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AN INTERNATIONAL PROGRAM IN SANITARY ENGINEERING DESIGN

by

JAMES C. BROWN and DANIEL A. OKUN

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For presentation at the IX Congress of AIDIS
in Bogota, Colombia, July 6-12, 1964.

SCHOOL OF PUBLIC HEALTH UNIVERSITY OF NORTH CAROLINA CHAPEL HILL

AN INTERNATIONAL PROGRAM IN SANITARY ENGINEERING DESIGN*

by

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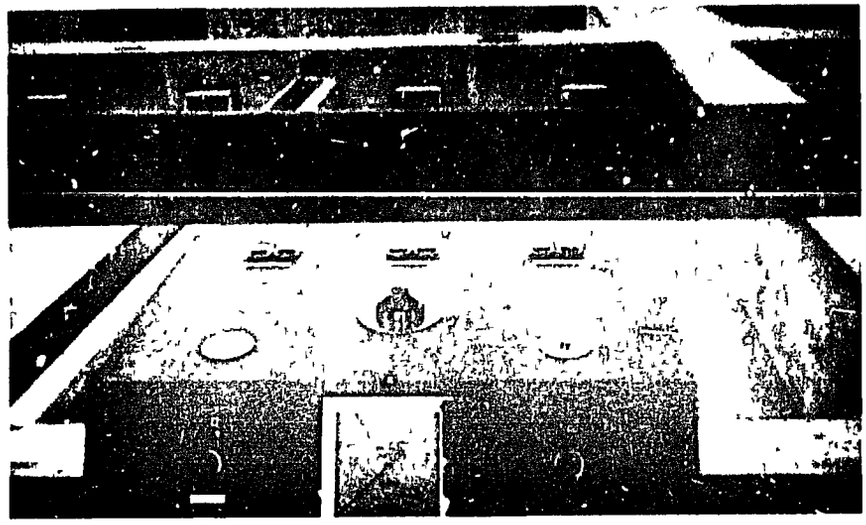
Engineering Associate and Project Director
Department of Environmental Sciences and Engineering
University of North Carolina, Chapel Hill

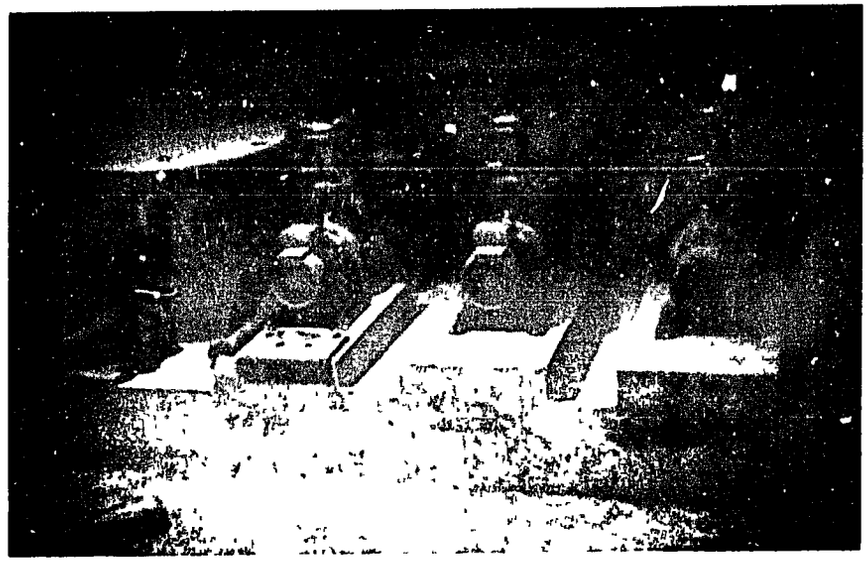
Some years ago a capital city was faced with a major water supply problem. The transmission mains from the water source to the city and the distribution system within the city were of inadequate size so that frequently much of the city was without water. Furthermore, during the rainy season when runoff from the mountains carried a heavy silt load, the quality of the water distributed to the city was poor indeed. It was decided that a filtration plant would provide considerable improvement in the quality of the water supply. Accordingly, a modern filtration plant was built. The plant includes automatic controls which permit, when the system is operating satisfactorily, each of the many filters in the plant to be washed automatically without the need for operators to observe a gage, or to open and close valves. Yet with all this, that city is still without an adequate transmission and distribution system, and the expensive automatic control system is not operating.

In the capital city of another country, a water filtration plant is being constructed. Laborers in great numbers can be seen pouring the concrete, carrying in the sand for the filters on their shoulders, and manually performing many other of the construction tasks. This plant, when completed, will also have automatic filter controls and, in addition, will be provided with a complex chemical feed system

* For presentation at the IX Congress of AIDIS in Bogota, Colombia, July 6-12, 1964.



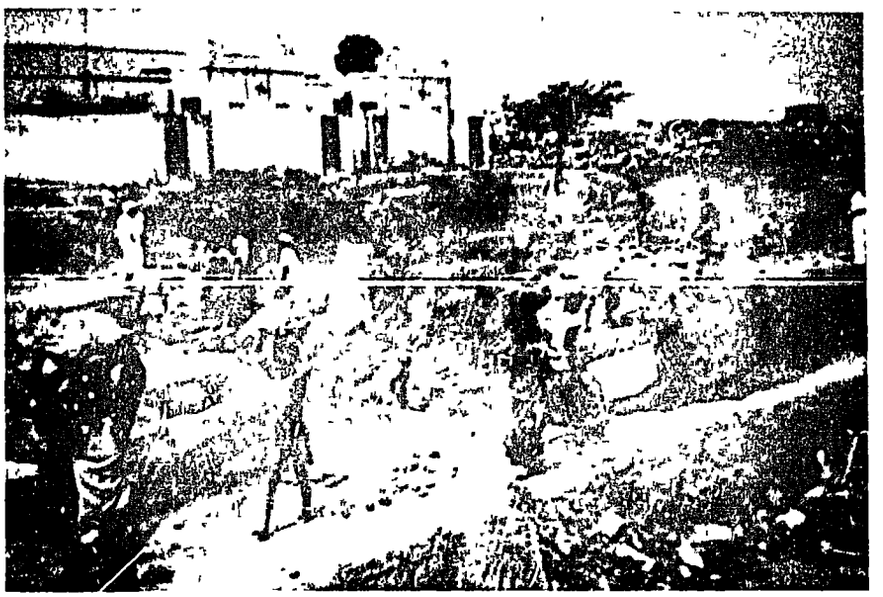
Automated Rapid Sand Filter Control System



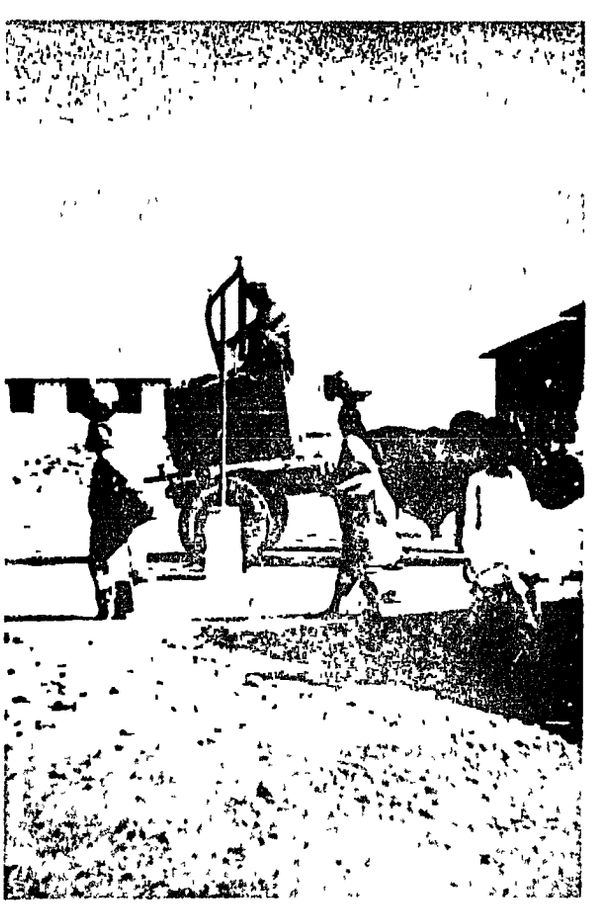
Electrically Operated Stainless Steel
Chemical Feed Pumps in Basement
of Chemical Building

with stainless steel pumps with electric motors installed in a sub-basement. Here, too, the distribution system is often without water and under vacuum, and because the sewerage system is not adequate the water supply is frequently contaminated. Cholera is an annual visitor. One wonders why automatic equipment and complex chemical handling systems are required. It cannot be to save labor, as labor is the most plentiful resource in that country.

In another important capital city a new water treatment plant is being built and earth is being excavated for the settling tanks by hand. One can see leterally hordes of men and women carrying baskets of earth from the excavation on their shoulders and their heads. Also, very near the construction site one can see women and children lined up at a service hydrant filling earthenware jars with water to be carried for miles to their homes. The plans for this plant as well as for plants already serving the city include modern, expensive mechanical equipment for removing the sludge from the settling tanks without the need for manual labor. Apparently manual labor is adequate for the construction of the plant when carried out by local contractors, but the designing engineers must have felt that manual labor is not satisfactory for the removal of sludge, and thus scarce foreign currency was expended on the importation of such equipment from abroad. Again one wonders about the reasoning that encourages such labor-saving devices when labor is so abundantly available. The foreign currency might better have been used for bringing piped water to more homes. More sensible reasoning was shown in other aspects of the work.



Excavation and Earth moving for a
New Water Filtration Plant

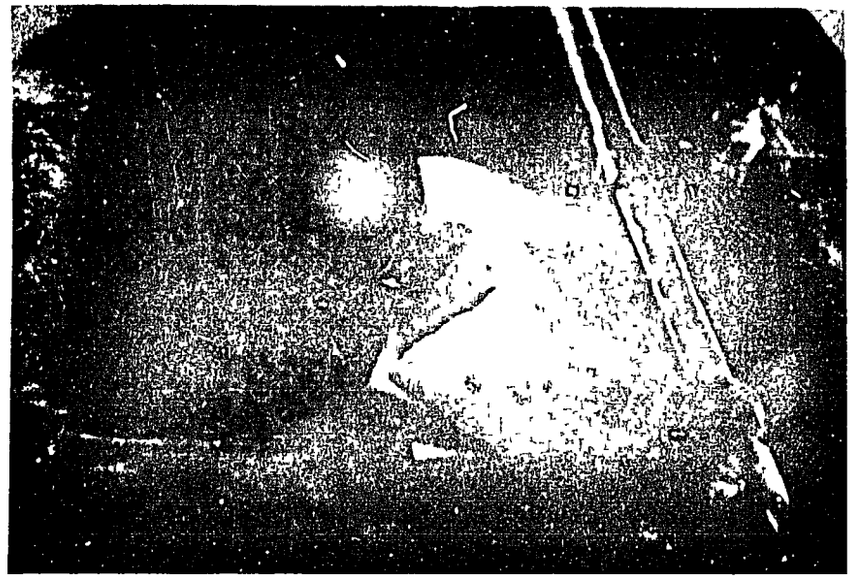


Typical Systems for Manual Distribution of Water

For example, chemical feeding was accomplished with simple solution pots. Filter washing was done with manually operated valves. These operations, so often mechanized, are much better left unmechanized in plants to be operated with unskilled labor.

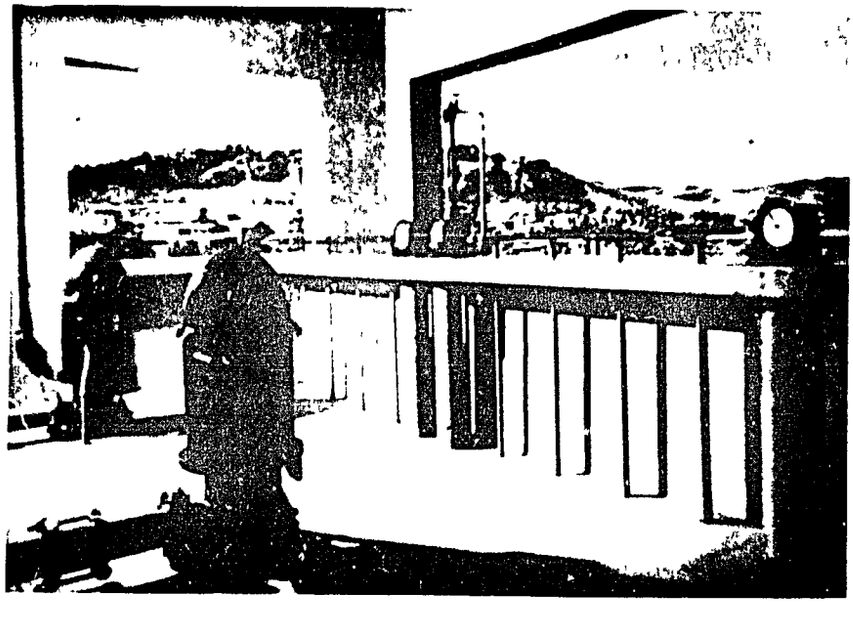
In another country nearby, also in the capital city, a new plant has recently gone into operation. Again, this is a country where skilled labor is scarce and unskilled labor is plentiful and low in cost. Mechanization was carried to an extreme, with mechanical coagulation devices and mechanical sludge removal equipment. The sludge removal equipment in one settling tank was not operating because a part was broken and had not been received from Europe where the equipment was designed and built. After a period of 18 months of operation this settling tank was manually cleaned and was found to have accumulated only two feet of sediment--certainly no indication that mechanical sludge removal equipment was necessary. Most incongruous of all, a large sampling table permitted samples to be taken from any one of dozens of points throughout the plant by merely flicking a switch. This expensive sampling table, also purchased from Europe at considerable cost, was of doubtful value because actually very few samples were being analyzed.

An ambitious project for providing water supply for villages throughout a country is under way, the major obstacle being the importation of thousands of meters of iron and steel pipe from abroad. If plans had been developed for the local manufacture of pipe, using locally available or imported raw materials, the project might have moved along much faster.



Locally Designed and Constructed
Alum Solution Box

Manual Operation of Filter
Valves in a Modern Rapid
Sand Filtration Plant



Manually Operated Valves for
a Small Rapid Sand
Filtration Plant

The above examples illustrate many points. First, water works are being constructed in increasing numbers, serving increasing millions of people throughout the world. This is good. The greatest need, however, is not for incorporation in designs of the most complex mechanical and electronic devices, but rather to bring water of adequate quality and quantity to as many people as possible. Design practice in any locality, whether it be Europe, the United States, or one of the developing countries, should strive for the most economic application of available capital, material and human resources. Certainly, where manual labor is plentiful, where electronic specialists are few, where money for purchase of equipment abroad is limited, and where the greatest need is to get as many people served with water as possible, it does not make engineering sense to invest limited resources in labor-saving equipment. In the United States, where such equipment is in wide use, it can sometimes be shown to result in no real savings in annual cost. Perhaps more important, the reliability of supply may not be increased. This is particularly true where adequate maintenance of such equipment cannot be assured.

In the majority of cases, the above examples do not reflect upon the competence or judgment of a country's engineers. On close investigation it is found that many of the fundamental decisions were made by consultants or equipment manufacturers from other countries. In some instances the local engineers were not consulted or their opinions were disregarded.

The eminent and practical early British engineer, James Watt, is credited with the following brief but rather profound

statement, "In all things but proverbially so in mechanics the supreme excellence is simplicity." Perhaps the engineering profession should develop an educational program to convince the public and its leaders that this tenet of Watts is worthy of acceptance. Too often the public and public leaders, particularly when they do not understand the basic principles behind the processes involved in water supply and waste treatment, seem overly impressed with complexities even to the point of attaching a certain prestige value to them.

To clarify this emphasis on simplicity, consider for a moment the basic processes involved in a rapid sand filtration plant, namely, coagulation, sedimentation, and filtration. The feasibility and efficiency of these processes have been known to man for thousands of years. All of these processes may operate with dependability and efficiency in relatively simple structures, with a minimum of mechanical equipment.

In the process of coagulation, the critical factor is not the type of mechanical equipment employed, but rather the combination of scientific and artful use of the coagulation chemicals. If a water can be coagulated with the chemicals available, and if they are properly used, coagulation can and will occur even in an inefficiently designed unit. Such simple devices as baffled flocculation tanks often prove quite effective, and may result in substantially lower annual costs.

Often the most complex machinery in a rapid sand filter plant is the chemical handling and feeding equipment. The modern

tendency is towards using chemicals in solution rather than dry, and this practice lends itself to the development of fairly simple feeding equipment as compared with the complex devices presently used in many plants.

How many surface waters used for public water supply are so turbid that mechanical sludge removal equipment is required in settling tanks? Or, if the water is this turbid, how often could the problem be solved with a simple pre-sedimentation basin? How many plants have no mechanical sludge removal equipment, and yet experience little difficulty because sludge must be removed from the tank only once every six months?

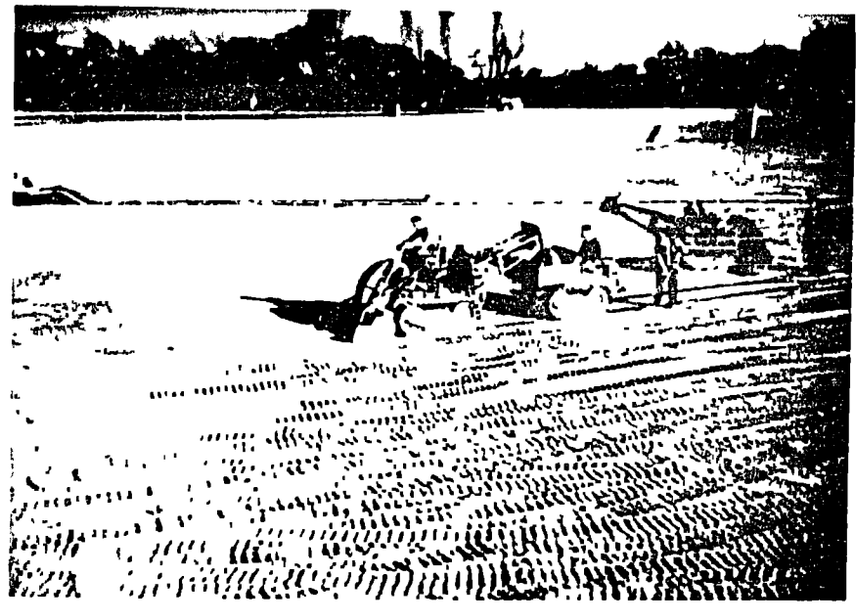
One may question the use of simple structures and the minimum of mechanical equipment after seeing some recent plants using complicated clarifiers and rapid sand filters with automated control systems. At this late date, however, we find research in sedimentation indicating that the efficiency of sedimentation is affected to a great extent by the opportunity for additional flocculation provided within the settling basin. This feature, when properly understood, can be promoted in relatively simple tanks.

Recent developments in filter design (1) indicate the desirability of declining filter rates, following the natural build-up of removed solids within the filter. So the latest thinking seems to lead to simpler types of equipment and control systems. Even using traditional concepts with constant filter rates, quite successful installations are found using the simplest of manual rate controls--perhaps a piezometer tube with a manually operated

control valve. Some of the most automated filtration plants in the United States have control systems which will automatically shut off a filter unit at a predetermined head loss, backwash the filter and put it back into service, if such is desired. It is found in practice; however, because the municipality must have an operator at the filter plant at all times, the filters are backwashed in the normal manner with the operator in attendance.

Engineers who have the true interest of their communities at heart will not discard a good solution just because it was perfected before their time. The slow sand filter, for instance, was highly developed before the end of the last century. For years, slow sand filters have provided safe and reliable water supplies for many of the cities of Europe and the United States. Many are still in use in northeastern United States and new units have recently been installed in Europe and England. One might be inclined to think tradition is at the root of this practice; however, an extensive engineering and economic study conducted by the London Metropolitan Water Board in the 1950's (2) (3), comparing rapid and slow sand filtration, reveals the latter to be more economical for the treatment of Thames River water. If water of the quality found in the Thames can be economically treated with slow sand filters, in a country with the technical and manufacturing resources of Britain, are the engineers of any country justified in ignoring this type of treatment when considering feasible alternatives? The very factors which weigh against the use of slow sand filters in an older more developed economy, namely, the cost

Manual Cleaning of Slow Sand
Filters in Rotterdam



Mechanical Cleaning of Slow
Sand Filters in London

of land, construction and operating labor, should make them especially attractive in developing countries and particularly so when the advantages are balanced against the cost and reliability of the imported equipment necessary for a mechanical plant.

Some recent developments are indicative of the type of thinking that will be required in solving sanitary engineering problems. The development and installation of simple tube wells in East Pakistan (4), the Fordilla service hydrant used on portions of the distribution system in Asuncion, Paraguay (5), and the modification of the aqua privy as developed in East Africa (6) for use in low-cost, high density residential areas, are examples of what can be accomplished. Considering the pressing need for all types of public facilities in rapidly developing countries, public utilities must not be monuments dedicated to prestige. On the other hand, this does not imply designs should be crude or unimaginative. The best engineers will recognize in the very things that hinder less inspired men manifold opportunities and professional challenges.

The foregoing examples and discussion indicate in a general way why the International Program in Sanitary Engineering Design was established. The technical or design philosophy of the program can be summarized as follows:

1. In waterworks design, reliability should be a primary consideration.
2. The design of any public works facility should be based on sound economic principles.
3. The total annual cost of a facility, including the

cost of operation and maintenance as well as amortization, should be considered in designing units and selecting equipment.

4. When considering alternate designs, that alternate providing the best combination of reliability and low total annual cost should be given priority.
5. Materials available within a country should be used whenever economical.
6. Facilities should be designed so they may be effectively operated by the personnel available.

Perhaps the general technical philosophy of the International Program in Sanitary Engineering Design can be characterized by quoting one of the early definitions of a civil engineer: "The civil engineer is one who develops the natural resources and natural forces of nature for the betterment of man." The closer an engineer approaches the simple ways of channeling the forces of nature, the more fundamentally practical his designs will be. Should not more prestige and respect be due the engineer who by his experience and knowledge efficiently channels the available natural forces to accomplish his ends, than to the engineer who accomplishes his objective by utilizing a great complexity of mechanical contrivances that often add to the problems and expense of operation? Unused or unnecessary equipment simply adds to the total annual cost and hence decreases a municipality's ability to meet its other obligations.

Fiscal Responsibility

In recent times more money has been made available for water supply and waste disposal facilities through various international lending agencies. In granting funds for these projects the lending agencies wish to be assured that the projects are based on sound technical and economic principles, and that they will be effectively operated upon completion. The expanding capital needs for all types of publicly supported facilities,,of which water supply and waste disposal represent a relatively small proportion, dictate careful economic analysis of all proposals. Because of the many demands upon limited capital, it is often necessary to design projects for short periods, with allowances for easy future expansion. No particular type of public facility should be supported at a level detrimental to the general good of the entire economy. This last objective is often referred to as the problem of the budget, and is considered to be in the sphere of the economist. Nevertheless, if the engineer is to properly represent his proposed project to the lending agencies he must broaden his horizons and compete on an economic basis for the funds necessary to translate his plans into reality.

The concept of "self support" as applied to public water utilities is one of the most fundamental in assuring long-term success. This concept, perhaps more than any other single factor, lies behind successful water utility operation, making possible reliable and growing water service in all but the smallest communities. Private lending institutions and individual investors

are willing to finance projects, at remarkably low interest rates, when there is a strong tradition of "self support." It may be necessary in some situations, particularly in the poorer areas of developing countries, to subsidize a water utility during its early years. However, a condition of maximum self support should be the long-term objective. In summary it may be said: Community water service requires community initiative and community fiscal responsbility.

The International Program

The International Program in Sanitary Engineering Design, as developed at the University of North Carolina, is a special program to assist experienced sanitary engineers in meeting the rapidly expanding problem of providing adequate facilities for water supply and waste disposal in the growing urban centers of the developing areas of the world. The Program is under the sponsorship of the Agency for International Development of the U.S. Department of State, and in general has been designed to assist in the execution of the Global Community Water Supply Program.

It has been estimated that three out of four people in the world today suffer from diseases spread by contaminated water. Furthermore, many urban communities and regions are economically retarded for lack of an adequate supply of safe water. In recognition of these problems the Agency for International Development and the University of North Carolina cooperated in establishing the International Program in Sanitary Engineering Design. The principle

upon which this program has been developed is to encourage participating engineers to use appropriate principles of engineering design and not necessarily to copy U. S. or European practice. The program is planned to give engineers the confidence to make design dicisions allowing the best use of a nation's resources. In this way every sole, bolivar, quetzal and dollar should yield the most in water supply for the most people.

Engineers who participate in the Program are selected by appropriate agencies of their own countries and are sponsored under fellowships available through 1) the U. S. Agency for International Development, 2) the World Health Organization or 3) the Pan American Health Organization. In awarding fellowships priority is given on the basis of an applicant's education and experience and his responsibility in the water supply and waste disposal activities of his country. The Program is particularly directed to the needs of those engineers who are or will be responsible for making the preliminary engineering reports, arranging for financing, preparing plans and specifications, and supervising the construction of sanitary facilities in their countries, whether they are employed publicly or privately.

Briefly, the Program consists of three months of work at the University of North Carolina followed by one month at a water and/or waste treatment plant, and finally five to eight months in the office of a consulting engineering organization. The first participants have completed the entire schedule and have returned to their countries, while later groups are now in the consulting office phase of their training. Participants in the Program have

been sponsored by the [illegible] countries: Bolivia, Brazil, Costa Rica, Colombia, Argentina [illegible] Jamaica Ghana, Nigeria, Iraq, Turkey, and the United States. A new Program is begun in February and September of each year. Each new session of the Program is initiated with the academic phase at the University and is limited to no more than twelve participants.

The Program is built upon full recognition of the basic competence of engineers from the various countries from which participants are drawn. The Program aspires to develop an awareness of the value of local decision-making when searching for either general or detailed solutions to a country's sanitary engineering problems. It is the firm belief of those responsible for the International Program in Sanitary Engineering Design that the best long-term answers, i.e., the solutions which have the best chance of ultimate success, are based on the technical, social, and natural resources available in any particular country. When a competent nucleus of sanitary engineers exists within a country, they are the ones who are best qualified to solve that country's problems. It may occasionally be desirable to consult qualified experts from outside the country; however, basic long-term plans which fit the socio-economic patterns and needs of the country must be the responsibility of those who have the best knowledge of the country's goals, resources, and social motivations.

If, as discussed above, solutions to a country's problems are best developed from within, then one of the primary goals of the International Program in Sanitary Engineering Design should be

to assist the participating engineers in developing the self-confidence necessary to accept the responsibility to make required decisions. Confidence is developed in several ways, one of which is good training, and another, perhaps the more important, is experience. Experience subjects a man's judgment to the cold light of reality; if his judgments are wrong, the fact is fairly obvious, and can lead to improved future judgments; if his judgment is correct the facts may not be so obvious, but without doubt in both cases his personal competence is strengthened. The International Program in Sanitary Engineering Design offers the participating engineer a chance to compare his judgments with those of other qualified practitioners, to hear and assess the opinion of experts in various specialized fields, to study plans and specifications prepared by engineers with considerable experience in water supply and waste disposal, to observe numerous facilities in operation, and to practice actual design in the offices of experienced consulting engineers. Participating engineers are forewarned that many of the engineering solutions they may study or observe are not appropriate to their countries. Participants in the Program have occasionally questioned the basis of some of the designs they have studied or plants they have visited. In some cases these questions can be answered from a basis of sound engineering practice. In other cases, particularly where custom, tradition, or gadgeteering dominated a project or part of a project, the questions reveal weaknesses in the design. Observation of both good and mediocre designs of others is an extremely fruitful way

to strengthen personal confidence. Confidence should not be a characteristic of the equipment salesman alone.

The Program is conducted by the staff of the Department of Environmental Sciences and Engineering with visiting lecturers drawn from various government offices, private engineering offices, and equipment manufacturers. Field trips are conducted to water supply and waste disposal projects in operation and under construction, to design offices, and to facilities of equipment manufacturers. The Program occupies a suite on the first floor of the School of Public Health. In addition to office space, facilities include a well-equipped classroom with an assigned desk for each participant, and a specialized design library housing books, catalogs, plans and specifications for plants throughout the world, and other technical data particularly related to design problems. The classroom phase of the Program covers the following general subjects:

Organization of field surveys and preliminary investigations.

Preparation of detailed plans and specifications with special emphasis on selection of equipment and materials.

Supervision of construction.

Project financing.

Organization and operation of a design office.

The general topics listed above are integrated into daily presentations. A week by week summary of the UNC phase of the

Program is given in Appendix 1.

Lectures are conducted in the morning while afternoon periods are devoted to individual project work, or to informal discussion of the material presented in the morning sessions. Special demonstrations are also conducted in the afternoon periods, and may consist of movies, demonstrations of unit operations, hydraulic demonstrations, or laboratory work. One day each week is devoted to a field trip.

Field assignment of participating engineers to water and waste treatment facilities, and also to private consulting offices, is made to satisfy the individual's main interests. The accompanying map shows the sites used thus far for participants' field assignments. In most instances the utility supervisors and consulting engineers as well as the Program participants have enjoyed and profited from the field assignment experiences. The rich experiences of the participants in their own country have proved of considerable interest to their North American colleagues.

SITES USED BY THE INTERNATIONAL PROGRAM FOR THE PARTICIPANTS

APPENDIX I

Weekly Summary of Lecture Program

First Week - Introduction and Background
- World and Community Water Needs, Water and Health
- The Preliminary Engineering Study
- The Period of Design
- The Basis of Design

Second Week - Surface Water Source Development
- Hydrology; Statistical Methods of Analyses
- Small Dams & Appurtenances

Third Week - Basic Hydraulics
- Elements of Hydraulics; Flow in Pipes & Networks
- Open Channel Flow

Fourth Week - Pumps & Pumping Systems
- Pump Theory; Types of Pumps & Application
- Pump Systems

Fifth Week - Ground Water
- Ground Water Geology; Aquifer Capacity, Recharge
- Ground Water Hydraulics; Drawdown Theory

Sixth Week - Ground Water
- Types of Wells; Well Design; Pumping Tests

Seventh Week - Chemistry & Chemical Treatment
- General Chemistry; Chemistry of Water Treatment
- Coagulation; Softening; Chemical Feeding & Handling Equipment

Eighth Week - Unit Operations in Water & Waste Treatment
- Biology of Water & Waste Treatment
- Mixing, Flocculation
- Sedimentation; Filtration

Ninth Week - Unit Operations & Plant Layout
- Theory of Disinfection
- Application of Disinfection; Principles of Water & Waste Treatment Plant Layout

Tenth Week - Treatment Plant Electrical Systems
- Water Transmission and Distribution
- Waste Collection; Materials & Construction Methods

Eleventh Week - Function & Organization of a Design Office
- Organization and Preparation of Plans and Specifications
- Preparation of Estimates; The Role of the Manufacturer and Contractor

Twelfth Week - Finance
- Project Feasibility Analyses; Project Financing
- International Lending Agencies; Water Rates

REFERENCE BIBLIOGRAPHY

1. Hudson, H. E. Jr., "Declining Rate Filtration," Jour. AWWA 51: 1455 (Nov. 1959).

2. Ives, Kenneth V., "Engineering Problems of Algae Removal," Ph.D. Thesis, University of London, 1955.

3. London Metropolitan Water Board, Reports of the Director, 1954 through 1960.

4. Directorate of Public Health Engineering, Government of East Pakistan, Dacca, "Facts About a Tube Well," (Publication of the Chief Engineer).

5. Ford, Richard V., "Fordilla Faucet May Make the Village Well Obsolete," Engineering News Record (Nov. 21, 1963).

6. Vincent, L. J., Algie, W. E., and Marais, G. von R., "A System of Sanitation for Low Cost High Density Housing," Report to the African Housing Board, Ridgeway, Lusaha, Northern Rhodesia, 1961.

ADDITIONAL BIBLIOGRAPHY

1. Fair, Gordon M., "Sanitary Engineering Education in Latin America," Proceedings, VIII Congresso AIDIS, 1962.

2. Pineo, Charles S., "International Health Assistance Program" (presented before the Engineering & Sanitation sections of the American Public Health Association, November 1963).

3. Hollis, Mark D., "Environmental Health & Water Supply in the New Technological Age," Proceedings, VIII Congresso AIDIS, 1962.

4. Wolman, Abel, and Bosch, Herbert W., "U.S. Water Supply Lessons Applicable to Developing Countries," Jour. AWWA 55: 946 (Aug. 1963).

5. Ripman, Hugh B., and Callejas, Peter, "The Challenge of Civil & Sanitary Engineering Work in Underdeveloped Countries." International Bank for Reconstruction and Development.

6. Grady, T., "The Role of Financial Agencies in the Development of Sanitary Engineering Facilities," Proceedings, VIII Congresso AIDIS, 1962.