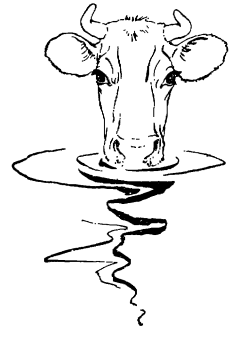
WATER



Our Need For Water

The Story of Water as the Story of Man

Bernard Frank

You could write the story of man's growth in terms of his epic concerns with water.

Through the ages people have elected or have been compelled to settle in regions where water was deficient in amount, inferior in quality, or erratic in behavior. Only when supplies failed or were made useless by unbearable silt or pollution or when floods swept everything before them were centers of habitation abandoned. But often the causes lay as much in the acts or failures of men themselves as in the caprices of Nature. So, too, man's endeavors to achieve a more desirable relationship with the waters of the earth have helped mold his character and his outlook toward the world around him.

People always have preferred to meet their water troubles head-on rather than quit their places of abode and industry. So people have applied their creative imagination, and utilized their skills, and released heroic energy. The ancient wells, aqueducts, and reservoirs of the Old World, some still serviceable after thousands of years, attest to the capacity for constructive thinking and cooperative ventures, which had a part in human advancement.

Fifty centuries ago the Mohan-Jo-Daro civilization of the Indus Valley in India enjoyed the benefits of well-designed water supply and drainage systems and even public swimming pools and baths. Excavated ruins of that period have revealed a surprising variety of waterworks, including tanks and irrigation canals.

The people of Assyria, Babylonia, Egypt, Israel, Greece, Rome, and China built similar facilities long before the Christian era. Egypt has the world's oldest known dam, a rock-fill structure built 5,000 years ago to store drinking and irrigation water and perhaps also to hold back floodwaters. Its length was 355 feet, and its crest was 40 feet above the riverbed. Apparently it was poorly designed, for it failed soon after, and no other was erected for 3,000 years afterward. Jacob's well was excavated through rock to a depth of 105 feet. The well is reported to be still in use. About 950 B. C., Solomon directed the construction of sizable aqueducts to provide for the needs of man, beast, and field. Ancient Arabia's enterprising farmers utilized extinct volcanic craters to store surface flows for irrigation and drove deep wells to get drinking water. Babylonia's King Hammurabi supervised the digging of an extensive network of irrigation canals and promulgated laws for their repair.

Among the early Greeks, Hippocrates recognized the dangers to health of

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polluted drinking water and recommended that water be filtered and boiled. The Romans used their poorer waters for irrigation and fountains.

The Tukiangyien system, built in China some 2,200 years ago, is another tribute to the genius and toil of ancient peoples. This skillfully designed multipurpose engineering project was intended to divert the flows of the Min River, a tumultuous stream that rises on the high plateau of Tibet. By building a series of dams and dikes on the main river where it first enters the broad plain from the mountain canyon, the farmers divided its flow into many parts so they could irrigate one-half million fertile acres. The structures—composed of bamboo frames weighted down by rocks—also reduced greatly the heavy toll of life and property from spring and summer floods.

THE HABITS OF MEN and the forms of their social organizations have been influenced more by their close association with water than with the land by which they earned their bread. This association is reflected in the Psalms of the Hebrew poets and in the laws, regulations, and beliefs among the civilizations of the Near East, the Far East, and South America.

Read, in the Old Testament: ". . . A good land, a land of brooks of water, of fountains and depths that spring out of valleys and hills . . ." (Deuteronomy 8: 7). "I did know thee in the wilderness, in the land of great drought." (Hosea 13: 5). "Drought and heat consume the snow waters . . ." (Job 24: 19). "He sendeth the springs into the valleys, which run among the hills. They give drink to every beast of the field: the wild asses quench their thirst. By them shall the fowls of the heaven have their habitation, which sing among the branches. He watereth the hills from his chambers . . . He causeth the grass to grow for the cattle, and herb for the service of man . . ." (Psalm 104: 10–14).

Property in water long antedated property in land in the arid lands of antiquity. Property rights were associated primarily with the uses of water—first for drinking, next for irrigation. Mohammed saw water as an object of religious charity. He declared that free access to water was the right of every Moslem community and that no Moslem should want for it. The precept of the Holy Koran, "No one can refuse surplus water without sinning against Allah and against Man," was the cornerstone of a whole body of social traditions and of regulations governing the ownership, use, and protection of water supplies.

All persons who shared rights to a watercourse were held responsible for its maintenance and cleaning. The whole community was responsible for the care of large watercourses. Cleaning was to start at the head of the stream or canal, descending in order to each waterside family. All users shared the cost in proportion to their irrigation rights.

Even marriage might be influenced by the difficulties of obtaining water. The inhabitants of one rural community in southeastern Asia must walk 9 miles to the nearest sources of drinking water—a group of wells. Local custom decrees that wives must fetch the water. One wife can make only one trip a day with her bucket—not enough for the family's needs—and so a man finds it desirable to have several wives.

ALL LIFE DEPENDS ON WATER. For us today water is as necessary for life and health as it was for our prehistoric ancestors. Like air, water is bound up with man's evolution—and doubtless his destiny—in countless ways. One of the basic conditions for life on earth is that water be available in liquid form.

The origin of all life on our planet is believed to be the sea, and today, after millions of years of evolution, modern man's tissues are still bathed in a saline solution closely akin to that of the sea when the earlier forms of life first left it to dwell on the land.

Every organic process can occur only in the watery medium. The embryo

floats in a liquid from conception to birth. Breathing, digestion, glandular activities, heat dissipation, and secretion can be performed only in the presence of watery solutions. Water acts as a lubricant, helps protect certain tissues from external injury, and gives flexibility to the muscles, tendons, cartilage, and bones.

The role of water in metabolism, in regulating body temperature, and in nourishing the tissues, explains why we could not long survive without adequate amounts of water. Yet our direct bodily needs for water are relatively small in terms of our total body weight (itself more than 71 percent water) and infinitesimal in relation to the total demands upon water by human societies, even among primitive cultures.

The average person in the Temperate Zone can get along with about 5.5 pints of water a day if he is moderately active. Slightly more than 2 pints are taken in with a normal mixed diet or created in the body by the oxidation of food, especially sugars, starches, and fats. Another 3 pints are taken in as fluids. Altogether it takes 5 or 6 pints to replace the daily losses in perspiration, exhalation, and excretion.

The amount for a given individual varies with his weight, age, activity, health, and other factors, but basic needs must be satisfied if life is to go on. The consumption of lesser amounts than those needed to replace losses will lead to a diminished appetite and eventually to undernutrition. A man in good health might be able to survive without water for a few days in a desert if he is only slightly active. If he tried to be more active he might not last a single day, because the consequent losses of water—as much as 10 pints an hour—from the body would greatly exceed the losses incurred under slight activity. Unless water were promptly made available, the losses would cause dehydration, incapacity, and painful death. By contrast, in the parts of the Tropics where high temperature and high humidity prevail, high rates of activity cannot be maintained even if abundant water were available, since the body is unable to dissipate heat and rid itself of waste products fast enough to prevent a breakdown in body functions.

WATER SERVES in many other ways to maintain life, health, vigor, and social stability. The nutritive value of food crops may be affected by the amount of moisture available to them when they are in active growth. Because the minerals in the soil can be taken up by plants only when they are in solution, the amounts thus made available are greatest when the soil is moist.

The oceans, lakes, and flowing waters and their shores furnish food and clothing. Men always have looked to such places for a goodly part of their diet of proteins and carbohydrates.

The gathering of fish, lobsters, crabs, and other crustacea, the waterfowl, fur bearers, and other wildlife that frequent riparian environments, and the stems, roots, bulbs, or fruits of bulrush, watercress, marshmarigold, water chinquapin, wildrice, and other water-loving vegetation have furnished sustenance to people the world over.

The occurrence of water in a locality confers advantages on the people who own or use the lands. The lakes, beaver ponds, the waterfalls, cascades, bogs, swamps, springs, or snowfields that feature wilderness, park, and the other recreational places and the colorful plants and wildlife that thrive there provide an appeal that attracts many people to the outdoors.

NATURAL WATERWAYS—oceans, lakes, and rivers—have greatly facilitated the worldwide spread of population and of commerce. Most of the permanent settlements in the arid regions—today as in antiquity—have concentrated along river valleys. Even along the seacoasts, habitation clustered around or near the convenient sources of fresh water.

The early Egyptians along the Nile and the Incas at Lake Titicaca in Peru employed rafts cleverly constructed of

native plants. Solid logs filled with double outriggers and platforms made seaworthy craft in Africa and Polynesia; later craft were constructed from logs hollowed out by fire and crude tools.

Inland transportation since early times has been facilitated by canals, first for irrigation and later for transport, as among the early Assyrians, Egyptians, and Chinese. The Grand Canal, built in China in the 13th century, served irrigation needs and also provided an important artery of commerce for the products of its millions of people. European countries, notably Holland, France, and England, later developed extensive systems of canals between natural waterways. So, too, in the Andes region of South America, rivers are the arteries on which rubber, lumber, and other products of the interior are carried to the coast.

Early settlement in the United States, at first restricted to the coastal strips, soon moved westward through the mountains by utilizing such streams as the Mohawk River in New York, the upper Potomac in Maryland and West Virginia, and the Ohio. By 1790, shortly after our country achieved independence, all but 5 percent of the 4 million inhabitants still lived along the Atlantic seaboard, but the way westward was rapidly being charted. River craft had navigated up the coastal rivers to the fall line. Canals to bypass the unnavigable parts of rivers were already built in Pennsylvania—connecting the town of Reading on the Schuylkill River with Middletown on the Susquehanna—and around the rapids at Harpers Ferry, W. Va., on the Potomac. Following the successful tests of steam-propelled craft, large fleets began to haul wheat, coal, and iron on the Ohio River, the Great Lakes, and the Mississippi.

As the country expanded and prospered, eyes turned increasingly to the opportunities on the major rivers. Today, notwithstanding the intensive networks of railroads, highways, and airways, our improved navigation waterways—developed largely by the Corps of Engineers—total more than 25,000 miles and in 1953 carried a volume of raw and manufactured products amounting to nearly 225 million tons. It is possible to travel by boat from the Gulf of Mexico to Sioux City, Iowa, a distance of 2,030 miles.

MODERN CIVILIZATION imposes heavy demands on water. Merely to sustain life takes relatively little water. But even in pastoral or other simple societies, additional amounts are needed in preparing food and washing our bodies and clothes. The total daily requirement for all purposes, including drinking, in ancient villages may have averaged 3 to 5 gallons a person. Now a person uses 60 gallons or more each day for household and lawn-watering purposes in the average electrified farm or urban home in the United States! The figures are for homes with running water; the corresponding average for homes without that convenience is only 10 gallons a person a day.

At the minimum comfort level of 5 gallons a day—corresponding to the needs of primitive living conditions—our country's 165 million people would have few serious water difficulties. That daily total consumption of 825 millions of gallons would represent 0.07 percent of the Nation's average daily runoff of 1,160 billion gallons a day and 1.2 percent of the amount used up (not available for reuse) in the United States.

But our technological civilization could not have been attained at a level of water consumption geared to the requirements of primitive societies, even in our humid sections, where the need for irrigating crops is relatively slight. The steady rise in the consumption of water in industrially advanced countries explains why we now regard our water supplies with great concern.

The impact of new inventions and new developments and growth in population and industry has not commonly been given the attention it has merited.

Many critical local water shortages

therefore have occurred that could have been forestalled. For example, rural electrification has brought about such heavy increases in the use of water for household and production purposes that the limited well-water supplies of many farms have been severely strained.

Similarly, factories have been built without prior studies to determine whether water would be available to operate the factories and to provide for the communities around them.

Towns, cities, industries, and farms have kept expanding beyond the safe limits of available water. Often makeshift efforts have been necessary to meet emergencies, especially in years of low rainfall. Such efforts have often hastened the depletion of the limited reserves in underground reservoirs, generated disputes with other cities or industries drawing on the same sources of water, introduced conflicts with the use of water for recreation, and threatened the permanent flooding of lands valuable for farming, forestry, wilderness, or wildlife.

To meet the difficulties, more thought is being given to the advance planning of storage reservoirs, aqueducts, canals, methods of recharging ground water, reclamation of waste waters, and other devices. Still the search for more and better water goes on. Use continues to rise; advancing standards of health and comfort, the application of more intensive farming practices, and the development of new products all impose additional demands. In fact, the proportion of our total economic and recreational activity—both in rural and urban areas—that depends on handy and abundant supplies of clean, safe water is greater than ever before in our history.

OUR WATER NEEDS are indeed great. Yet they do not begin to compare with the needs of the millions of people in Asia Minor, India, Africa, and South America who must still scoop up water from shallow pools or foul streams or haul it up by hand from wells. Travelers relate how in Madagascar the women carry water home in jars on their heads across miles of hot sands. In parts of the Egyptian Sudan, water is stored in the trunks of large, hollow trees. The openings are sealed with wet clay to keep it uncontaminated. Thousands of these small reservoirs—which hold 300 to 1,000 gallons each—appear along routes of travel. In one province all the trees are registered and the contents noted for information on the extent of the water resource.

Among the early pioneers, especially in the southern Appalachian Mountains, the ownership and control of a clean, abundantly flowing spring was considered an indispensable prerequisite to staking out a homestead. Once chosen, the spring was cherished. It meant cleanliness, health, and comfort. It was sheltered against contamination and protected against trespassers.

How far have most of us strayed from the old family spring! Generations of men and women have grown up without experiencing the joy of satisfying their thirst from cool, sparkling, spring water. Modern living standards have made it necessary to rely upon water supplies of far greater volumes than the one-family—or even the community—spring could furnish. Many of us have lost contact with the land and the pure waters that came from its depths. We must get water from distant rivers or reservoirs and then only after it has been made safe by filtration and chemicals.

THE TASK OF FINDING, developing, and maintaining suitable water supplies has not been limited to modern times. It has had to be faced wherever large numbers of people have crowded together in small spaces.

Paul B. Sears, discussing climate and civilization (in the book *Climatic Change*, edited by Harlow Shapley), wrote that the highly developed civilization of Babylon finally disintegrated because "for centuries the operation of agriculture had been increasingly burdened by heavy loads of silt in the life-giving [irrigation] canals." He added: "So

much labor was required for their annual cleaning that little leisure remained for anything else, and the long piles of silt . . . grew steadily in height and volume. Presumably this was due to increasing pressure, through cutting and grazing, upon the vegetation of the highlands whose runoff supplied the water. Under those conditions, the landscape became increasingly vulnerable to the effects of climate with its infrequent but violent rains and dry-season winds."

During the several centuries of stability under the Roman Empire, vast and intricate systems of waterworks had been constructed to provide the millions of people with safe supplies. Disposal of sewage was well developed for the times, and, in general, the value of clean household water and of sanitation was well understood. But when the empire disintegrated, chaos reigned, and the hard-won gains were rapidly dissipated. The constant warfare and political disturbances broke down the social concerns over water supplies, among other important public services. As ignorance and poverty increased, sanitary precautions came to mean less and less, and in time cleanliness was frowned upon as evidence of wicked thoughts and self-indulgence. Bathing, formerly widely practiced for its therapeutic values, was abandoned. The citizens no longer took pride in clean homes and streets, which became filthier and filthier. Worst of all, the water, obtained mostly from wells, eventually became so fouled as to be unfit for use.

Illness and death from waterborne diseases have plagued one country after another down to the present time. And not only were the poor people struck down. Records indicate that many famous characters of history also fell victim to waterborne diseases. Among them was King Louis VIII of France, Charles X of Sweden, Prince Albert of England, his son Edward VII, and his grandson George V. George Washington was known to have suffered from dysentery. And Abigail Adams, wife of the second President of the United States; Zachary Taylor; and—ironically enough—Louis Pasteur's two daughters are said to have died of typhoid fever.

Apparently the popular indifference toward safe, clean water prevailed well into the 19th century, even in England and the United States, where the dangers from the polluted supplies were generally known.

The effects of polluted waters now are considered to be the foremost obstacle to raising the living standards of underdeveloped countries.

GREAT STRIDES have been made since 1900 toward meeting our needs for water—and we have been going farther and farther away to get it. Today, for example, Los Angeles obtains its water not only locally—from the Sierra Madre in southern California—but also from the Owens River on the east side of the Sierra Nevada, 240 miles away; Mono Lake, 350 miles away; and from the Colorado River, 450 miles away.

But the end is not yet. New sources of water are sought for the swelling population of southern California. Sewage, formerly discharged into the ocean, is reconditioned for irrigation and industrial use; eyes are turning to the better watered, less densely peopled northern part of the State; and the possibilities of converting sea water are being studied by scientists.

EACH ONE OF US is affected by the water problems now before us. L. K. Sillcox, a sanitary engineer, estimated that about one-quarter of our total population is up against actual water shortages or poor quality of water or both. Population has doubled since 1900, but the per capita use of water has quadrupled, mostly because of industrial and agricultural demands. The 17 Western States, with about 37 million people, use a daily average of 85 billion gallons (77 billion for irrigating arid farmlands alone) as against 80 billion gallons in the 31 Eastern

States with their 128 million people. Industrial water in the East amounts to 65 billion gallons, as against 3 billion in the West. Farm irrigation in the East has taken only 3 billion gallons, but this use is growing so fast, and its impact on other uses has become so heavy, that many States—South Carolina, Georgia, Minnesota, and Wisconsin, for example—are closely reexamining their water policies with a view to developing new and more adequate legislation on this problem.

Mr. Sillcox estimated the Nation's annual water supply bill at 3 billion dollars, of which the urbanites' share is 500 million dollars. Farmers spend 200 million dollars (mostly for irrigation water). Investments in reservoirs, aqueducts, and other works to use or control water already total about 50 billion dollars—as against an outlay of 32 billion dollars to build our railways. (During the next 50 years we can expect to see further such investments by private, State, and Federal interests of 75 to 100 billion dollars.)

What to do about industrial wastes is another urgent and perplexing question. The Public Health Service estimates that it would take 9 billion to 12 billion dollars to rid our rivers of pollution and another 12 billion to 15 billion dollars to keep them unpolluted.

A special case of pollution as it relates to human health concerns the protection of the municipal and rural water supplies from radioactive wastes.

The coming years will bring an increase in the use of radioactive materials in manufacturing, for the production of electric power, and for experimentation in medicine, agriculture, and industry. The operation of nuclear power reactors alone will produce a manifold increase over the amount of radiation released to the air.

Radioactive materials released into the air are deposited sooner or later on the surface of the earth, including streams and lakes. Much of the radiation is noninjurious, and most of that which enters municipal reservoirs or other surface waters is rendered harmless by the application of modern detection and treatment methods. Not yet known, however, are the longtime, cumulative effects on human beings of the very small amounts of harmful radiation that still remain in the water we drink after it has been treated.

Studies indicate that the water that comes from underground sources, such as deep wells, is much less susceptible to contamination by airborne materials than are the surface waters. Other researches indicate that the distillation methods of purifying water are effective in eliminating sources of harmful radiation, even in large amounts; perhaps the future may bring radically different ways of handling our water supplies. Perhaps the same watershed conditions that favor the slow movement of water through the soil into underground storage may prove to be highly desirable also in facilitating the natural purification of contaminated waters. If so, watershed management, especially in localities that represent sources of underground water recharge, will take on added significance by providing an important safeguard to the protection of human health.

A serious challenge to our ingenuity is how to convert to useful service the savage energies of runaway floodwaters. The rapid growth in population in new and settled localities, on the flood plains and hill lands, and the corresponding expansion in highways, airports, factories, and homes have aggravated the tendencies of rivers, streams, and brooks to break loose when rain comes or snow melts. Despite heavy expenditures for levees, dikes, reservoirs, and other devices for curbing overflows, the damages from floods average about 1.2 billion dollars a year, including the value of the soil lost from productive farms and the deposition of silt and debris in irrigation canals and reservoirs and on the farms and city streets.

WE HAVE TO pool our efforts if we expect to apply appropriate and durable prescriptions for our water ills. Few

activities have so clearly brought out the interdependence of all individuals, communities, States, regions, and nations as have our harried concerns with this product of the heavens. How it moves over the land and whether it aids or harms us depend on its behavior during its return to sea and atmosphere. The behavior of water directly reflects the conditions and uses of the lands from which it drains. Since drainage basins are composed of many kinds of land in many kinds of ownerships, our efforts to ameliorate those traits of water that we consider harmful bring into play the deep-seated, although often submerged, instincts of cooperation inherent in all forms of life. In that sense, water, perhaps to a greater extent than any other resource, takes on social significance.

Planning for the maximum development of our water resources for the longtime benefit of all of our people, when properly conceived, can bind together individual and the community, farmer, and urbanite, as few other conservation activities can do. Conservation has received perhaps its greatest impetus since our dealings with soil, forests, wildlife, recreation, community betterment, and industrial development have come to be viewed in terms of their interrelationships with water. More and more people have become informed and interested in all these fields because our water troubles and our attempts to resolve them on the watershed lands and in the river channels have had a direct impact upon their personal, economic, social, or recreational affairs. Thus, farmers on the Rifle River watershed in Michigan, who once seemed indifferent to rebuilding their eroding land, now enthusiastically participate in a watershed improvement program because they became convinced that fishing on their local streams would thereby be greatly improved.

Similarly, indifference toward stream channels, as exemplified by their use as dumps for garbage and trash, are changing with the development of individual and group awareness of what clean waters mean for their well-being. Men, women, and boys and girls in hundreds of communities are studying, thinking, planning, and carrying out programs to restore the attractiveness and utility of their local watercourses. In so doing they are developing a positive appreciation of the meaning of harmonious living with their fellowmen and their natural environment. As these wholesome cooperative endeavors spread through the land, we Americans cannot help but become richer in mutual understanding, more secure in spirit, more united in purpose.

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