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WATER QUALITY STANDARDS AND INTERNATIONAL DEVELOPMENT

Office of Science and Technology
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PREFACE

The purpose of this report is to offer those concerned with social and economic progress in developing countries insights into the concept of water quality standards, and a summary of progress to date in establishing such standards in the United States and in developing countries. The report is not intended as a technical guide for specialists in the field of water quality, since it contains little information that is not already available in technical journals. Neither is it a statement of policy of the Federal Government or the Agency for International Development. Rather it is designed to assist officials concerned broadly with environmental policies to better understand past efforts and future needs in this field.

The World Health Organization and its associated regional and national organizations have been a major force in introducing drinking water standards in the developing countries, and also in promoting techniques to increase the availability of safe community water supplies in those countries. Now, with the spotlight on the 1972 United Nations Conference on the Human Environment it is appropriate to emphasize water quality in developing countries, not only in relation to human health, but more broadly in all aspects of water usage.

Of all the environmental problems in developing countries that have been debated during preparations for the 1972 Conference, water quality repeatedly emerges as an issue of central concern. At the same time, there is considerable uneasiness over the concept of water quality standards, lest efforts to achieve such standards unnecessarily constrain economic progress in a variety of activities which interact with water resources, or divert financial resources from priority development tasks to pollution abatement.

There is a deepening appreciation of the value of clean water for tourism, industrial, and agricultural purposes, as well as for household uses. In developed

countries, priorities among competing uses of water are now being examined more critically in an effort to achieve the optimum benefit from available water resources. It seems likely that similar approaches will become more commonplace in developing countries.

Scientists have estimated that of the total volume of fresh water in the world about 75 percent is in the form of polar ice and glaciers, nearly 25 percent is ground water -- most of it deep in the earth -- and less than half of one percent is readily available at any given time in the form of lakes and rivers, and moisture in the atmosphere and soil. The total water supply available in each country, from all sources, does not fluctuate greatly from year to year. Throughout the developing world, the need for clean water increases, while at the same time the quality of water resources is deteriorating from the pollution caused by economic development and population growth.

The development of water quality criteria, based on scientific techniques and data, is an essential step in determining the degree of water pollution, specific needs for pollution abatement, requirements for health and safety in the use of water, and requirements for water quality control in industry, agriculture, and other uses. There is little evidence thus far that water quality standards appropriate to their needs are being adopted by developing countries.

A clear distinction should be noted between standards for drinking water and standards for natural surface waters. The term "drinking water standards," as used for example by the U.S. Public Health Service and the World Health Organization, relates to the quality of water in a distribution system, in the form available to the ultimate consumer. In this instance, the word "standards," as applied to drinking water, means a rule for the measure of quality.

On the other hand, standards for "surface water" or "raw surface water," as these terms are used, for example in the Report of the Committee on Water Quality Criteria, U.S. Department of the Interior, relate to the quality of water as it occurs in lakes and streams, in a form available for many uses, including recreation,

fish and wildlife habitat, industry and agriculture, and public water supplies. As used in this sense, and as used in the Water Quality Act of 1965, the word "standards" means a rule for the measure of quality and also a plan for implementation and enforcement. These definitions apply as well to the terms as used in this report.

CONTENTS

I. WATER QUALITY CRITERIA AND STANDARDS IN THE UNITED STATES

In the United States the respective roles of the Federal and state governments in administering drinking water standards and quality standards for surface waters have developed along lines of authority prescribed by the Constitution. The activities of the Federal government in these areas have been associated with its authority over common carriers in interstate commerce, with the national communicable disease quarantine program, and with Federal responsibilities for interstate and navigable waters. At the same time the individual state governments have implemented appropriate programs to protect their citizens from contaminated water supplies and to control pollution in surface waters within their respective state borders.

Drinking Water Standards

The development of safe community water supplies and drinking water standards proceeded slowly in the United States. In 1850 there were only 68 communities with planned water supplies. Today there are over 30,000 systems, which provide over 150 million people with water. The first efforts to disinfect public water supplies with chlorine were made in Jersey City, New Jersy in 1908[1].* In 1914 the United States adopted standards for drinking water supplied to the public by common carriers engaged in interstate commerce. While these initial standards were designed to apply to trains and steamships, it became apparent almost immediately that any public supply system that could not meet the carrier's needs under these standards was unsafe. Accordingly, most community systems proceeded unofficially to apply water standards.

The commission that formulated the 1914 Drinking Water Standards was careful to explain that "The recommendation here presented are limits of permissible impurity; they are in no sense standards of purity." The United States Public Health Service Drinking Water Standards (hereafter referred to as the Drinking Water Standards) have been refined and revised four times since 1914. Most recently, in 1962, they were revised to provide,

*Literature citations in this report are indicated by superscript numbers, which correspond to the numbered references listed at the end of the report.

for the first time, limits on concentractions of radioactivity in water, as well as limits for physical, chemical, and biological characteristics.2/

The current Drinking Water Standards continue to apply to water used by common carriers engaged in inter state commerce. The Drinking Water Standards have been adopted officially by 14 states and are used with minor modifications or without formal adoption in all of the other states.

Federal-State Relationships in Water Quality Control

Congress traditionally has recognized the basic role of the states in implementing and enforcing water pollution control regulations and water standards. Until recent years, the role of the Federal government in this area was limited for the most part to the administration of the Oil Pollution Act of 1924 and a little used statute of 1899, known as the Refuse Act, which authorizes the licensing of activities that result in the discharge of pollutants into navigable waters.3/ Federal enforcement authority over interstate and navigable waters has been strengthened very significantly in the past 15 years by the Federal Water Pollution Control Act of 1956, the Water Quality Act of 1965, and the Water Quality Improvement Act of 1970.

The Water Quality Act of 1965, Paragraph 3, Section 10 provides as follows with respect to the nature of state standards subject to approval by the Federal government.4/

"Standards of quality established pursuant to this subsection shall be such as to protect the public health or welfare, enhance the quality of water and serve the purposes of this Act. In establishing such standards the Secretary, the Hearing Board, or the appropriate state authority shall take into consideration their use and value for public water supplies, propagation of fish and wildlife, recreational purposes, and agricultural, industrial, and other legitimate uses."

Upon acceptance by the Environmental Protection Agency of the Federal government, the state standards become Federal standards also, and are legally enforceable by both state and Federal agencies. Most of the state standards have now been approved by the Federal

government. Under the provisions of the Refuse Act of 1899, the Federal government now prohibits the discharge of industrial pollutants into navigable waters without a permit. To obtain such a permit, an industry must disclose the quantity and composition of the effluent it intends to discharge.3/ Initially at least, the permit system serves primarily to provide a survey of the nature and extent of industrial pollution in navigable waters.

The Federal and state governments are bringing increasing pressure to bear on industry and municipalities to abate the pollution of surface waters, through direct court action and by other means. For example, one state recently granted a rate increase to an electric power company on the condition that the utility take several specific pollution abatement actions. In still another approach to the attainment of surface water standards, substantial Federal financial assistance grants are made available for waste treatment projects that discharge into waters for which stated quality standards have been approved.

Development of Comprehensive Surface Water Quality Criteria

Since about 1950 a number of the states and interstate agencies have made significant progress in the development of surface water quality criteria and standards. As an important initial step in implementing the Water Quality Act of 1965, a National Technical Advisory Committee on Water Quality Criteria (hereafter referred to as the Committee) was established by the Federal government in 1967 to collect into one volume a basic foundation of water quality criteria for natural or raw surface water.4/ This was an essential undertaking to assist state and Federal agencies in setting and evaluating standards to achieve water quality objectives. For its purposes the Committee adopted the following definitions:

> Standard - a plan that is established by governmental authority as a program for water pollution prevention and abatement.
>
> Criteria - a scientific requirement on which a decision or judgment may be based concerning the suitability of water quality to support a designated use.

In the following discussion of surface water criteria, these terms will be used in the sense defined above.

On completing its detailed report on water quality criteria in 1968, the Committee emphasized the "lack of adequate knowledge concerning many of the quality characteristics upon which criteria and, hence, standards should be based. The unknowns still outweight the knowns." The Committee added that "complicating factors in setting standards are varying natural conditions affecting water quality, such as climate, geography, and geology of a specific location," and added that its criteria "are meant as guidelines only, to be used in conjunction with a thorough knowledge of local conditions." Finally, the Committee underscored its conviction that the achievement of water quality goals in any locality will depend not only upon research and basic water resource data, but also on qualified and responsible administrators and "well-trained scientists, engineers, and technicians, sympathetic legislators and stockholders, and an informed public." With these caveats the Committee presented criteria for five general areas of surface water use. These are summarized very briefly, as follows:

"Recreation and Aesthetics"

The Committee concluded that "All surface waters should contribute to the support of life forms of aesthetic value." To this end the numerical criteria for Fish, Other Aquatic Life, and Wildlife are applicable. While surface water must be pleasing to the senses to be aesthetically acceptable, owing to great variations in local conditions no numerical criteria for aesthetic uses, as such, were recommended.

A single set of criteria was prescribed for recrea tion related to fresh, estuarine, and marine waters. The Committee, with certain exceptions in each case, recommended criteria for each of three categories of surface water used for recreation, involving (a) Waters for general use, including the taking of fish and waterfowl, without official designation of the waters for recreational purposes; (b) Waters designated for use for recreation other than recreation requiring primary contact, such as fishing and hunting; and (c) Waters designated for use for recreation requiring primary contact, such as wading, swimming, water skiing, and surfing.

For water recreational uses that do not require primary contact, the Committee recommended fecal coliform limits, as well as the application of water criteria for Fish, Other Aquatic Life, and Wildlife, and the Public Health Service guidelines on Sanitation of Shellfish Growing Areas. In waters designated for primary contact recreation the Committee recommended fecal coliform limits as well as limits on pH, clarity, and temperatures.

"Public Water Supplies"

The Committee concluded that the most common surface water treatment processes in the United States, in their simplest forms for public use, include coagulation, sedimentation, rapid sand filtration and disinfection with chlorine to the extent necessary. At the same time the Committee recognized that a wide variety of modifications of these processes are in use for removing various impurities or altering quality characteristics and called attention to

> "the very great regional variations in water quality entirely aside from man-made pollution. In addition, human occupance and activity have inevitable effects on water quality. These facts make it difficult and sometimes impossible to develop uniform numerical criteria suitable for national application."

"Permissible criteria" were described by the Committee as those characteristics of raw surface water which will allow the production of a safe and acceptable public water supply which meets the limits of the drinking water standards after treatment.

"Desirable criteria" were described as those characteristics of raw surface waters which represent high quality water in all respects for use as public water supplies. The Committee felt that "Water meeting these criteria can be treated in the defined plants with greater factors of safety or at less cost than is possible with waters meeting permissible criteria."

In prescribing both permissible and desirable surface water criteria for public water supplies, the Committee specified limits on 4 physical, 2 microbiological, 3 radiological, and 41 chemical constituents or characteristics. For example, with reference to the highly critical micro-

biological criteria, the Committee fixed "permissible" limits of 10,000 coliform organisms and 2,000 fecal coliforms per 100 milliliters (ml), while establishing "desirable" limits of 100 coliforms per 100 ml, and 20 fecal coliforms per 100 ml, respectively. The permissible criteria for chemical constituents follow very closely those of the Drinking Water Standards.[2/]

"Fish, Other Aquatic Life, and Wildlife"

As in the case of criteria for Public Water Supplies, the Committee established limits on numerous physical, microbiological, chemical and radiological characteristics of water considered to be satisfactory in each case, for fresh water organisms, marine and estuarine organisms, and for wildlife. With regard to temperature and dissolved oxygen characteristics of fresh water, separate criteria were provided for warm-water and cold-water biota. In most instances the water quality requirements established for aquatic life were applied as well to wildlife; however separate criteria were prescribed for wildlife insofar as DO, pH, alkalinity, salinity, light, settleable solids, oil and nuisance growths are concerned.

"Agricultural Uses"

The Committee prescribed separate criteria for farmstead waters, water supplies for livestock, and water for irrigation. It noted that most of the supply for farmstead use comes from wells, and that, aside from precipitation, about three-fourths of the remaining water used in agriculture comes from surface supplies. Heavy reliance was placed on the Drinking Water Standards in developing criteria for farmstead water. Criteria for water supplies for livestock were fixed in some instances for each of several species, and a similar approach was applied to irrigation water for crops having significantly different tolerances.

"Industry"

The water quality requirements of industry are so varied that the Committee concluded that no meaningful criteria for surface water could cover a majority of such uses. Moreover, water treatment technology now permits the utilization of surface water of any available quality to create water of any desired quality, usually

at a small fraction of the total industry product production cost. In most instances an improvement in the quality of surface water at a given industrial site will not significantly decrease the cost of treatment at that site.

The Committee fixed general minimum standards for all surface waters used as sources for industrial water supplies. For the most part these require that such water be free from objectionable sludge deposits, and free from debris, oil and other deleterious pollutants including those that produce color or odor nuisances. Because about 90 percent of the total quantity of water used by manufacturing plants and thermal electric utilities is for cooling and condensing purposes, the quality characteristics of surface water used for steam generation and cooling were given special emphasis. The Committee listed specific quality characteristics for each of the following industrial groups:

a) Steam generation and cooling
b) Textile, lumber, paper and allied products
c) Chemicals and allied products
d) Petroleum and coal products
e) Primary metal industries
f) Food and kindred products, and leather tanning and finishing.

The Report of the National Technical Advisory Committee on Water Quality Criteria, published in 1968 by the Federal Water Pollution Control Administration* has been a significant factor in reconciling the views of the Federal and state governments on the present water quality standards on interstate and coastal waters in the United States.[4/] It should be noted, however, that these standards do not extend to groundwater, intrastate waters, or waters of the contiguous zone and the high seas, although legislation is pending to provide and enforce standards in these areas.[3/]

Application of Surface Water Criteria and Standards

Under the terms of the Water Quality Act of 1965, all of the states, including also the territories and the District of Columbia, are encouraged to establish water quality standards for interstate and coastal waters within their borders. In each case this involves: (a) designation of the uses which the waters are to serve,

* Since 1971, the Office of Water Programs of the Environmental Protection Agency

(b) specification of numerical and narrative criteria to protect and enhance water quality, and (c) documentation of specific remedial measures and time schedules for achieving the quality levels thus established. As indicated earlier, standards for surface waters have been developed by each state and, in most cases, they have been approved by the Federal government.

In most instances the designation of water uses for defined areas of surface water involve multiple uses, and the criteria applied in each case are the most demanding or most stringent for any of the uses intended. Thus, where a given stretch of river is designated for use for water contact recreation (swimming, water skiing etc.), and industrial water supply, the criteria for water contact recreation are used.

In many areas, where fishing is determined to be an important use, the water quality standards reflect the criteria for aquatic life, although the standards are not specifically identified with the fishery resources as such. For example, the standards for a specified stretch of the Potomac River may reflect the water temperature, dissolved oxygen, and other critical requirements of native fish in those waters. In other respects they may reflect as well the criteria for water contact recreation and other designated uses of the river.

Standards for the Potomac and other surface waters, within the boundaries of the District of Columbia, were adopted by the District in 1967, and these were fully approved by the Federal government in 1969.[6/] Pursuing the above example, in that stretch of the Potomac upstream from Key Bridge, the initial step in establishing standards involved the designation of uses for this portion of the river. These were identified as water contact recreation (predicated on suitable water quality at the Maryland State-D.C. Line), fish and wildlife propogation, recreational boating, and industrial water supply.

In this stretch of the river the general criteria for all waters of the District of Columbia apply, except to the extent that natural conditions such as floods prevent their attainment. The general criteria provide, in effect, that all waters shall be free of substances

attributable to sewage, industrial waste, or other waste that create a nuisance, or that interfere with the prescribed water uses, or which are harmful to human, animal, plant, or aquatic life.

The specific or special criteria assigned to the stretch of the Potomac upstream from Key Bridge, are as follows:

Minimum Dissolved Oxygen Level	4.0 mg/l
Minimum Daily Average Dissolved Oxygen Level	5.0 mg/l
Maximum Fecal Coliforms (Not applicable during or immediately following rainfall)	(240/100 ml in 90% of samples collected monthly)
Maximum Allowable Temperature Increase by Artificial Heat Input	5.0° F.
Maximum Water Temperature (There shall be no sudden or localized temperature changes harmful to aquatic life)	90.0° F.
Maximum pH	8.5
Minimum pH	6.0

Finally, the implementation plan of the District of Columbia standards sets forth detailed requirements for the abatement of conventional municipal and industrial waste discharges that affect interstate waters. Programs are included as well for dealing with other water pollution control problems, including waste from vessels and marinas, land erosion, and floating debris. The District regularly collects and analyzes water samples from about 50 locations. Except for a target date of 1975 for water contact recreation in the Potomac above Key Bridge, the District has fixed the year 1972 for attaining its water quality standards in interstate waters.

II. WATER SUPPLY PROBLEMS AND WATER STANDARDS IN THE DEVELOPING COUNTRIES

About 90 percent of the developing countries are situated in the wet tropical areas of Central and South America, Africa, and Asia. In general, these areas are characterized by sharply contrasting "rainy" and "dry" seasons. Water supply problems arise, on one hand, from excessive quantities of water that overflow drainage systems and erode the soil during the wet season, and on the other hand, from inadequate surface moisture for domestic, agricultural, and industrial needs during extended dry periods.

Developing countries in the arid and semi-arid zones are concerned with a problem throughout the year of obtaining an adequate volume of water. They are heavily dependent on groundwater for domestic and livestock needs, yet must use the limited supply sparingly to realize the maximum benefits for domestic and agricultural purposes. In general, a shortage of water is the principal limiting factor to economic development in such countries.

Many developing countries have experienced rapid increases in population, industrialization, and urbanization. These trends in most instances, however, have not been accompanied by adequate land use planning, the construction of essential community water and sewerage systems, or the development of water resource management programs. The result very frequently has been the degradation of public water supplies and the pollution of water systems and beaches.

While 9 out of 10 people in the United States have water service in their homes, protected for the most part by effective water quality standards, the great majority of people in developing countries has no water service of any kind.

Water Supply Problems

The International Conference on Water for Peace, held in Washington, D. C., in 1967 focused world attention on the monumental problem of community water supply needs,

especially in the developing countries.[7] On that occasion the World Health Organization (WHO) reported that a survey of 75 developing countries in 1962 revealed that less than one-third of the urban dwellers, or about ten percent of the total population, were supplied with piped water in or near their homes. Many of these people have access, however, to water supplies that do not meet even minimum hygienic standards. "About 41 percent of the urban population and probably at least 70 percent of the total population, have no access to piped water at all within reasonable distances. These people rely for their supplies of drinking water on wells, rivers and other sources that are open to contamination with pathogenic organisms..."

WHO estimated that more than 500 million people suffer each year with typhoid, amoebic dysentaries, and other waterborne diseases, and that more than 5 million infants die each year of such diseases. In some countries, 30 to 50 percent of the total population is debilitated by schistosomiasis, a parasitic disease with a form of fresh water snail as the intermediate host. The adverse effects of contaminated water supplies on the well being of the peoples of developing countries are incalculable. The economic viability and social well-being of communities are directly dependent upon a safe and continuous supply of ample water for both industry and the working force which makes industry possible.

There is abundant evidence of the effectiveness of water supplies of good quality in controlling waterborne disease. In response to a survey by WHO in 1962, Japan, Cuba, Peru, Colombia, Pakistan, Ceylon, Madagascar, Kuwait and India all reported that the incidence of such diseases had declined significantly following improvements in the quality of public water supplies. In Uttar Pradesh, India, for example, after sanitation improvements in the water system the cholera death rate decreased by 74.1%, the typhoid fever death rate by 63.6%, the dysentery death rate by 23.1% and the diarrheal disease death rate by 42.7%.[8]

The community water supply program in the developing countries has been assisted by more than 20 donor nations, by international lending agencies and by international organizations such as the World Health Organization, the Pan American Health Organization (PAHO), and the United Nations Infants' and Children's Emergency Fund

(UNICEF). In the past 25 years the U.S. program administered by the Agency for International Development (AID), and its predecessor agencies, has involved the expenditure of over $300 million.

The economic progress of developing countries, as well as the health and vitality of their citizens, is dependent upon wholesome drinking water and clean natural surface waters. For example, tourism - a major element in the economy of many countries - has been seriously handicapped in some instances by outbreaks of typhoid fever and other waterborne diseaes, and by beaches polluted with sewage and oil. In such countries, including many in the Caribbean and Mediterranean areas, the water must be attractive as well as wholesome if tourists are to continue to invest in transportation to reach those areas. The abatement of widespread pollution of water systems is essential also to halt deterioration in the quality of commercial fishery and other processed food products, to meet increasingly stringent food quality standards in international trade.

Status of Community Water Supply Systems

Although it is estimated that only 10 percent of the people in developing countries now have adequate safe water supplies, relatively meager data are available for many areas, particularly the rural sections of Africa and Asia. In many countries the population is increasing at rates of 2.5 to 3.5 percent annually, and 5 to 7 percent in urban areas, negating in large measure efforts to extend water service to a greater proportion of the people. Frequently too, the absence of adequate sewage disposal facilities compounds the problem of providing safe water supplies. In this regard, a distinction should be noted between water service or piped water, that provides the consumer "safe" or "protected" water, and water service that delivers "unprotected" or "unsafe" water.

In Africa, owing to the widespread scarcity of surface water, much of the foreign aid effort to improve water supplies has been oriented toward the study and development of ground water. Few African countries have educational institutions for sanitary engineers. Some do not have a single native-born, educationally qualified sanitary engineer. In 1964, some 200 million people,

or about 70 percent of the population of the developing countries in Africa, had no access to water service of any kind, safe or unsafe.[9/]

In East Asia, including Burma, Cambodia, Laos, the Philippines, South Korea, South Vietnam, Thailand and Taiwan considerable progress has been made in the training of sanitary engineers and water-supply technicians. The Asian Institute of Technology in Bangkok serves as a regional training center in this regard. In 1962, the most recent date for which information is available, about 57 percent of the urban population, or 32 million people, did not have access to piped water, and it appears likely that some 70 percent of the total population, or about 170 million people, did not have water service at that time.[9/]

In the developing countries of the Near East and South Asia, from Turkey to East Pakistan, the problems of providing adequate water supplies are magnified by the extreme poverty, poor sanitation, and inadequate nutrition among three-quarters of billion people, and by widespread population pressures. The emphasis of U.S. assistance to these countries in the past ten years has been on strengthening training programs for sanitary engineers, and on engineering studies. In this region of largely rural populations it is estimated that in 1962 at least 80 percent of the total population had no access to water service.[9/]

In Latin America, the inauguration thirty years ago of improvements in water supply systems, and the development of institutions and professional manpower for that purpose, has resulted in a much better water supply situation than that in most developing areas of the world. The participation of the Inter-American Development Bank and PAHO, as well as direct assistance from the U.S., have been significant factors in the progress of the Latin American water supply program. By 1968, 44 percent of the population of Latin America, or 118.5 million people, had access to piped water supplies. Projections of PAHO have indicated that by 1971, 49 percent of the population will have water service.[10/]

Drinking Water Standards

The different meanings of the word "standards" as used in the terms "drinking water standards" and "surface

water standards" are defined in the Preface to this report. In the following discussion of drinking water standards it should be noted that the term is used in its commonly accepted sense as a rule for the measure of the quality of water delivered to the ultimate consumer.

Since the turn of the century most developed countries, including the United States, have adopted drinking water standards and have refined these standards as their respective technologies have improved. In the developing countries on the other hand, the general absence of public water systems and of strong national and local public water supply institutions, has inevitably delayed the advent of drinking water standards.

In 1958, WHO published International Standards for Drinking Water, establishing minimal standards of chemical and bacteriological quality which could reasonably be expected of public supplies of water for domestic use. In the ensuing five years they were adopted by five nations as legal standards of water quality. They also were widely used as a reference in the development of local standards and for improving water treatment practices. The International Standards were revised and reissued by WHO in 1963.[11] (Selected criteria from these Standards appear in Appendix I.)

In 1961, WHO also published the European Standards for Drinking Water. In that publication it was noted that "International Standards for Drinking Water proposes minimal standards which are considered to be within the reach of all countries throughout the world at present time. In view of the different economic and technological capabilities of various countries there will be some areas in which higher standards than those propose for the world as a whole will be attainable and these areas should be encouraged to attain such higher standards. It is believed that Europe is such an area..." The second edition of the European Standards was published by WHO in 1970. [12]

Many of the countries of Southeast Asia participated in a seminar in Bangkok in January, 1970, on the subject of Water Supply and Wastewater Disposal in Developing Countries.[13] Among the conclusions reached by the participants were the following:

"There is urgent need to develop unique criteria for all phases of water supply and waste disposal programs in Southeast Asia and this will require additional data for evaluation purposes. It was agreed that neither American standards nor those proposed by the World Health Organization necessarily apply directly to the region; with economy as an overriding factor, it was agreed that lower standards than those generally in worldwide use could be justified."

"Regardless of the social benefits of adequate water supply and waste disposal facilities the primary objective should still be the control of communicable disease. Cholera, dysentery and other similar waterborne diseases are still epidemic in a large part of the region."

In 1969 the U.S. Public Health Service published an evaluation report on the water supply programs of developing countries, in accordance with a Participating Agency Service Agreement with AID.[14] In order to obtain the essential data for the report, teams of consultants were sent to 12 developing countries in various parts of the world. With reference to water quality standards the report states, in part, as follows:

"The teams of consultants reported that a number of countries have adopted drinking water quality standards within recent years, but that few countries are now enforcing those standards. Drinking water standards of the Public Health Service and the World Health Organization (WHO) are very similar. Both serve as a guide but are not closely followed by those countries that have established their own standards. Some have adopted one or the other in toto ***."

The bacteriological and chemical quality of community water supplies in the developing countries usually fail to meet the international standards recommended by WHO. Inadequate treatment, poor operation of treatment plants, negative pressures in the distribution system, and cross connections are major contributors to large outbreaks of waterborne diseases. The standards of water service

which provide for continuous water under pressure at the customers tap twenty-four hours a day every day for the year are extremely important in maintaining water quality standards. Constant water service may also eliminate the use of some other source of poor quality."

"Responsibility for enforcement of drinking water quality standards is usually placed in the ministry of health. Unfortunately this responsibility frequently is not carried out. Too often, the water producer is left to check the quality of his own system. The consumer will benefit when water quality enforcement is performed by an agency other than the water utility administration."

"Having adopted drinking water quality standards, the ministries of health need to establish regional laboratories capable of chemical, microbiological, and physical testing for water quality. This is essential for proper enforcement of the standards."

Surface Water Quality Control

The quality of, and the standards for, drinking water are determined for water in the distribution system, as it is received by the ultimate consumer. In contrast, the standards for surface waters, such as lakes and rivers, are determined for the raw water - in the natural state - in the form available to many potential users.

With some exceptions, the developing countries have done very little in the area of national water resource planning and surface water quality control. In many instances, particularly in the new countries of Africa, significant competition for such resources has not as yet developed among the advocates of public water supply, industry, agriculture, tourism, etc. While priorities have not been consciously assigned to competing uses of water resources, such decisions have been made, in effect, when water resources have been committed to the construction of specific irrigation or other major water use projects.

Among the older and the more densely populated countries interest is developing in the concept of national water resource planning and water pollution control, for economic as well as public health benefits.

This was evident in a meeting of Indian and American scientists in New Delhi, in September 1971, to discuss India's water problems. Such meetings serve to emphasize the difficulties of developing countries in determining national priorities and programs for improving water resource management.

For example, about 80 percent of the population of India lives in rural areas. Most of the 450 million people in small villages presently depend on shallow, uncovered dug wells for their water supply. For many reasons, including the general absence of sewage disposal systems, the water from such wells is contaminated. In the urban areas it is estimated that 40 percent of the population has access only to unprotected water supplies. About one-third of the deaths in India result from communicable diseases, attributed in large degree to those diseases that are water-borne. Faced with ever increasing requirements for clean water for industry, irrigation, thermal power, and other major water users, government planners must balance such needs against the immediate needs of people for safe water supplies.

In Latin America an advisory Committee on Environmental Sanitation, established in 1958 by PAHO, has had a significant impact on water resource development priorities in that part of the world. The Committee concluded that available resources should be concentrated on extending and improving existing water supply systems, and on constructing new systems, to furnish water of good quality and ample quantity through house connections. The Committee felt that this was the best method of reducing disease, accelerating the rhythm of economic development, increasing tourism, and serving as an incentive for the construction of new housing. The Committee agreed, with regard to environmental sanitation, that water supply should have first priority and sewage disposal second priority. These conclusions were embraced in programs adopted by the Governments of Latin America in 1961, in the Charter of Punta del Este, designed to accelerate the construction of water supply and sewer systems, and other facilities, throughout Latin America. Aided by the earlier development of institutions and technical personnel for the purpose, these programs - and particularly that for community water supply systems - are making excellent progress.10/

Essential Steps to Water Quality Standards

Developing countries face common problems in achieving water quality standards. Their populations are increasing very rapidly - at rates beyond the capacity of local economies to sustain them above marginal levels. Economic productivity per capita is low, due in part to the absence of adequate technical training and modern tools of production, and in part to the debilitating effects of endemic diseases. Water resource management and safe public water supplies are only two of many problems demanding the attention of planning, administrative, and technical agencies, and competing for the limited available investment funds.

In most developing countries the achievement of more adequate supplies of water of suitable quality for domestic use and for economic development, is dependent upon the strengthening of national institutions and policies in the water resource field, and leadership to bring this about. Essential actions in this direction were prescribed in a report by the U.S. Public Health Service in 1969, which followed a comprehensive survey of water resource programs in the developing countries[14/] These steps are as follows:

a) "Establish a national water policy and enact the basic water laws necessary to carry out expanded national programs as envisioned by this policy."

b) "Develop the institutions and methods necessary for financing capital investments suited to the local economic conditions."

c) "Obtain and correlate the basic data required for conducting intelligent community water supply and water resource development programs."

d) "Establish and finance the organizations necessary to plan, develop, and administer these nation-wide programs. In the larger countries this should include plans by the national agency to support and strengthen similar organizations at the provincial level."

e) "Implement the administrative, technical, and managerial training programs necessary to ensure competent management and operation of water systems following their construction."

In addition to these prerequisites the Public Health Service report, and many similar surveys in the same subject area, have emphasized the great importance of public education concerning the direct relationship between clean water and the health and well being of society.

Planning and program requirements for attaining essential supplies of clean water to meet national needs vary from one country to another, depending upon many factors. The size, climate, and geography of a country, as well as its culture and its economic and technological capabilities, are important considerations.

Ethiopia offers an example of how one country assessed its water supply program needs for a largely rural population. In 1967 a six-year evaluation study of Ethiopia's rural health center program was concluded by a study team representing Ethiopia's Ministry of Public Health and AID. The recommendations produced by the study, with regard to rural community water supplies in Ethiopia, offer helpful guidance for all who are concerned with water supply problems in developing countries. The following actions were urged in the published evaluation study [15]:

1. A national Community Water Supply Board should be established, representing all appropriate agencies of Government, to provide technical and financial support in the development of rural community water supplies.

2. The order establishing the Board should state the specific responsibilities of each agency representative on the Board with regard to planning, design, construction, financing, supervision of operation and safety of water produced, and other essential functions.

3. Ethiopian national grants-in-aid funds should be appropriated for, and administered by, the Board for use on a matching basis, to encourage and assist communities in constructing safe water supply systems in accordance with criteria adopted by the Board.

4. Operation of the water supply systems should be on a self-support basis and should be a responsibility of the local government involved, with technical supervision-including regular laboratory testing - and fiscal control provided by appropriate ministries.

5. As a general rule, the installation of water connections in buildings should be discouraged until adequate provision has been made for waste water disposal Relatively simple plans should be provided for protected water supplies in the smallest communities.

III. SUMMARY AND CONCLUSIONS

In the United States the Drinking Water Standards of the Public Health Service serve as the basis for quality control programs for public water systems in all of the states,

Within relatively recent years a number of the states and interstate agencies have developed quality control programs for their surface waters, such as lakes and streams. Comprehensive water quality criteria were published by the Federal government in 1968. Under the provisions of the Water Quality Act of 1965, the Federal government encourages the states to establish water quality standards for interstate and coastal waters. Upon acceptance of such standards by the Federal government they become Federal standards as well.

In 1962 a survey of 75 developing countries by the World Health Organization revealed that only about ten percent of the total population was supplied with water service in or near their homes. Many of the people with water service have access, however, to water that does not meet even minimum hygienic standards. At the same time WHO estimated that more than 500 million people suffer each year from debilitating, and often fatal, water-borne diseases. In most areas of the developing world the rapid rate of population growth is negating efforts to extend the distribution of safe water to a greater proportion of the people. Numerous surveys have established the direct relationship between the quality of water supplies available to a nation and the health and well being of its people.

In 1958 WHO published International Standards for Drinking Water, which it identified as minimal requirements - necessary and attainable by every country. These standards were revised and reissued by WHO in 1963. While they were adopted in some degree by a number of developing countries, a survey by the U.S. Public Health Service in 1969, reported that few countries are now enforcing drinking water standards, and their community water supplies usually fail to meet the standards recommended by WHO. The report concluded that "Inadequate treatment, poor operation of treatment plants, negative pressures in the distribution system, and cross connections are major contributors to large outbreaks of water-borne diseases."

In addition to widespread deficiencies in water service, and in the quality of water supplies available for domestic purposes, the economic life in developing countries frequently is severely handicapped by the absence of clean water. With some exceptions, the developing countries thus far have done little to control the pollution of their water resources or to implement standards to achieve the optimum benefits of these resources for industry, agriculture, tourism and other uses. In some instances this reflects a studied conclusion that water supplies for communities are of overriding importance to the nations' welfare, justifying the concentration of available resources on that aspect of water resource development.

It seems clear that the limited progress thus far in improving water supplies for communities and for economic development is the result, in large part, of inadequate policies, laws and institutions for the purpose. Because of these inadequacies there is a strong tendency for improved water supply systems, once established, to deteriorate due to improper management, operation, and maintenance. Frequently this deterioration occurs through lack of regular inspection and followup procedures by the upper echelons of government.

Specific steps for overcoming deficiencies in water resource policies, laws and institutions are outlined in Part II of this report. Clean water supplies for industry, agriculture, recreation, and other major water users can be provided with much the same types of laws and institutions necessary for a successful

community water supply program. Planning for this purpose involves the accumulation of extensive hydrological information, and data on national water requirements. As in the United States, the essential components of effective surface water quality control programs include a determination of the use or multiple uses to be made of each water way; the establishment of criteria to protect the water for the uses designated; and plans to implement and enforce the quality levels decided upon.

The water resources of developing countries, and the conditions and programs for their optimum use, present a different set of circumstances in each country. However, each can draw on the experience of developed countries with similar problems, on the technical expertise of international development agencies and private institutions, and on the resources of the international lending agencies.

The needs of developing countries for clean water for public health and for economic development are monumental. In the final analysis each country must determine the priority to be assigned to water quality, and the quality standards that are appropriate for its level of social and economic development, and must depend to a large extent on its own efforts to resolve its water quality problems. The technical and financial assistance agencies of the world should consider how they can use their resources in strengthening the water resource management programs and institutions of developing countries; in strengthening their training programs for water resource scientists, engineers, and technicians; in supporting their regional water development programs; and in the dissemination to the developing countries of current literature and technical data relating to the development and protection of water resources.

APPENDIX I - SUMMARY OF SELECTED CRITERIA FROM INTERNATIONAL STANDARDS FOR DRINKING WATER, WHO, 2ND ED., 1963[a/]

Bacteriological Requirements

"The major danger associated with drinking water is the possibility of its recent contamination by sewage or by human excrement, and even the danger of animal pollution must not be overlooked ..."

"The organisms that have been most commonly employed as indicators of faecal pollution are Escherichia coli and the coliform group as a whole ..."

"With regard to samples to be collected from the distribution system, whether the water has been subject to treatment or not, the following maximum intervals between successive samplings and minimum numbers of samples to be examined in each month are proposed:"

Population Served	Maximum Interval Between Successive Samplings	Minimum Number of Samples to be taken from Entire Distribution System
up to 20,000	One month	One sample per 5,000 of population per month
20,001 - 50,000	Two weeks	
50,001 - 100,000	Four days	
More than 100,000	One day	One sample per 10,000 of population per month

For treated water - "When the microfilter technique is used, the arithmetic mean of numbers of coliform group organisms shall be less than 1 per 100 ml, and shall not exceed 4 per 100 ml in two consecutive samples, or in more than 10 percent of the samples examined."[b/]

a/ These criteria are recommended by WHO, "for present use throughout the world, with the hope that improvements in economic and technical resources will permit stricter standards to be adopted in the future."

b/ Additional criteria are provided for untreated water and also for the dilution-tube technique of water examination.

Chemical and Physical Requirements

Toxic Substances

"There are certain substances which, if present in supplies of drinking water at concentrations above certain levels, may give rise to actual danger to health. A list of such substances and of the levels of concentration which should not be exceeded in communal drinking water supplies is given below:"

Substance	Maximum allowable concentrations (mg/l)
Lead	0.05
Arsenic	0.05
Selenium	0.01
Chromium (Cr hexavalent)	0.05
Cyanide	0.2
Cadmium	0.01
Barium	1.0

Chemical substances affecting the potability of water

"The following criteria are important in assessing the potability of water. In view of the wide variations in the chemical composition of water in different parts of the world, rigid standards of chemical quality cannot be established. The limits thereafter designated "acceptable" apply to a water that would be generally acceptable by consumers; values greater than those listed as "allowable" would markedly impair the potability of the water."

"However, these limiting concentrations are indicative only and can be disregarded in specific instances."

APPENDIX I (continued)

Substance	Max. acceptable concentration	Max. allowable concentration
Total solids	500 mg/1	1500 mg/1
Colour	5 units*	50 units*
Turbidity	5 units**	25 units**
Taste	unobjectionable	--
Odour	unobjectionable	--
Iron (Fe)	0.3 mg/1	1.0 mg/1
Manganese (Mn)	0.1 mg/1	0.5 mg/1
Copper (Cu)	1.0 mg/1	1.5 mg/1
Zinc (Zn)	5.0 mg/1	15 mg/1
Calcium (Ca)	75 mg/1	200 mg/1
Magnesium (Mg)	50 mg/1	150 mg/1
Sulfate (SO_4)	200 mg/1	400 mg/1
Chloride (Cl)	200 mg/1	600 mg/1
pH range	7.0-8.5	Less than 6.5 or greater than 9.2
Magnesium + sodium sulfate	500 mg/1	1000 mg/1
Phenolic substances (as phenol)	0.001 mg/1	0.002 mg/1
Carbon chloroform extract (CCE): organic pollutants)	0.2 mg/1	0.5 mg/1***
Alkyl benzyl sulfonates (ABS: surfactants)	0.5 mg/1	1.0 mg/1

Radiological Requirements

"The following limiting values are tentatively established to serve as a guide to the maximum acceptable limits in drinking water as supplied to consumers for lifetime use for large populations;"

Strontium-90..... 30 uuc/liter
Radium-226..... 10 uuc/liter
Graoss beta concentration (in the absence of strontium-90 and alpha-emitters).....1000 uuc/liter

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* Platinum-cobalt scale.
** Turbidity units
*** Concentrations greater than 0.2 mg/1 indicate the necessit for further analyses to determine the causative agent.

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