CONSERVATION AND DEVELOPMENT OF WATER RESOURCES

14 February 1952

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CONSERVATION AND DEVELOPMENT OF WATER RESOURCES

14 February 1952

COLONEL VAN WAY: General Holman, members of the Industrial College, visitors: This class period will serve to introduce our course in Public Services, which will run through the first week in March, concurrently with the Production Course.

The purpose of the course is to acquaint you with certain of the public services which will greatly affect our mobilization in time of war and which, in turn, may be seriously hampered by enemy action directed against this continent.

We will not attempt an exhaustive treatment. Instead, we shall give you an outline of the fundamentals in the fields of power, transportation, telecommunications, water, and community problems. These will be examined in their relationship to economic mobilization.

The course will consist of 20 periods, with another 10 periods or so available for study. The details of the lectures, seminars, and motion pictures are contained in the curriculum book or will be issued in the weekly schedules, so I will not dwell on them further.

The oral presentations will be made by four students in four of the areas of this course. The names of these students, with their assigned subjects, have been posted on your bulletin board. The additional comment I would make now is that the presentation will be along somewhat original lines. The common theme which will tie them together will be the planning of operations of vital facilities under emergency conditions in the city of Baltimore. Of that, more later.

To start the course we will have a presentation by one of our instructors, Commander A. H. Castelazo. He needs no introduction to any of you, I am sure. We were fortunate last year in getting him from the Navy when he was graduated from the Naval War College at Newport. Most of you know him as a well-informed and competent instructor in manpower; but, to emphasize the fact that he is first, last, and always an engineer of high professional standing, he has prepared an excellent discussion of a vital element of our economy, water, which is normally so plentiful that we are liable to take it for granted. The industrial dislocations and pressures which we suffer in an emergency, however, will require that we make the most judicious use of this vital resource. Commander Castelazo sets this forth in a most interesting way in "The Conservation and Development of Water Resources." I take pleasure in introducing to you at this time, Commander Castelazo.

COMMANDER CASTELAZO: General Holman, gentlemen: One of the objectives of the Public Services Course is to give you an understanding of the role of water supply in the functioning of our national economy.

This morning I will discuss, first, the availability, demand, and use of water; secondly, the pollution of water resources; and lastly, the conservation and development situation.

The foundation of our national economy is built on our natural resources. The United States has an abundance of natural resources upon which its great economic strength has been built. Did you ever stop to think how useless the minerals in the ground and products of the soil would be without an adequate supply of water?

The presence and availability of water has been one of the main factors in the development of civilization. Water is required to produce food from the soil, for the growth of timber, for the processing of minerals and chemicals, for the generation of electric power, and for other items in the industrial economy of the country. Water is required to carry away domestic and industrial wastes and to provide protection against fire.

Water--that substance which too many people take for granted and some people say "will rust your pipes if you drink it"--is most essential to the maintenance of all forms of life--human, animal, and vegetable. Man cannot live without it.

Water is the one natural resource which is constantly being replenished. The hydrologic cycle, which is the continuous movement of water from the atmosphere to the land and through the various channels back to the atmosphere, is the replenishment process.

Charts for this lecture were not reproduced.

I have a rather simplified chart showing the hydrologic cycle. Inasmuch as the first evidence that we have of this particular cycle is when the rain falls upon us, let us start here with the clouds. These rain clouds hovering over the mountains let loose sometimes a deluge of water; at other times a light steady rain. Some of that water is intercepted while it is falling and is vaporized by the sun's energy. Some of it falls and lies on the leaves and on the vegetation and is vaporized by interception. Still other portions of the water hit the ground, soak into the ground, and enter through the aquifers in the earth's crust. Some of it goes into the soil; some of it is used by the vegetation and the trees in their growing processes, and through the process of transpiration goes back into the atmosphere.

Some of it goes into the ground water aquifers, into the lakes and streams, and then back to the ocean. The sun, on the other hand, is working all the time. It vaporizes moisture from all the water surfaces and carries it back up to the atmosphere. The vapor forms clouds, condenses, and then we get rained upon again.

Thus, the hydrologic cycle of evaporation, condensation, and precipitation is completed. In the great economy of nature, water is neither lost nor gained. Man's activities, however, can upset nature's balance of water, land and vegetative cover, and greatly alter the local course of the hydrologic cycle.

When this cycle is disturbed by indiscriminate logging, forest fires, or plowing of grass lands, the result is severe land erosion and disastrous floods. The reservoir effect on the vegetation is gone and therefore less water is stored for useful purposes.

Rainfall is the most extensive form of precipitation. Its occurrence and quantity is influenced by many factors and varies considerably in different parts of the world. It is distributed irregularly over the United States and fluctuates in intensity and volume throughout the year. Fluctuations in annual precipitation occur in more or less regular cyclic patterns causing periods of wet and dry years. The United States Weather Bureau maintains thousands of rain measurement stations throughout the country. The information collected is tabulated and published.

Snow is formed at temperatures below freezing. It usually occurs in the cooler latitudes and higher altitudes. It may lie on the ground for long periods of time and thereby provide a reserve source of water, which, upon melting, finds its way into the surface and ground-water aquifers. The measurement of snowfall and estimation of its water content has been carried on for many years by power companies and irrigation districts, in cooperation with the United States Weather Bureau, in an effort to forecast probable summer stream flow.

An average of about 30 inches of precipitation occurs annually over the United States. Of this, about 21.5 inches soon returns to the atmosphere and 8.5 inches runs off directly through streams to the ocean. Estimates show that approximately 0.75 of an inch is all that is intercepted for human consumption throughout the country. The total consumption amounts to from 100 to 150 billion gallons a day.

This next chart shows the average annual precipitation in the United States. You will notice that, generally speaking, the average precipitation in the eastern part of the United States is between 30 and 80 inches. Through the Central States from Minnesota to Texas there is a strip in which the rainfall is between 20 and 30 inches. As we go farther west,

we see the influence of the Rocky Mountains and the mountains along the Pacific Coast. Note an area of deficient rainfall shown in yellow on the chart. The coastal region of northern California, Oregon, and Washington has rainfall in excess of 80 inches per year.

This area along the Redwood Highway of California and up on the Olympic Peninsula are areas of heavy rainfall. If you have ever been on the Olympic Peninsula you will know what I mean.

One thing I want you to notice is the yellow area which is the area of deficit rainfall, under 10 inches; in some places way under 10 inches. One thing about this chart that might cause you a little wonderment, the figures are a little bit out of order. In looking at the chart we want to remember that those are average annual figures and they must be used with caution in estimating local water conditions.

Many factors control the amount of runoff and modify stream flow rates. Among these factors are:

1. The character, quantity, and distribution of precipitation.

2. Climatic conditions.

3. Topography and geology of the watershed.

4. Condition of the watershed with respect to forest cover and character of soil.

All of the above factors must be studied in order to make a reasonable estimate of available water supply.

Usable water is obtained from surface water, ground water, sea water, and reclaimed water from sewage treatment plants. Of these, the principal sources are: Surface water, which supplies roughly three-quarters of our total water needs, and ground water, from which industry draws three-quarters of its requirements. Sea water and reclaimed water are used for industrial cooling purposes, irrigation, and in some instances for fire protection. In general, the selection of the water source for any use depends on the size, character, water requirements of the user, and the location of the user with respect to an available water supply of suitable quantity and quality.

How much water do we use? The USGS estimates that of a total rainfall of 4,300 billion gallons per day, 3,000 billion are lost by evaporation and transpiration and 1,300 billion become runoff, of which only 180 billion gallons per day are used for domestic, industrial, and irrigation purposes.

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The consumption of water in cities and urban areas varies from 45 gallons to 300 gallons per capita per day. Such variations depend upon a number of important factors, including the climate; the size of the city; types of industry; quality of the water, its cost, and pressure; characteristics of the population; extent of metering; and the efficiency of the waterworks maintenance organization.

A few examples of municipal water consumption expressed in gallons per capita per day are:

1.	Chicago	246
2.	New York City	129
3.	Los Angeles	109
4.	San Francisco	65
5.	Dallas	56

and in Washington, D. C., each person uses 160 gallons per day.

Many cities obtain their water from pumped wells and near-by lakes, requiring relatively inexpensive installations for procurement and treatment. Other cities, such as New York, San Francisco, and Los Angeles, have constructed large projects, including reservoirs and long conduits, to use surface waters. The problem of purification varies considerably.

Industrial uses of water are considerably different. Industry uses more water than any other commodity--as a raw material, for cooling, power, and for processing. Air conditioning requires large quantities of water, but its volume is far surpassed by the use of water in oil refining, paper production, metallurgy, and chemical manufacturing.

Other heavy industrial users are distilleries and breweries, ice and cold storage plants, rubber factories, and meat-packing establishments. The Dow Chemical Company estimates that it takes up to 200,000 gallons to produce a ton of viscose rayon and 600,000 gallons for a ton of synthetic rubber. General Motors estimates that 12 to 15 thousand gallons are used in the production of one automobile. Twenty-two million gallons a day are used in a paper mill.

Steam-electric generating plants use enormous quantities of cooling water. A large plant will use 500,000 gallons per minute, or more, for surface condenser operations. The 300,000 Buzzard's Point plant of the Potomac Electric Power Company, our next-door neighbor, requires 450,000 gallons per minute for cooling purposes.

Among the primary factors in the selection of a site of a new industrial plant are the proximity of an abundant supply of easily procurable water of suitable quality and a means of disposal of waste water.

The quality of water for industrial uses is a highly important factor in the determination of its value. Water, as raw material, must be conditioned and treated to meet the specific needs of the particular plant. In the chemical industry the consumption of water is so great, and the specific physical, chemical, and bacterial requirements so diverse, that no standard specification for qualify can be adhered to.

Impurities in cooling water that cause trouble are: scale-forming constituents, dissolved corrosive gases, acids, and slime-forming organisms.

Boiler feed water must meet the most exacting quality requirements. This is especially true in plants where make-up is a high percentage of the total feed water. High-pressure steam boilers demand water free from almost all organic and inorganic solids. Even traces of silica can cause trouble.

About 21 million acres of land are irrigated in the United States. The use of water varies with the type of soil, climate, kind of crops, farming methods, and the irrigation system. The quantity of water used for irrigation purposes varies from 30 million to 250 million acre feet per year. This huge quantity of water is vital to the agricultural production of our country.

About 30 percent of the electric power capacity of the United States is generated by water power. The production of electricity using water power as a source of energy takes advantage of the energy released by the gravitational flow of water. The use of water for this purpose generally does not prevent its use for other purposes. Hydroelectric plants therefore can be combined with other water-using projects.

The capability of hydroplants to produce at rated capacity depends entirely on the available flow in the river. This in turn depends upon the rainfall and runoff distribution throughout the water year.

Other important uses of water resources are for navigation and recreational purposes, the needs of fish and wildlife, and a medium of transportation.

Water cannot be taken for granted. This fact, well understood in western United States, has been brought forcefully to the attention of other sections of the country in recent years. Taken as a whole, there

is plenty of water to meet all possible needs but it is not evenly distributed over the country. The Annual Summary Report of the United States Geological Survey for the water year ending 30 September 1951 stated that:

> "The water year 1951 was characterized by droughts in the Southeast, Texas, and the Southwest, and excessive runoff in most of the remaining area . . . in Texas, Arizona, and Southern California, new record-low ground water levels were reached, which in Southern California were the lowest in 40 to 50 years."

Shortages of water in local areas are caused by:

1. Deficient rainfall
2. Use in excess of natural replenishment
3. Inadequate planning of water developments
4. Unforeseen demands
5. Waste

In an effort to relieve critical water shortages, various methods for producing rain artifically have been devised. Cloud seeding with Dry Ice or silver iodide smoke has been used with varying degrees of success in local areas. The practical application of distillation of sea water is under experimentation.

The shortage of water in New York City for the last several years has not been caused by drought conditions alone. The real trouble lies in the inadequacy of existing facilities to meet the large increases in water requirements during and since World War II. New York is now faced with the problem of increasing its facilities either on the upper Delaware River or by using Hudson River water. A program for eliminating excessive use and waste has been started. The use of Hudson River water is not too popular for psychological reasons caused by the polluted condition of the river.

The ground water in Southern California is being pumped at an excessive rate. As a result, the water table near Long Beach has dropped 75 feet below sea level and the salt water from the ocean is moving inland at the rate of 300 feet per year. Texas; Long Island, N. Y.; New Jersey; and other areas are experiencing water shortage due to the depletion of the ground water.

In order to obtain an adequate supply of water, the Los Angeles Metropolitan Water District has constructed facilities to bring water from the Colorado River, some 300 miles away. During World War II, the military and industrial defense establishments in and around San Diego

made tremendous unforeseen demands upon the water supply. A connection was built to the Los Angeles-Colorado River Aqueduct which delivered water to the San Diego reservoirs in the nick of time. Recent studies indicate that the demand is still exceeding the supply in this area and a new aqueduct paralleling the existing one is proposed for construction.

Our modern water law had its origin in Europe and was brought to the United States by two different routes. The two broad doctrines under which rights are acquired to the use of water are the riparian and appropriation doctrines.

The riparian doctrine was brought from England by the colonists, as part of the common law. Under this doctrine, an owner of land along a stream is entitled to the natural flow of the stream through or alongside his land, undiminished in quantity and unpolluted in quality. This right only applies to lands riparian to the stream. Legal decisions handed down through the years have limited a riparian owner's use of the water to "reasonable use."

The appropriation doctrine came to the United States from Spain through Mexico into California and the Southwest. It is based on the concept of prior appropriation and beneficial use.

These two basic doctrines are diametrically opposed to each other, the former being based on the ownership of land contiguous to a stream, without regard to the time of use or to any actual use at all, and the latter on the time of use and on actual use without regard to the ownership of land contiguous to the watercourse.

The application of the two doctrines varies from state to state. However, the trend is toward more use of the appropriation doctrine, especially in those areas of scarce water supply.

Now let us consider the pollution problem. The productive capacity of our highly industrialized and urbanized economy is seriously threatened by the destruction of the quality of our water resources as the result of bacterial and chemical pollution.

When this country was young, the population was predominantly agrarian and rural with relatively few cities. The problems of water supply and disposal of wastes were fairly simple. As the country grew and became industrialized, large concentrations of population developed. The health of the public demanded that serious attention be paid to the disposal of domestic and industrial wastes. Towns, cities, and industries took care of their immediate needs by constructing sewer systems discharging into near-by watercourses without any attempt to treat the raw sewage.

Disposal was accomplished by dilution. Today this simple method of disposal is no longer permissible in many parts of the country. Too many people and too many industries depend upon those bodies of water for their water supply.

The first sewer systems were built in the 1880's. Today we have 9,000 such systems serving 75 million people. The first filtration plant in the United States was built at Poughkeepsie, N. Y., in 1875. By 1900 the water supply of only 3 percent of the population was being treated and in that year more than 23,000 people died of typhoid fever--a water-borne disease. Today some 16,000 waterworks supplying nearly 100 million people--two-thirds of the population of the United States--are helping to eliminate disease.

Water pollution has become such a serious problem that whole rivers have been polluted. For example, the Ohio River is now one of the most polluted rivers in the country. Into it pour the mine draining and sulphuric acids, and indistrial and domestic wastes of the Monongahela, the Mahoning, and other tributaries. The resulting pollution is so serious as to discourage further industrial expansion and imposes a tremendous load on users to make their water suitable for use.

Nearly two-thirds of our drinking water comes from surface sources. Many of these sources are rivers into which upstream cities discharge their sewage. Many city dwellers would be shocked to learn that a considerable portion of their water had already been flushed through someone else's bathroom.

The United States Public Health Service estimates that there are 22,000 sources of pollution in the United States. Despite the existence of 9,300 treatment plants, the waste from domestic and industrial sources, still being discharged into our waters, causes serious problems.

Raw domestic sewage discharged directly into a large enough body of water will be diluted and the bacteria in the water will, in time, "eat up" the organic portion of the material and cause its eventual decomposition and disappearance. This process consumes the oxygen dissolved in the water upon which all forms of fish life depend for existence. When the body of water is too small, the oxygen is used up, the fish die, decomposition of wastes is stopped, and the watercourse becomes an aquatic graveyard.

A sewage treatment plant, designed to allow maximum practical use of water resources, removes most of the solid matter in domestic waste and speeds up the natural action so that the effluent discharged from the plant requires a great deal less natural decay.

Reclamation of solid material from sewage treatment plants is a source of agricultural fertilizer. The effluent can be used to replenish depleted ground water or used by industry for cooling water, as is done by the Bethlehem Steel Company in Baltimore, Maryland.

Industrial wastes are as varied and complex as American industry itself. Intensive laboratory research and experimentation puus actual tests and pilot plants are required to ascertain the most effective methods of treatment to reduce their harmful effects or convert them to useful by-products.

Industrial waste consists generally of oils, acids, chemicals, greases, mineral salts, and animal and vegetable material--some virulent, others noxious, and still others merely nauseous and offensive to the eye and nose.

In navigable waters the discharge of bilge water and other wastes, especially oil, from ships causes a pollution problem.

A different type of pollution is the discharge of hot water into a river. The Mahoning River at Youngstown, Ohio, is polluted by heat. The demand for cooling water by industry in this area is in excess of the natural river flow. As a result, this water is re-used many times and is discharged into the river at high temperature. The river has reached 140 degrees Fahrenheit in some locations. This is heat pollution--and it is very discouraging to an industrial water user.

Pollution of surface and ground waters from oil-field brines, wastes from coal mining and washing, zinc and lead mining, smelting, oil refining, coking, and similar developments has developed into a serious problem, for which the solution is very difficult, particularly with respect to oil brines.

Ground waters have become polluted to an alarming degree by the intrusion of sea water. In Southern California, New York, and New Jersey, excessive pumping has drawn the water table so low that sea water has intruded as much as two miles inland in some places.

During periods of deficient precipitation, many rivers do not have sufficient flow to prevent pollution of the stream by sea water. Water users along the lower reaches of the river are seriously affected by the increased salinity.

Silt carried by rivers cuts down the light entering the water on which plants depend for their normal growing process and production of oxygen. It increases the cost of water purification and shortens the

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life of pumping and power generating equipment. Silt deposited on stream beds reduces the capacity of rivers to carry flood waters and silts up reservoirs and navigable channels.

As has been pointed out previously, the disposal of raw sewage by dilution has become objectionable because of stream pollution problems. Treatment before disposal has become necessary.

The principles of treatment are segregated into six categories:

1. Mechanical separation.
2. Hydraulic separation.
3. Chemical coagulation.
4. Chemical reaction.
5. Disinfection.
6. Biological reaction.

The application of these principles are grouped into three main phases:

1. Primary treatment--which removes the solids and suspends matter either by screening, sedimentation, or chemical precipitation.

2. Secondary treatment--which involves oxidation by filtration, aeration, and chlorination.

3. Disinfection by chlorination.

The degree of treatment actually required will depend largely on local requirements of public health agencies and character of the sewage. In certain locations only primary treatment is required.

It has been found by many operators that the by-products of their waste disposal and treatment plants have produced a revenue which materially reduces the cost of operation.

For example, a chemical company, ordered by a State health department to abate its pollution, discovered that its waste contained a high vitamin content. Today, vitamins are the company's main product.

Many paper mills have saved large quantities of alkalies, pulp, carbon, and other materials which previously contributed to stream pollution. One company recovers over nine tons of usable pulp per day.

This pollution problem has become so serious that it has resulted in the enactment of state legislation and, in a few cases, interstate compacts to cope with the increasing pollution. The Ohio River Valley Sanitation Commission, created in 1948 by compact among eight states, has made substantial progress toward the realization of its objectives.

Although the primary responsibility for control of stream pollution rests with the states and their political subdivisions, the national aspects of the problem have been recognized by the Congress in the Water Pollution Control Act of 1948, Public Law 845, 80th Congress. This law declares it a congressional policy to recognize the primary responsibilities and rights of the states in controlling water pollution, and provides a program of assistance to the states in combatting the problem.

Public Law 845 requires the Surgeon General of the Public Health Service to cooperate with other Federal agencies, with state and interstate water pollution control agencies and others, to eliminate or reduce the pollution of interstate waters.

Technical data upon which to base the development of such programs is sorely lacking. The first task of the Public Health Service has been to collect all available data on the sources and extent of pollution, the damages to water resources, prevention methods in use, existing treatment plants, and future requirements. These data are being collected and published in a series of summary reports covering the 15 major drainage basins in the United States.

The summary report on the North Atlantic Drainage Basins was published early last month and is available in the ICAF Library, as are several of the other drainage basin reports.

The Public Health Service has also sponsored the formation of the National Technical Task Committee on Industrial Wastes. The objective of this committee is to promote industrial research on water pollution problems and to disseminate technological information. The committee is made up of Federal, State, and industrial representatives on a voluntary basis.

Large sums of money are required to construct waste treatment plants. In many cases the cost of constructing intercepting sewers is a sizable amount. The financial responsibility for constructing facilities for pollution abatement rests with those causing the pollution.

It has been estimated by the Public Health Service that the total cost of a national, municipal, and industrial pollution abatement program would range from 9 billion to 12 billion dollars, depending on the degree of treatment chosen as equitable to all concerned.

By Executive Order 10014, dated 3 November 1948, the President directed the various Federal agencies to cooperate with State and local authorities in the fight against water pollution.

In many cases, military installations have connected their sewer systems to near-by municipal systems and are participating in the cost of operation and maintenance of those facilities. In other cases the treatment and disposal of wastes are accomplished by means of government-owned facilities. The armed forces are carrying, or have plans to carry, their equitable share of the cost of pollution abatement. The pollution of our water resources is a real national problem.

Now let us leave pollution for a minute and discuss conservation and development of our water resources. An editorial appeared in a recent issue of "Electrical World" which reads in part as follows: "Where is the condensing water going to come from to support the prospective 200 million of national generating capacity founded on steam? How many kilowatts can be sustained by rivers on which inland plants have to be located before the thermal possibilities are exhausted?"

The newspapers of the country have carried headlines such as: (1) "Many Cities Face Water Shortage" and (2) "Water Holiday Proclaimed."

Articles such as: "Warning: The Water Problem is National" appear in periodicals from time to time. These are all indications that we can no longer take our water supply for granted. Averages on a nation-wide basis are misleading and give us a false sense of complacency.

Mr. Hugh H. Bennett, Chief, U. S. Soil Conservation Service, stated recently:

> "Our water requirements are multiplying with each passing year, and in the face of this mounting need we continue to waste fantastic amounts of the limited supply.
>
> "Our reservoirs are generally unprotected against siltation and are frequently inadequate for either present or potential need.
>
> "We have not given adequate attention to methods which would permit greater re-use of water.
>
> "Continued stream pollution ruins billions of gallons annually.
>
> "We do not know, accurately, how much ground water we have or where it is located.
>
> "Water conservation, in the thinking of too many people, is still an emergency measure rather than a routine, accepted habit."

What is the answer to this ever-increasing problem? The answer is conservation and long-range intelligent planning. According to Mr. Bennett:

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"The remedy includes the investment of billions of dollars of public and private money over a period of many years for the development, conservation, storage, purification, and distribution of all available water resources we can find and utilize . . . . In addition, the remedy involves a considerable change in the attitude of most Americans toward their natural resources, from prodigality and indifference to care and concern."

Gentlemen, one of the best places to start the process of conservation is the leaking water faucet--eliminate this waste.

This culprit, leaking at the rate of one drop per second, wastes 113 gallons per month. Multiply this by 2,500 faucets at Fort McNair, add the leaking faucets in the Naval Gun Factory, the Pentagon and the entire metropolitan area of Washington, D. C. Say one-tenth of these are leaking, the accumulated waste amounts to 900,000 gallons per day or an amount equivalent to the entire water supply for a community of 5,600 people. Think what this would amount to if all sources of waste were considered.

The city of Chicago, through a systematic waste water survey and campaign for the prevention and elimination of waste over a period of 20 years, has reduced its pumpage from one billion gallons to 972 million gallons per day. During the same period the increase in population was about 400,000. A net saving of 200 million gallons per day was realized.

Conservation of water resources involves many more problems than just fixing leaking plumbing fixtures. Conservation programs, to be effective, require carefully prepared, long-range plans which consider the use of water for navigation, flood control, irrigation, domestic and industrial supply, power, recreation, and maintenance of fish life and wildlife. Consideration must also be given to fire prevention, soil conservation, pollution abatement, and management of the watershed.

Development projects have been accomplished piecemeal without regard for the effects on other projects and certainly without the benefit of a national policy. From a national point of view, it is evident that the development of water resources should be based on a river basin coordination concept. Projects which include the multiple and coordinated use of water in the entire river basin require extensive long-range planning. These projects are usually of such a magnitude that their accomplishment must be by State or Federal agencies.

Because of the interstate nature of most rivers, the Federal Government has accepted the responsibility for their development in connection with flood control, navigation, irrigation, and, in some cases, hydroelectric power development.

The need for a national water policy became evident as the complexity of the water problem increased. The President, by Executive Order 10095, dated 3 January 1950, created a temporary Water Resources Policy Commission to:

> ". . . study, and make recommendations to the President with respect to, Federal responsibility for and participation in the development, utilization, and conservation of water resources, including related land uses and other public purposes to the extent that they are directly concerned with water resources."

The Commission's report, a wordy document in three volumes, was submitted to the President and released for publication in December 1950. The Commission proposes that planning procedure be through drainage basin commissions, made up of Federal agency representatives under an independent chairman and with advisory boards representing the interested states. Many of the 70 recommendations of the Commission have met with general agreement by the public; however, there is considerable controversy over others. The Commission is now drafting bills for submission to Congress to implement its proposed program.

Now to summarize--our natural resources, our industrial might, and even the very existence of all human, animal, and vegetable life depends upon the availability of water for useful purposes.

Fortunately, water is continually being replenished through the phenomenon of the hydrologic cycle. Its usability is influenced by the variations in precipitation, run-off, and efficiency of the collection and distribution systems constructed and operated by mankind.

The consumption of water for domestic uses in cities varies from 40 to 300 gallons per capita per day, while the industrial use of water will be as much as 22 million gallons per day for a single plant.

The quality of water is an important factor influencing its value to industry. The chemical industry, particularly, must control impurities in its water supply for each type of product of use.

Irrigation, navigation, power, recreation, transportation, and maintenance of fish life and wildlife are all important uses of our water resources.

Although enormous quantities of water exist in the United States, it is unevenly distributed geographically and seasonally. This fact combined with the increasing demand for water and the inadequacy of waterworks in many localities has caused serious shortages to develop. Indications are that the number of water-shortage areas are increasing.

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The pollution of our water resources is a real national problem. Its damaging effects on the public health, natural resources, and the operation and expansion of industry are a matter for great concern as a menace to the welfare and industrial economy of the Nation.

Under the authority of the Water Pollution Act of 1948, the U. S. Public Health Service is actively engaged in a program to assist the states and industry to solve their pollution problems.

Our water requirements are multiplying as our country continues to grow and new technological developments improve and expand our industrial activities. In spite of these increasing requirements, the conservation and development of our water resources have not kept pace with the demand. It is true that in many cities and regions throughout the country, programs for the conservation of water have achieved good results. Federal, State, and private interests have already invested millions of dollars in water development projects but have had the benefit of a national water policy. To do a real job of development, utilization, and conservation of our most vital, natural resource, we should have the guidance of a sound water policy. The recommendations of the President's Water Resources Policy Commission, if implemented by appropriate legislation, will be a big step in the right direction. Gentlemen, the Nation is becoming really water conscious.

Thank you.

QUESTION: I got the impression that 70 percent of the annual rate of water in the rainfall in the United States went down into the ground and didn't find its way to the ocean by rivers. It made me wonder what has been done about searching out underground rivers where some of this water is run into the ocean through the surface river. I know of one just south of here that feeds that area. I wonder if there is any effort around the country to find underground rivers like that where nature takes care of purification?

COMMANDER CASTELAZO: That is very true. When you realize that on an average the rainfall over the United States is 30 inches, that is a tremendous amount of water. As I said probably 70 percent or more goes down the drain, as it were, but is not recovered for usable supply for several reasons. One is that the water is distributed pretty unevenly across the United States and it is not economical to transport water very far. Los Angeles transports water about 300 miles, which is a long way to bring water. It takes a lot of capital to do this.

As to searching out underground streams, that is being done spottily, let us say, all over the country. Ground water is one of those things--well every farmer in the country has a well. A great many cities and

small towns depend entirely upon water pumped from wells for their entire supply. In California, southern California particularly, the ground-water situation has reached a point where they are recharging the ground-water system through alluvial and porous soils, taking water from streams and spreading it out over porous areas so the water will get down into the ground.

It is correct that a great many underground streams have not been located. The areas in which they find and use ground water are usually localized, heavy industrial or agricultural areas where thousands of wells have been put down. That is the cheapest way to get water. You just pump it out of the ground. When the rate of pumping exceeds the replenishment of the ground water, the water table goes down, down, down. If you go any distance at all you are running into millions of dollars of operating and capital expense to bring that water to where you want to use it, so that the water users should investigate the over-all ground water situations before investing in wells to obtain a large water supply.

Some of the companies have gone down deep for ground water. It has cost so much to raise the water to the ground surface and use it, and the more they use, the more the water table is lowered, that they have abandoned a lot of wells and have brought surface water from distant streams and rivers. That problem is becoming more serious every year.

QUESTION: Is there underground water in the form of rivers? Is there movement in the underground supply? I recall in Wisconsin we have a very large underground-water supply that is moving. This underground river moves three inches a minute. It is a little better than half a mile wide and comes within around two feet of the surface at some points. Of course, at that point we can put dye in the water and determine the direction of the flow and the rate of flow. I wonder if all underground water doesn't have a flow?

COMMANDER CASTELAZO: There are some underground basins that are fairly stationary. Let me put that hydrologic map up here a minute. Graphically this shows the travel of the water from the atmosphere on down through the soil. Now some areas are more porous than others. Water falling on an impervious area--that is an area where it is difficult for the water to get into the ground--will naturally run off on the surface. In other areas it will percolate down into the ground stream. The strata under the earth's surface is a broken, varied formation. Where there are faults, which are dams in the earth's crust, the water can't flow so easily; where it finds a porous stratum of gravel or sand, the water will flow and it will naturally flow downhill. So in many cases you will find that water falling on the earth's surface up in the higher regions will appear away down here some place.

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In the area that you speak of in Wisconsin, that is true, there is a large underground stream that is fairly well defined in its limits.

I had occasion some years ago to make a study of the ground water supply in the Santa Clara Valley south of San Francisco. That water comes from the surrounding hills. Some of it even probably comes from the mountains south and north of there. It is a rather concentrated area, however. The pumping from that underground basin is used in irrigating the orchards and the farms in the Santa Clara Valley. Excessive pumping took the water table down in ten years time, 150 feet in some places. We had occasion to plot the contours of the underground-water table using, I believe it was, 1920 as a base and plotting conditions for 1930; it was surprising how far in some localities that water was drawn down. To replenish the water supply, small dams have been constructed, diverting the water from the streams and spreading it over alluvial fans and porous areas, thereby allowing the water to get back into the ground water again.

The Central Valley in California has a large underground basin of water and that, of course, is moving all the time under the force of gravity from the higher catchment area to the lower elevations of the valley.

QUESTION: I notice on this other map there it looks like Lake Champlain is a kind of dry spot in the middle of the rainfall area. Have you any explanation for that?

COMMANDER CASTELAZO: I don't know the explanation for that but that is a fact that the average annual precipitation is less in area of the lake than the adjacent areas. It is probably due to the influence of the surrounding mountains. You will notice the color shows that the average rainfall over the year there is considerably under 30 inches. As you see these averages are rather misleading if you don't watch what you are talking about.

QUESTION: The discussions regarding these river valleys and the relationship to flood control, irrigation, recreation, and power generation seems to be a little confusing. Would you comment on that general situation?

COMMANDER CASTELAZO: When a large project for the development of water resources of a river basin is considered, very often the planners conclude that they will build a project primarily for irrigation purposes and will plan a storage reservoir. The water has to come out of the reservoir, so they take advantage of the fall of the water to generate power. The concept of the river basin development is to take maximum advantage of all uses of the water. We all like good recreational areas where the lakes are very constant in their elevations. That can't always be done without good management and regulation.

Flood control reservoirs are constructed in the upper reaches of rivers. For good flood control, they should be kept empty so that when a flood comes along, its damaging effect can be eliminated. A happy medium, however, is to keep the water level in the reservoirs to a minimum and leave enough room in that reservoir to take any probable flood that comes along. Water for industrial and domestic use is a consumptive use. This takes the water away for use in some other place but eventually it goes back into the stream, and into the ocean as waste.

So there has to be an over-all plan if you are going to make the maximum use of the water in the stream for all of these purposes. In too many cases the project is only considered for one or two of those uses. That is what is causing some of the problems and the headaches in some of our river basins. I noticed a report last night in one of the engineering magazines that the President has appointed a commission to study the over-all aspects of the Missouri River Basin, which is another problem.

QUESTION: What have the older European countries achieved? Have they had similar problems? They have had their populations for quite a long time; their industrial areas for quite a long time. Do we have any lessons to learn from them or haven't they any problems?

COMMANDER CASTELAZO: Let me start back with the Egyptians. We have learned a lot from the Egyptians. They taught us a great deal about irrigation. Irrigation was practiced in ancient Egypt and because it was practiced, the Pharaohs had to lay down certain laws governing the use of that water. In Europe, in some places, the water supply isn't too much of a problem. The water supply in England must have developed into problems because of the foundation that we have in our water law. In most of the semiarid regions in any part of the world, water is a problem. I don't know too much about the specific problems in the European Continent with respect to water, although I do know that many reservoirs and dams have been constructed for the utilization and conservation of water.

COLONEL VAN WAY: Thank you for a very fine job, Commander Castelazo.

(23 May 1952--350)S/hmb