired from the inside with a specially developed rubber band, steel clamp and epoxy resin filled to void, to avoid excavation work in the road. This technique is also put into practical use by TMW.

3-5 Improvement of water distribution system focused on leakage prevention

There are numerous practical measures for effective leakage prevention. And the most funfamental and important measure is to improve the facilities possible to locate easily and accurately for the leak-point and the quantity.

For that, following measures are necessary:

(1) Preparation of the maps of distribution mains

At the same time of the pipe location, working test for the auxiliary fitting of distribution mains, such as open and shut of velves, working condition of air valves, etc., should be done. Based on these investigations, the maps of distribution mains are prepared.

The scale of TMW's these maps are 1/7,500, 1/5,000 and that of branch pipe is 1/500, etc.

(2) Partition of water supply area and installation of valves and block-meters

In order to grasp leakage conditions as accurate as possible, the water supply area is separated into independent small block areas of which pipe length is about 3 KM. The next step is installing the valves at the proper part of each block area to make it independent from the other areas, and block-meter which consist of a stop valve and two hydrants is to be installed at a border of the block area.

In TMW, the distribution submains (350 mm in diameter and less) in urban area, the network has been so arranged that it can be temporarily separated into 3,690 independent blocks each of which has an average pipe length at 2.5 KM (total pipe length is 9,500 KM), by closing peripheral valves whenever necessary using the 1/5,000 maps. TMW had executed the installation of the block-meters in 1970 to 1978.

(3) Measurement of the amount of leakage by the block minimum flow measurement method

The amount of leakage can be measured quantitatively by the block meter. TMW is at present doing leakage measurement at midnight. This method is developed by TMW. The minimum flow in such a block is used ordinarily to appear in the midnight, from two to four o'clock, and if it might catch the flow in the service-vacant time, it could be considered the leaked flow. A newly developed special car is used for the work.

Electro-magnetic flow meter and all of measuring instruments are loaded in this car. The crew of work consist of five members. The leakage detection work is done giving priority of measurement to the block showing a lot of leakage and having had good results.

4. Conclusion

The are various measures that aim at securing stabilized water supply, through developemt of sufficient water resources, realizing water qualities control, effective utilization of water, etc.

In Tokyo, especially, an effective utilization of water through leakage control is considered as one of the most important tasks to be tackled at due to delay of water resource development and difficulty of new water resource development.

The rapid incerease of urban noises and trafic volume annually has made the work environment and efficiency worse. And the ratio of leakage detection and control cost to unit cost has been increasing annually.

It seems difficult to analyze and estimate the effectiveness of leakage prevention, and we consider that the investment for the leakage prevention must be continued because an additional water resources development requires a great amount of investment. Meanwhile, some basic works ought to be promoted in a water works by strunggling with leakage detection measures in full scale, establishing exclusive organizations and budget, and arranging necessary maps and apparatus through analyzing the amount of delivered and leaked water (distribution, causes, etc.). Besides, the big size of leakage must be repaired immediately according to the research. Further, at the planning stage of water supply the preventive measures should be taken into account. – For example; In order to make a pipiline balanced one. The most adequate quality pipes and joint have to be used in concert with the natural and external conditions. The expansive joints are favorable providing against earthquakes and various soil foundations. A service pipe with saddle type ferrule and material are also favorable against corrosion.

These three measures, the basic, the repair and the preventive measures, have to be done at the same time and the result have to be fed back to the next plant with evaluations. In this sense, if a waterworks hopes to decrease the leakage and to increase the effectiveness ratio, the deliberate planned and continuous measures should be taken.

Consequently, this method is considered to be a sole and the most effective measure.

Table – 1 The leakage prevention works in TMW

Work	Items	Measures
	Preparations	. Finance and organization . Arrangement of maps and apparatuses
	Investigations	. Analysis of delivered and leaked water (distribution and causes of leakage) . Measuring of water pressure
	Development of pipe-materials and leakage prevention technique	. Improvement of pipe-materials, joints and other instruments . Leakage measuring; pipe locating; leakage detecting; pipe repairing
	Repairing work on site	. Rapid finding and repairing of underground leaks
	Planned field work	. Rapid finding and repairing of underground leaks
	Planning and Designing	. Planning and designing of pipeline system in consideration of leakage prevent, safe measures against earthquakes, corrosion and water pressure
	Replacement of old mains and service pipeline	. Old distribution mains to new ones . Old service pipelines to stainless–steel ones
	Structural enforcement of service pipeline	. Unification of road crossing service pipelines . Removal of residual dead pipelines in the street
	Safe measures of pipeline	. Special fittings against leakage; corrosion–proof; pipe protection at bends, tees, etc.
	Maintenance work of pipeline system	. Monitoring and guidance of other utilities construction works close to the water main
	Water pressure control	. Partition of water supply area according to the distribution main system . Setting of press reducing valves

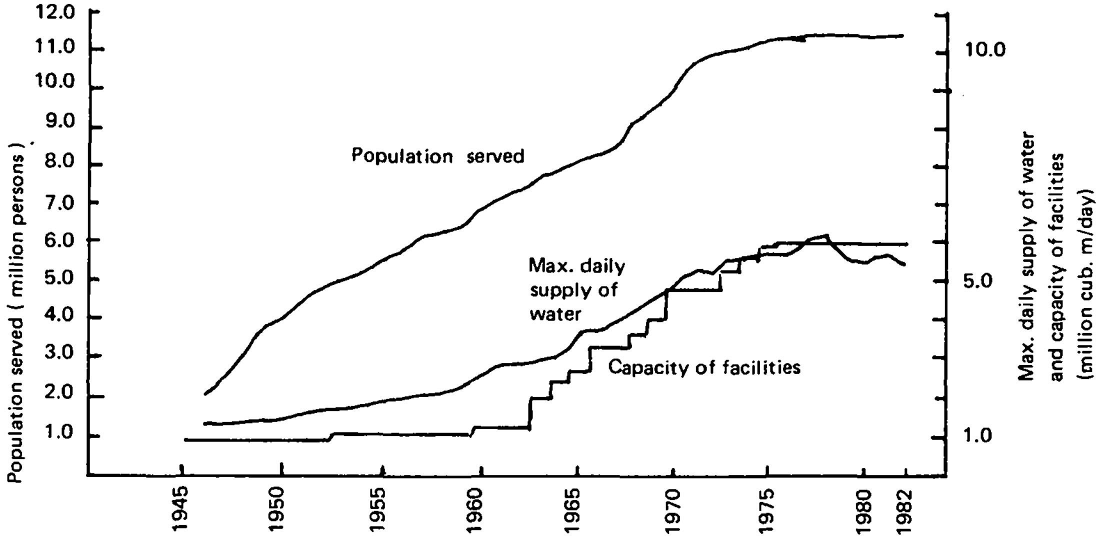


Figure - 1 Population served, Max. daily supply of water and capacity of facilities in TMW.

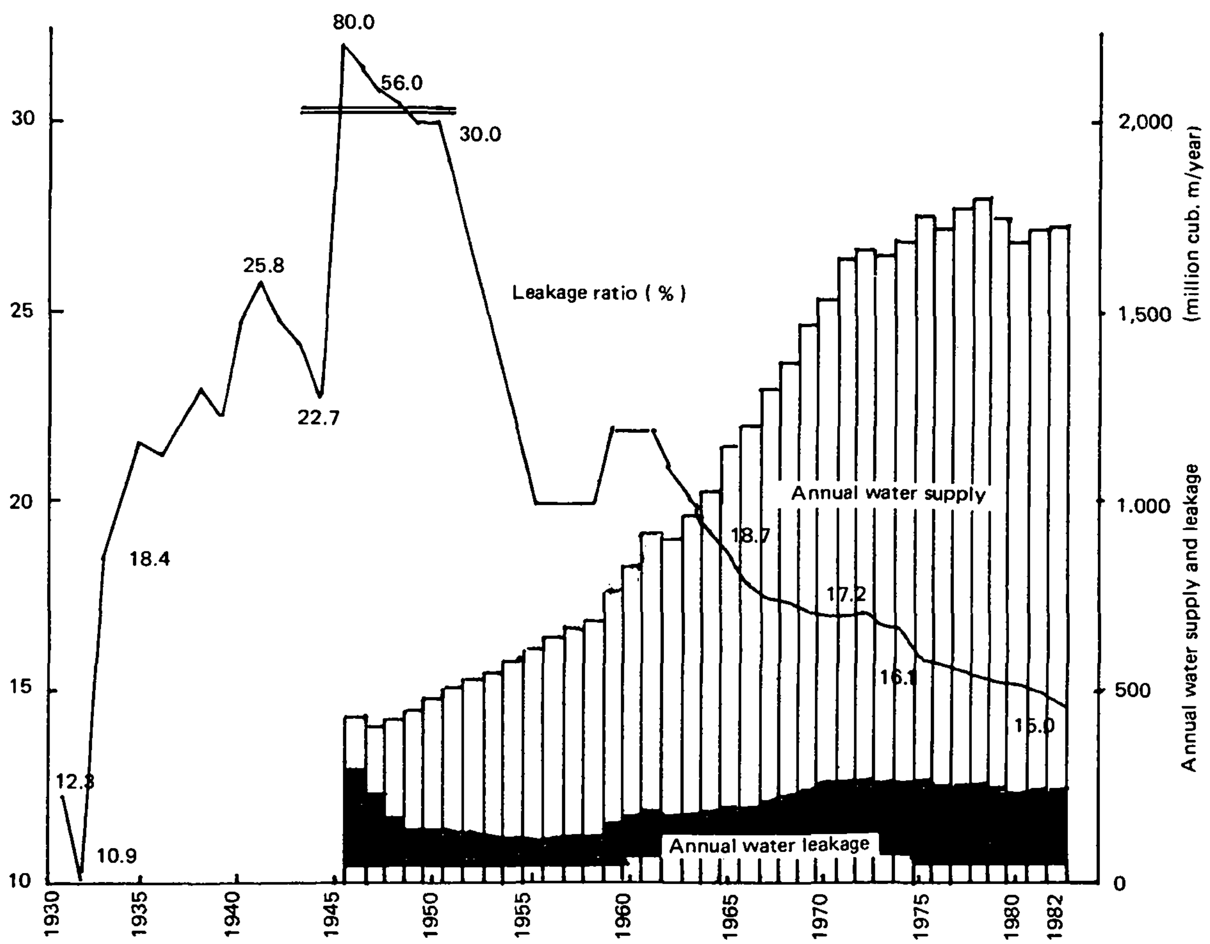


Figure - 2 Tendency of Annual water supply and leakage in TMW.

Table - 2 Analysis of delivered water 1982

Item			Estimation (1000 m3)	Ratio (%)
Total			1,731,958	100.0
Effective water			1,387,694	80.1
	Accounted water		1,325,334	76.5
		Charged water	1,298,763	75.0
		Wholesaied water	26,306	1.5
		Compensation water	265	0.0
	Unaccounted–for water		62,360	3.6
		Meter-insensible water	56,462	3.3
		Publicly used water	5,285	0.3
		Presumption difference	613	0.0
Ineffective water			334,264	19.9
		Leakage water	260,537	15.0
		Adjustment reduction water	6,030	0.4
		Obscure water	77,697	4.5

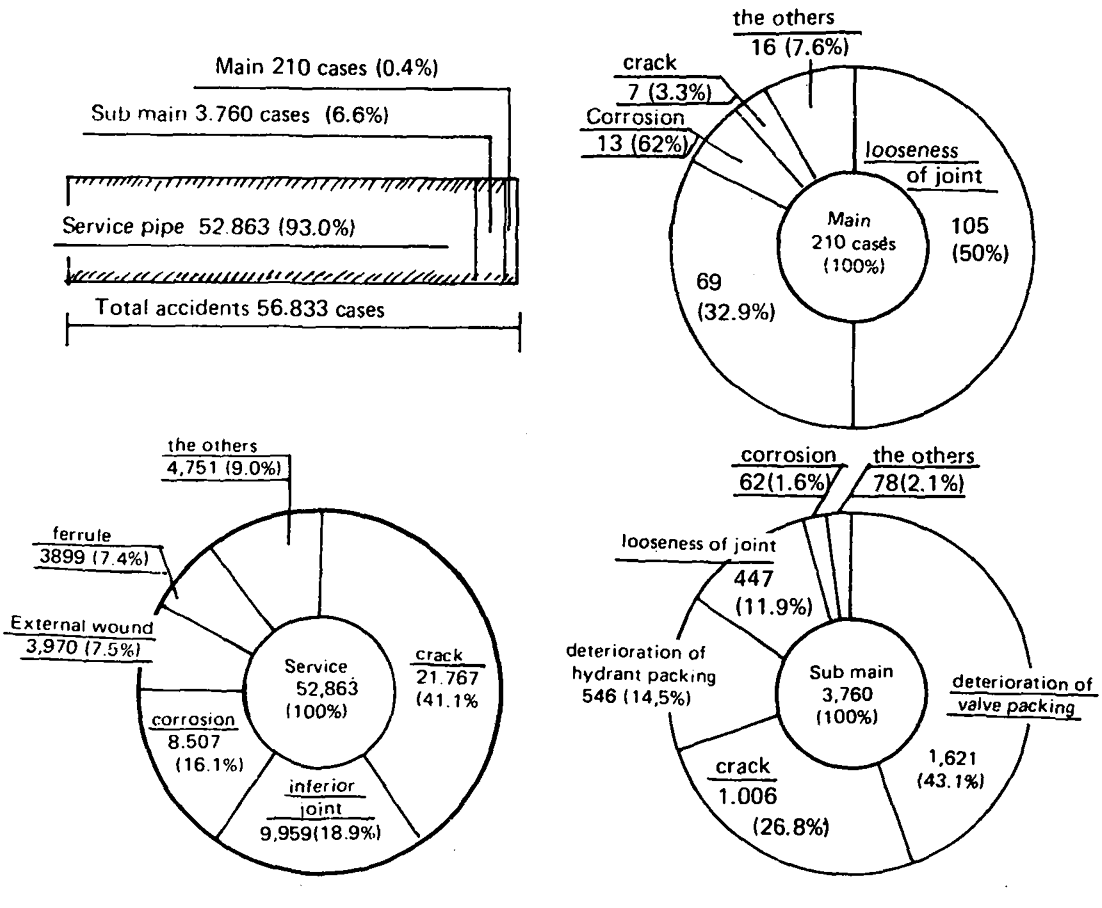
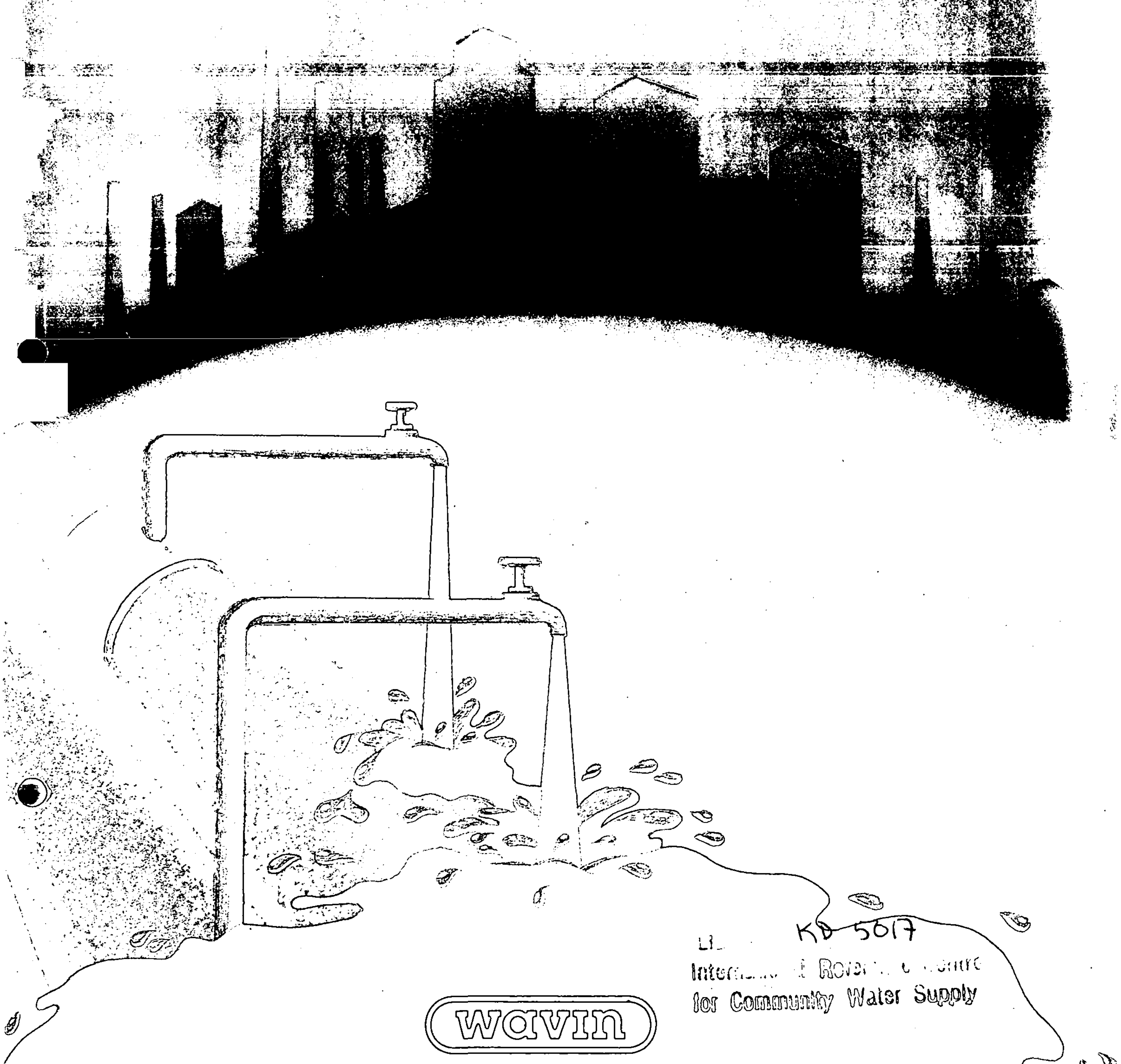


Figure - 3 Number of leakage accidents in 1982

Pilihan Untuk Penggunaan Khusus Transportasi Air Minum dan Air Limbah



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Karya pengalaman lebih dari 25 tahun

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Wavin tidak hanya berhenti disitu, pipa uPVC dikembangkan dan disempurnakan yang akhirnya menghasilkan pipa uPVC seri ISO (International Standard Organization) yang terbukti sangat baik digunakan pada kondisi lingkungan yang tidak menguntungkan.

Saat ini Wavin merupakan produsen pipa plastik utama di Eropa dan memiliki pabrik di 7 negara, yaitu :
Denmark, Inggris, Republik Federasi Jerman, Perancis, Irlandia, India dan Indonesia. Bahkan 28 lisensinya tersebar di 21 negara.

Pelbagai pilihan untuk kebutuhan kini dan masa mendatang

PT Wavin Duta Jaya telah siap menyediakan serangkaian pipa yang lengkap dengan kemungkinan lebih dari 50 pilihan. Mulai dari diameter 16 mm sampai dengan 315 mm dan dengan tekanan kerja 8 bar sampai dengan 16 bar plus serial pipa pembuangan. Ini memungkinkan pilihan ekonomis dengan mempertemukan tekanan kerja dan diameter pipa yang paling mendekati persyaratan disain.

Seluruh pipa Wavin diproduksi dengan pengawasan mutu yang ketat dan mempergunakan mesin yang dirancang dan dibuat oleh Wavin sendiri, menjamin kekuatan pipa dan ketepatan dimensi yang homogen.

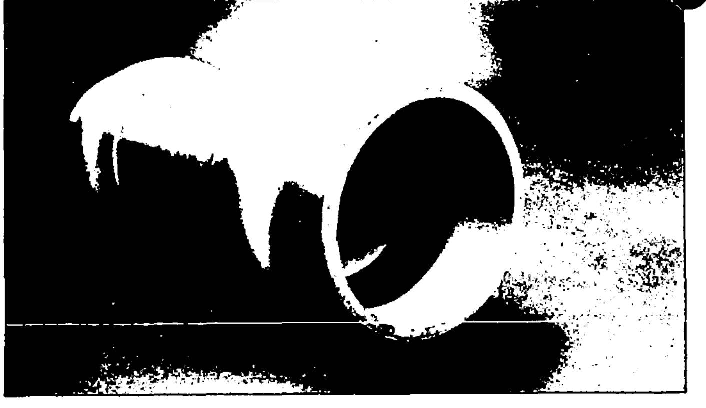
Selain kelebihan di atas, karakteristik pipa uPVC Wavin yang ringan, ulet dan tahan usia lebih dari 50 tahun dapat diharapkan pada masa mendatang mendapat tempat tersendiri untuk menggantikan pipa-pipa dari bahan konvensional.

Pipa uPVC pertama yang memenuhi Standar Industri Indonesia (S.I.I)

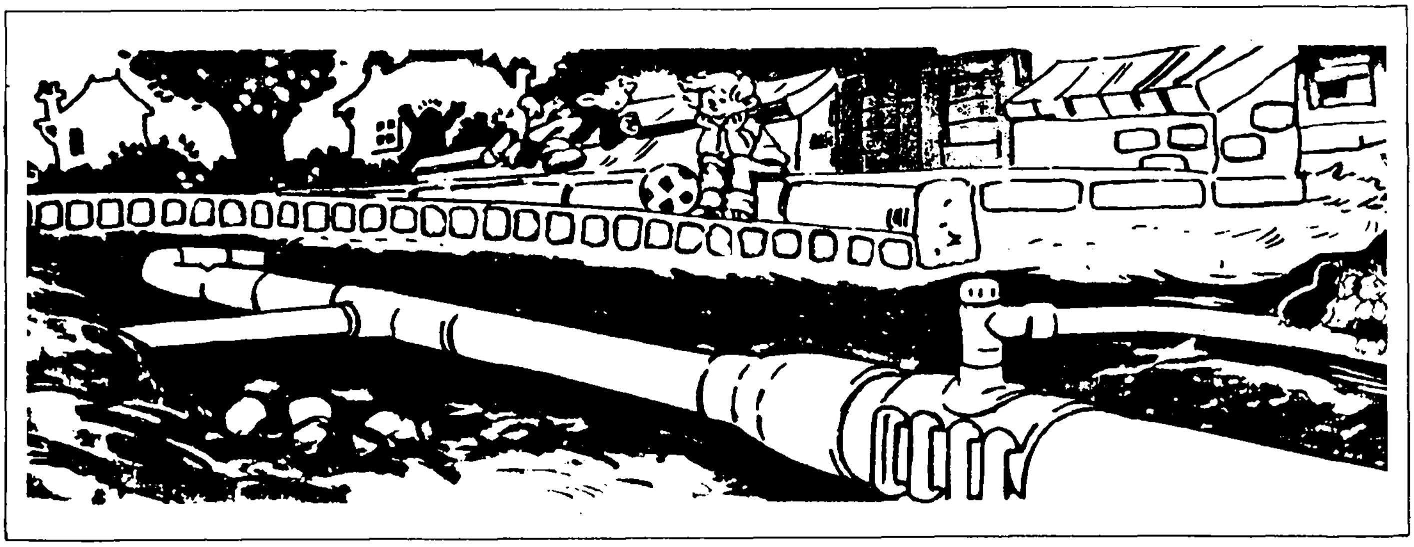
Produksi pertama Wavin di Indonesia terealisasi tahun 1974 yang dilaksanakan oleh PT Wavin Duta Jaya sebuah perusahaan joint-venture antara Wavin BV-Holland dengan PT Pembangunan Jaya dan PT Nusantour Duta Development Corp.

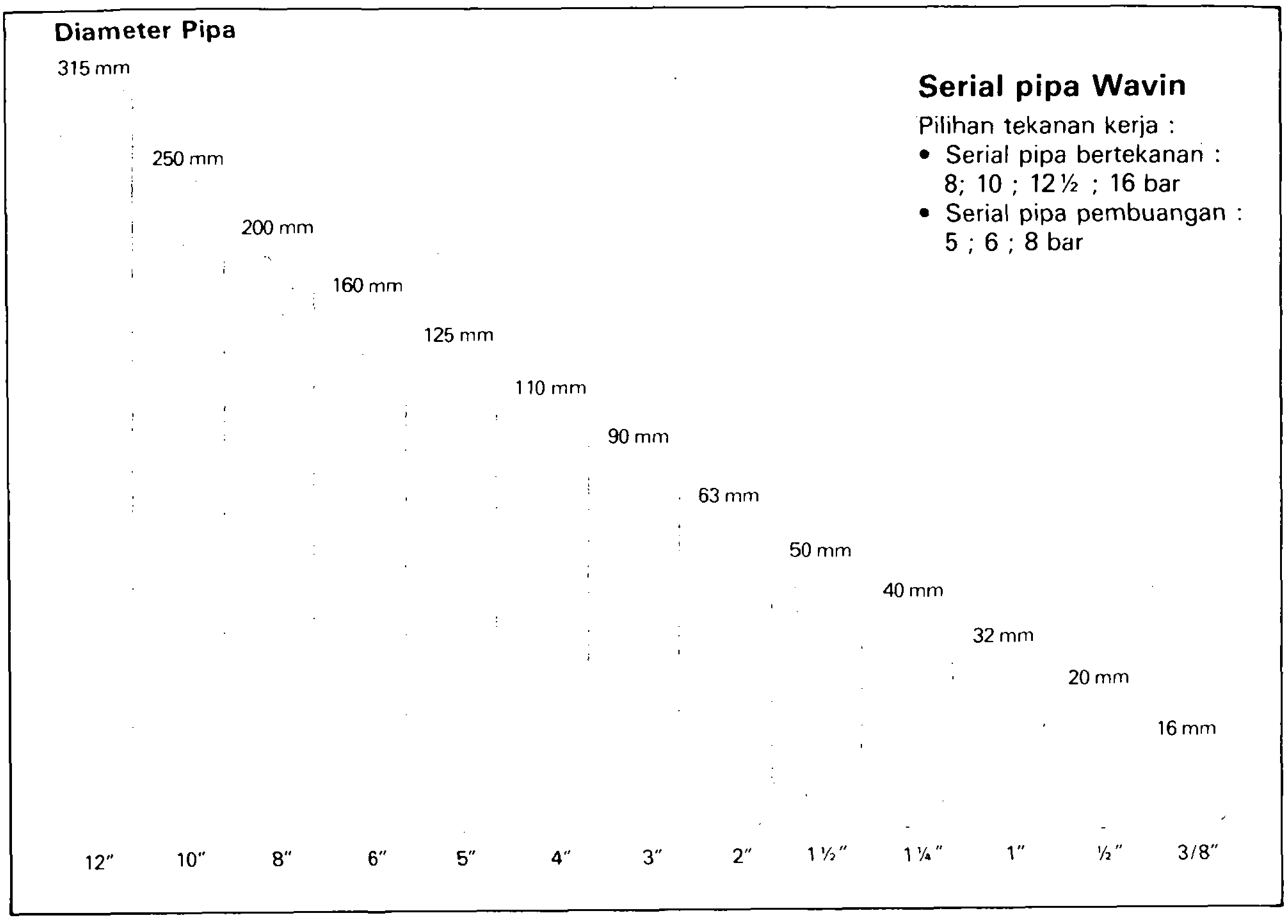
Produk ini dengan cepat mendapat sambutan baik dikalangan pengelola air minum untuk transportasi air bertekanan tinggi. Penggunaan di Indonesia makin meluas tidak hanya untuk transportasi air bertekanan tinggi bahkan juga dipakai untuk saluran pembuangan gedung-gedung bertingkat, bangunan-bangunan industri dan komersil yang menuntut penggunaan pipa uPVC bermutu.

Dengan tersusunnya Standar Industri Indonesia untuk pipa uPVC bertekanan maka Wavin merupakan pipa uPVC pertama yang sesuai dengan Standar Industri Indonesia.



Penyambung Z Wavin

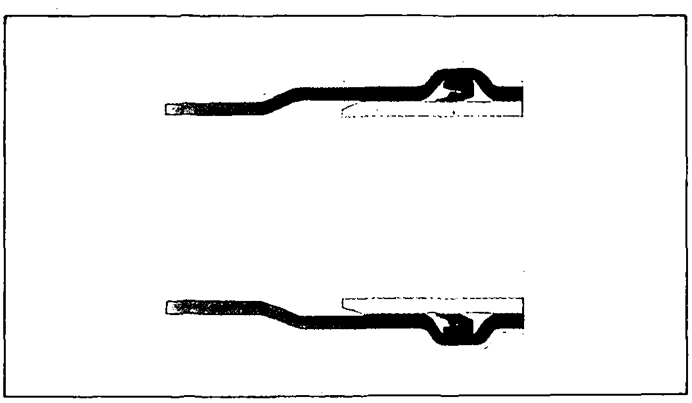




Sistem Penyambung Terpadu Anti Bocor

* **Sistem penyambung Z (Z — joint)**

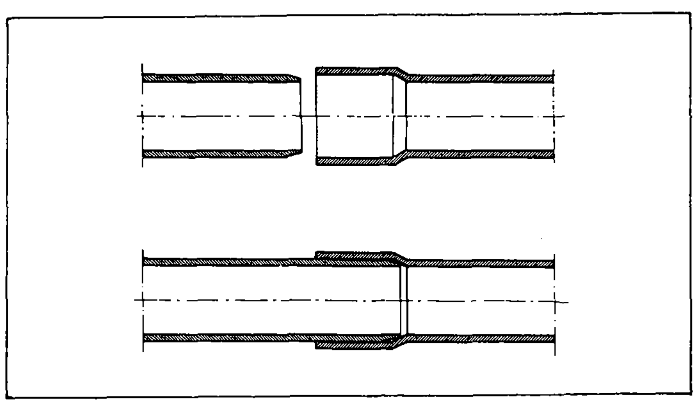
Yang dipatenkan merupakan rancangan sempurna untuk menyambung pipa-pipa Wavin pada medan yang buruk dan cuaca yang kurang menguntungkan.
Sistem penyambungan ini dilengkapi ring karet khusus yang mencengkram pipa secara erat terlebih pada tekanan cairan yang tinggi. Sistem penyambung z memberikan keuntungan waktu pemasangan pipa yang pendek dengan jumlah pekerja yang lebih sedikit tanpa membutuhkan peralatan khusus.



Sambungan Z

* **Sistem Penyambung Lem (Solvent Cement joint)**

Terutama dipakai untuk menyambung pipa berdiameter kecil. Sistem penyambung dengan persyaratan ISO, dirancang untuk mendapatkan permukaan tersambung yang luas dan menghasilkan sambungan yang kokoh, anti bocor.
Penggunaan Wavin Tropical Glue akan mempersenyawakan sambungan dan bukan sekedar merekatkannya.

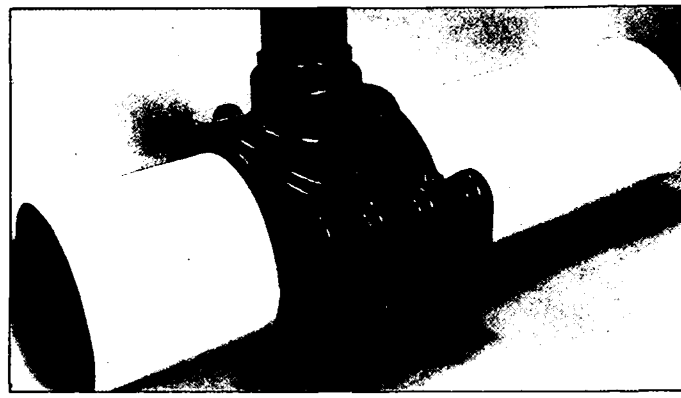


Sambungan Lem

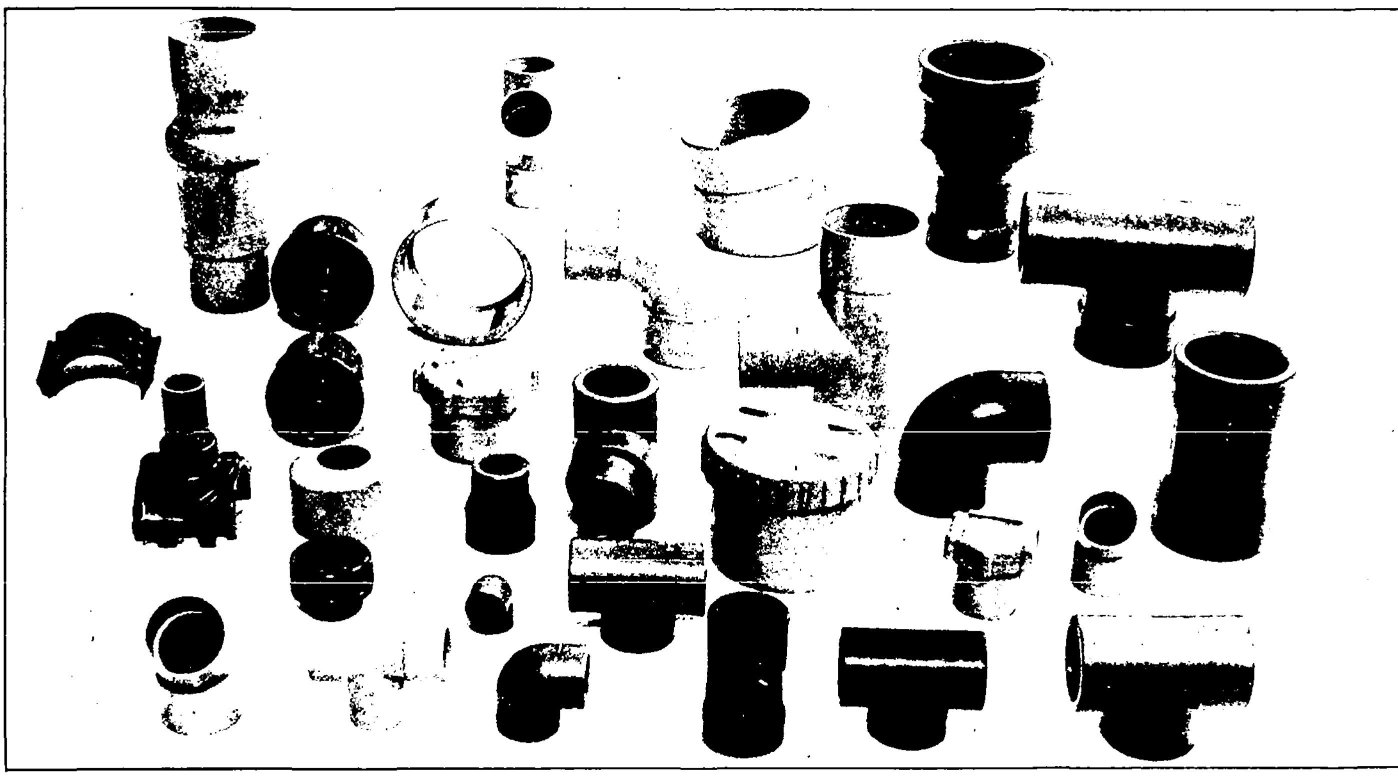
Perangkat Perlengkapan yang makin lengkap

Kini perlengkapan penyambung Wavin makin lengkap, memungkinkan kombinasi pemakaian yang tak terbatas. Penyempurnaan disain dilakukan secara terus menerus yang bahkan melahirkan perlengkapan-perlengkapan baru yang lebih menguntungkan.

Sebagai salah satu contoh Clamp Saddle Wavin merupakan salah satu perlengkapan penyambung hasil inovasi kami untuk penyambungan pipa air minum ke rumah-rumah secara lebih murah cepat dan kokoh. Dan banyak lagi perlengkapan yang tidak di peroleh pada sistem pipa uPVC merek lain.



Clamp Saddle PVC Wavin



Perangkat Perlengkapan Wavin

Wavin siap membantu Anda secara tuntas

Wavin akan siap membantu memecahkan problem Anda mulai dari taraf disain hingga pelaksanaan di lapangan. Tenaga-tenaga terdidik kami yang digembleng selama lebih dari 7 tahun, merupakan jaminan pelayanan total dari kami. Wavin bukti keunggulan teknologi uPVC.

AN IMPORTANT INVESTMENT DRINKING WATER–WASTEWATER HOW NOT TO WASTE FUNDS ?

Jacques COUSTILLAS
Compagnie Generale des Eaux

4TH Asia Pacific Regional
Water Supply
Conference & Exhibition
Jakarta, Indonesia
5-11 November 1983

TIRTA DHARMA
INTERNATIONAL WATER SUPPLY ASSOCIATION

AN IMPORTANT INVESTMENT DRINKING WATER–WASTEWATER HOW NOT TO WASTE FUNDS ?

Jacques COUSTILLAS
Compagnie Generale des Eaux

Water is an element essential to human well–being on three accounts : healt, nutrition, and hygiene.
Man has always been subjected to water's whims. He has had to clam up its excesses and palliate its shortcomings.
The domestication of water gave rise to the dawning of civilization in the Nile Valley and Assyria around 4,500 B.C. and to the establishment of the first cities. Many vestiges attest to the efforts man has since made to secure a water supply. One need only think of the norias of Hama in Syria and of the Roman and Arab aqueducts in the Mediterranean countries.
Cities have always developed around water intake points and man has worked wonders to control, store, channel and distribute water.
At present, new problems have arisen, owing to :
– population growth and the greater water needs entailing the depletion of readily–available and high–quality resources ;
– the complexity of economic and social phenomena ;
– the higher living standards and expectations.
Supplying water has become a matter for specialists. On November 10, 1980 the United Nations launched th International Water Supply and Sanitation Decade. The Decade, now well under way, calls for providing "clean water and sanitation for all by 1990". Its objective are ambitious and its program vast.
Currently, for most of the world's population, the greater part of which lives in developing countries, drinking water supply is nonexixtent. Sanitary facilities are even rarer than water supply systems. International organizations estimate that 25 million people die every year form water–borne diseases.
In 1980 the population of developing countries, excluding the People's Republic of China, was about 2,300 million people. In these countries, according to a study by the World Health Organization (WHO), only 43% have access to drinking water and 25% to sanitary facilities (Table 1). Over two thirds of the population of developing countries lives in rural areas, where the quality of the service provided is far worse than in urban areas.
The Decade's target of providing safe drinking water and hygienic waste disposal to all of the world's population by 1990, will require substantial efforts, especially in rural areas. According to the WHO, by 1990 more than 1,800 million people in developing countries will be needing water supply, and about 2,400 million people needing sanitary facilities (break–down shown in Table 2).

— The investments necessary to meet these goals are enormous :
– 60 billion dollars for drinking water supply ;
– 500 billion dollars for sanitation.

The first difficulty is financing and constructing new water supply and sanitation works. Supposing this can be done, the facilities will be useless, however, uniess they are in steady operation and provide the population with the basic service they are intended for. Measures must therefore be taken to ensure the long life of the facilities and their proper and continuous operation. This extensive program moreover entails the training of several hundred thousand specialized technicians.
It is common to note that in many countries the existing facilities work badly or are not kept up well. The investments going to new works are thus wasted. Breakdown of recently commissioned installations are common and their causes many. Yet is seems that in general they are related to an inadequate study of the socio–economic conditions, in contrast with the attention paid to the technical aspects of projects. In many cases, great care has gone into the planning and construction of new works, while the problems of their maintenance and operation have been completely forgotten.
Under these conditions, it is most unlikely that the International Water Supply and Sanitation Decade Will reach its targets. But it does appear that a number of developing countries and the international organization are becoming aware of this situation and are according greater importance to the renovation or maintenance of existing works. It has become apparent then, that a prime consideration must be given to maintenance, operation and management of existing and future facilities.
It is no doubt on what is called operational assistance that will depend the success or failure of undertakings in urban areas, and even more so in rural areas.
How, when, by whom can such operational assistance be provived ?
It seems useful to recall first of all that a drinking water supply must meet all quality and quantity requirements and guarantee a steady distribution.
This objective exacts a progressive and concerted effort and gives shape to a rigorous process involving.
– a greater understtanding of the status of existing facilities, in particular as regards corrosion and leaks ;
– a precise assessment of all water needs in time and in space ;

- a detailed inventory of available resources to meet needs allowing for losses and waste ;
- a long–term plannning of water supply and distribution facilities in stride with the urban development in progress ;
- definition of a work schedule allowing to meet need at all times ;
- study of projects, impoundments, water intakes, pumping stations, treatment facilities, aqueducts, reservoirs and distribution systems ;
- research of financing enabling work to get under way;
- execution and control of construction work ;
- finally, organizing the management of technical departments ensuring rational and effective operation and maintenance of the facilities.

The same process applies to wastewater management shose two–fold aim involves evacuating sewage and stormwater to receiving waters (revers, ocean, land application, ground infltration) an reducing nuisances to the maximum.

As for drinking water, here again, a series of stages is necessary to attain objectives which demand :

- a thorough knowledge of existing structures, in particular as regards the water–tightness and the condition of collectors (aggradation) and the quality of water discharged into receiving waters ;
- a precise knowledge of the hydrology of the drainage area discharging into the urban area to be developed;
- a wualitative and quantitative knowledge of industrial, domestic and public effluents and of sources of pollution in the zone to be urbanized ;
- set–up of a master plan for wastewater on the basis of the urban development plan and definition of a work schedule ensuring adequate wastewater treatment for the coming decades ;
- study of projects to be constructed, combined or separate collection networks, stormwater collection and grit removal facilities, treatment and pumping plants, stormwater overflows and discharges to receiving waters ;
- research of financing of works ;
- execution and control of constuction work ;
- organizing of management of technical departments to enable rational and efficent operation of the new facilities.

The conception and implementation of a project is a very lenghty operation extending from six to ten years, and is hence inevitably also a very expensive one.

For such a major undrtaking, steps must be taken to ensure its success. Success will often depand on the orginal choice, the preparation and execution of the project, and finally on the use made of the new facilities.

Only a specialist will be able to provide, at the various stages of a projet, the input to ensure its success. Such experienced and highly–qualified specialists exist. they are operators and daily perform this task within an undertaking that manages or operates water supplies or wastewater facilities.

The compagnie Generale des Eaux is a water supply undertaking with know–how and experience. Founded over a century ago, in 1853, it provides assistance to communities in the fields of water, sanitation, and household wastes. It is the leading water supply firm in France, managing a network supplying over 20 million people. It thus has a large number of engineers, executives, and technicians specialized in water supply and wastewater. This specialized personnel is available to carry out the most varied missions and to meet the concrete needs of each country.

Operational assistance can take several forms. Most often, it involves either detaching experts or executing particular tasks. In the first case, the expert operates within the existing structure. He can guide or advise a homologue or else be integrated into the existing hiearchy. Depending on the circumstances, these missions can be short–term actions, lastings a week or two, and sometimes be repetitive. Or they may consist of longer–term actions going from one to several years. In the case where specific tasks are executed, they are confided to an expert or a team. In the operation of water supply or wastewater facilities, such may be manifold : analysis of network operation, leak detection and control of meter quality, organization of maintenance, improvement of operation of treatment facilities, identivication of subscribers, billing, organization of departments, etc. As these examples show, these missions touch on all aspects of operation, both the technical and the administrative.

The contribution of an expert or the execution of a particular task constitutes but a single step in operational assistance. In fact, to be effective and constructive, collaboration must neccessarily involve training. Training activites should moreover be adapted to each case.

Operational assitance, through which training and the transfer of knowledge can be achieved, should therefore be considered fundamental to ensure the success of the operations under way and of future operations.

Such operational assistance can take on a very general form and touch on all aspects of drinking water and wasterwater. For example, it might involve :

- evaluation of surface water and groundwater resources, hydrology, water surveillance, management of water resources, regulations concerning the policy of water mangement and protection of water resources;
- the establishment and organization of public bodies or national agencies responsible for water ;
- treatment, transport and distribution of industrial water ;
- purification in urban and rural areas ;
- treatment of industrial wastewater ;
- operation of water distribution systems including personnel training as well as all forms of management assistance, such as accountancy and administrative management.

Compensation for operational assistance can be envisioned several ways :

Compensation foir operational assistance can be envisioned several ways :

- on the basis of the time involved, in which case the contract sets the price per man per .month of the specialist (s);
- as a service contract ;
- or finally in the form of a management contract.

Concretely, such procedures of operational assistance have already been implemented in many parts of the world. In this area, for example, our Company has carried out action of this kind :

- in the Philippines for implementation of a maintenace service for electro–mechanical installations with the help of the Asian Development Bank;
- in Indonesia with detachment of an engineer for feasibility study for the supply of water to an industrial estate ;
- in Laos People's Democratic Republic for study of a drinking water supply nework in Savannakhet and Pakse by computer modelization.

As mentioned in the beginning of this discussion, the target of the Decade is to meet the needs of some 2,000 million people, that is, more than twice the population presently supplid. Will this goal ge attained ? It is hard to answer this question today, yet everything must be done to move towards its achievement. To my mind, operational assistance is a means of doing so.

NUMBERS OF PEOPLE IN THE DEVELOPING WORLD (Excluding China) WITHOUT CLEAN WATER AND SANITATION IN 1980

	Population (million)	Population (million) without clean water		Population (million) without adequate sanitation	
URBAN	703	177	25%	331	47%
RURAL	1612	1143	71%	1399	87%
Total	2315	1320	57%	1730	75%

Source : Government figures supplied to WHO

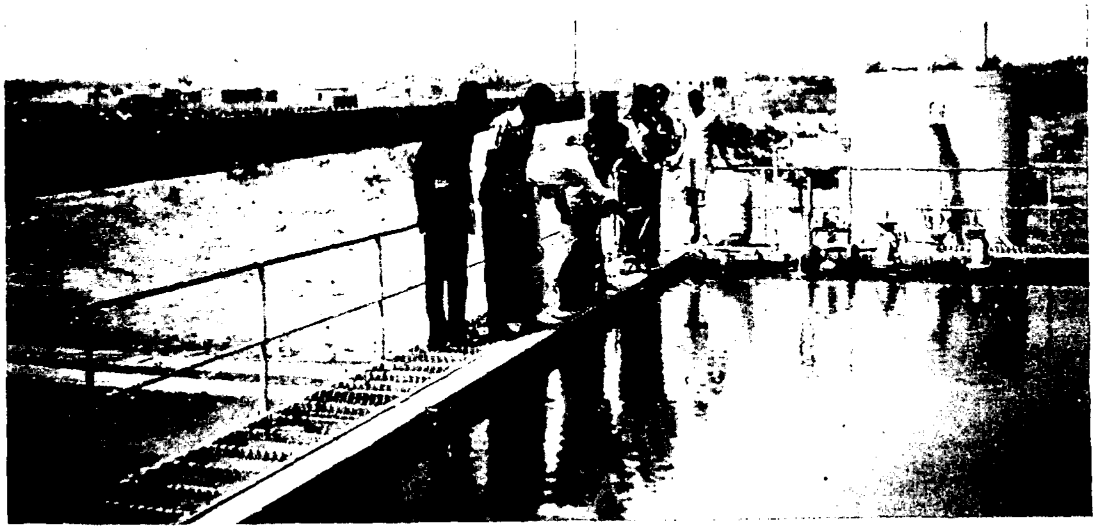
NUMBERS OF PEOPLE IN DEVELOPING COUNTRIES.
(in million)
TO BE REACHED WITH CLEAN WATER AND SANITATION BY 1990

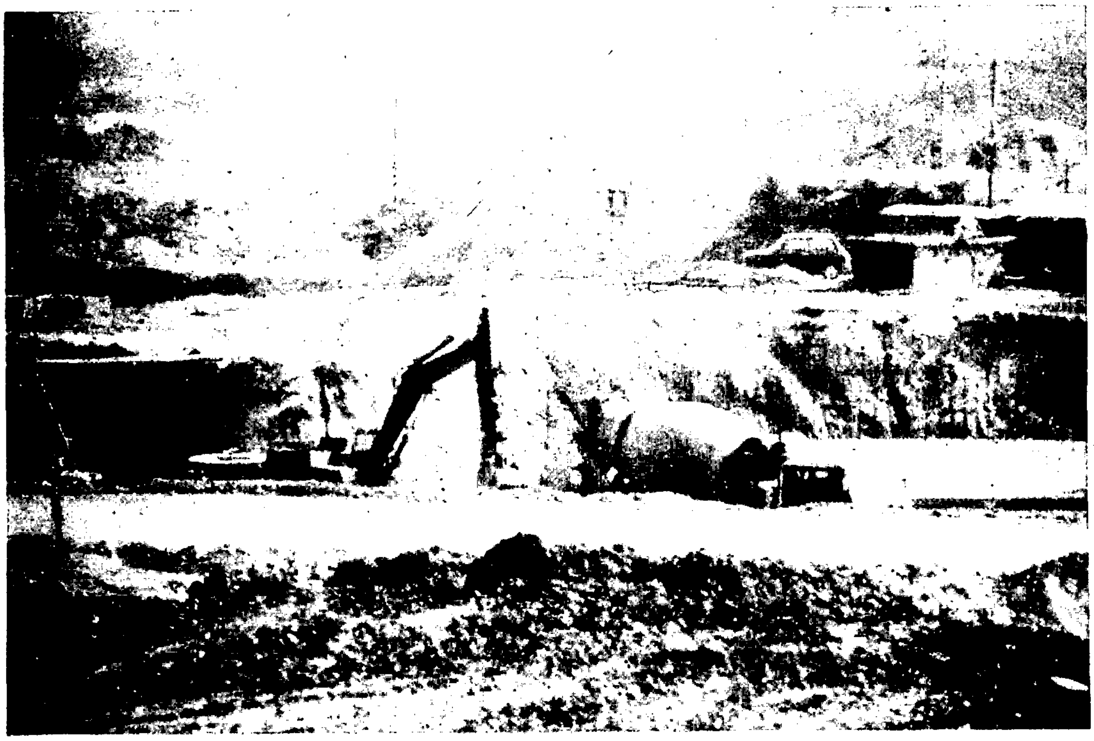
UN Region	WATER			SANITATION		
	Urban	Rural	Total	Urban	Rural	Total
Asia and the Pacific	203	925	1128	355	1136	1491
Latin America	108	110	218	212	120	332
Africa	104	310	414	130	342	472
West Asia (Arab World excl. Africa)	16	22	38	20	25	45
Europe	14	21	35	30	30	60
WORLD TOTALS	445	1388	1833	747	1653	2400

Notes : Excluding China
This table assumes that the Decade 100% targets will be achieved.

Sources : WHO figures based on data supplied by governments.

Measures must be taken to ensure that water supply and sanitation facilities work properly and continuously. The Decade will therefore involve the training of several hundred thousan specialized technicians. Prime consideration must be given to the maintenance, operation and management of the facilities, and it is no doubt on operational assistance that the success of projets will depend.





LIST OF SLIDES

1. PROJECT II - SOURCES OF SUPPLY
2. PROJECT II - TREATMENT COMPLEX
3. NEW IPO DAM
4. NEW IPO DAM
5. LA MESA PLANT KD 5017
6. LA MESA PLANT
7. LA MESA PLANT
8. PROCESS OVERVIEW
9. FLOCCULATION BASINS
10. FLOCCULATION BASINS
11. VERTICAL TURBINE FLOCCULATOR
12. SEDIMENTATION BASINS
13. SEDIMENTATION BASINS
14. CLEANING SEDIMENTATION BASINS
15. CLEANING SEDIMENTATION BASINS
16. FILTERS - FILTERING MODE
17. FILTERS - BACKWASHING MODE
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19. BACKWASH IN PROGRESS
20. FIXED GRID SURFACE WASH
21. "TEEPEE" FILTER BOTTOM
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Operation Proves Out Innovative Design of La Mesa Water Treatment Plant

By : Oscar I. Ilustre
John F. Willis, and
J. Kevin Reilly

KD 5017

Last April, the Metropolitan Water Works and Sewerage System (better known as MWSS) formally marked the implementation of its Manila water Supply Project II with the dedication of the 1500 megaliter per day (MLD) La Mesa Water Treatment Plant.

The new La Mesa plant is the heart of our ambitious -- and highly successful -- 10-year program to effect an 80 percent increase in water supply to Metro Manila, adding some 1975 MLD of safe supply to serve a population that is projected to be more than 10 million by 1990.

Our project II exploits the full potential of the Angat - Ipo - La Mesa - Alat sources, which lie about 40 km from Metro Manila (1,2)* in the western highlands of the Sierra Madre range. The project supports multi-purpose use of supply for potable water, hydroelectric power generation and irrigation.

Future works already in planning stages will develop new sources of

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*Figures in parentheses indicate slide numbers.

SUPPLY AND GREATLY EXPAND RELIABLE DISTRIBUTION SERVICE IN THE METRO MANILA SUBURBS.

PROJECT II GOT UNDERWAY IN 1975 WHEN MWSS ENTERED INTO AN AGREEMENT WITH THE AMERICAN CONSULTING ENGINEERS, CAMP DRESSER & MCKEE, INC., IN ASSOCIATION WITH SUBCONSULTANTS JAMES M. MONTGOMERY, CHARLES T. MAIN AND THE LOCAL PHILIPPINES FIRM OF DCCD ENGINEERING CO, TO DEVELOP A LONG RANGE, MULTI-STAGE PLAN TO SUPPLY THE METRO MANILA AREA INTO THE NEXT CENTURY AND TO BEGIN DESIGN OF THE INITAL ELEMENTS AS PROJECT II.

THE MAJOR SOURCE OF WATER UNDER PROJECT II IS THE MULTI-PURPOSE ANGAT RESERVOIR WHICH IS ALSO USED FOR POWER GENERATION AND IRRIGATION. ANGAT POWER TURBINES DISCHARGE INTO THE ANGAT RIVER WHICH CONNECTS WITH THE IPO RIVER. JUST BEYOND THE CONFLUENCE OF THE ANGAT AND IPO RIVERS, A NEW DIVERSION DAM HAS BEEN BUILT, TO REPLACE AN EXISTING DAM (PICTURES). IT INCREASES THE HEAD ON TWO (3,4)
EXISTING TUNNELS SO THAT GREATER CAPACITY CAN BE ACHIEVED WITHOUT THE NEED FOR NEW OR LARGER TUNNELS. SCREENING FACILITIES WERE INCLUDED AT THE DIVERSION STRUCTURE. BEYOND THE TUNNELS, THREE EXISTING AQUEDUCTS, AND A NEW 16-KM-LONG, 3.4 M-DIAMETER TUNNEL AND CUT-AND-COVER AQUEDUCT, TRANSMIT WATER TO THE NOVALICHES RESERVOIR AT THE LA MESA DAM.

AT THE ENTRANCE TO NOVALICHES, A NEW DIVERSION STRUCTURE WILL DIRECT UP TO 1500 MLD TO THE NEW LA MESA TREATMENT PLANT. ANOTHER 1600 MLD CAN BE DISCHARGED TO THE NOVALICHES RESERVOIR FOR TRANSMISSION TO THE BALARA TREATMENT PLANT (AN EXISTING FACILITY

BUILT IN SEVERAL STAGES BEGINNING IN 1938 AND MOST RECENTLY EXPANDED TO A TOTAL CAPACITY OF 1600 MLD UNDER PROJECT II).

FROM THE LA MESA PLANT, TREATED WATER IS DISCHARGED VIA A NEW AQUEDUCT AND THE NEW 200 ML BAGBAG BALANCING RESERVOIR TO FEED INTO THE PRIMARY LOOP THAT SERVES METRO MANILA.

THE LA MESA PLANT IS THE SPECIAL FOCUS OF MY PRESENTATION TODAY (PICTURES). THE PLANT'S DESIGN EMPHASIZES RELATIVELY LOW (5,6,7) CAPITAL COSTS AND HIGH OPERATIONAL RELIABILITY; FEATURES THAT HAVE WIDE APPLICABILITY IN OUR REGION OF THE WORLD.

TREATMENT PLANT PROCESSES AT LA MESA COMPRISE CHEMICAL FEED, FLASH MIXING, FLOCCULATION, SEDIMENTATION AND FILTRATION, DIVIDED INTO TWO IDENTICAL AND PARALLEL PROCESS TRAINS, FOLLOWED BY POST CHLORINATION, FLUORIDATION, AND LIME FEED FOR PH CONTROL. BACK-WASH WATER AND SLUDGE FROM THE SEDIMENTATION BASINS ARE (8) COLLECTED IN SLUDGE LAGOONS WHERE THE BACKWASH WATER IS RECOVERED AND PUMPED BACK TO THE HEADWORKS.

EACH PROCESS TRAIN CONSISTS OF THREE VERTICAL TURBINE TYPE FLASH MIXERS FOLLOWED BY SIX PARALLEL FLOCCULATION-SEDIMENTATION BASINS. (9,10) EACH FLOCCULATION BASIN CONSISTS OF SIX COMPARTMENTS EACH WITH A VERTICAL FLAT-BLADE TURBINE TYPE MIXER (PICTURE). THE SIX (11) SEDIMENTATION BASINS, DESIGNED FOR MANUAL REMOVAL OF SLUDGE BY FLUSHING (PICTURE), ARE FOLLOWED BY 12 FILTERS OF THE DUAL-MEDIA (12,13) (COAL-OVER-SAND) TYPE AND DESIGNED TO BE SELF-BACKWASHING WITHOUT NEED FOR PUMPS OR ELEVATED TANKS.

AS CAN BE NOTED, THE PLANT IS BASICALLY "CONVENTIONAL" IN DESIGN. HOWEVER, MANY FEATURES -- SUCH AS DESIGN LOADING RATES ON THE SEDIMENTATION BASINS, AND THE FILTER CONTROL AND BACKWASHING MODES -- ARE UNCOVENTIONAL AND HAVE PROVEN TO BE HIGHLY EFFECTIVE IN OPERATION.

THE DESIGN APPROACH WAS BASED ON THE FOLLOWING CONSIDERATIONS:

- FIRST, THERE IS A READY LABOR MARKET IN THE MANILA AREA, SO THE DESIGN WAS BASED ON MANUAL OPERATION, WITH EQUIPMENT AND AUTOMATION MINIMIZED, FOR REASONS OF OPERATIONAL ECONOMY AND RELIABILITY.
- SECOND, SPARE PARTS FOR IMPORTED EQUIPMENT ARE OFTEN DIFFICULT TO OBTAIN. THUS, THE DESIGN SHOULD CONSIDER MINIMUM EQUIPMENT SYSTEMS TO ACHIEVE RELIABILITY.
- THIRD, FINANCIAL RESOURCES WERE LIMITED SO THAT DESIGN WAS OPTIMIZED, AND APPROACHES WERE TAKEN TO MINIMIZE BOTH CAPITAL AND OPERATING COSTS.

WITH THESE CONSTRAINTS IN MIND, OUR CONSULTANT, CDM, UNDERTOOK EXTENSIVE PILOT TESTING AND PLANT SCALE TESTING AT THE BALARA PLANTS FOR THE PURPOSE OF ESTABLISHING RECOMMENDED EXPANSION CAPABILITIES AT BALARA AND DESIGN LOADING RATES FOR LA MESA.

THE PILOT TESTING AND ASSOCIATED WATER-QUALITY STUDIES SHOWED THE SUPPLY TO BE OF RELATIVELY GOOD QUALITY. TURBIDITY IS 2 TO 5 TURBIDITY UNITS (TU) FOR PART OF THE YEAR, TYPICALLY DURING OTHER PERIODS SOMEWHAT HIGHER, AT 5 TO 60 TU, AND WITH SEASONAL PERIODS OF HIGH TURBIDITY UP TO 580 TU.

THERE IS NO COLOR PROBLEM. THE TURBIDITY IS DERIVED PRIMARILY FROM SILT.

THE RAW WATER IS OF A UNIFORMLY HIGH TEMPERATURE, ENABLING FASTER SETTLING OF SUSPENDED PARTICLES AND PROMOTING BETTER CHEMICAL REACTIONS THAN ARE TYPICALLY OBTAINED IN TEMPERATE CLIMATES.

FROM THESE STUDIES, THEREFORE, CDM RECOMMENDED THAT THE FLOCCULATION BASINS BE DESIGNED FOR A 20-MINUTE DETENTION TIME (ABOUT HALF THAT OF "TEXTBOOK VALUES") AND THAT THE SEDIMENTATION BASINS BE DESIGNED FOR AN OVERFLOW RATE OF 5.6 MM/MIN (ABOUT TWICE THAT OF "TEXTBOOK VALUES").

IN ADDITION, CDM RECOMMENDED DUAL- MEDIA FILTERS DESIGNED FOR A LOADING RATE OF 14.6M/HR, (6 GPM/S.F.)A RATE THAT WAS 50 PERCENT HIGHER THAN RATES TYPICALLY USED BY MANY ITNERNATIONAL FILTER SUPPLIERS AT THAT TIME, BUT THAT WAS CONSISTENT WITH THE CONSULTANTS' EXPERIENCE FOR PERFORMANCE OF DUAL-MEDIA FILTERS IN THE U.S.

ALSO, THE OPERATING EXPERIENCE AT THE BALARA PLANT, WHERE THERE ARE NO PROVISIONS FOR MECHANICAL SLUDGE REMOVAL AND WHERE EMPHASIS IS PLACED ON LABOR-INTENSIVE OPERATION, LED TO THE RECOMMENDATION THAT LA MESA BE DESIGNED FOR MANUAL CLEANING (<u>PICTURE</u>). THIS MEANT (14,15) THAT AN ADDITIONAL DEPT OF 1.5 METRES WAS ADDED TO THE SEDIMENTATION BASINS FOR SLUDGE STORAGE, WITH A TOTAL DEPTH OF 6 METRES. (THE BASIN WALLS WERE, HOWEVER, DESIGNED FOR POSSIBLE FUTURE INSTALLATION OF SLUDGE REMOVAL EQUIPMENT.) THE EXTRA DEPTH WAS COST-EFFECTIVE WHEN COMPARED TO MECHANICAL SLUDGE COLLECTION,

SINCE THE RELATIVELY LOW COST OF CIVIL WORKS CONSTRUCTION MADE THE DEEPER TANKS LESS EXPENSIVE THAN SHALLOWER TANKS WITH IMPORTED EQUIPMENT.

THIS FACTOR OF LOW COST CIVIL WORKS CONSTRUCTION WHEN APPLIED TO THE EVALUATION OF SIMPLE FILTER CONTROL EQUIPMENT LED TO THE SELECTION OF THE SELF-BACKWASHING FILTER CONCEPT, WHEREBY THE WASHING OF A FILTER IS DONE WITH THE EFFLUENT OF THE OTHER FILTERS.

TO DO THIS, THE FILTER BOX IS DESIGNED SO THAT THE ELEVATION OF THE BACKWASH TROUGHS IN THE FILTER IS SET AT 1.1 METRES BELOW THE LEVEL OF WATER IN THE EFFLUENT CHANNEL, WHICH IS CONTROLLED BY A WEIR AS SHOWN IN FIGURE 3 . THE NUMBER OF FITLERS MUST BE (16)
CAREFULLY SELECTED SO THAT THE PRODUCTION RATE OF THOSE FILTERS IN SERVICE WILL BE ADEQUATE TO CLEAN THE FILTER TO BE WASHED.

BACKWASHING IS THEN ACCOMPLISHED BY CLOSING THE FILTER INFLUENT VALVE -- STOPPING FLOW TO THE FILTERS -- AND CLOSING THE EFFLUENT/BACKWASH VALVE. THE DRAIN IS THEN OPENED. WHEN THE WATER DROPS TO THE LEVEL OF THE BACKWASH TROUGHS, THE EFFLUENT/BACKWASH VALVE OPENS GRADUALLY OVER A 3-MINUTE PERIOD. AT THIS POINT, THE WATER LEVEL IN THE FILTER IS LOWER THAN THAT OF THE EFFLUENT CHANNEL BY 1.1.METRES, HENCE, THE EFFLUENT PROVIDES WATER FOR BACKWASHING. (17)
WHEN WASHING IS COMPLETE, THE PROCEDURE IS REVERSED AND THE FILTER RETURNED TO SERVICE.

THE BACKWASHING CYCLE REQUIRES OPERATION OF ONLY THREE SLUICE GATES (IN THIS CASE BY ELECTRIC OPERATORS BECAUSE OF THEIR LARGE SIZE). (18,19)

THERE ARE NO CONTROL VALVES OR PUMPS EXCEPT FOR AN AUXILIARY SURFACE WASH.

MECHANICAL OR ELECTRICAL FILTER CONTROLS ARE ALSO NOT REQUIRED. FLOWS TO EACH FILTER ARE SPLIT EQUALLY BY HYDRAULIC MEANS OVER INFLUENT WEIRS. THUS, FLOW TO EACH FILTER IS AT A CONSTANT RATE. AS THE EFFLUENT LEVEL IS WELL ABOVE FILTER MEDIA LEVEL, THERE IS NO DANGER OF THE FILTER GOING DRY OR OF NEGATIVE PRESSURES; THUS, AS FILTRATION TAKES PLACE, THE WATER LEVEL RISES IN THE FILTER BOX TO OFFSET THE DEVELOPING HEADLOSS. THE RATE OF THE HEADLOSS BUILD-UP IS EASILY MONITORED BY WATCHING THE FILTER -- NO GAUGES ARE REQUIRED. ALSO AS FLOW IS CONSTANT, NO RATE GAUGES ARE NEEDED. THE RATE FOR EACH FILTER CAN EASILY BE DETERMINED BY DIVIDING PLANT FLOW BY THE NUMBER OF FILTERS IN SERVICE.

THUS, THE DESIGN PROVIDES FOR SIMPLE FILTER CONTROL AND ESSENTIALLY AUTOMATIC BACKWASHING WITH AN ABSOLUTE MINIMUM OF EQUIPMENT: ONLY THREE ELECTRIC MOTOR OPERATED GATES; ON THE INFLUENT, DRAIN AND EFFLUENT/BACKWASH.

WHILE THESE FILTERS ARE ABOUT 1.5 TO 2 METRES DEEPER THAN A TYPICAL CON-CONVENTIONAL FILTER, THEY WERE 10 TO 20 PERCENT LESS COSTLY THAN ALTERNATIVE MECHANICALLY CONTROLLED AND BACKWASHED FILTERS.

ONE MECHANICAL COMPROMISE WAS MADE IN THE AREA OF AUXILIARY FILTER WASH. HERE, THE CONSULTANTS THOROUGHLY EVALUATED AIR BACKWASH SYSTEMS, AND ROTATING AND FIXED GRID SURFACE WASH SYSTEMS.

A SURFACE WASH SYSTEM WAS SELECTED FOR SEVERAL REASONS, THE MOST IMPORTANT BEING THAT IT WOULD ALLOW FOR THE USE OF A PRECAST CONCRETE (20
FILTER BOTTOM CONSTRUCTED OF INVERTED "V" SHAPED UNITS, AND CALLED BY U. S. ENGINEERS A "TEEPEE" BOTTOM. THESE UNITS COULD BE MADE LOCALLY (21
BY THE CONTRACTOR THUS AVOIDING MORE EXPENSIVE PROPRIETARY UNITS NECESSARY FOR AIR BACKWASH SYSTEMS. ALSO, THE USE OF SURFACE WASH WOULD INCORPORATE PUMPS-- WHICH OUR MAINTENANCE PEOPLE ARE USED TO SERVICING-- RATHER THAN LARGE AIR BLOWERS WITH WHICH THEY ARE LESS FAMILIAR.

HAVING SELECTED SURFACE WASH, THE CONSULTANTS THEN SELECTED A FIXED-GRID SYSTEM USED SUCCESSFULLY IN MANY U.S. AND SOUTH AMERICAN PLANTS. IT COULD BE FABRICATED FROM LOCAL PIPE AND WOULD AVOID BOTH THE COST OF IMPORTED ROTATING MECHANISMS AND THE MAINTENANCE ASSOCIATED WITH THESE SYSTEMS.

PLANT CHEMICAL FEED SYSTEMS ARE PROVIDED FOR ALUM, LIME, POLYMERS, CHLORINE, AND FLOURIDE AS SODIUM SILICOFLOURIDE. ALL CHEMICALS ARE LOCALLY MANUFACTURED EXCEPT THE POLYMERS. BULK STORAGE SYSTEMS ARE PROVIDED, AND CONVENTIONAL MECHANICAL FEED EQUIPMENT IS UTILIZED. HOWEVER, THE ALUM SYSTEM PROVIDES FOR FEEDING BY GRAVITY USING
BIF ROTO-DIP FEEDERS (PICTURE) WHICH MWSS HAS USED SUCCESSFULLY (22)
FOR MANY YEARS AT THE BALARA PLANTS. LIME FOR pH CONTROL IN THE EFFLUENT (FOR CORROSION CONTROL) IS ALSO FED BY GRAVITY FROM THE FEEDER SLAKER UNITS TO THE FEED POINTS WHICH ARE LOCATED NEARBY.

THE CHEMICAL FEED AND CONTROL BUILDINGS (PICTURES) ARE OF SIMPLE DESIGN MAKING EXTENSIVE USE OF REINFORCED CONCRETE AND MASONRY (23) TO MINIMIZE MAINTENANCE. LABORATORY FACILITIES ARE PROVIDED BUT THEY ARE OF A CONTROL NATURE ONLY, WITH THE MORE SOPHISTICATED ANALYSES DONE AT OUR CENTRAL LABORATORY AT BALARA. BUILDINGS ARE LOCATED CENTRAL TO REQUIREMENTS. OPERATIONS ARE CENTERED IN THE EAST AND WEST CHEMICAL WINGS ADJACENT TO THE TREATMENT UNITS. CHEMICALS ARE LOCATED NEAR THE MAJOR POINT OF USE. ALUM AT THE PRETREATMENT END, CHLORINE, FLOURIDE, AND LIME NEAR THE EFFLUENT. FILTERS ARE OPEN, BUT COVERED WALKWAYS ARE PROVIDED TO GIVE SOME CLIMATIC PROTECTION TO STAFF AND TO THE LOCAL CONTROL PANELS (FILTER VALVE OPEN-SHUT CONTROLS).

PLANT OPERATION

THE LA MESA TREATMENT PLANT BECAME 25% OPERATIONAL IN FEBRUARY 1982 WITH THREE SETTLING BASINS AND SIX FILTERS. IT ACHIEVED 50% CAPACITY BY MAY 1982. THE REMAINING 50% IS OPERABLE AND WILL BE PUT ON-LINE WHEN MORE OF THE WATER DISTRIBUTION SYSTEM HAS BEEN COMPLETED. PRESENTLY THERE ARE 56 PEOPLE INVOLVED IN THE DAILY OPERATION OF THE PLANT WHILE ANOTHER 20 ARE EMPLOYED FOR THE SUPPORT SERVICES OF SECURITY AND BUILDING MAINTENANCE. THE SUPERVISORY STAFF NUMBERS FIVE AND CONSISTS OF A SUPERINTENDENT, A CHEMICAL ENGINEER, A FILTRATION ENGINEER, A CHIEF CHEMIST, AND A MAINTENANCE ENGINEER; EACH HEADING HIS OWN DIVISION

THE IN-PLANT CONTROL LABORATOY IS DESIGNED TO ANALYZE SAMPLES FROM ALL MAJOR PORTIONS OF THE PLANT PROCESS THUS CONTINUOUSLY MONITORING

THE WATER QUALITY AT THE DIFFERENT PHASES OF TREATMENT. PRESENTLY THE LABORATORY MONITORS TURBIDITY, pH, COLOR, FLOURIDE AND CHLORINE RESIDUALS WITH JAR TESTS BEING PERFORMED ONCE, TWICE OR THREE TIMES A DAY. THE FREQUENCY OF JAR TESTS IS DICTATED BY THE RAPID CHANGES THAT OFTEN OCCUR IN THE RAW WATER TURBIDITY DURING THE RAINY SEASON. THE TURBIDITY RANGE IN THE UNTREATED WATER HAS OCCASIONALLY RISEN FROM 1.5 TO MORE THAN 550 TU IN THE SPACE OF FOUR HOURS. DESPITE THESE SHARP INCREASES THE FINISHED WATER TURBIDITY CONSISTENTLY REMAINS BELOW 1.0 TU. THE pH ENTERING THE PLANT RANGES FROM 6.8 TO 7.7 WHILE THE EFFLUENT pH PRIOR TO pH CORRECTION IS CHARACTERISTICALLY 0.3 OF A UNIT BELOW THAT. THE FLOURIDE RESIDUAL IS MAINTAINED AT 0.6 MG/1 AND FREE CHLORINE AT 0.2 TO 0.6 MG/1 AT THE INTERMEDIATE CHLORINATION POINT AND 0.6 TO 1.0 MG/1 AT THE PLANT EFFLUENT.

IN THE NEAR FUTURE THE LABORATORY WILL BEGIN MONITORING BACTERIOLOGICAL QUALITY ON A DAILY BASIS FOR THE DIFFERENT STAGES OF TREATMENT.

PRESENTLY THE FLOW AVERAGES 520 MLD, THROUGH ONE-HALF OF THE PLANT. THE FLOW RATE WILL INCREASE AS THE DISTRIBUTION NETWORK - NOW UNDER CONSTRUCTION - IS COMPLETED. THE PLANT HAS DEMONSTRATED WATER QUALITY-WISE AND OPERATIONALLY, THAT IT IS MORE THAN CAPABLE OF MEETING WATER QUALITY STANDARDS AND OPERATIONAL REQUIREMENTS AT MAXIMUM RATED FLOW. THE LABORATORY RESULTS TESTIFY TO ITS CAPABILITY WITH REGARDS TO WATER QUALITY. OPERATIONALLY IT HAS PERFORMED EXTREMELY WELL ESPECIALLY IN REGARD TO THE SETTLING BASINS AND FILTERS.

THE SETTLING BASINS ARE CLEANED MANUALLY BUT WERE DESIGNED TO ACCOMODATE MECHANICAL SLUDGE COLLECTION LATER ON , IF DESIRABLE. AT THIS TIME IT APPEARS THAT SUCH A MODIFICATION WILL NOT BE IMPLEMENTED IN THE FORSEEABLE FUTURE DUE TO THE EASE WITH WHICH THE BASINS ARE MANUALLY CLEANED. AT THREE-MONTH INTERVALS, EACH BASIN IS TAKEN OUT OF SERVICE FOR CLEANING. USUALLY, THE SLUDGE ACCUMULATION AMOUNTS TO FROM 1.9 TO 3.0 METRES IN DEPTH WITH AN AVERAGE OF ABOUT 1.5 METRES. THE DEEPEST ACCUMULATION OF SLUDGE IS BETWEEN 25 AND 45 METERS FROM THE UPSTREAM END OF THE SETTLING BASINS. TYPICALLY, A BASIN IS TAKEN OUT OF SERVICE AT 3 AM AND IS FULLY DRAINED BY 7 AM. AT THAT TIME A 6-MAN CREW ENTERS THE BASIN AND HOSES DOWN THE REMAINDER OF THE SLUDGE - ABOUT 15 CM DEEP - FROM THE BASIN FLOOR, ALONG WITH THE SURFACE COATING ON THE WALLS, LAUNDERS, BAFFLES AND FLOCCULATORS. THE CLEANING OPERATION IS USUALLY COMPLETED BY NOON OF THE SAME DAY,AT WHICH TIME THE FILLING PROCESS BEGINS; LASTING FOR 6 HOURS.

PRESENTLY THE FILTERS ARE BACKWASHED EVERY 72 HOURS AT A MAXIMUM RATE OF 55 M/HR (22.5 GPM/S.F.). WASH WATER AMOUNTS TO ABOUT 1.3% OF PLANT THROUGH-PUT. THE FILTER RUNS WOULD NORMALLY BE LONGER BUT SINCE THE SURFACE WASH SYSTEM IS STILL INCOMPLETE, SHORTER FILTER RUNS ARE ADVISABLE TO PREVENT MUDBALL PENETRATION INTO THE MEDIA. EVEN DURING THE HIGHEST TURBIDITY CONDITIONS,THE FILTER WATER LEVEL NEVER EXCEEDS 0.8 METRES BELOW THE DESIGNATED BACKWASH LEVEL. THE FILTERS HAVE PERFORMED EXCEPTIONALLY WELL IN THIS REGARD AND SHOW AN EXCELLENT DISTRIBUTION OF BACKWASH WATER FLOW DURING THIS OPERATION.

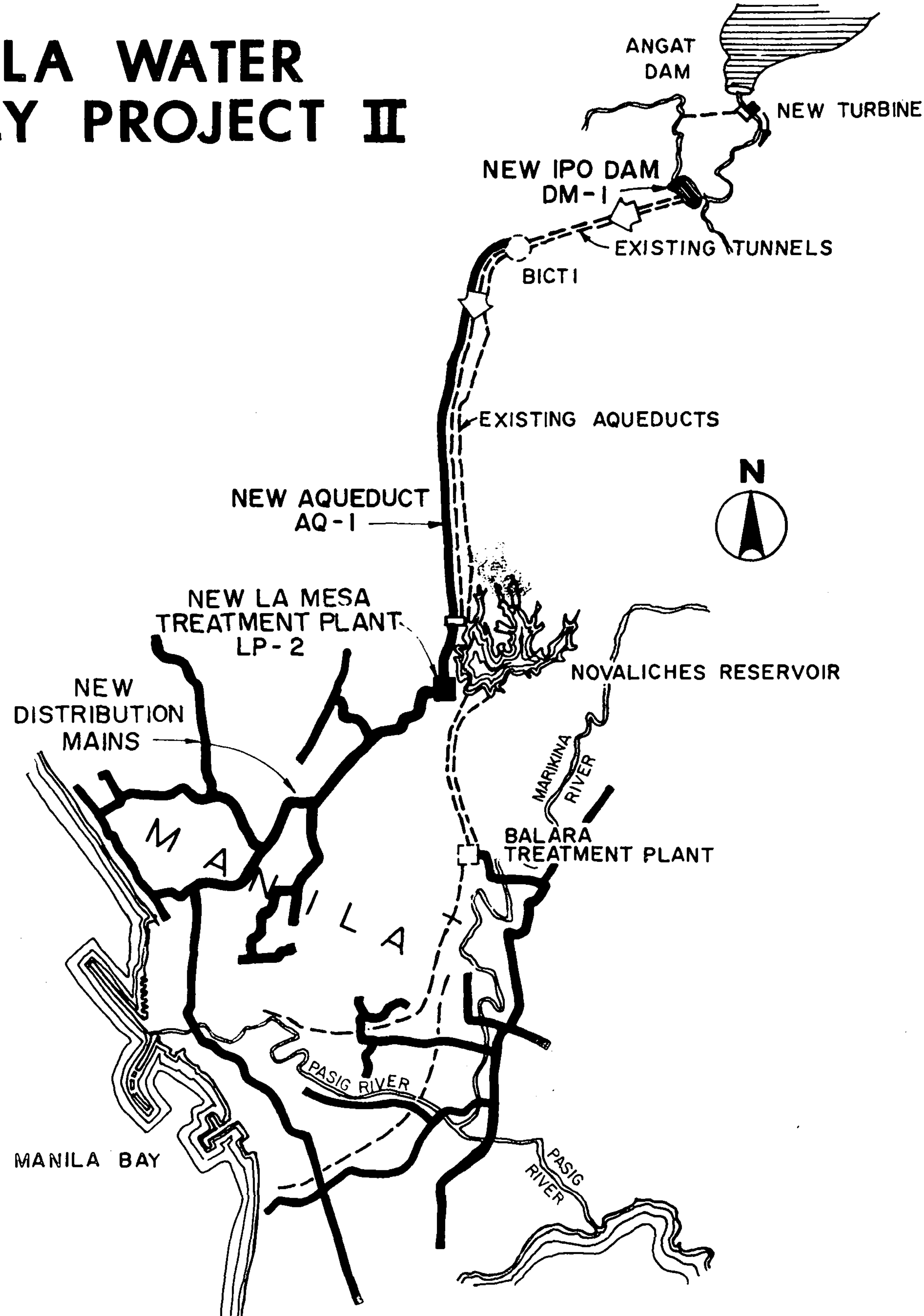
A WORD OR TWO SHOULD BE MENTIONED AT THIS POINT ABOUT BAGBAG RESERVOIR. EVEN THOUGH THE RESERVOIR IS FOUR KILOMETERS DOWNSTREAM OF THE PLANT, IT ACTS AS THE PLANT CLEAR WATER BASIN. IT SERVES TO DAMPEN THE OUTPUT FLUCTUATIONS WHEN A FILTER IS BACKWASHED. THE FLUCTUATIONS CAN BE CONSIDERABLE SINCE BACKWASHING A FILTER USES FINISHED WATER AT A RATE OF 280 ML/D OR 18.5% MAXIMUM PLANT FLOW, FOR A FIFTEEN-MINUTE PERIOD.

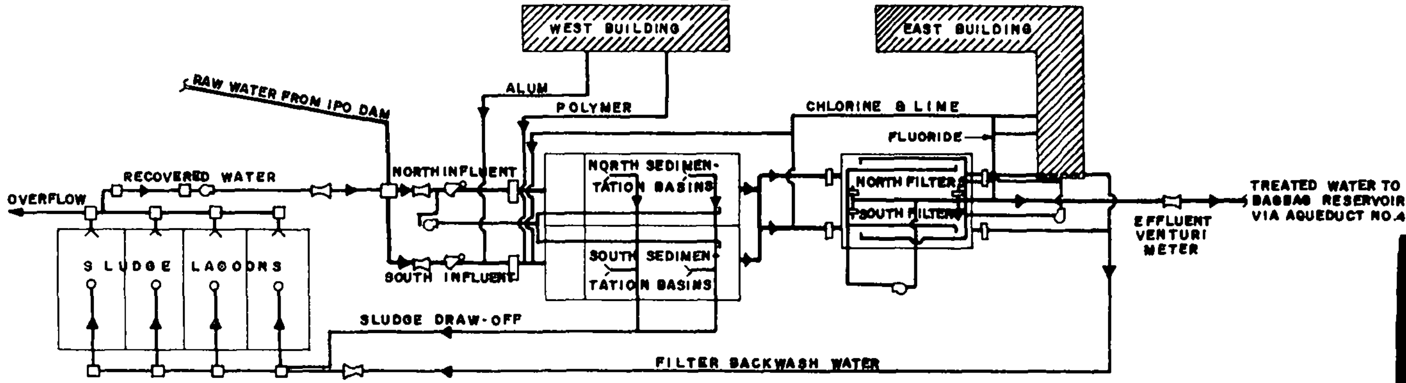
A KEY ELEMENT OF THE OPERATIONAL PROCEDURE IS THE TRAINING OF THE OPERATING STAFF. THIS IS BEING ACCOMPLISHED IN TWO WAYS. THE FIRST IS BY MANUFACTURERS' REPRESENTATIVES FOR EACH MAJOR PIECE OF EQUIPMENT INSTALLED IN THE PLANT. THE SECOND INVOLVES THE CONSULTANT'S REPRESENTATIVE USING THE OPERATING AND MAINTENANCE MANUALS PREPARED BY THE CONSULTANT FOR THE TREATMENT PLANT AS A WHOLE. EACH MANUAL RECEIVES ITS DETAILED "FINAL" REVIEW IN THE THE CLASSROOM BEFORE BEING PRINTED. THE REVIEW CONSISTS OF A PAGE BY PAGE DISCUSSION OF EACH CHAPTER, IN COMBINATION WITH HANDS-ON OPERATION OF EACH PLANT PROCESS. THIS PROCEDURE NOT ONLY GIVES THE OPERATORS A SOLID BACKGROUND IN OPERATING ALL PROCESSES BUT ALSO ENSURES THE CORRECTNESS OF PROCEDURES OUTLINED IN THE MANUAL.

OSCAR I. ILUSTRE IS GENERAL MANAGER OF THE METROPOLITAN WATERWORKS AND SEWERAGE SYSTEM, MANILA, THE PHILIPPINES. JOHN F. WILLIS, VICE PRESIDENT, CAMP DRESSER & MCKEE HEADED THE DESIGN TEAM AND J. KEVIN REILLY, CAMP DRESSER & MCKEE WAS IN-CHARGE OF PLANT START-UP AND TRAINING OF THE OPERATING STAFF.

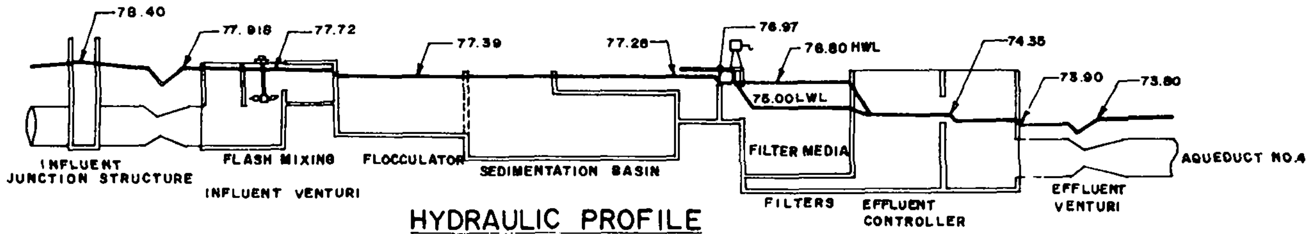
MANILA WATER SUPPLY PROJECT II

M. W. S. S.

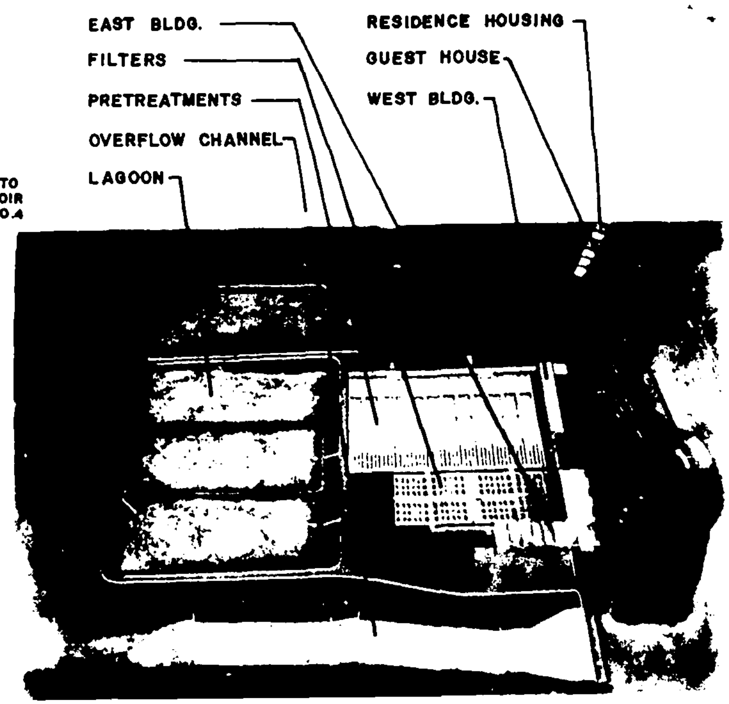




PLANT FLOW DIAGRAM
NOT TO SCALE



HYDRAULIC PROFILE
NOT TO SCALE



LA MESA WATER TREATMENT PLANT

DESIGN CRITERIA

DESCRIPTION	UNITS	CAPACITY
PLANT CAPACITY		
Maximum Plant Capacity	Ml/d	1500
FLASH MIXERS		
Vertical Turbine Type	Number	6
FLOCCULATION BASINS		
Basin & Dims. No. L-W-D	NO./Min.	72-8-8-4-6
Detention Time	Min.	20
Flocculation (Vertical Turbine Type)	Number	72
SEDIMENTATION BASINS		
Basin & Dims. No. L-W-D	NO./m	12-97-16-4.5 (+1.5 Sludge Storage) Total depth = 6 m.
Detention Time	Min.	80
Overflow Rate	mm/Min.	5.6
FILTERS		
Filters (Dual Media Type)	Number	24
Filtration Rate	m/Hr.	14.5
Area per Filter	m^2	180
Backwash Rate	m/Hr.	55
Backwash Flow Rate	m^3/Min.	165
Surface Wash Flow Rate	m^3/Hr.	30
Filter Media		
Anthracite - depth	m	0.60
Sand - depth	m	0.25
Gravel - depth	m	0.45
Surface Wash Pumps	Number	2
Capacity of Each	Ml/d	43.6
LAGOONS		
Washwater Recovery Sludge	Number	4
Surface Area Total	m	80,000

DESCRIPTION	UNITS	DOSAGE Min.	Ave.	Max.
CHEMICALS				
Primary Coagulant	mg/l			
Aluminum Sulfate		10	35	70
Ferric Chloride		10	25	50
Polyelectrolyte		0.2	1.0	2.0
Coagulant Aid - Polyelectrolyte		0.025	0.05	0.10
Filter Aid - Polyelectrolyte		0.025	0.05	0.10
Sodium Silico Fluoride		0.5	0.5	0.75
Chlorine				
Prechlorination (intermittent)		—	2.0	5.0
Intermediate Chlorination		—	0.5	1.0
Post Chlorination		0.5	0.5	1.0
PH Control - Quick Lime		—	10	20

CHEMICAL FEED	UNITS	CAPACITY
Aluminum Sulfate		
Roto-dip Type Feeders	Number	5
Capacity of Each	l/Min.	70
Ferric Chloride		
Roto-dip Type Feeders	Number	5
Capacity of Each	l/Min.	70
Polyelectrolyte - Piston Pumps	Number	5
Fluoridation - Gravimetric Feeder	Number	1
Capacity	kg/hr	50
Chlorination		
Evaporators	Number	2
Capacity of Each	kg/d	3600
Chlorinators	Number	3
Capacity of Each	kg/d	3 at 3600
Quick Lime		
Slakers	Number	3
Gravimetric Feeders	Number	3
Slurry Pumps		

The MANILA WATER SUPPLY PROJECT II, being undertaken by the MWSS is part of a program to improve the water supply and distrib facilities within the Metropolitan Manila Area. Construction and commissioning the New 1500 ml/d is an integral and critical portion of that pr The Plant is scheduled to be partially complete and in production of 60% of plant capacity by 1 June 1981 with total completion and operat scheduled by February 1982. The plant is being constructed by CDCP, at a contract bid cost of ₱ 186 M.

WATER QUALITY

GENERAL

The water to be treated at the La Mesa Plant will come from the Angat-Ipo supply system. The Angat-Ipo system consist of the Angat mu purpose dam which discharges through power turbines to the Angat River, thence to the Ipo Diversion Dam, and thence through tunnels and alo aqueducts to the Novaliches Reservoir. Prior to entering the Novaliches Reservoir, the water will be diverted into an open channel to the La Mesa ment Plant. Angat water is subject to long periods of storage in the Angat Dam and, thus, is of substantially better quality than stream flows. How in flowing from Angat to Ipo, the water is subject to surface run-off which in the rainy season is of high turbidity.

PROJECTED RAW WATER QUALITY

The Angat-Ipo source is a mountainous area with a low density of population and little development. The likelihood of much development or for development is low. Therefore, it is expected that water received from this source will continue to be of good quality with turbidity being the ma constituent of concern for treatment.

One alternate for a future water source is the diversion of the Umiray River, through Angat. The Umiray River basin is also a mountainous r uninhabited area. The quality of this water is therefore expected to be very similar to that presently in Angat.

TREATED WATER QUALITY

The existing Balara Water Treatment Plant presently produces a finished water with an average turbidity of about 0.8 Formacin turbidity uni This corresponds to the proposed United States Environmental Protection Agency (USEPA) standard of 1.0 units, an American Waterworks As tion (AWWA) quality goal of 0.1 units, and the current Philippine standard of 5 units. Color is normally 5 units or less as compared to the sta (USEPA and Phil.) of 15 units and AWWA quality goal of 3 units. Iron is 0.1 mg/l or less again well below the standard of 0.3 mg/l and only sli above the AWWA goal of 0.05 mg/l.

It is recommended that the physical and chemical treatment goals at the new plant should be to produce a water with an average turbi of 0.1 FTU or less and complying with the Philippine National Standards for Drinking Water in all other respects.

STANDARDS PROGRAM

by Paul A. Schulte

THE AMERICAN WATER WORKS ASSOCIATION WAS FOUNDED IN 1881, 102 YEARS AGO. SHORTLY AFTER ITS FOUNDING, THE WATER UTILITY MEMBERS OF THE ASSOCIATION DISCOVERED THAT ONE OF THE PRINCIPAL PROGRAMS THAT AWWA COULD PROVIDE THE WATER INDUSTRY WAS THE STANDARDIZATION OF PRODUCTS USED IN THE WATER SUPPLY INDUSTRY. IN THE LATE 1800s, AWWA, IN CONJUNCTION WITH SEVERAL OTHER ORGANIZATIONS, FORMED THEIR FIRST STANDARDS COMMITTEE FOR THE STANDARDIZATION OF CAST-IRON PIPE AND FITTINGS. ON MAY 12, 1908, AWWA ADOPTED A "STANDARD SPECIFICATION FOR CAST-IRON PIPE AND SPECIAL CASTINGS."

KD 5017

SLIDE #1 - 1ST STANDARD

AWWA CONTINUED TO DEVELOP STANDARD SPECIFICATION FOR A VARIETY OF WATERWORKS MATERIALS AND IN 1926, IN CONJUNCTION WITH THE AMERICAN NATIONAL STANDARDS INSTITUTE, A NON-GOVERNMENT ORGANIZATION RESPONSIBLE FOR COORDINATING THE STANDARDIZATION IN THE UNITED STATES, ORGANIZED COMMITTEE A21 ON CAST-IRON PIPE AND FITTINGS. THREE OTHER STANDARDS-WRITING ORGANIZATIONS JOINED WITH AWWA IN THE ORGANIZATION OF THIS FIRST NATIONAL STANDARDS COMMITTEE.

IN THESE EARLY YEARS, MOST OF THE STANDARDS WERE WRITTEN BY SMALL COMMITTEES OF TWO OR THREE EXPERTS ON THE SUBJECT FOR WHICH THE STANDARD WAS BEING DEVELOPED. AS MORE PEOPLE DEVELOPED AN INTEREST IN STANDARDIZATION AND AS THE AMERICAN WATER WORKS

ASSOCIATION GREW IN NUMBERS, THE COMMITTEES WERE EXPANDED AND THE PROCEDURES REFINED. BY 1970, AWWA HAD DEVELOPED 70 STANDARDS FOR CHEMICALS AND OTHER PRODUCTS, AND HAD DEVELOPED THEIR OWN PROCEDURES FOR STANDARDS DEVELOPMENT AND APPROVAL.

IN 1973 THE AWWA PROCEDURES FOR DEVELOPING STANDARDS WERE APPROVED BY THE AMERICAN NATIONAL STANDARDS INSTITUTE AND IN 1976, AWWA WAS ACCREDITED AS A BONAFIDE STANDARDS-WRITING ORGANZATION BY THE AMERICAN NATIONAL STANDARDS INSTITUTE. THIS ACCREDITATION MEANS THAT AWWA APPROVED STANDARDS CAN BE SUBMITTED DIRECTLY FOR REVIEW AND APPROVAL AS AMERICAN NATIONAL STANDARDS WITHOUT BEING REVIEWED BY OTHER STANDARDS COMMITTEES.

THE AWWA PROCEDURES ARE ESTABLISHED TO PROVIDE FOR THE DEVELOPMENT OF STANDARDS BY COMMITTEES COMPOSED OF ALL INTERESTS.

SLIDE #2

THE MANUFACTURERS, WHOSE EXPERTISE ON THE PRODUCTS IS OF UPMOST IMPORTANCE TO THE COMMITTEES, COMPRISE UP TO ONE-THIRD OF THE TOTAL MEMBERSHIP ON THE COMMITTEE. THIS RESTRICTION IS PLACED ON THE MANUFACTURING COMMUNITY IN ORDER TO USE THEIR SPECIAL EXPERTISE WITHOUT ALLOWING THEM TO CONTROL THE MATERIALS TO BE SUPPLIED TO THE INDUSTRY.

SLIDE #3

THE USER MEMBERS INCLUDE PRIMARILY THE WATER UTILITIES, BOTH PRIVATE AND PUBLICLY-OWNED. SINCE THE UTILITIES ARE THOSE WHO MUST OPERATE AND MAINTAIN THE FACILITIES AND USE THE CHEMICALS STANDARDIZED, THEY LEND A VERY IMPORTANT EXPERTISE TO THE DEVELOPMENT OF THE STANDARD. WHILE THE NUMBER OF USER MEMBERS IS NOT RESTRICTED, AWWA ATTEMPTS TO HAVE THEM REPRESENT APPROXIMATELY ONE-THIRD OF THE COMMITTEE MEMBERSHIP. USER MEMBERSHIP ALSO INCLUDES GOVERNMENT AGENCIES, SUCH AS THE U.S. CORP OF ENGINEERS AND THE U.S. BUREAU OF RECLAMATION THAT PLAY A PROMINENT PART IN THE CONSTRUCTION AND OPERATION OF A VARIETY OF WATER RESOURCES PROJECTS, PARTICULARLY FOR THE AGRICULTURAL COMMUNITY.

SLIDE #4

THE GENERAL INTEREST MEMBERS CONSTITUTE THE REMAINDER OF THE COMMITTEE MEMBERSHIP, USUALLY ABOUT ONE-THIRD. GENERAL INTEREST MEMBERS INCLUDE CONSULTING ENGINEERS, MEMBERS OF THE ACADEMIC COMMUNITY, MEMBERS OF THE REGULATORY COMMUNITY AND CONTRACTORS WHO DO WORK FOR THE WATER SUPPLY INDUSTRY.

AWWA HAS PROVIDED A CONSIDERABLE NUMBER OF CHECKS AND BALANCES IN THE DEVELOPMENT OF STANDARDS.

FIRST, THE COMMITTEE OUTLINED ABOVE DEVELOPS THE STANDARD AND BALLOTS THE COMMITTEE UNTIL A CONSENSUS IS REACHED ON THE CONTENT OF THE STANDARD. CONSENSUS DOES NOT MEAN UNANIMITY, BUT IS SUBSTANTIALLY MORE THAN A MAJORITY. IN ORDER FOR A STANDARD TO BE APPROVED ON THE FIRST BALLOT, THE APPROVAL MUST BE UNANIMOUS. ON SUBSEQUENT BALLOTS, THE COMMITTEE MEMBERS MUST BE ADVISED OF ALL NEGATIVE VOTES CAST ON THE FIRST BALLOT, THE REASON FOR THOSE NEGATIVE VOTES AND THE COMMITTEE CHAIRMAN'S RESPONSE TO EACH OF THE STATED REASONS. BALLOTS BEYOND THE INITIAL BALLOT CAN BE APPROVED BY A CONSENSUS VOTE.

SLIDE #5

ONCE THE COMMITTEE HAS APPROVED THE STANDARD, IT IS FORWARDED TO OUR STANDARDS COUNCIL FOR A REVIEW OF THE PROCEDURE USED IN THE APPROVAL BY THE COMMITTEE AND FOR A REVIEW OF THE TECHNICAL CONTENT OF THE STANDARD. THE AWWA STANDARDS COUNCIL IS MADE UP OF APPROXIMATELY ONE-HALF WATER UTILITY MANAGERS AND ONE-HALF CONSULTING ENGINEERS. THESE CONSULTING ENGINEERS AND MANAGERS MAKE USE OF THE EXPERTISE OF THEIR STAFFS WHEN REVIEWING THE TECHNICAL CONTENT OF THE STANDARDS SUBMITTED BY THE STANDARDS COMMITTEES.

ONCE AGAIN, IN ORDER TO RECEIVE FIRST-BALLOT APPROVAL, THE COUNCIL MUST BE UNANIMOUS. FOR SUBSEQUENT BALLOTS, ALL STANDARDS MUST BE ACCOMPANIED BY THE NEGATIVE VOTES CAST AND THE REASONS

FOR THOSE NEGATIVES. TO RECEIVE APPROVAL OF A STANDARD BY THE COUNCIL, A TWO-THIRDS MAJORITY IS REQUIRED ON THE SECOND OR SUBSEQUENT BALLOT.

IF A STANDARD FAILS TO RECEIVE APPROVAL BY THE COUNCIL, IT IS REFERRED BACK TO THE COMMITTEE WITH THE REASONS FOR NOT BEING APPROVED.

IF THE STANDARD RECEIVES APPROVAL BY THE STANDARDS COUNCIL, THE ACTION OF THE STANDARDS COUNCIL IS PUBLISHED IN THE AWWA NEWSLETTER ADVISING THE GENERAL MEMBERSHIP OF THE ACTION OF THE COUNCIL. CURRENTLY, AWWA ALSO PUBLISHES THE ACTION OF THE COUNCIL IN THE AMERICAN NATIONAL STANDARDS INSTITUTE NEWSLETTER FOR CONSIDERATION BY THE MEMBERS OF ALL STANDARDS-WRITING ORGANIZATIONS.

SLIDES #6 AND 7

IF NO COMMENTS ARE RECEIVED IN 30 DAYS, THE STANDARD IS FORWARDED TO THE AWWA BOARD OF DIRECTORS FOR APPROVAL AT THEIR NEXT MEETING. AFTER APPROVAL BY THE BOARD OF DIRECTORS, THE STANDARD BECOMES EFFECTIVE ON THE FIRST DAY OF THE MONTH FOLLOWING PUBLICATION.

IF ANY MEMBER FINDS OBJECTION TO THE STANDARD EITHER THROUGH PUBLICATION IN THE AWWA NEWSLETTER OR BY THE AMERICAN NATIONAL STANDARDS INSTITUTE, AWWA STANDARDS COUNCIL APPROVAL IS SUSPENDED UNTIL THE COMMENTS ARE RESOLVED.

IF SUBSTANTIAL CHANGE IS REQUIRED TO RESOLVE THE COMMENTS, THE STANDARD IS REFERRED BACK TO THE ORIGINATING COMMITTEE AND THE APPROVAL PROCESS STARTS ALL OVER AGAIN. IF ONLY EDITORIAL CHANGES ARE REQURIED TO RESOLVE THE COMMENTS, THE STANDARDS COUNCIL ACTION OF APPROVAL STANDS AND THE STANDARD IS FORWARDED TO THE AWWA BOARD OF DIRECTORS FOR APPROVAL.

AS YOU MIGHT IMAGINE, DEVELOPMENT OF AWWA STANDARDS TAKES A CONSIDERABLE AMOUNT OF TIME. AWWA HAS A POLICY TO WRITE STANDARDS ON ONLY PRODUCTS THAT ARE MANUFACTURED BY MORE THAN ONE MANUFACTURER AND PRODUCTS THAT HAVE SOME HISTORY OF USE. AS THE TERM IMPLIES, STANDARDS ARE WRITTEN ON PRODUCTS THAT ARE IN GENERAL USE AND NOT FOR NEW OR UNPROVEN PRODUCTS. THIS IS NECESSARY TO ASSURE THE USERS THAT THEY ARE DEALING WITH A PRODUCT THEY CAN RELY ON.

AWWA STANDARDS ARE UNIQUE FROM THE STANDPOINT THAT THE UTILITY MANAGER, THE INDIVIDUAL RESPONSIBLE FOR OPERATING AND MAINTAINING THE FACILITIES USING THE STANDARD PRODUCTS HAS A VERY SIGNIFICANT

ROLE IN THEIR DEVELOPMENT. THIS ONE FACT ASSURES THE INDUSTRY THAT THEY ARE USING PRODUCTS THAT HAVE A GREAT POTENTIAL FOR PROVIDING THE LONG-LASTING SERVICE REQUIRED BY THE NATURE OF OUR INDUSTRY.

AWWA IS PROUD OF THEIR STANDARDS PROGRAM, PROBABLY THE MOST SIGNIFICANT OF ALL AWWA SERVICES.

PAS/mt
10/27/83

WATER SUPPLY FOR TRANSMIGRATION SETTLEMENTS IN CENTRAL KALIMANTAN, INDONESIA

by

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Kampsax International A/S
in association with
Amythas - Multi Phi Beta Consortium

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CONTENTS

SUMMARY

The water supply requirement of transmigration settlements is for cheap but reliable sources serving low-density rural communities. The range of potential water resources development is dictated by economic, social, geological and climatic constraints. Four types of source, namely direct river abstraction, surface water storage, shallow wells and rainwater tanks are evaluated sequentially in terms of yield and cost. Intensive field studies are required to evaluate each source. Reliance on direct river abstraction as the primary source is high since yields from shallow groundwater are very low. Recommended designs and standards for installation, operation and maintenance are as simple and inexpensive as possible. Extension work is vital to protect water supply sources, as is judicious land clearing. Improvements in design are anticipated once feedback from implemented transmigration schemes becomes available.

1 INTRODUCTION

1.1 Transmigration

Transmigration is a national policy of utilizing surplus manpower from Java, Madura and Bali to promote development in the less populated areas of Indonesia. Much transmigration has already been implemented, mainly to Sumatera. Provinces currently being investigated include : Irian Jaya; Maluku; North, Central and South-East Sulawesi; Aceh, Riau, Bengkulu, Jambi, South Sumatera; East, West and Central Kalimantan.

1.2 National Policy

The government of Indonesia have commissioned several consultants, responsible to the Minister of Transmigration, to assess the suitability of undeveloped areas for transmigration settlement. The national target for transmigration of 5 million people in 5 years is indeed a mass demand for rural water supply.

1.3 Kampsax Studies

Kampsax International A/S in association with Amythas-Multi Phi Beta Consortium, have already assessed some 8400km² of Central Kalimantan and are currently commissioned to assess a further 15000km². This area alone has a potential total population of about 0.5 million, although, with an acceptability rate of about 20%, the actual population settled may be as low as 100.000.

1.4 Planning Concept

The basis development unit is a group of villages or an "SKP" covering an area of up to 300km² and comprising 1000-3000 families or "KK's". Each group of villages consists of several villages or "SP's" with capacities of 100-500 families. Several SKP's are grouped into a development area or "WPP".

Each SKP has a centre village which provides appropriate community facilities (school, mosque, clinic etc.). All components and centres are linked by roads or by river access.

1.5 Development Phases

Assessment of each potential SKP area is in four phases :

Phase I	:	Overall WPP structure planning and selection of SKP areas to be assessed
Phase II	:	"Screening" - Determination of feasibility for settlement from air photo interpretation and, if feasible, estimation of the settlement capacity of an SKP from a limited field survey.
Phase IIIA	:	"Structure Plan" - from an intensive field survey design of a detailed structure plan of the SKP, defining areas to be cleared, type of agriculture, water supply, roads network and the true settlement capacity of the SKP.
Phase IIIB	:	Land clearing, physical plan and supervision of implementation.

1.6 Water Supply

This paper deals with the provision of water supply under Phase IIIA. The population to be served is in low density rural communities. For the design of the water supply system demand centres of 100-500 families are taken at each hamlet or SP centre.

2 CONSTRAINTS TO PLANNING

2.1 Location

Since the existing population of 1.2 million in Central Kalimantan is located along the major rivers and since the national policy is to minimise the impact of transmigration on existing settlements, the areas to be assessed are located away from the major rivers. Thus the traditional water supply of the existing population will not be available to transmigrants.

2.2 Communications

Most transmigration areas in Central Kalimantan are remote from existing centres of population. Existing transport routes are long and slow; all-weather roads are rare and river access is limited to the larger rivers. Thus any construction materials not available locally will be expensive to transport to the area.

2.3 Materials

Available raw materials are limited to timber, rattan, stone, clay and in some areas limestone. Sand for cement is not generally available. Processed materials, such as iron, plastic and concrete, and manufactured goods, such as hand-pumps and pipes, have to be imported into the area.

2.4 Budget

Only minimal provisions have been made for water supply capital costs in transmigration budgets. Now that transmigration studies are moving into areas with less abundant water, these provisions are being revised. Nevertheless, water supply schemes for transmigration should be designed on a minimum cost basis. There is no provision for revenue expenditure on water supply.

2.5 Demand for Water

Demand figures are derived from experience in the South East Asian region in general and in transmigration in Indonesia in particular. Per capita demand is taken as 55 litres/head/day, which comprises 20 litres of drinking and cooking water and 35 litres of washing water. A family (or KK) of 5 persons thus has demand of 275 litres/KK/day. Adding 10% for water supply to communal facilities, a demand centre of 300 families will require some $90m^3$/day.

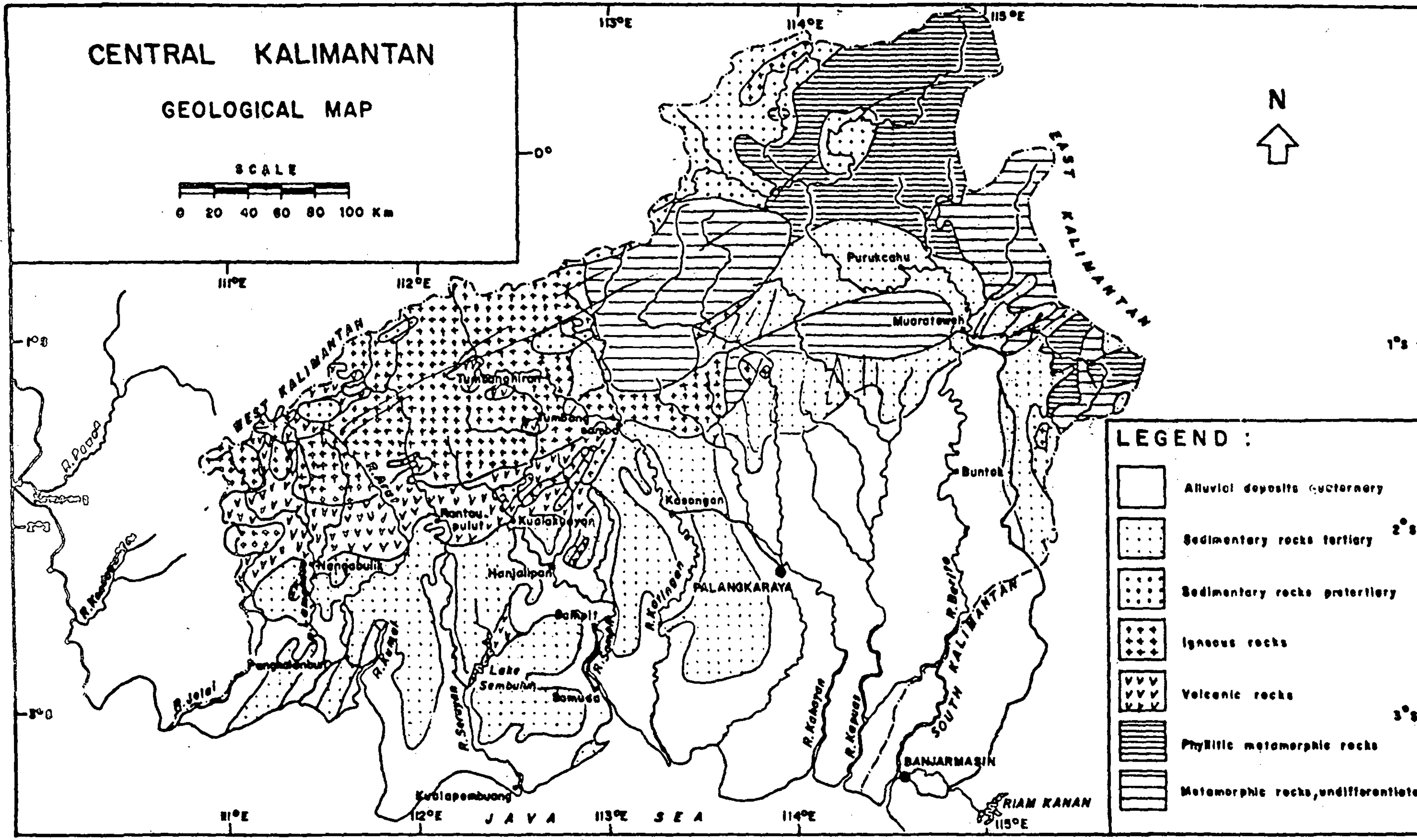
It is assumed that, in times of shortage, demand can only be reduced by 30%. The planning horizon for water supply is a once in five years failure.

Ideally all sources should provide water at the point of demand. In practice,a source is only rejected if the walking distance to the source exceeds 5 km.

2.6 Terms of Reference

In the above and other matters, consultants are following the "Terms of Reference" issued by the Ministry of Transmigration.

Figure : 1


CENTRAL KALIMANTAN
GEOLOGICAL MAP
SCALE
0 20 40 60 80 100 Km
N
LEGEND :
Alluvial deposits quaternary
Sedimentary rocks tertiary
Sedimentary rocks pretertiary
Igneous rocks
Volcanic rocks
Phyllitic metamorphic rocks
Metamorphic rocks, undifferentiated
WEST KALIMANTAN
EAST KALIMANTAN
SOUTH KALIMANTAN
JAVA SEA
Purukcahu
Muarateweh
Buntok
PALANGKARAYA
BANJARMASIN
RIAM KANAN
Kasongan
Kualakurun
Tumbanghiran
Rantau pulut
Nangabulik
Pangkalanbun
Sampit
Samuda
Lake Sembuluh
Kualapembuang
R. Jelai
R. Seruyan
R. Katingan
R. Kahayan
R. Kapuas
R. Barito
113°E
114°E
115°E
111°E
112°E
0°
1°S
2°S
3°S

3 GEOLOGY

3.1 Introduction

The geology of Central Kalimantan is formed on two major systems, the stable Sunda Shelf System which, is part of the Asiatic Continental Block, and the less stable East Asiatic System. The latter, is confined to the mountainous north-west of the province, covering less than one fifth of the area.

The geology is a relatively simple sequential build-up from NW to SE from the Metamorphics and Igneous rocks through Sedimentaries with Volcanics to the Quaternaries. This pattern is evident from Figure 1 which maps the major geological formations of Central Kalimantan. The characteristics of each formation are described below and an indication of their potential for abstractable groundwater is given.

3.2 Metamorphic Rocks

Phyllitic Rocks

Phyllitic rocks, presumably of permo-triassic age, cover extensive areas of the far north and smaller areas of the extreme east of Central Kalimantan. They are densely foliated and probably originate from clay-rich mudstones. Intercalations with siliceous rocks such as cherts and siliceous slates are common.

The extractable groundwater content is likely to be very low due the dense foliation and to low permeability.

Undifferentiated Metamorphic Rocks

These rocks comprise later mesozoic deposits. Gneiss, schist, quartzite and limestone as well as phyllite are the most common rock types. They are found in the north and east of Central Kalimantan.

All rocks are impervious with no groundwater potential, except for the limestone which forms large solution cavities. Some groundwater may be found along faults or joints but is unlikely to be abundant.

3.3 Igneous Rocks

The Schwaner Mountains in West and Central Kalimantan belong to the young Paleozoic major geosyncline which is characterised by batholiths of intermediate composition. Granite and Granodiorites are by far the most common. Pronounced lineaments show NNW-SSE orientation and, in places, control the main river courses. The igneous rocks are heavily jointed and weathered.

Extractable groundwater only occurs in connection with the major fracture systems and along faults where a sizeable crushed zone is found.

3.4 Volcanic Rocks

Enormous volcanic activity during the Tertiary period gave rise to extensive areas of andesitic and basaltic breccia and lava flows together with tuff and tuffaceous sandstone. These volcanic rocks are often intercalated between other deposits.

Since the volcanic rocks are very dense and the tuff is fine textured, the probability of extractable groundwater occurring is very low.

3.5 Sedimentary Rocks

Pre-Tertiary Sedimentary Rocks

These rocks consist of medium to coarse, but occasionally fine, textured sediments of marine origin. They are mainly found in the mountainous area in the far north of the province and are intensely folded. Thicknesses are estimated to vary between 300 and 500m.

Groundwater content is likely to be high. However, it is unlikely that transmigration will be planned in such mountainous areas.

Tertiary Sedimentary Rocks

These rocks consist for the greatest part of fine to medium textured sediments. They are mainly of marine origin but continental and brackish facies are also common due to eustatic movements. Thicknesses can reach several thousand meters. Tertiary sedimentary rocks are often mixed with material of volcanic origin and volcanic content appears to increase to the north and east.

North of Palangkaraya and also east of Muaratewe tuffaceous sandstone and conglomerates occur together with eruptive breccias and lava flows. In the northeast of the formation, limestone occurs as isolated units giving rise to Karstic landforms.

There is appreciable groundwater at depth in the limestone units where deep percolation is high. However, all other Tertiary deposits are dense and impervious and have no solution cavities and so have little groundwater potential.

3.6 Quaternary Alluvial Deposits

The extent of these deposits, over 30% of Central Kalimantan, is due to the several eustatic movements and to the severe weathering of the Tertiary surface.

The older alluvial terrace deposits are dominated by fine to medium textured sediments. They can be found as erosion remnants inside the older geological formations. They are often characterised by poor forest, kerangas or heath forest. Thicknesses rarely exceed 10m.

More recent alluvial river deposits are also fine to medium textured but thicknesses can reach 20m.

Alluvial swamp deposits consist of fine to very fine textured sediments with some organic content. Some deposits have been subject to marine infiltration. This is especially marked in the Barito basin where thicknesses may exceed 200m.

Groundwater abstraction is only feasible from the coarser river deposits.

3.7 Soils

The intensive and prolonged weathering of Central Kalimantan has produced relatively deep soils. In flatter areas over Tertiary and Quaternary deposits soils can be up to 15m deep. Where slope is significant, soil depths are commonly 2 to 5m and bedrock outcrops are infrequent except as erosion remnants. Underlying rocks are usually decomposed to some depth with fractures being filled with leached soil.

The dominant soil types [1] are Ultisols and Oxisols which are rich in clayey material and can have

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[1] The soil classification used is that of the United States Department of Agriculture (USDA). Other classifications in use in Indonesia are FAO and LPT (Soil Research Institute) Bogor.

restrictive layers (e.g. plinthite). Other soil types are the coarser textured derivatives of siliceous parent material, which are typified by good drainage and heath forest vegetation, and soils formed on limestone with a Karstic landscape.

Ultisols are red-yellow coloured with a clay-rich sub-horizon. Despite being relatively young, they show a high level of leaching and are very acidic with pH's of 4.5 to 5.5. They tend to be formed on relatively siliceous parent material.

Oxisols are strongly coloured. The clay content is high (50%-95%) but stickiness is low and the subsoil is friable and therefore easily penetrated by roots. The parent material of Oxisols is normally intermediate to basic igneous rocks or old alluvial deposits.

Spodosols are concentrated on the beach sand along the south coast but are widespread throughout Central Kalimantan especially the mountain areas in isolated pockets on sandstone or quartzite. Since all parent materials are low in clay, these soils are well drained apart from waterlogged areas.

Histosols or peaty soils are found in back-swamps and areas with poor drainage. Peat thicknesses vary from 0.5m up to 10 or 15m. Peat is characterised by a very high acidity with pH's of less than 4.0.

Soils derived from alluvial deposits are often weakly developed. Hydromorphic processes are usually dominant with fluctuating or stagnant water levels close to the ground surface.

3.8 Geomorphology

Central Kalimantan has been subject to a long period of erosion and peneplanation. Weathering has been and remains strong. The present climate has continuously high rainfall and temperatures; past climates have been similarly severe although high rainfall has not always been a feature. The area has also been strongly affected by the several (at least three) major changes in sea-level. These eustatic movements have alternately accellerated erosion or deposition. At present erosion processes are dominant following a drop in sea-levels.

These processes have given rise the present-day landscape, the major features of which are described below.

Mountainous landforms of pre-Tertiary or Volcanic Tertiary origin dominate the north of Central Kalimantan. Two mountain ranges also occur in the Seruyan catchment. Altitudes vary from 200m up to the major peak of Bukit Karang at 1728m. Mountain areas are highly dissected.

Hilly landforms composed of Tertiary sedimentary rocks are found south of the mountainous area and where more resistant rocks occur. Altitutes vary between 100 and 600m. Dissection is marked and occasionally advanced.

The plain landforms of alluvial origin are found in connection with the existing river system, tidal marshes and erosion remnants. Altitudes are from zero to 300m.

4 CLIMATE

4.1 General

The climate of Central Kalimantan can be broadly classified as "humid equatorial". This climate gives rise to the equatorial rain forest also found in the Amazon and Congo basins. The soils in this climatic region are typically heavily leached and low in nutrients.

Various climate classifications (Koppen and Thornthwaite i.a.) merely abbreviate climate statistics; a more useful classification, based on geomorphology, is by Buedel who talks of the "Inner Tropical Zone of Partial Planation".

4.2 Rainfall

Rainfall is persistently heavy throughout the year. The duration of the "dry" season between July and September is very variable, from 3 weeks in a wet year to over 3 months in a dry year. The drought of 1982 was not so severe in Central Kalimantan as in other parts of the South East Asian region; nevertheless rainfall was only 30% of average from May to October, with less than 15 rain-days in 6 months.

A short dry period occasionally occurs in January, which is of more concern to crop yields than to water supply.

There is a gradual increase in average rainfall from 2500mm to over 3500mm/year with increasing altitude and distance from the Java Sea. Short-term rainfall is extremely variable spatially due to the limited storm size. Rainfall intensities are high but the extreme intensities of Java and Sumatra have not been recorded in Kalimantan.

4.3 Other Climatic Factors

Temperatures are persistently high throughout the year. Near the coast the absolute range is 17-40°C, with monthly averages of 25-27°C. In the primary forest away from the coast, night temperatures can fall below 15°C.

Relative humidity is also high throughout the year averaging 80-90%. Winds are light and sunshine averages 8 hours per day.

Evaporation is encouraged by the high temperatures, but somewhat inhibited by high humidities and light winds. Estimates of potential evapotranspiration for primary forest average 4.5 mm/day or 1650 mm/year, and vary little throughout the year.

4.4 Runoff

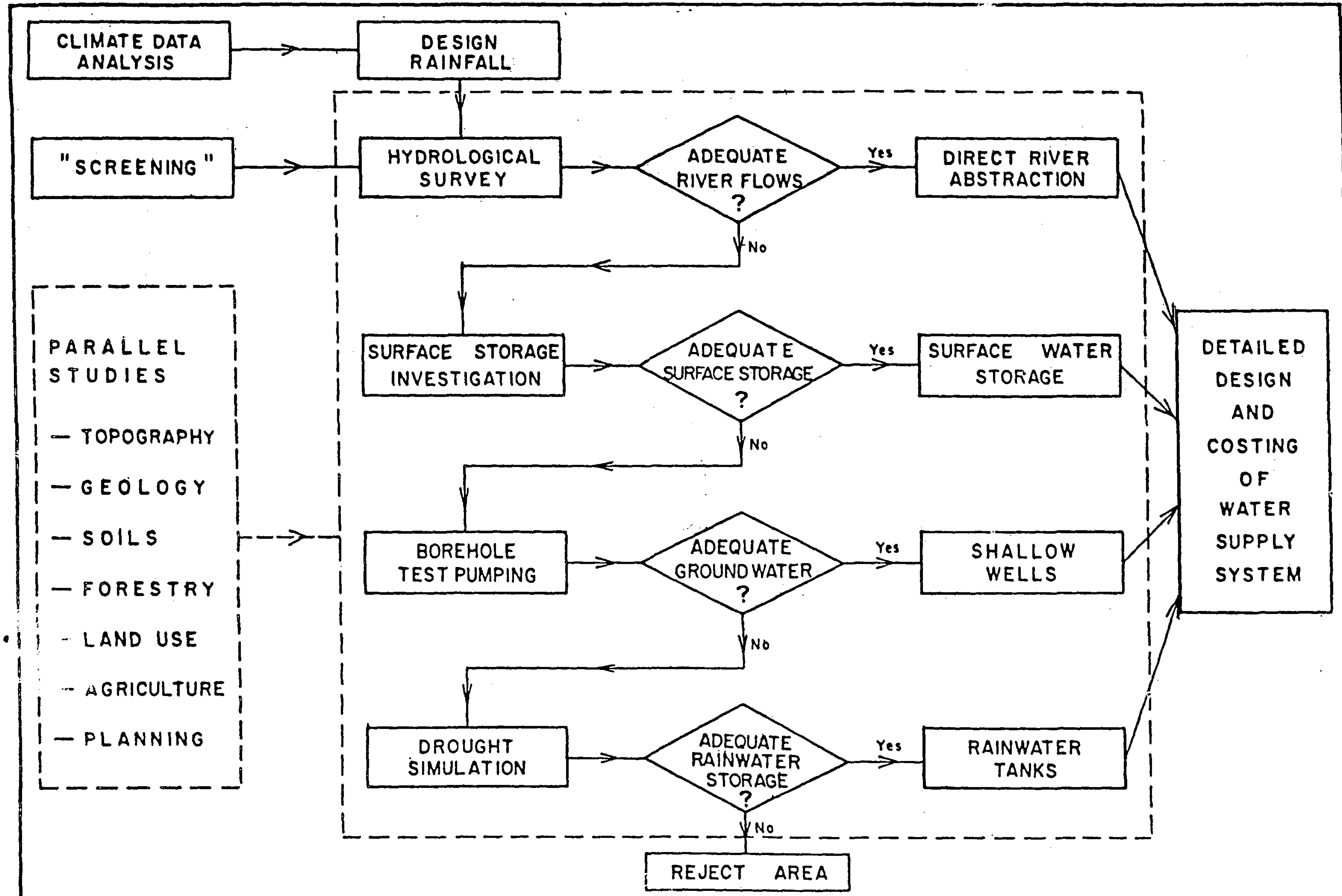
Streams and rivers respond quickly to rainfall. The fast rise and fall of water levels is evidenced by the rectangular shape of most channels. Soil and ground water storage are minimal causing baseflows to be very low. In the absence of runoff data, average runoff is estimated from rainfall and evaporation at 1600 mm/year or 50 litres/sec/km^2.

4.5 Data Limitations

Records are available from some 15 rainfall and 4 climate stations in Central Kalimantan. Most of the stations are in the south or east of the province often over 50km from an SKP. However, long-term spatial variation is uniform and so estimates of conditions at an SKP are reliable.

Figure : 2

WATER SUPPLY PLANNING FOR TRANSMIGRATION



5 WATER SUPPLY INVESTIGATIONS

5.1 Principles

The physical characteristics and the planning constraints detailed above dictate the following principles for water supply investigations.

A The four types of source to be investigated are, in order of priority :

1. Direct River Abstraction
2. Surface Water Storage
3. Shallow Wells
4. Rainwater Tanks

B The factors by which each type of source is to be evaluated are :

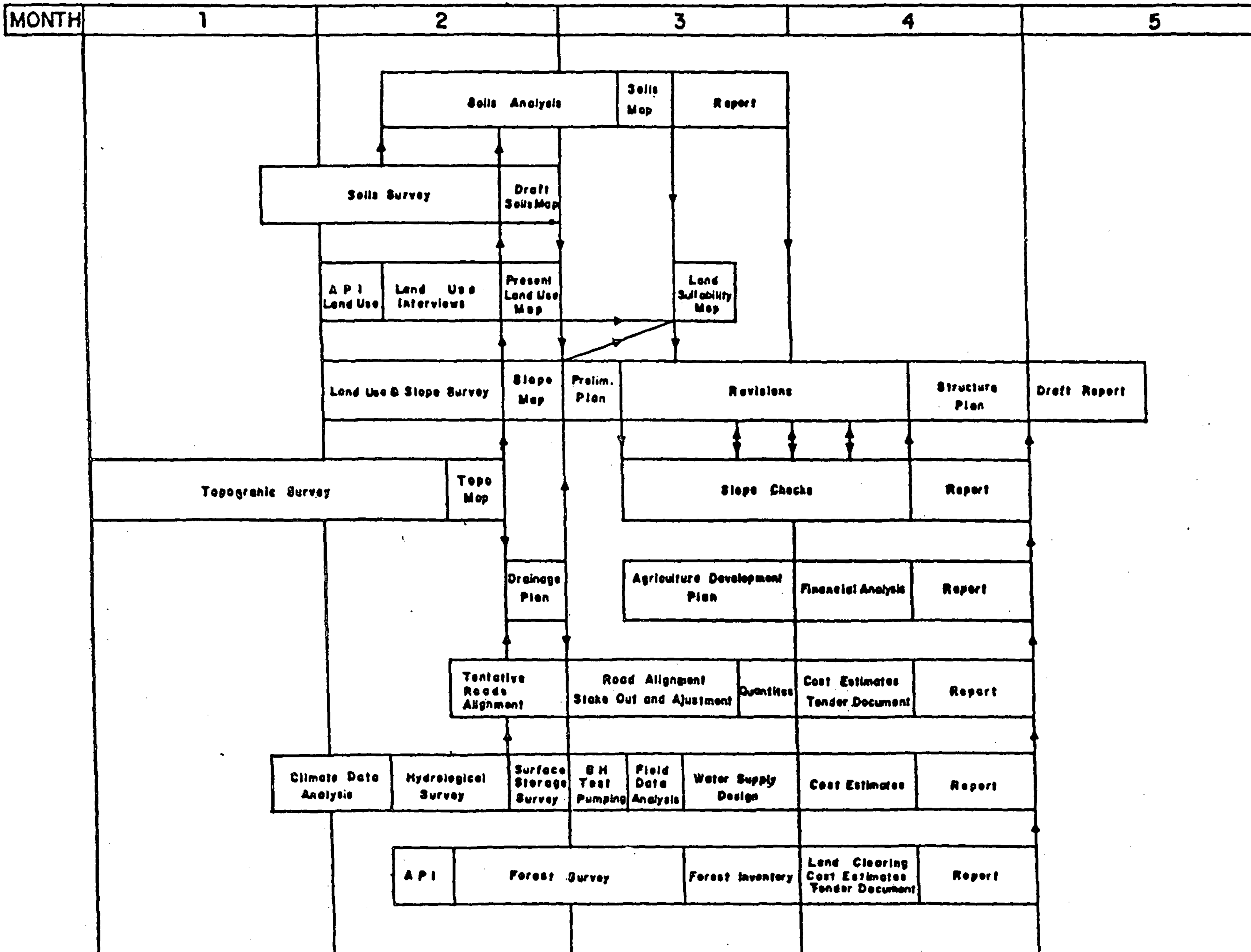
1. Yield
2. Reliability of yield
3. Water quality
4. Cost and simplicity of design
5. Cost and simplicity of operation
6. Cost of evaluation

C The order of priority in A above results from an overall evaluation of these factors for conditions likely to be found in Central Kalimantan. Each source is evaluated in turn until a reliable yield is found (see Fig. 2), thus avoiding unnecessary fieldwork. The order of evaluation can be changed but this is only likely in areas far from surface water, in limestone areas and on coastal sands where groundwater may replace direct river abstraction as the primary source.

D Direct river abstraction scores well on all relevant factors except that the reliability of yield will often not meet the requirement once in 5 years failure. For surface water storage and rainwater tanks, construction costs limit the size of storage, which is unlikely to be sufficient to.

Fig. 3

PHASE III A STUDY FOR ONE SKP



cater for the 1 in 5 year drought. Shallow well yields are expected to be generally very low although yields may persist throughout a drought. The cost of evaluation of groundwater is higher than for other types of source.

5.2 Interaction with Other Studies

In order to design a detailed structure plan for a village each discipline necessarily interacts with all others (see Fig. 3). Water resources investigation relies for additional input on :

(a) Topographic survey for surface drainage,
(b) Soils survey for hydromorphic soils and shallow groundwater,
(c) Forestry survey for swamp forest areas,
(d) Air photo interpretation for landforms.

Conversely, water resources investigation provides input not only for the design of the water supply system but also for :

(a) Rainfall reliability for crops,
(b) Erosion protection zones for watercourses,
(c) Areas liable to flooding,
(d) Road alignment and drainage design.

Also there is a continual dialogue with the planning engineers as to the location of housing.

5.3 Desk Studies

The findings and recommendations of earlier Phase II (screening) studies are assessed. Analyses of geology and climate are expanded to provide design criteria.

The order of priority of sources is confirmed (or amended). Sites of potential surface water sources are identified as are areas where surface water sources are scarce.

The fieldwork program is drawn up after discussion with other disciplines.

5.4 Field Studies

(a) Surface Water

Basic surface drainage data is gathered during the topographic survey. The hydrological survey concentrates on potential sites for surface sources. Water levels, streamflows, and water quality are measured and catchment hydrology is assessed from drainage characteristics, soils, vegetation and topography. Where natural streamflows appear inadequate potential surface water storage sites are identified.

Throughout the survey, local inhabitants are questioned as to the behaviour of rivers, streams and springs. They are also asked about their own water supply although this is nearly always a large river.

Dry season flows are estimated from recession rates and the feasibility of abstraction is determined. If both are adequate for the planned population then detailed design follows.

Otherwise any potential surface water storage sites are surveyed in detail to determine storage size and feasibility. To be viable, surface water storage sites require a wide but well-defined valley with an in-situ supply of lining clay. Again, if adequate then detailed design can be started.

(b) Groundwater

If not, then shallow trial boreholes are sunk and logged in the most promising groundwater areas. Use is made of auger boring and trial pit data from the soils survey. Resistivity traverses are made to confirm and extend lithological logs and to estimate aquifer thicknesses. At least one borehole per demand centre is test pumped to determine transmissivity. Normally transmissivity is too low for drawdown in an observation borehole to be detected and single hole test pumping is required. In such cases storage coefficients have to be estimated from porosity or infiltration tests before minimum reliable yields can be estimated.

(c) Rainwater

If yields are still inadequate then the size of rainwater storage tanks is determined by simulation through a once in 5 years drought.

Basic operation rules used for drought simulation are that rainwater tanks are not used until all other sources have been exhausted and that after tank draw-down exceeds a certain level then demand is reduced to the basic requirement of 40 litres/head/day.

If a total absence of shallow groundwater is obvious, then rainwater storage is evaluated without first testing groundwater. Also, costs of rainwater tanks and low yielding wells may be comparable, in which case rainwater tanks may be more cost effective that wells.

Thus an area can only be rejected for development due to inadequate water supply if the cost of the required size of rainwater tanks is prohibitive.

5.5 Design

The basic design decision is between individual or communal abstraction. The former is usually preferred due to low cost and minimal maintenance. Although the latter may enable a greater yield to be abstracted, the inevitable rise in consumption may more than cancel out this advantage.

(a) Surface Water

Direct river abstraction by individuals requires least design. In the absence of natural rock, the river banks and bed are protected to prevent erosion and to maintain water quality. Permanent access to the bank and down the bank to the lowest water level is provided. A small weir may be required to increase depths at minimum flows.

Direct river abstraction by pump to a central distribution point requires more extensive and permanent river works. The intake cross section must be stabilised as above and the pump sited out of the flood plain. The delivery main must be securely laid above ground to allow leak detection. Storage facilities can be minimised by efficient management.

A compromise solution for direct river abstraction is a bank mounted hand-pump operated by individuals.

Surface water storage has not yet been recommended in Central Kalimantan and design will depend on the exact location. Major costs are in earth-moving and in flood protection. Use of existing or proposed road embankments could reduce costs.

(b) Groundwater

Shallow well yields so far found in Central Kalimantan are too low to contemplate communal wells. The wide wells, with porous retaining walls and concrete well covers and surrounding slabs, serving only a few families are very expensive. Costs are even higher if a hand-pump (desirable to maintain yield and water quality) is added to the design.

Thus shallow wells are extremely costly unless yields are sufficient for more than 10 families (i.e. over $3m^3$/day).

(c) Rainwater

The size of rainwater tanks depends on the design drought and on efficient management, but can be up to $4m^3$. Recommendations for design include :

- plastic gutters with slopes sufficient to carry away average rainfall intensities (10 litres/min) at velocities which will keep gutters free of debris.

- plastic downpipes with coarse removable mesh to trap debris.

- standardised $1m^3$ bucket-shaped plastic tanks.

- abstraction from tank by scoop or preferably by fitted tap.

Locally available timber is not suitable for rainwater tank construction. Concrete construction is feasible but, even if units are cast in-situ, is more expensive than plastic.

The standardisation on a $1m^3$ unit has several advantages, especially for plastic. Remote or in-situ construction can be standardised; empty units can be manhandled and cleaned; thinner tank walls require less material; guttering design is simplified with two or more units.

6 IMPLEMENTATION

6.1 Installation of Sources

It would be more cost effective for transmigrants to be involved in the installation of their own water supply system. However, a temporary supply is often not available and so the permanent supply needs to be installed before the transmigrant arrives.

This is especially the case where the permanent supply has not been finalised. All wells sunk need to be tested after construction for adequate yield and, if yields are not adequate, then additional wells must be sunk or rainwater tanks must be provided.

6.2 Operation and Maintenance

In order to achieve design yields it is necessary to operate sources as designed. Spare parts of all components likely to need replacement (e.g. hand-pump, roof guttering) should be available. Villagers should be trained to repair and replace components.

Villagers should also be trained as to how to operate each source and how to prevent deterioration of a source. At direct river abstraction sites, access should be maintained and abstraction only allowed at the designated site. At low flows an adequate water depth should be maintained, if necessary by making temporary weirs. Accumulated silt and debris should be cleared regularly. Similarly surface water storages and shallow wells should be cleared periodically. Meshes and filters on rainwater tanks should be kept clean and whenever empty, the tanks themselves shoud be cleaned.

Where more than one type of source is used, villagers should told in which order to use the sources. Normal practice would be to use direct river sources first, then surface water, then wells and finally rainwater tanks. However it is very difficult to persuade a household to walk some distance to a river source when a full rainwater tank is standing next to the house.

Sources should not be over-abstracted, so that yields can be sustained or, in the case of river abstraction, so that downstream sources can still be operated. Again this is particularly important for rainwater tanks, where households must reduce their demand once a certain amount of storage has been used up.

The avoidance of faecal contamination is essential to the continued use of any source. Transmigration development provides for a septic tank on each houselot. Wells should be sited as far as possible upslope from septic tanks. Well surrounds should be kept clean and free of animals. Surface water sources should not be polluted by upstream defecation; this is of particular importance when a river is used as a source by several demand centres.

From the above it can be seen that a great deal of extension work is required to ensure efficient operation of water supply sources.

3 Land Clearing

Source yields are estimated assuming that the effects of the initial land clearing for settlement are minimised. This requires all major and where possible minor watercourses to be left uncleared. Also steep slopes and floodable areas should not be cleared. Of crucial importance is the immediate establishment of a cover crop on the cleared area.

If unselective land clearing allows erosion to start, the yields of all types of source could be reduced. Faster runoff means lower dry season flows and less recharge to groundwater. Higher bed loads mean faster siltation of surface water storages. Also a cleared area with no regrowth can cause reduced rainfall for rainwater storage.

CONCLUSION

The authors have presented a methodology for the design of water supply to low density rural transmigration settlements based on their experience in Central Kalimantan. This methodology will be refined once feedback from implemented transmigration schemes becomes available.

Actual costs and operational yields will be the most valuable information from implemented schemes. Also of value will be the effectiveness of extension work and the effects of land clearing.

The authors consider Central Kalimantan poses unique problems for rural water supply. Nevertheless it is hoped that this methodology will be adapted for use in other parts of the South East Asian region. Also experience from similar rural water supply schemes in the region would be welcomed in order to refine this methodology.

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DEVELOPMENT OF REGIONAL WATER ENTERPRISES IN INDONESIA

An outline for institutional development, manpower development and training programmes

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water supply

1. *INTRODUCTION.*

The Government of Indonesia is giving a high priority to water supply development programmes throughout the country. During the current (1979/1984) and following Five Year Development Plan enormous budgets from both local and foreign sources are made available for the physical development of water supply systems, in order to reach the national targets for water supply, viz. provision of a dependable water supply to 75% of the urban population and to 60% of the rural population by the year 1990.

Once the physical development of a water supply system has been completed, it shall be operated, maintained and further developed so as to provide the population with an adequate and reliable supply of this basic commodity. To do so there must be an organisation: the water supply undertaking. The water supply undertaking is responsible for a regular supply of dependable water to the consumers, as well as for a regular flow of money from the consumers to the undertaking through revenues from water sales and connection charges. See Figure 1.

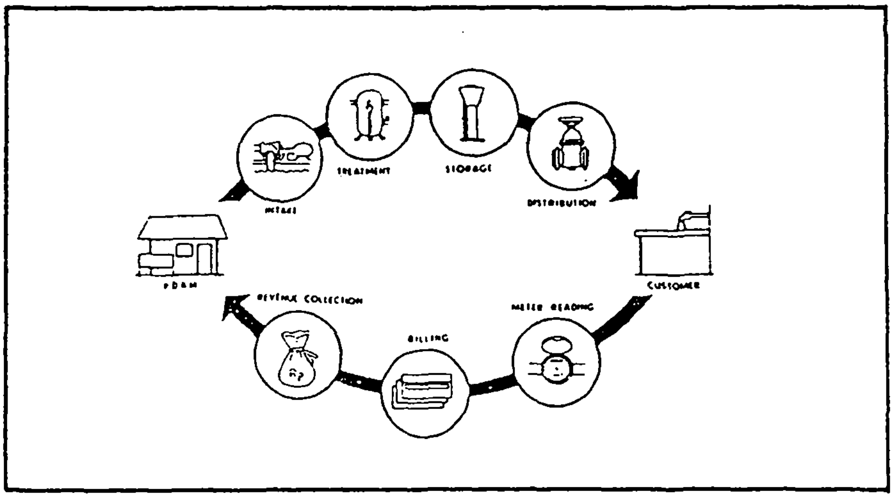


Figure 1. The two flows of a water supply undertaking.

Sufficient revenue shall be generated to cover the expenditures of the water supply undertaking and hence pursue its continued existence. These expenditures include costs for personnel, consumables, maintenance and repair, replacements and insurance.

The management, operation and maintenance of a water supply undertaking involves a great number of technical, financial/adminsitrative and managerial activities. A number of major activities are given in Table 1.

Table 1. Major activities of a water supply undertaking

- REGULAR AND INCIDENTAL OPERATION AND MAINTENANCE OF WATER PRODUCTION, TRANSMISSION AND DISTRIBUTION WORKS
- PERIODICAL INSPECTION AND PREVENTIVE MAINTENANCE
- PERIODICAL WATER QUALITY MONITORING
- METER READING, BILLING AND REVENUE COLLECTION
- NEW CONNECTION PROCEDURES
- WAREHOUSE PROCEDURES
- PETTY CASH PROCEDURES (REVENUES/DISBURSEMENTS)
- GENERAL ACCOUNTING (ON ACCRUAL AND/OR CASH BASIS)
- GENERAL ADMINISTRATION
- MANAGEMENT REPORTING
- BUDGETTING
- CONSUMER RELATIONS
- EXTERNAL RELATIONS
- PERSONNEL MANAGEMENT
- MANPOWER DEVELOPMENT AND CAREER PLANNING
- UPKEEP AND/OR IMPROVEMENT OF TECHNICAL AND FINANCIAL/ECONOMICAL PERFORMANCE IN THE WATER SUPPLY UNDERTAKING
- PUBLIC HEALTH PROGRAMMES

Water supply undertakings shall develop sufficient capabilities to handle the various technical, financial/administrative and managerial activities. These capabilities are a prerequisite to obtain the maximum benefit of the physical water supply structures as well as to attain the ultimate objectives of the national water supply development programme.

The professional development of water supply organisations involves due attention for essential issues, such as:

- organisational framework and institutional arrangements,
- manpower development and training,
- monitoring and promotion of enterprise performance development.

These issues will be discussed more in detail in the following sections. The contents of this paper are based on the current practice and experiences within the "Eleven Cities" and "IKK" Organisation, Management and Training projects as administered at present by DHV Consulting Engineers for water enterprises in the North Sumatra Province and D.I. Aceh. The said projects are part of the bilateral cooperation programme between the Governments of Indonesia and The Netherlands.

2. *ORGANISATIONAL FRAMEWORK AND INSTITUTIONAL ARRANGEMENTS.*

The Ministry of Public Works, through its Subdirectorate of Development of the Directorate Sanitary Engineering of the Directorate General Cipta Karya has adopted the policy that water supply operations shall be developed as a specific entrepreneurial activity with its own legal and managerial identity as well as its own responsibility to incur and discharge financial obligations. The water supply undertakings normally have an area of operation corresponding to the administrative organisation of the country, i.e. they observe the administrative boundaries of Regencies and Principal Towns. A fully developed water supply undertaking is called a PDAM, or Regional Water Enterprise. It is an autonomous organisation at Regency level and answerable to the Regency Administration. It is supervised by a Board of Supervisors of which the Regent or Major (for a Principal Town) is the Chairman. The PDAM is responsible for the management, operation and maintenance of all urban and semi-urban (e.g. Subregency capitals) water supply systems of its administrative entity. It is expected that in the near future the Regional Water Enterprises will also take charge of improved (piped) rural water supply systems. A Regional Water Enterprise has normally a management staff of three people, viz. Director, Head of Technical Department and Head of Finance/Administration Department. Each of the two departmentscontains several setcions with duties and responsibilities for a number of clearly defined tasks.
A typical organisational layout for a Regional Water Enterprise is presented in Figure 2a. Large water enterprises may have an organisational structure which is considerably more complicated.

As an initial stage of development towards a Regional Water Enterprise a BPAM (Water Supply Management Board) or an Embryo-PDAM may be established. A BPAM is a temporary organisation answerable to Cipta Karya/Subdirectorate Development through the Provincial Water Supply Project Organisation (PAB). The PAB undertakes the necessary arrangements for the establishment of the BPAM, in consultation with the Regent or Major. The formal establishment requires the endorsement of the Director of Sanitary Engineering. A typical organisational layout for a BPAM is presented in Figure 2b.

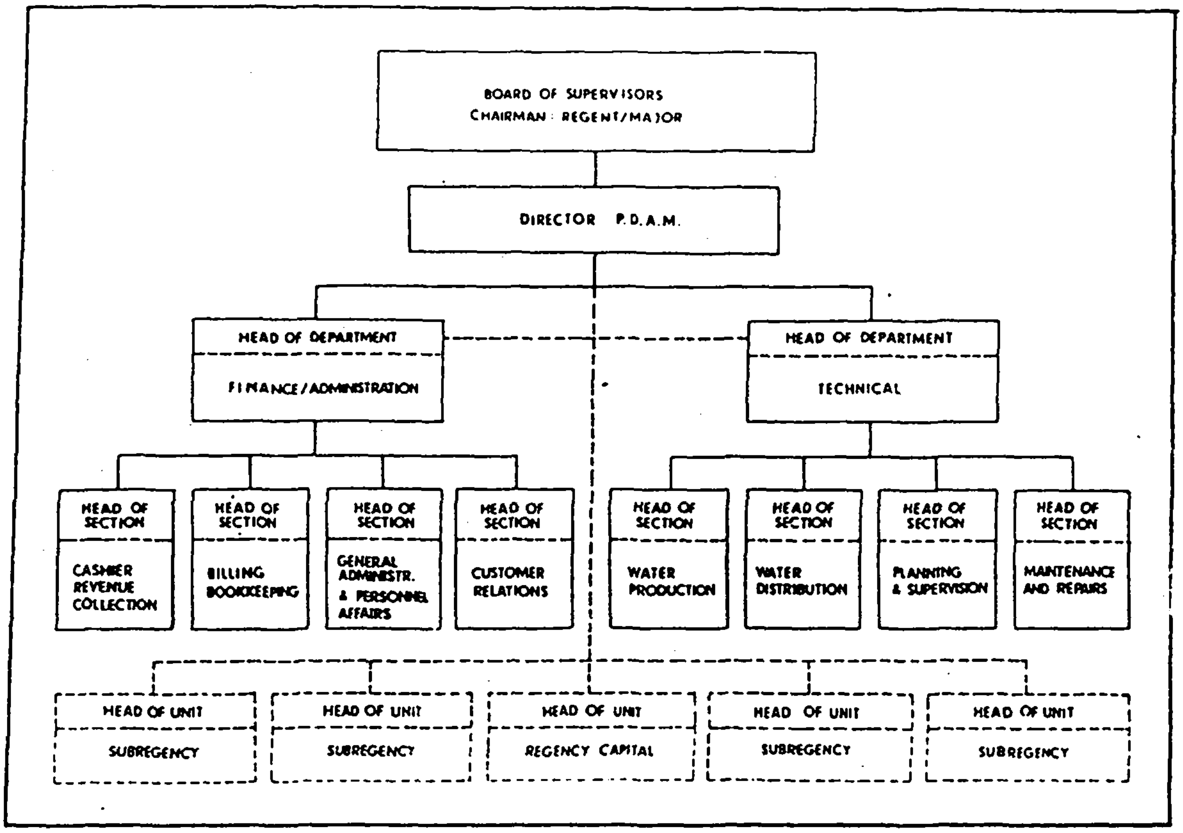


Figure 2a. Organisational layout of PDAM.

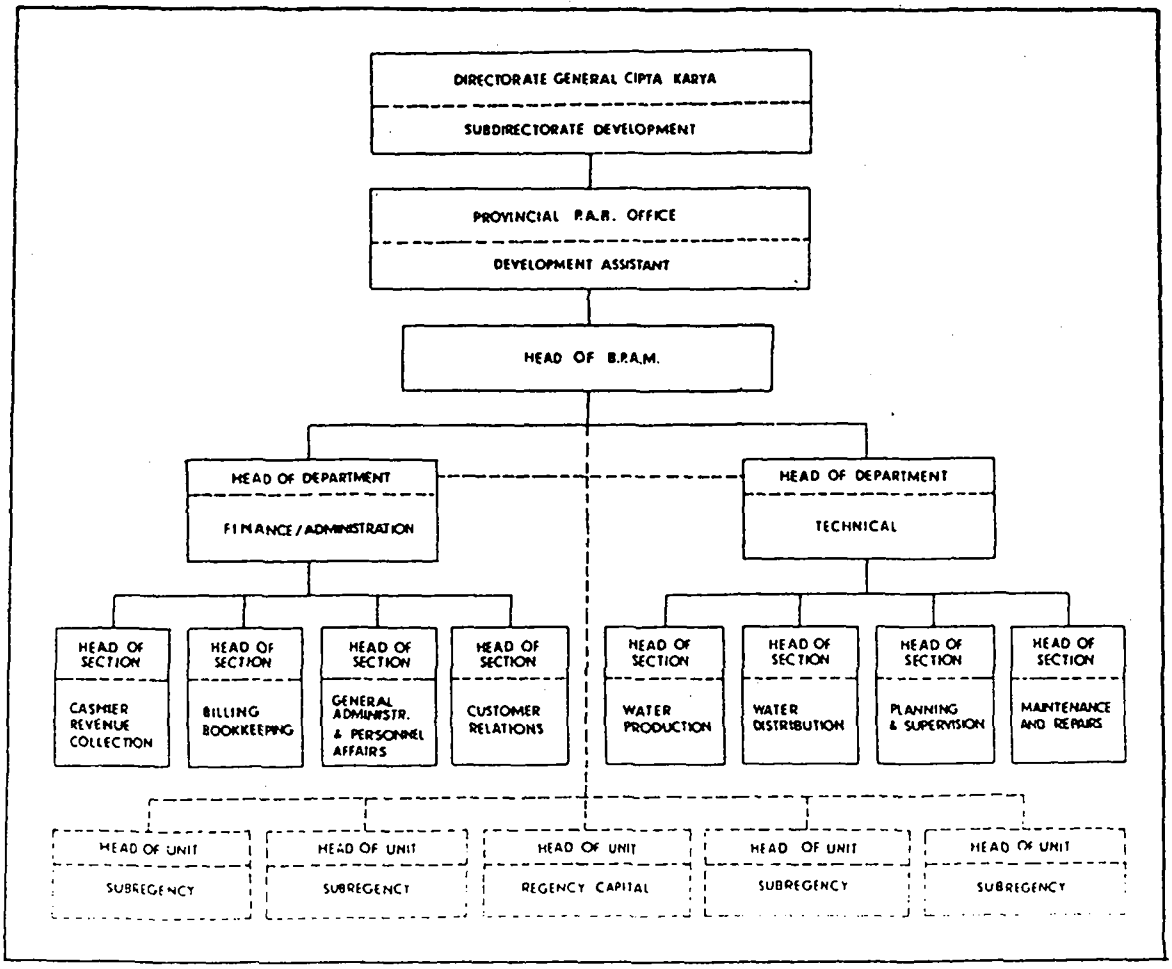


Figure 2b. Organisational layout of BPAM.

During the first years of operation the BPAM receives support, in terms of finance and technical, financial/administrative as well as managerial assistance, from SDD/DSE throughout the PAB. Once the BPAM has gained sufficient viability it should be transferred into a PDAM.

The Embryo-PDAM is a rather new concept in the Indonesian setting for the development of water enterprises, and is applied on an experimental basis in some provinces (e.g. North Sumatra and D.I. Aceh). Although the complete terms and conditions of operation of an Embryo-PDAM are not defined in all aspects, the legal status and procedures for establishment of an Embryo-PDAM are taken to be those applicable for a PDAM, whereas support in technical and financial terms by SDD/DSE and PAB are similar to those for a BPAM. A livespan of approximately 2 years is considered appropriate for an Embryo-PDAM. After that conversion into a PDAM has to take place.

The Regional Water Enterprise (PDAM) is responsible to the Regency Administration and has to abide by existing laws and regulations for regional enterprises. The establishment of a PDAM involves the processing of several Regional Regulations (PERDA) through various levels of the Regional Administration. In addition, letters of decision (SK) have to be issued concerning the appointment of staff and procedures involved in water enterprise operations.
The most important documents (PERDA and SK) are summarized in Table 2. A typical flow chart for the processing of a PERDA is presented in Figure 3. The complete cycle between conceptualisation and operationalisation of a PERDA may take from a few months to over a year.

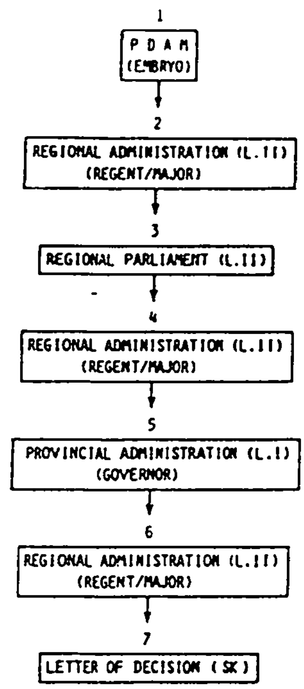
The PDAM provides a basic commodity to the population and has to take due notice of customer requirements which may be brought forward directly or through the people's representation (local parliament; DPR). See also Figure 3.

It goes without saying that good relations and mutual understanding between PDAM, Regional Administration and the public are essential for the proper functioning of the water enterprise. This presupposes that the regional administration, members of parliament, and the

Table 2. Official documents for establishment and operation of a water enterprise.

PERDA I	ESTABLISHMENT PDAM
PERDA II	WATER TARIFF STRUCTURE
SK-GOVERNOR:	ENDORSEMENT PERDA I; ENDORSEMENT PERDA II;
SK-REGENT	ENDORSEMENT PERDA I; ENDORSEMENT PERDA II; APPOINTMENTS: -- BOARD OF SUPERVISORS; -- MANAGEMENT STAFF W.E.;
SK-DIRECTOR:	REGULATION FOR NEW, DIS- AND RE-CONNECTIONS; APPOINTMENT OF W.E. STAFF;

Figure 3. Formal schedule for establishment of a Regional Regulation (PERDA) for a Regional Water Enterprise.



public have a general knowledge about the water enterprise operations. Moreover, one of the objectives of improved water supply systems, i.e. improvement of public health conditions, can only be attained if customers are provided with the essential knowledge about the relations between water supply and public health.
Information meetings and discussion sessions are very appropriate and in fact essential activities in creating such general awareness and general understanding with all parties concerned. Such sessions offer a good opprotunity to explain the service levels and limitations of the water enterprise, to set out the required attitude of consumers when using the water supply utility, and to formulate local water supply objectives and requirements (input for water enterprise development plan).
These information and discussion sessions should be organised for target groups of various compositions, such as:

- Regional Authorities (Level II) of different Regencies in order to stimulate cross fertilisation and a certain competition between Regencies in one Province,
- Regional Authorities (Level III) of different Sub-regencies of a Regency,
- Regional Authorities (Regent, Regional Administration staff, Members of Parliament, other authorities) of a specific Regency,
- The general public in the supply areas of the water enterprise.

Audio-visual information materials such as slide-tape programmes, video programmes, posters, leaflets and the like are valuable assets in conducting these information programmes.

Apart from its attachment to the Department of Home Affairs, through the Regional Administration, the PDAM has to maintain good relations with the:
- Department of Public Works, through CK/DSE and its PAB, for financial and technical support towards improvement and extension of its physical assets as well as temporary support for operation and maintaince expenditures,
- Department of Health, through the Regional Health Office, for a periodical assessment of the physico-chemical and bacteriological quality of the water distributed, as well as for the permanent monitoring/improvement of public health conditions as far as related to the water supply conditions.

Finally, the water enterprise will have various interactions with its external environment. Its operations will be affected by conditions prevailing in the environment, such as government policies and regulations, market conditions, supply of equipment and materials, manpower supply, and financial resources.

3. *MANPOWER DEVELOPMENT AND TRAINING.*

3.1 *Human resources development*

The multitude of activities to be undertaken by water enterprises requires an appropriate development of human resources to ensure an adequate supply of staff having sufficient knowledge, skills and motivation to satisfactorily carry out their assignments.
If current physical development targets in the water supply sector in Indonesia for the decade 1981-1990 are reached, it is forecast [1] that the need for manpower for operation and maintenance of water supply systems could rise from the present 14,000 employees to over 35,000 by 1990, or an annual increase of over 3,000 personnel between 1984 and 1990. It is obvious that adequate manpower development and training programmes will be required at the national level in order to cater for these needs. In addition there is a considerable backlog of training required for many of the existing 14,000 staff.
Manpower development and training programmes involve numerous considerations. The most important of these are summarized in Table 3.

Table 3. Important issues for manpower development and training programmes.

-- JOB DESIGN/JOBDESCRIPTIONS, MANPOWER CLASSIFICATION, ORGANISATION DEVELOPMENT	-- TRAINING NEED ANALYSIS
-- MANPOWER PLANNING AND FORECASTING	-- TRAINING DESIGN AND PROGRAMMING
-- SELECTION AND RECRUITMENT	-- TRAINING MATERIALS ASSEMBLY AND TRAINING IMPLEMENTATION
-- EMPLOYMENT CONDITIONS, SALARY SCALES AND CAREER DEVELOPMENT STRUCTURES	-- PERFORMANCE APPRAISAL SYSTEMS (INDIVIDUALS, ORGANISATIONS)
-- CONCEPTUALISATION OF ENTREPRENEURIAL APTITUDES AND ATTITUDES	-- ENTERPRISE PERFORMANCE DEVELOPMENT

A systematic and effective human resources development programme presupposes a comprehensive identification and inventory of all tasks and duties to be performed by a water enterprise. Once these tasks and duties are grouped and assigned to a required number of jobtitles and jobholders a logical organisational framework can be built up. The Subdirectorate of Development, through its Manpower Development Programme, has prepared a "Simplified Guide to Manpower Classification" which provides a good description of key jobs within small and medium sized water enterprises in the Indonesian water supply sector [2]. The document presents typical organisational layouts for various conditions as well as jobdescriptions for key jobtitles.

Comparison of the actual organisational layout and manpower engagement with the recommended situation, taking into account organisational growth potential, will provide the necessary data about the human resources development requirements for each individual water enterprise. These data are an essential input for training programmes.

3.2 *Training*

Training may be regarded as giving people the necessary skills and knowledge to allow them to do their jobs adequately and effectively. Once the need for training has been recognized the following steps are to be undertaken:

- Analysis of the training needs;
- Planning of training programmes;
- Production of training materials;
- Implementation of training programmes;
- Evaluation.

The analysis of training needs shall involve two types of analysis in order to obtain an accurate insight into the total training needs, viz. organisational analysis and job analysis. The organisational analysis will indicate the various functions per department or section which have a great bearing on the training programme and training methods selected. The analysis of individual jobs will provide understanding of the skills and knowledge required for the tasks contained in each individual job. It is important that the organisational and job analyses are undertaken effectively by interview and study of the different jobholders in a practical work situation. For practical reasons training needs are often generalized on the basis of pre-entry qualifications of staff and their jobtitle. If conditions allow for it, due attention shall be given to individual training needs of staff. The training need analysis should result in detailed information on total training needs for each jobtitle, jobdescriptions and training objectives.

The planning of training programmes can be undertaken upon completion of the training need analysis survey.
This includes activities such as:

- selection of jobtitles/jobholders to be trained within available time and budgets,
- selection of duration of training programmes,
- design of course syllabi and programmes,
- selection of appropriate training environment (classroom, workshop or on-the-job),
- selection of training staff and, if required, training of trainers.

Formal training programmes may not always meet the exact training need requirements of each individual trainee since each training involves a group of people with different aptitudes, as well as different educational background and working experience. Moreover, the actual operationalisation of skills and knowledge acquired during formal (classroom) training programmes in practical working situations may cause some constraints to the recipients of such training. These drawbacks can be offset by the implementation of an additional inservice training programme. Trainers visit their trainees at the location of work and monitor their performance. Based on this assessment, corrective measures, assistance and more individual training can be implemented.
The appropriate distribution between formal training and inservice training programmes is a critical element in the overall planning of training programmes.

The production of training materials shall preferably be based on the concept that most training is associated with training people to perform specific tasks. Analysis of water supply operations shows that for several jobtitles skills and knowledge on similar tasks are required. Consequently, when training each of these job-

titles, the same training document may be used. It is therefore recommendable to develop training documents on a modular basis whereby each training module is applicable as a selfcontained Training Package. When training any jobtitle a series of appropriate training modules can be selected in order to compile a Training Manual for that particular jobtitle.
Each training package shall contain the necessary documentation for trainers as well as for trainees and be supplemented by an adequate set of training aids (viewfoils, audio-visual materials, models, drawings, demonstration equipment, etc.). It is estimated that approximately 500-600 training packages are required to cover the spectrum of tasks in the Indonesia water supply sector.
A considerable amount of training modules was produced recently by a group of Dutch Consultants in cooperation with the Subdirectorate Development [3].

The implementation of training programmes may be undertaken at regional training centres catering for two to four provinces.
A regional training centre (RTC) should serve as a focal point for human resources development in the water supply sector. It should provide services for the rapid implementation of crash formal training programmes, inservice training programmes, and other supporting services required for the enterprise performance development. Basically an RTC is to function as a training implementing institution which obtains its training programmes and training materials from a national training research centre where complete training programmes are developed and validated.
An RTC should have adequate classroom training facilities, a small workshop, a small laboratory, an outdoor training ground, 4-6 permanent training staff, 4-8 supporting staff, offices, and preferably boarding and lodging facilities.
Formal training courses should last 2-4 weeks for each key jobtitle, whereas inservice training programmes should take approximately 8-12 weeks per water enterprise.

4. *ENTERPRISE PERFORMANCE DEVELOPMENT.*

The development of an adequate performance of the water enterprise is the ultimate objective of the institutional and human resources development programmes geared towards the professional managament, operation and maintenance of the physical infrastructure of the water enterprise.

The intended development of the water enterprise shall be laid down in a Development Plan. A development plan formulates a set of intended objectives (both development and routine objectives) and describes the activities that are to be undertaken, and funds that are required, during specified periods in order to reach these objectives. The activities selected have to be tuned to the enterprise resources in terms of manpower and funds, and in case these resources cause obvious constraints an appropriate resources development programme shall be part and parcel of the development plan. Implementation of the development plan may also involve manpower, funds and other inputs from the external environment of the water enterprise. The feasibility of the procurement of such external support has to be duly evaluated in order to produce a realistic development programme.

The development plan should be based on issues such as:

(i) the needs of the customers;

(ii) the attainment of financial/economical viability of the water enterprise;

(iii) the resources in terms of manpower and funds that can be tapped;

(iv) any other issues that are relevant to a proper functioning of the water enterprise in its environment.

A Development Plan should preferably consists of at least two sections with different planning horizons, i.e. long-term development plan and short-term development plan.
The long-term development plan, covering a period of say 3 years, provides an outline of the phased programme of the water enterprise towards the realisation of the national objectives for urban, semi-urban and rural water supply.

The short-term programme should be geared towards objectives attainable during the first year of the long-term plan, and include those activities for which implementation is necessary in order to realize an appropriate level of performance of the water enterprise, within the context of available resources (manpower, funds, etc.).

Development plans shall pay due attention to a gradual sophistication of various routine objectives which serve as guidelines for the enterprise performance development (Management-by-objective Approach).

The preparation of a development plan involves three stages:

1. The present situation must be analysed.
2. The objectives (i.e. the situation desired to be reached) must be determined.
3. The best method of proceeding from the present situation to the desired situation must be selected among the available alternatives.

The first stage of planning is to establish the present situation, i.e. the present level of service (% of population which has direct access to water supply), and the quality, quantity and reliability of the water supply are evaluated. In addition, an inventarisation is made of those aspects of the water enterprise operations which develop satisfactorily, and those which cause various constraints and require due attention and improvement so as to obtain an appropriate performance of the Water Enterprise, based on its existing assets and resources.

Having determined the present situation, the next stage is to decide upon the ultimate goal (i.e. long-term objectives) and, since it is unlikely that this will be reached during the period of a single programme, an intermediate goal, attainable during a specific time should be selected (i.e. short-term objectives).

The short-term objectives constitute a summary of the works that can be carried out during a definite time, with the resources of money, manpower and administrative capacity that can be made available during that period.

The Water Enterprise's Development programme is the final result of the planning process, and may be described as an analysis of the means whereby the objectives can be reached.
The parties which should be involved in the preparation of the development programme of the regional water enterprise include the regional authorities, the regional administration, the Board of Supervisors and the Management Staff of the water enterprise, the public (through its parliamentary representatives), PAB officials, and (if required) Consultants. An early involvement of all these parties may considerably enhance the feasibility of the proposed development plan.

A periodical enterprise performance assessment by an external institution (DSE/SDD, PAB, Consultants), based on a standardized set of performance indicators as well as on a comparison between actual performance and intended performance as laid down in the development plan, will reveal where the water enterprise is still facing shortcomings in the execution of its duties and responsibilities. Corrective measures as well as additional training and coaching programmes answering to the needs of each enterprise can then be identified and implemented.

The application of this Management-by-Objectives Approach in the ongoing "Eleven Cities" and "IKK" Organisation, Management and Training projects, covering organisational and institutional development assistance (May 1982 - to date), formal training programmes (November 1982 - June 1983) and inservice training programmes (July 1983 - December 1984), appears to result in the gradual development of successful regional water enterprises.

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3. *Training Manuals for the Indonesian Water Supply Sector (30 volumes), DSE/SDD/DHV/IWACO/TGI, Jakarta, March 1983.*

4. *Various project documents of the "Eleven Cities" and "IKK" Organisation, Management and Training Projects, DHV Consulting Engineers, Medan, 1982/1983.*

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KINGDOM OF THE NETHERLANDS

SOCIO – ECONOMIC AND FINANCIAL ASPECTS OF IKK WATER SUPPLY

A Case Study in North Sumatera Province
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1. THE IKK APPROACH CONSIDERED

1.1. Government policy

The Government of Indonesia has adopted a low cost standardized approach for its nation-wide IKK Water Supply Programme. We can summarize this approach as follows :

1. Four standard systems are used : 2,5 l/sec, 5 l/sec, 7,5 l/sec, and 10 l/sec to serve 3,600, 7,200, 10,800 and 14,400 people respectively.

2. The ratio between the population served by public faucets and the population served by house connections is standardized at 50% : 50%.

3. Water is supplied at reduced supply and service levels, i.e. the water flow is restricted by means of a flow restrictor to 600 liter per house connection per day maximum, and 6,000 liter per day per public faucet, which is supposed to serve 20 households.

1.2. Socio-economic case study in North Sumatera

The socio-economic and financial aspects of this standardized approach have been the subjects of a case study carried out by DHV Consulting Engineers in the Province of North Sumatera. This case study, carried out in the first half of 1982, had the following (summarized) objectives :

1. To provide sufficiently reliable information on household incomes and ability and willingness to pay for water supply under the IKK Programme.

2. To assess a consistent overall water tariff structure and cross-subsidy system for a typical future water enterprise at Kabupaten level.

3. To obtain an indication of the feasibility of the ongoing IKK Water Supply Programme.

4. To assess the need for developing a more flexible design approach for the IKK Programme.

This case study has been carried out prior to the implementation of IKK water supply projects. It consisted of a structured questionnaire survey among 934 households in six IKK-towns in Kabupaten (Regency) Langkat in the Province of North Sumatera. Their location has been indicated in figure 1.1.*

1.3. The objectives of this paper

This paper concentrates on two aspects of the IKK Water Supply Programme :

1. The socio-economic aspects of this type of water supply in terms of community acceptance and ability and willingness to pay.

2. The issues of water tariffs and cost recovery or, in other words, the financial feasibility of the Programme.

The contents of this paper are based on the results of before mentioned case study which are, where required, adapted to more recent data.

Chapter 2 of this paper describes the results of the case study with respect to community acceptance and ability and willingness to pay for domestic water supply.

The financial feasibility of the IKK Programme applied for a water enterprise at Kabupaten level (Kabupaten Langkat) is analysed in Chapter 3.
Finally, preliminary conclusions of the Programme are presented in Chapter 4.

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* *The results of this case study have been published in :*
DHV Consulting Engineers, May 1982
Socio-Economic Case Study Kabupaten Langkat
Ibukota Kecamatan Water Supply Project in North Sumatera and Aceh

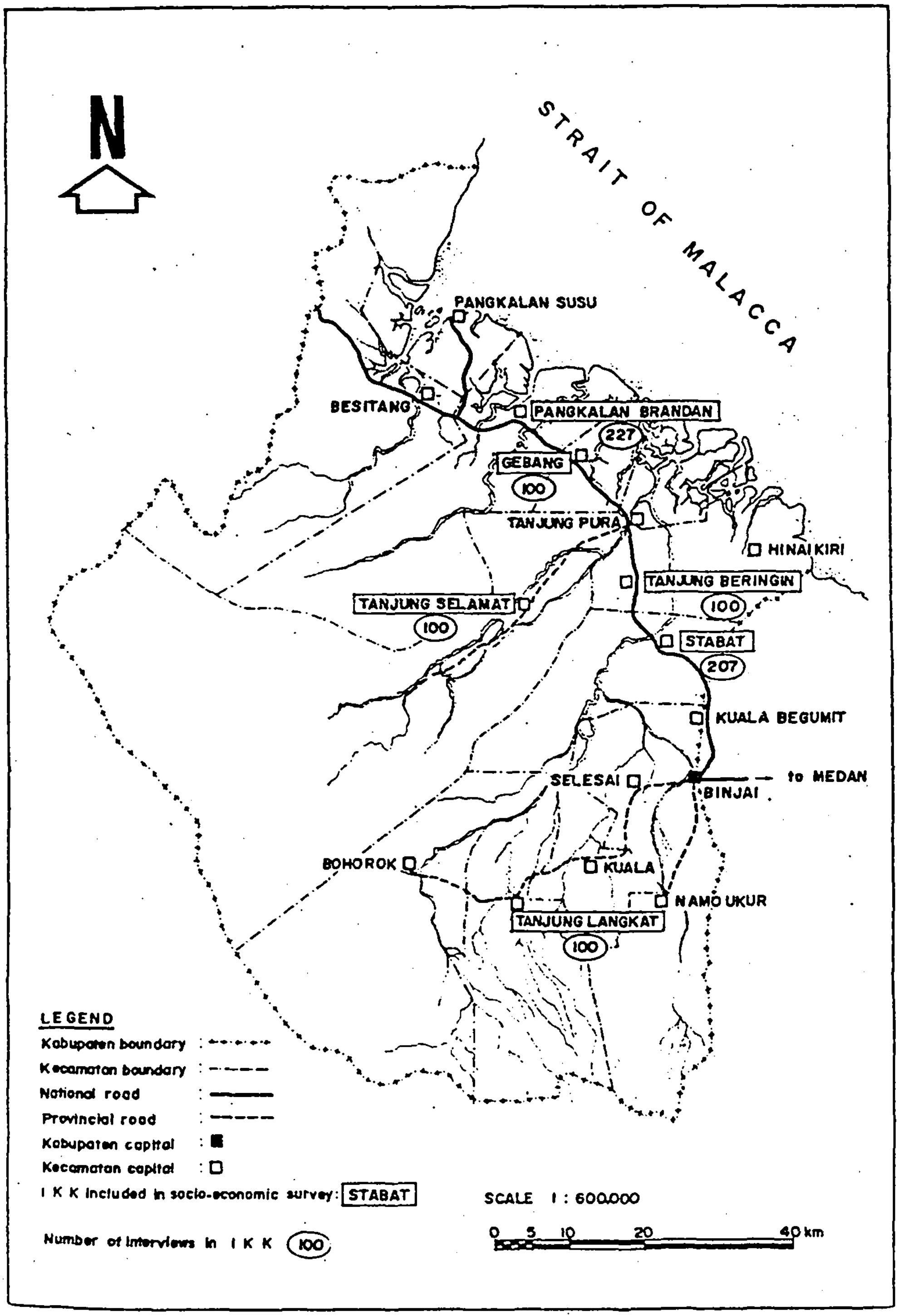

Figure 1.1. Kabupaten Langkat : location of IKK-towns covered by 1982 socio-economic case study

2. SOCIO-ECONOMIC ASPECTS OF THE IKK APPROACH

2.1. Standardized versus taylor-made approach

In the attempt to cater for the water supply needs of some 3,000 IKK-towns, the Indonesian authorities have opted for a standardized approach : Standard-sized systems cater for predetermined numbers of consumers; Both the number of consumers to be supplied from house connections and those to be served from public faucets are fixed; Finally, the amount of water as well as its flow capacity are standardized.

In the larger Indonesian towns on the other hand, water supply systems are of a so-called taylor-made design. These urban systems are mostly designed in accordance with the specific conditions, such as population size and paying ability of the populations,in the town or city concerned.

The option for a standardized approach for the IKK Water Supply Programme stems from sound technical and financial reasoning: Ease of design, restricted implementation duration and low per capita investment costs, which characterize the IKK approach, contribute to the realization of policy targets under conditions of limited development funds.

The ultimate users on the other hand, may opt for quite different starting-points for the approach to supply them with water. Needs, wishes, priorities and financial abilities of the IKK populations constitute some of the starting-points of a more flexible approach.
In other words; Do the future consumers need and want improvement as provided by the IKK approach? What is even more important: Can people afford to pay for the operation and maintenance of these standard systems?

2.2. Need and demand for water supply improvement

The case study indicated that private or public open shallow wells and rivers constitute the main sources for domestic water use in North Sumatera.
From a scientifically-objective point of view these conditions are likely to be rated as "poor", considering consequences for the health situation. It is mainly on the basis of such general considerations that the IKK Water Supply Programme is implemented.
The populations of the studied IKK's, on the contrary, considered their water supply as relatively good.
We cannot deny the impression that the IKK Programme aims at satisfying ascribed rather than perceived needs, with consequences for the successful acceptance by potential users.

2.3. Paying ability for improved water supply

Factors determining paying ability
The ability of a household to pay for improved water supply depends, among others, on its income.
The median household income level in the six IKK-towns studied ranged between Rp 55,000 and Rp 95,000 per month (cf table 2.1).
The extent to which people can afford to pay for improved water supply, however, is not only determined by their level of income.

Income may be in kind, a part which is not available for cash expenditure. The results of the case study revealed that, on average, receipts in kind account for less than ten per cent of total income.
Only for the lower income categories account income in kind for a higher share in total income, i.e. up to 30 per cent.

Table 2.1. Distribution of average monthly household income for selected IKK-towns (1982).

Category of monthly income (Rp)	Percentage of households with income within indicated category (1) and within indicated category or less (2)											
	Stabat		P.Brandan		Tg.Langkat		Tg.Beringin		Tg.Selamat		Gebang	
	1	2	1	2	1	2	1	2	1	2	1	2
0 - 19,999	-	-	-	-	-	-	-	-	2	2	1	1
20,000 - 29,999	3.4	3.4	0.8	0.8	-	-	5	5	7	9	2	3
30,000 - 39,999	10.6	14.0	3.8	4.6	13	13	13	18	17	26	13	16
40,000 - 49,999	14.5	28.5	5.5	10.1	15	28	16	34	18	44	9	25
50,000 - 59,999	9.6	38.1	8.2	18.3	10	38	13	47	12	56	12	37
60,000 - 69,999	11.6	49.7	13.6	31.9	12	50	9	56	17	73	21	58
70,000 - 79,999	11.1	60.8	9.8	41.7	9	59	11	67	12	85	14	72
80,000 - 89,999	7.2	68.0	6.0	47.7	9	68	6	73	3	88	8	80
90,000 - 99,999	6.3	74.3	4.0	51.7	7	75	7	80	3	91	5	85
100,000 - 124,999	8.7	83.0	19.1	70.8	10	85	15	95	6	97	7	92
125,000 - 149,999	3.4	86.4	11.7	82.5	3	88	2	97	1	98	7	99
150,000 - 174,999	6.3	92.7	7.4	89.9	5	93	-	97	2	100	-	99
175,000 - 199,999	1.0	93.7	3.3	93.2	2	95	2	99	-	100	1	100
200,000 - 249,999	3.9	97.6	4.1	97.3	3	98	1	100	-	100	-	100
250,000 and more	2.4	100.0	2.7	100.0	2	100	-	100	-	100	-	100

Income may vary over the year. This pertains particularly to farm income which occurs on a seasonal basis.
In that case, regular monthly expenditure obligations for water supply would require a certain habit and/or discipline to put aside an amount of cash sufficiently large to cover the "slack cash-income-season".
In five of the selected IKK-towns cash income from farming accounted for less than fifteen per cent of average income, in spite of the apparently rural character of these towns.

Income, particularly from farming, might vary also from year to year. The low percentage which farming contributed to the income in the selected IKK-towns was mainly due to adverse climatological conditions for the particular reference period concerned.

Willingness
Finally there is the willingness of people to spend money on water supply. This is mainly determined by the factors mentioned above as well as by the individual priority setting in expenditure. This priority setting again depends on the perception of needs for improvement of water supply and the level of service foreseen. This will be different from one household to the other.

Paying ability criterion
Little consensus can be found in literature on the part of the household income which could be afforded for improved water supply :
Cairncross et all in their publication "Evaluation for Village Water Supply Planning" regard five per cent or at most ten per cent of cash income as available for domestic water supply (WHO/IRC, 1980, p.155).

The World Bank in the publication on Village Water Supply considers three to five per cent of family income an affordable percentage for water supply.
The strategy of the IKK Programme initially adopted a maximum of five per cent of household income. Later this percentage was increased to eight per cent.

One proper way of estimating the amount people are willing to pay for water is to examine cases, where they do pay for their supply of domestic water.
The case study included one town, Pangkalan Brandan, where part of the population paid for their water supplied either from a private connection to the existing system or from water vendors.
It appeared that the part of income spent on water amounts to nearly four per cent for those households paying for their water. For the lower income categories this percentage is even higher (cf table 2.2.).

Table 2.2. Part of monthly income spent on water consumption by income category : Pangkalan Brandan* (%)

Income category - Total income - (Rp)	Part of income spent on water (%)
Less than 30,000	3.3
30,000 - 39,999	5.1
40,000 - 49,999	4.6
50,000 - 59,999	7.6
60,000 - 69,999	5.0
70,000 - 79,999	2.0
80,000 - 89,999	3.4
90,000 - 99,999	4.9
100,000 - 124,999	4.4
125,000 - 149,999	5.1
150,000 - 174,999	3.2
175,000 - 199,999	5.9
200,000 - 249,999	2.2
equal to and more than 250,000	2.9
AVERAGE	3.9

* Data refer to people paying for water only, thus excluding households using water from privately owned sources only.

When considering the representativeness of Pangkalan Brandan for other IKK-towns the following remarks should be made:

1. It is a large town, with a population of nearly 40,000 when the adjacent villages are included. IKK-towns genrally have a population between 3,000 and 15,000.

2. Due to its location near to the sea, groundwater sources (shallow wells) cannot be used as an alternative to buying water. In other words the perceived needs are high.

3. Pangkalan Brandan is "rich", with some 50 per cent of households having an income of Rp 95,000 of more whereas this is only on average Rp 65,000 in the other IKK-towns

However, with respect to the latter condition; the households with a monthly income of less than Rp 100,000, still spent an average 4,5 per cent on water.

When we assume that :

1. households can afford to spend four(4) per cent of their income on domestic water supply.

and we take into consideration that ;

2. initial tariffs for a house connection in the IKK Programme have been set at Rp 1,000 per month and for the supply of water from a public faucet at Rp 300 per month,

it turns out that the minimum monthly income for the use of a house connection is Rp 25,000 and Rp 7,500 for the use of water from a public faucet.
This would mean that at least 95 per cent of the populations in the selected IKK's could afford water supply from a house connection.

Asked after their willingness to pay the indicated monthly tariff for a house connection, the results were somehow less optimistic. Only between 46 and 92 per cent of the interviewed populations expressed their willingness to pay the indicated tariff of Rp 1,000 per month (cf table 2.3.)

Table 2.3. Ability and willingness to pay for water from a house connection*

IKK	Percentage of households:	
	able to pay Rp 1,000 per month	willing to pay Rp 1,000 per month
Stabat	99%	65%
Pangkalan Brandan	100	92
Tanjung Langkat	100	91
Tanjung Beringin	99	46
Tanjung Selamat	95	69
Gebang	98	80

* *Ability based on 4% of income criterion*
Willingness based on survey results

We have to be careful however with the survey results on "willingness to pay". The predictive value for a future behaviour based on present opinions is restricted :
The experience on innovation distribution learns that there is always a certain sequence with early acceptors, followed by the mass only after some time of "wait and see".
This has been observed also with the implementation of the first IKK projects in the Provinces of North Sumatera and Aceh :
When these systems were implemented, the number of available house connections exceeded the number initially applied for. However, before actual operation of the system started, additional subscriptions generally outnumbered the remaining capacity.

These results indicate that a standard approach in which the service level has been standardized is likely not to satisfy actual demand in many cases. The reluctance observed in some of the IKK-towns to accept public faucets as a means of water supply, as alternative to house connections, supports this conclusion.

3. FINANCIAL FEASIBILITY OF IKK WATER SUPPLY

3.1. Government revenue policy

Subscription fee

Subscribers to an IKK Water Supply System do not pay any subscription fee. This applies both to house connection users and users of public faucets.
In other words, all investment costs are paid from Government funds.
This policy is different from some water supply systems constructed under other, urban programmes. It has been reported that subscription fees exceeding Rp 100,000 are occasionally normal practice.

The payment of a subscription fee of Rp 30,000 was not considered a major problem by many of the households in the selected IKK-towns.
Particularly if it would be possible to pay this fee in twelve monthly instalments of Rp 2,500 (cf table 3.1)

Table 3.1. Willingness of households in selected IKK-towns to pay subscription fee of Rp 30,000.

IKK	Percentage of people willing to pay subscription fee of Rp 30,000		
	in instalments	cash	total
Stabat	43%	16%	59%
Pangkalan Brandan	57	35	92
Tanjung Langkat	78	12	90
Tanjung Beringin	24	18	42
Tanjung Selamat	34	29	66
Gebang	74	5	79

The imposition of a subscription fee has various advantages:

1. It will constitute a threshold, preventing eligible households which in fact cannot afford to pay the monthly tariff on the longer run, to get such a connection. Survey results and paying ability assumptions suggest, that all households able and willing to pay the monthly tariff are also capable and willing to pay for subscription.

2. It will lower the subsidies otherwise to be provided for by the Government.

3. Morover, the revenues from subscription can be used to pay for the operation of the system (salary and fuel costs particularly) during the initial period. In this period, collection of consumption tariffs are started-up and likely not adequate to cover all costs.

Water tariff

It is Government policy to cover the costs of operation and maintenance of the IKK Water Supply Systems from revenues derived from the sale of water.
Replacement costs are not to be covered by water revenues, although at one time proposals have been made to include depreciation costs as well.
The Government, by subsidizing the depreciation costs, apparently tries to supply water at an attractive rate also for the low-income communities.

3.2. Cost recovery performance

Initially the IKK Programme followed a Ministerial Decree by fixing the water rates at Rp 50/m^3 and Rp 30/m^3 for house connection users and users of public faucets respectively (1981/1982 financial year).
These rates correspond to Rp 1,000 and Rp 300 per month per household for a house connection and public faucet respectively.

These tariffs would be far from adequate to cover the estimated operation and maintenance costs of any of the thirteen IKK Water Supply Systems which are to be constructed in Kabupaten Langkat (cf table 3.2).
Cost recovery performance would particularly be poor for the smaller systems (2.5 l/sec) and systems with treatment facilities, 48 per cent and 45 per cent (7,5 l/sec. system) resp. The financial consequences of adhering to the initial water rates would be serious, i.e. continuous subsidizing by the Government. This subsidy would amount to Rp 5,000,000 monthly for Kabupaten Langkat.

Table 3.2 Cost recovery performance IKK-towns in Kabupaten Langkat.

IKK	Capacity of system (l/sec)	Source[1]	Treatment	Cost recovery[3] (%)
Bohorok	eligible[2]	-	-	-
Tanjung Langkat	2.5	s.w	-	50
Namo Ukur	2.5	d.w	-	48
Kuala	5.0	d.w	-	64
Selesai	10.0	d.w	-	77
Kuala Begumit	eligible[2]	-	-	-
Stabat	5.0	d.w	-	59
Tanjung Selamat	5.0	d.w	-	64
Tanjung Beringin	10.0	d.w	-	77
Hinai Kiri	2.5	d.w	-	48
Tanjung Pura	7.5	d.w	-	65
Gebang	5.0	d.w	-	64
Pangkalan Brandan	40.0	river	yes	67
Besitang	2.5	d.w	-	48
Pangkalan Susu	7.5	river	yes	45

1. s.w = shallow well
d.w = deep well
2. Eligible due to population number less than required 3,000
3. For summarized details on estimates see Appendix 1

Furthermore, cost recovering rates for individual systems would cause considerable inequality in water tariffs between the IKK-towns within a single Kabupaten.
This would negatively affect in particular the smaller towns, which generally also concern the lower income towns.

This situation has been foreseen by the Indonesian authorities. Therefore the IKK Programme aims at applying cross subsidy between individual IKK-towns within a Kabupaten to achieve a certain degree of equity in water tariffs.
To this end, a Kabupaten level Water Enterprise -PDAM-* will be responsible for management of all systems, major repairs and extension and financial administrative matters.
In this way the less profitable systems are subsidized by the more profitable ones.
We estimate, however, that total operation costs are increased with nearly ten per cent (salaries, administration and communication.

3.3. Cost recovering water rates

Estimates for a water rate which would cover the costs of operation and maintenance of all water supply systems in Kabupaten Langkat amount to Rp 90-100/m^3 and Rp 45-50/m^3 for a house connecetion and public faucet respectively.
This corresponds with Rp 1,600-1,800 and Rp 400-500 per household per month for house connection and public faucet user resp.

This tariff covers the costs of the mix of systems only.
In case the smaller systems and systems with treatment facilities are constructed first, initial cost recovery would still be negative.

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* *PDAM - Perusahaan Daerah Air Minum*

Cost-recovering tariffs and paying ability

Pursueing a cost-recovery policy with respect to water consumption rates will have its consequences on the proportion of the population being able to pay these tariffs.

The percentage of the households which could afford to pay for water, based on the "four per cent criterion" (cf section 2.3.), has been presented in table 3.3.
The figures in table 3.3 indicate that the use of water from a public faucet could be afforded by all households. A house connection could be afforded by about 70 per cent in the poorest IKK-town to some 94 per cent in the richer IKK-town.

Table 3.3. Percentage of households which could afford to pay cost recovering tariff in selected IKK-towns*.

IKK	Percentage of population able to pay tariff for use of :	
	public faucet	house connection
Stabat	100 %	83 %
Pangkalan Brandan	100	94
Tanjung Langkat	100	85
Tanjung Beringin	100	78
Tanjung Selamat	100	71
Gebang	100	83

* *We appreciate that 1983-cost estimates are compared here with 1982-income figures. Recent validity checks in one of the IKK-towns did not reveal any major shift in the income distribution patterns.*

4. PRELIMINARY CONCLUSIONS

4.1. Community information

The IKK Water Supply Programme is to be executed nation-wide in some 3,000 IKK-towns.
This Programme has been initiated at central government level. It has been based on the general consideration that domestic water supply conditions in IKK-towns are poor and detrimental to the health situation.

The results of the North Sumatera case study support this consideration from an objectively-scientific point of view: Open unlined shallow wells and rivers generally provide a poor quality water.

The interviewed population in the six IKK-towns in Kabupaten Langkat, however, did not perceive the quality of their water as poor. Under such conditions a vigorous attempt to inform and involve the future users is warranted if the Programme is to be accepted and to become a success.

DHV Consulting Engineers has developed a clear and handy brochure, for distribution among future users (cf figure 4.1). These brochures, at poster-size, are pinned to walls in public buildings such as offices, restaurants and health centres.
But information only is not enough to "sell" the water : Direct community participation is required as well. In the IKK Programme early participation is realised by involving the future users already in the survey and design phases of a water supply project. In general meetings with local authorities, representatives of the health service, education department and police and with villagers, the project is introduced and explained in detail.

1

PROYEK

Proyek IKK ini adalah salah satu dari program nasional yang pertama untuk penyediaan air minum sehat pada 1700 IKK diseluruh tanah air.

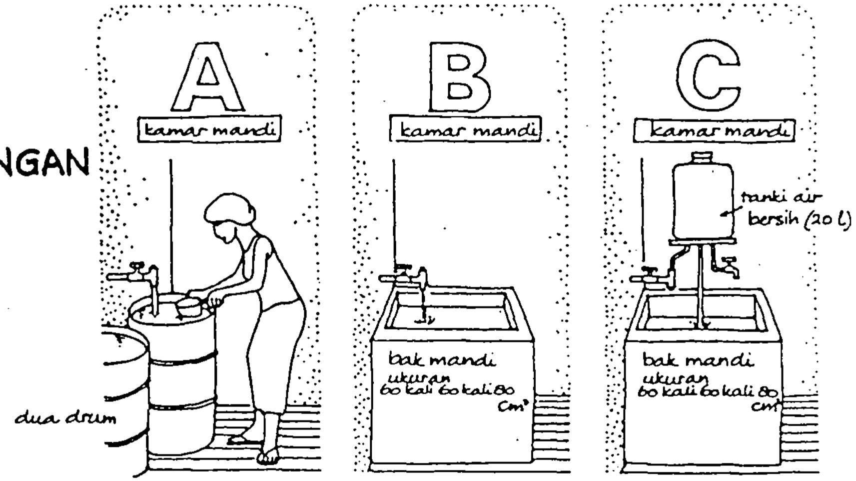
Untuk memenuhi kebutuhan air minum IKK sebanyak mungkin, Pemerintah telah memakai suatu sistim baru penyediaan air minum yang seragam dan murah biayanya.

Air akan didistribusikan melalui kran - kran umum demikian juga melalui sambungan rumah.

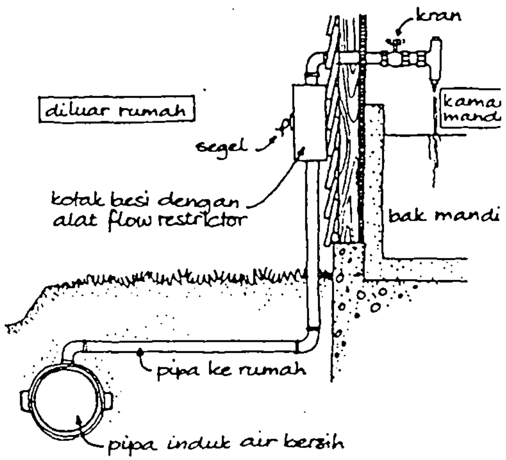
Kran - kran umum menyediakan 300 l/hari/keluarga. Sambungan rumah menyediakan jumlah air yang tetap yaitu 600 l/hari. Keduanya dilengkapi dengan pembatas aliran yang akan menjaga agar setiap orang memperoleh jumlah air yang sama banyaknya.

2

SAMBUNGAN RUMAH

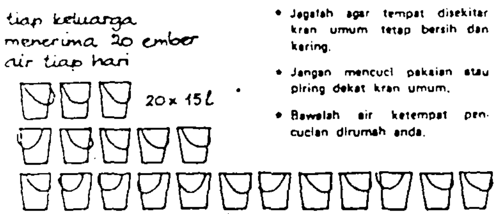


- Air akan selalu dapat diperoleh.
- Biarkanlah kran anda terbuka siang dan malam.
- Simpanlah air anda dalam bak mandi atau pergunakanlah dua buah drum.
- Untuk memperoleh air yang bersih pasanglah sebuah tangki kecil diatas bak mandi anda atau diatas drum.
- Jagalah agar tempat mencuci dirumah anda tetap bersih dan kering.
- Lengkapi dengan saluran air yang memadai

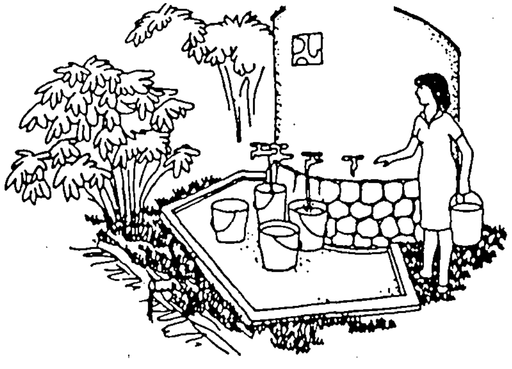


3

KRAN UMUM



- Kran - kran umum menyediakan air yang cukup untuk sekitar 20 keluarga.
- Setiap keluarga mendapat 300 liter (20 ember) setiap hari.
- Kran - kran umum ditempatkan disekitar kira - kira 200 m dari rumah.
- Jagalah agar tempat disekitar kran umum tetap bersih dan kering.
- Jangan mencuci pakaian atau piring dekat kran umum.
- Bawalah air ketempat pencucian dirumah anda.



- Setelah mengisi ember - ember anda, tutuplah kran dengan baik.
- Air tak boleh ada yang terbuang.

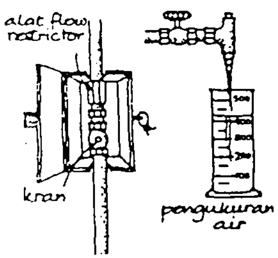
4

PEMERIKSAAN

Setiap pembatas aliran dilindungi dengan kotak besi. Kotak besi itu ditutup dan disegel oleh Perusahaan Air Minum.

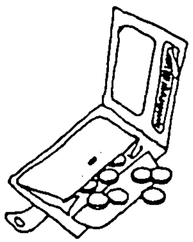
Segel tersebut akan diperiksa setiap bulan. Secara teratur Perusahaan Air Minum akan mengukur aliran dari kran dirumah untuk memastikan bahwa pembatas aliran tidak tersumbat atau dirusak.

Apabila perlu pembatas aliran atau pipa kerumah akan dibersihkan dan dikuras.



5

TAGIHAN



Pemasangan pipa kerumah tidak dipungut bayaran. Pemasangan bak mandi, drum - drum dan tangki kecil ditanggung sendiri oleh para langganan.

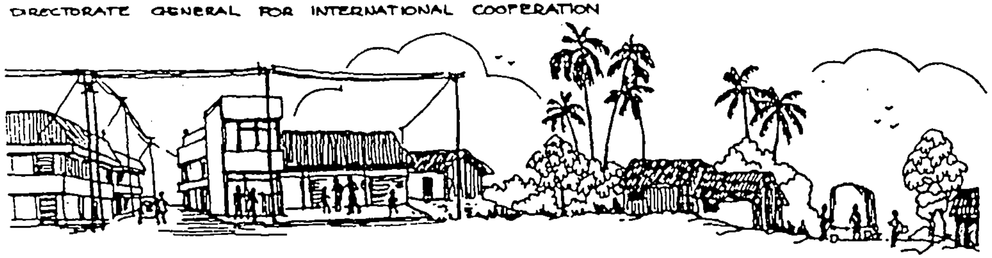
Tarip untuk pemakaian sambungan rumah dan kran - kran umum akan diumumkan didalam surat tersendiri.

Uang langganan akan ditagih setiap bulan oleh pegawai Perusahaan Air Minum.

Perusahaan Air Minum tersebut mempunyai wewenang untuk menyesuaikan tarip dengan peraturan daerah setempat.

PROYEK AIR BERSIH IKK SUMATRA UTARA
DIREKTORAT TEKNIK PENYEHATAN
DIREKTORAT JENDERAL CIPTA KARYA DEP. P.U.

GOVERNMENT OF THE NETHERLANDS MINISTRY OF FOREIGN AFFAIRS
DIRECTORATE GENERAL FOR INTERNATIONAL COOPERATION



NOVEMBER 1982 DHV CONSULTING ENGINEERS

Subsequently the population, via local leaders, provides information on desired lay-out of the system. Afterwards the preliminary lay-out design is presented again in the IKK-town and if needed adjustments are made.
Even during the implementation phase are adjustments made to the lay-out on the request of the population.

It is appreciated that only by involving the population at an earliest stage possible, can the IKK Programme become a success.

4.2. Flexible service design approach

The socio-economic case study in Kabupaten Langkat has revealed that the ability to pay for a house connection differs from one IKK-town to the other. For all selected IKK-towns the larger part of the households could afford to pay for water from a house connection. Most likely this will also be the case in many other towns in North Sumatera and Aceh.
In other, poorer regions in Indonesia, it may very well occur that house connections turn out to be too expensive for the majority of households.

These conditions give rise to opt for a more flexible service approach in which the number of house connections and public faucets can be adjusted in relation to the paying ability of an IKK-town's population.

Such a flexible approach could fairly easily be incorporated in the design approach without too much complicating effects.

A more flexible approach has various advantages :

1. The Programme will be better accepted by populations which are more satisfied by a system which takes into consideration their wishes.

2. Better use will be made of the facilities and most likely also the tariff collection rate will improve.

3. Further, water supply systems with a higher population served from house connections compared with public faucets show a better cost recovery (cf table 4.1).

However a more flexible approach has a major disadvantage, namely with regard to per capita investment costs.
As the number of households served from house connections increases in relation to the number of households served from public faucets, per capita investment costs increase.
This is explained as follows : Each public faucet is supposed to serve 20 households with 300 litres per household per day. One public faucet serving 20 households can be exchanged against 10 house connections serving one household each with 600 litres of water per day.
In other words the total population served decreases as the number of house connections increases (cf table 4.2).

The effects of the present world-wide economic recession for the Indonesian Government budget are well-known.
The present budgettary constraints provide little room to exchange a cheap standard approach for an approach which may require higher investment costs.
It may be worth mentioning in this connection to reconsider the policy with respect to subscription fees. The imposition of a small fee, not necessarily covering actual connection costs, could very well lighten the burden on the national budget.

Table 4.2. Consequences of flexible service level for investments, cost recovery and population served (based on 5 l/sec system as sample).

Flexible ratio HC /PF			(Example for 5 l/s standard system)						
Users ratio (%)	Number of		Population served*			Index (compared to 50/50 ratio=100)			
HC / PF	HC	PF	From HC	From PF	From HC + PF	Per capita investments	Cost recovery	Population served	
0/100	0	54	0	10800	10800	67	37	150	↑ poorer
10/90	100	44	1000	8800	9800	74	54	136	
20/80	180	36	1800	7200	9000	80	68	125	
30/70	250	29	2500	5800	8300	87	81	115	
40/60	310	23	3100	4600	7700	93	91	107	
50/50	360	18	3600	3600	7200	100	100	100	
60/40	400	14	4000	2800	6800	106	107	94	
70/30	440	10	4400	2000	6400	112	114	89	
80/20	480	6	4800	1200	6000	120	121	83	
90/10	510	3	5100	600	5700	127	126	79	
100/0	540	0	5400	0	5400	133	131	75	richer ↓

HC = House connection

PF = Public faucet

* = Population served based on : ten (10) persons per house connection
twenty (20) households of ten (10) persons per public faucet

4.3. Tariff setting

Preliminary estimates of operation and maintenance costs for the IKK Water Supply Systems which are to be implemented in Kabupaten Langkat, have revealed considerable differences in cost recovering tariffs from one system to the other. The IKK Programme therefore, aims at applying cross-subsidy between individual IKK-towns within a Kabupaten to achieve a certain degree of equity in water tariffs.

Further, these calculation have revealed, that the initially adopted water tariffs of Rp 1,000 for house connection (= Rp 50/m^3) and Rp 300 for the use of a public faucet would be inadequate to cover estimated operation and maintenance costs.
Cost recovering tariffs for a Water Enterprise in Kabupaten Langkat would amount to at least Rp 1,600 for a house connection and Rp 400 for the use of a public faucet.

4.4. Kabupaten Master Planning for the IKK Programme

Cost recovering tariffs will likely be different from one Kabupaten to the other. This tariff will depend on the special mixture of systems in the Kabupaten concerned.
In case the majority of systems in a Kabupaten are small systems (2,5 l/sec) or many of them are equipped with treatment facilities, the tariff will be relatively high. The opposite will be the case for a Water Enterprise with mainly large systems without treatment.

To establish a tariff which will cover the operation and maintenance costs of all individual water supply systems within a Kabupaten Water Enterprise a Master Plan is needed based on a reconnaissance study.

This reconnaissance study should establish for each IKK-town or other small town - which will in future be incorporated in the Kabupaten Water Enterprise:

1. The source of water supply by means of a hydrological survey.
2. The size of the water supply system, in relation to the population number.
3. An indication of household income distribution and other factors which might influence the priority setting of the implementation of the systems.

Based on this information and other cost estimates a Kabupaten specific rate can be determined.
To limit the need for Government subsidies, we would recommend to implement larger and cheaper systems first so that a profit can be made initially.
This profit will gradually diminish as smaller, less profitable systems are implemented. For the same reason we recommend to implement water supply systems first in the richer IKK-towns where a better revenue recovery may be expected.

Appendix 1. Kabupaten Langkat : Estimates for costs of operation and maintenance and revenues from water sales (Rp/month - September 1983 financial prices)

IKK[1]	System[2] (l/sec)	Salaries/ wages (Rp/month)	Adminis- tration (Rp/month)	Chemicals (Rp/month)	Power[3] (Rp/month)	Maintenance[4] (Rp/month)	Miscel- laneous (Rp/month)	Total oper- ation and maintenance (Rp/month)	Revenues from water sales[5] (Rp/month)
Tanjung Langkat	2.5	100,000	15,000	50,000	115,000	90,000	7,500	377,500	189,000
Namo Ukur	2.5	100,000	15,000	50,000	115,000	105,000	7,500	392,500	189,000
Kuala	5.0	100,000	27,500	100,000	230,000	135,000	15,000	607,500	388,000
Selesai	10.0	140,000	40,000	200,000	400,000	200,000	30,000	1,010,000	776,000
Stabat	5.0	100,000	27,500	100,000	230,000	190,000	15,000	662,500	388,000
Tanjung Selamat	5.0	100,000	27,500	100,000	230,000	135,000	15,000	607,500	388,000
Tanjung Beringin	10.0	140,000	40,000	200,000	400,000	200,000	30,000	1,010,000	776,000
Hinai Kiri	2.5	100,000	15,000	50,000	115,000	105,000	7,500	392,500	189,000
Tanjung Pura	7.5	140,000	35,000	150,000	340,000	200,000	22,500	887,500	577,000
Gebang	5.0	100,000	27,500	100,000	230,000	135,000	15,000	607,500	388,000
Pangkalan Brandan	40.0+*	270,000	65,000	2,450,000	1,440,000	540,000	150,000	4,915,000	3,316,000*
Besitang	2.5	100,000	15,000	50,000	115,000	105,000	7,500	392,500	189,000
Pangkalan Susu	7.5+	185,000	35,000	460,000	340,000	240,000	30,000	1,290,000	577,000

1. *Only eligible IKK's in Kabupaten Langkat included.*
2. *System in l/sec :*
   + = With treatment plant
   ** = System in P. Brandan is executed as urban system with water meters with 80% house connection users @ 100 l/c/day @ Rp 50/*m^3*/month and 20% public faucet users @ 30/l/c/day @ RP 30/*m^3*/month*
3. *Power consumption based on diesel generator.*
4. *Maintenance cost estimates annually*
   - *40% pumps and gensets*
   - *2,5% treatment plant*
   - *1,0% building and network*
5. *Based on tariffrecovery:*
   - *90% of house connection users*
   - *50% of public faucet users*