72-23,098

GOVAERTS, Kenneth Charles, 1939-
IMPACT OF CHANGING LIFESTYLES ON WATER DEMANDS.

The University of Oklahoma, Dr.Engr., 1972
Engineering, civil

University Microfilms, A XEROX Company, Ann Arbor, Michigan

THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

IMPACT OF CHANGING LIFESTYLES ON WATER DEMANDS

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements of the

degree of

DOCTOR OF ENGINEERING

BY

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Norman, Oklahoma

1972

IMPACT OF CHANGING LIFESTYLES ON

WATER DEMANDS

APPROVED BY

DISSERTATION COMMITTEE

DEDICATION

To my wife, Kathryn, who worked lovingly to assist me through the hard times, and my children, Beth and Tim, who gave up the time for my studies which could otherwise have been spent with them.

ACKNOWLEDGEMENTS

The list of people to whom I am indebted is a long one and I regret that I cannot name each individually. I wish to thank, first of all, the Faculty, School of Civil Engineering, The University of Oklahoma. A special note of appreciation is due my major professor, Mr. George Reid, without whom the work could not have been started, and to the other members of my Dissertation Committee, Dr. William Southard, Dr. Leal Streebin, and Mr. Robert Goins, all of whom remained patient even when I thought their criticisms too severe.

Many thanks to my colleagues who gave me ideas and inspiration, my editor Tom Hawthorn, and a special thanks to Dave Overstreet for his original poem written especially for this dissertation.

Finally, warmest thanks to my parents who interrupted their vacation to assist me in this project.

THESE WATERS

How many of these waters are there?
And how many are mine?

These clouds and this ocean,
they revolve around my tap.
I turn the spigot:
the oceans empty,
clouds dry.

I wash;
the water table plunges
like a thirsty neck line.

I rinse my car,
and necks go unwashed.

How many of these waters
slide down my drain?
How many glasses of water
are in my bath?
How many drains are enough?
And how many questions can I flood?

These waters are mine.
This body is mine.
How much is enough?

How many people are my water?
Is one a shower?
Are two a bath?
How am I to know?

---David Overstreet

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CHAPTER I

INTRODUCTION

There are three principal elements in a successful response to societal crisis: (1) recognizing the threat (or, more importantly, perceiving the consequences of not averting it), (2) changes in attitudes and values which must precede any drastic action, (3) translation of new consensus into a structure capable of implementing it.[1]

The space age has caused the unity of the Earth's environment to come into the focus of human perception, as it always was in physical fact. The spaceship is a unified system dependent upon the coordinated and continued functioning of interrelating systems and parts. It has surpluses and back-up capacity, but its resources are limited. Ecological facts that man prefers to evade concerning his Earth are universally acknowledged for a spaceship. No one doubts that there is a limit to the number of passengers that the ship can accommodate, and the need for

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[1]John P. Holdren and Ralph R. Ehrlich, Global Ecology (New York: Harcourt, Brace, Jovanovich, Inc., 1961), p. 2.

reserve capacity to meet unforeseeable contingencies is not questioned. It is obvious that the spaceship cannot indefinitely transform its nutrients into waste. If extruded from the ship as waste, energy sources are irretrievably lost; if accumulated as waste, the ship is ultimately destroyed from within. There is no escape from the necessity of recycling waste materials. For the duration of its voyage, the ship must remain in ecological balance. Disruption of any of its systems may mean disaster for the mission and the crew.[2]

A great proliferation of rhetoric has recently emerged from a number of noted writers in defense of the environment. How modern society responds to this plea for an "ecological ethic" may be the most important event of the twentieth century. One advocate of a restructuring of the hierarchy of values and institutions by which man now attempts to govern his behavior has written that

> . . . preoccupation with maintaining the momentum and stability of an accelerating system, if projected indefinitely, appears to lead toward self-defeat . . . Eventually, the technoeconomic system must slow down or drop back to a steady state, perhaps dynamic but no longer expansive . . . A time must come when human society will either effectively manage its relationship to the planetary life support system or see the decline and fall of the human species. . .[3]

What is happening is a conceptual basis for a new system of thought which

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[2]Lynton Keith Caldwell, Environment: A Challenge to Modern Society (New York: The Natural History Press, 1970), p. 119.

[3]Lynton K. Caldwell, "The Only Way Out Lies in Change . . . World Wide, Fundamental, and Pervasive," New Engineer, Vol. I, No. 5 (February, 1972), 8.

has slowly been forming, converging in the worlds of scientists, engineers, theologians, artists, and political leaders. This is to say that a new level of human organization must be achieved if the effects of an already inevitable world tragedy are to be contained and then reversed.

The engineer and scientist can no longer function under the myth that science and technology can solve the resource problems of the earth, provide for the projected population growth, and cope with the existing environmental degradation trends. The uncontrolled consumption of non-renewable resources has a predictable, finite conclusion. The fate of renewable resources, such as water and air, is not so well-defined. It is the fate of the earth's most important so-called renewable resource, namely water, that is the concern of this study.

Projected American water requirements in 1980 will be about 700 billion gallons. Even on the basis of the most optimistic technological and economic assumptions, only an estimated 650 billion gallons can be made available.[4] If this is the expectation for less than ten years in the future, the world faces an extremely grave water shortage in the more distant future. It is obvious that something must be done to change the course of resource utilization.

There is, of course, prospect for change. Population growth must decline if man is to continue to exist. Social attitudes and values are being altered. Who would have believed that ZPG would become a

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[4] Ibid., 65.

common household acronym? It is even conceivable that legislation will be initiated controlling family size. Mass vasectomies or other means of sterilization will become common in underdeveloped countries, but it is the assumption of many that the most pervasive and dynamic source of accelerating change is science and the multiple technologies that stem from it. Even if population growth were to come to a standstill in 1970, the ecological consequences of technological advancement may have already been too severe for a satisfactory recovery. Man's demands on the environment are accelerating many times more rapidly than the rate of population growth.

Any future increases in demand on local water works, for instance, will soon reach crisis proportions if ways of preventing this are not found quickly and efficiently. There are other major problems associated with increases in water demand. Growth does not begin to pay for itself in municipal taxes for a good many years. Many cities have strained their bonding capacities to the limit. Along with this goes the problem of increased pollution to streams. The urban wastes and sewage ride the waterways downstream to sister suburbias where the entire adulteration is compounded and sent on to the next inadequate treatment facility downstream. This shocking practice of imposing our wastes on the neighboring community has a longstanding tradition which began in the early days of urban development.

By the end of the nineteenth century, a standard credo had been established by the urban dweller--the solution to pollution is dilution. Man was thus deliberately, as well as unwittingly, emitting wastes into the environment. Waste control became keyed to waste transfer, the idea being to dispatch the wastes somewhere else. In an age of waste load devoid of recyclable containers, pesticides, hydrocarbons, and high BOD, this strategy is inevitable and encourages habits and attitudes that have proved hard to break. Under this logic, the environment as a dump has been considered a resource.

Over a century ago, Justus VonLiebig established a principle known as the "law of minimum." It says, in essence, that the size of a population or the life of an individual will be limited by whatever requisite of life is in the shortest supply. It is not yet clear what that requisite will be for the human population, but apparently a system of priorities will have to be established. A ledger of "tradeoffs" for the resources of the earth will be kept and man will sacrifice one commodity in favor of another. This is being done in the technological system today, but only in retrospect, and with awed amazement the technologists are realizing the impact of their advances. If a balanced ecosystem involving man and his environment is eminent or, more basically, if man is to survive his own pillage of the earth's resources, a "change of mind" as Mumford describes in Technics and Civilization must again take place. Modern technology can no longer rely on synergism and serendipity.

Mumford, in his description of the "Fourth Migration," marks the automobile, modern communication, and electric transmission as the most important factors which bear upon the new layout of population.[5] He paints a vivid picture of the physical forces which pattern the lifestyle of the urban dweller.

> . . . But, we are in the midst of . . . destruction . . .: the population explosion, the freeway explosion, the recreation explosion are all working toward the same blank goal--that of creating more and more featureless landscapes populated by more and more featureless people. Never before has any country possessed such surplus of wealth, food, energy, and natural resources as the United States. . . . But in addressing ourselves to the increase of power, profit, and prestige, we have failed to develop a varied, many sided culture, a culture based on the realities of life itself, on human growth in a biologically sound and socially stimulating environment, on a sexual maturation and a good family life, on a disciplined emotional expression in the arts and in the daily practice, or constant citizen participation in the public affairs of the community, for the sake of human association as well as for the practical and cultural ends. Rather, all our dominant forces today now tend to cramp and dwarf our life, to automatize and increasingly dehumanize our activities, . . .
>
> Now, where the machine takes precedence of the man, and where all activities and values that sustain the human spirit are subordinated to making money and privately devouring only such goods as money will buy, even the physical environment tends to become degraded and inefficient. . . .[6]

Mumford goes on to state that conditions cannot be improved without altering the prevailing view of life. If we want to improve the environment, we must ". . . change our minds and alter our objectives, advancing from a money economy to a life economy. . . ."[7] Vast corporations

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[5] Lewis Mumford, The Urban Prospect (New York: Harcourt, Brace & World, Inc., 1968), p. xvi.

[6] Ibid., pp. 4-5.

[7] Ibid., p. 13.

and powerful governments cannot be effective in preserving the environment; only people, after they have developed values, sensitivies, and new goals, will be able to insure a self-sustaining life--people capable of projecting human goals in the face of conditions favorable to exploit some immediate opportunity for power.

> . . . we shall have to overthrow the myth of the machine and replace it with a new myth of life--based upon a richer understanding of all organic processes, a sharper insight into man's positive role in changing the face of the earth.[8]

Rationale for This Study

The primary goal of this study is to identify factors that influence water requirements for domestic use, and to show how reductions in demand for water can become a practical reality. This necessarily implies a micro-level of investigation--the individual water uses. A brief history of development of water supplies in the United States presented in a later chapter will give a background for projecting changes in water requirements through changing lifecycles over a span of some 200 years.

The great prognosticator, Benjamin Franklin, developed the first public water supply system and left in his will in 1789 £1000 to each of the cities of Philadelphia and Boston.[9] The money was to be spent,

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[8] Ibid., p. 22.

[9] Nelson M. Blake, Water for the Cities (Syracuse, New York: Syracuse University Press, 1956), p. 11.

after drawing interest for 200 years, on public water works for those cities. Even in his most scrupulous calculations, Franklin could not have predicted the ineffable change in the lifestyle of the American people which was to occur. Franklin's experience with the disease-inflicted and crowded Philadelphia alleys told him that part of the answer to developing a stimulating living environment in the cities was to provide safe and plentiful water to each home. His ideas were visionary for his day and time, but in his conservative views of the simple life he could never have expected that a family would ever require more than enough water each day to boil potatoes and clean porringers.

Today, the average family, with automatic washer, dish-washer, two or three bathrooms, two cars, garbage disposal, air conditioner, three-fourths acre of lawn and shrubs, and all the conveniences of modern living, may use more than 1,000 gallons of water in a single summer day. At least 60 percent of this may be used during the hours between 4:30 and 10:00 p.m. Never is any thought given to the association of water with disease, nor to the fact that water may some day be available only on a rationed basis.

Modern design criteria for domestic use perpetuates this attitude. Politicians have seldom in the history of public water supplies considered the possibility of lower water use as a source of supply. Engineers have used the existing "rate of consumption" to calculate supply and reservoir capacity. The idea of a reduced rate of consumption seems unlikely as a possibility for future design. In other words, the basis for present design criteria is that maximum demand is the minimum draft requirement. All requirements for the future are based on lifestyle (gallons per person per day) and projected number of people, both of which are being upgraded as world goals.

In the past, this acceleration of production has been based on the assumption of unlimited resources or renewable resources, and that these resources are here for the benefit of man's natural needs: industrialization, expansion, and economic growth. The award structure has been associated with greater productivity, greater resources conversion, and a mythical "higher standard of living."

Ecologists have now entered the picture with some very startling calculations: space, air, water, food, energy, and life are finite. The impact of constant new production has been that the costs to society are outweighing the benefits. The primary determinant for the overwhelming domestic water demand is the affluent lifestyle of the contemporary western culture. The hypothesis of this study is that changing lifestyles, and the technological changes resulting therefrom, could produce acceptable designs for lower water use requirements. The results of decreasing demand will not only be new sources of water supply for urban areas, it will also lower concentration and accumulation of waste by-products which are disposed of in the natural waterways of this country.

Several mathematical models have been developed that are capable of incorporating the influence of forecasts for water requirements in urban areas. Reid has developed an extensive model which, depending on availability of local data, may be reliably used to develop projected needs for municipal water.[10] By utilizing existing data from a population, an economic model is produced. This consists of a population model and an employment forecast model. The function of the population model is to insert into the overall model the numbers of people by attribute. The employment forecast model supplies economic and employment data. Both of these models feed into the economic model proper. The total population and time is used via transducers to produce public sector requirements: health, education, water, etc. Cohorts are developed which can be used to provide additional desagregation of these values, and as a check to insure that requirements which are highly dependent on certain cohort characteristics of the population are satisfied.

Shift analysis is used to provide a comparative estimate of employment. Transducers are used to reduce the projections to public sector commitments. Technical coefficients are developed which provide the total summation of all population requirements for services. The computer is used to assimilate and analyze all the data simultaneously. This model can be used to develop projected needs for municipal water based on the projected population. The problem is that even though

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[10] George W. Reid, A Multistructural Demand Model for Water Requirements Forecasting, A Report prepared for the Office of Water Resources Research, Department of Interior, Washington, D.C., January, 1970, p. 254.

population estimates might be extremely accurate, the per capita usage of water cannot be determined exactly. Thus, the accuracy of the overall model is limited.

Urban water requirements are broken down into several distinct segments defined as follows: (1) domestic or residential, (2) commercial, (3) public losses, (4) industrial, and (5) rural irrigation. The component make-up used in determining the future water requirements of an urban area are basically municipal and industrial. Transducers which were developed for the Reid model were applied to each sector or component and, thereby, it was possible to obtain a sector requirement over time. Methodology for forecasting future sector parameters are based entirely on projection of historical data. This system, briefly, takes future sector parameters at some given point in time where these parameters are known and relates water demands to these parameters, thereby obtaining water requirements at some future time. It has also been assumed in the past that population growth can be expected to cause the unit use consumption of water in the municipal sector to increase about one to two gallons per capita each year based on historical figures.[11] In addition, this increasing demand is further explained by virtue of the fact that as a family's "standard of living" increases so does its capacity for water consumption. By applying mathematical formulation and scientific calculations to data of this nature,

[11] Ibid., p. 255.

water requirements have been calculated for future population on the basis of continuous increases as a public goal.

No model has as yet been designed which will predict the future water requirements under conditions of decreasing water use for these sectors. Furthermore, few planners are interested in pursuing this possibility. No structure exists which would allow for anything but "growth." In fact, if results of some study on water use should produce figures showing decrease in use, most analysts would interpret this as faltering economy.

By reviewing base requirements of the individual water user and fundamental concepts of engineering design, this study will inquire into the range of possibilities that exist for lowering water use, particularly in the public sector. It is possible that other solutions to water problems may result from a different approach to predicting water usage of the future by providing alternatives in lifestyle and physical facilities design which require less water consumption rather than increased water consumption. Figure 1 delineates this spectrum.

Fig. 1.--Alternative Demand Possibilities

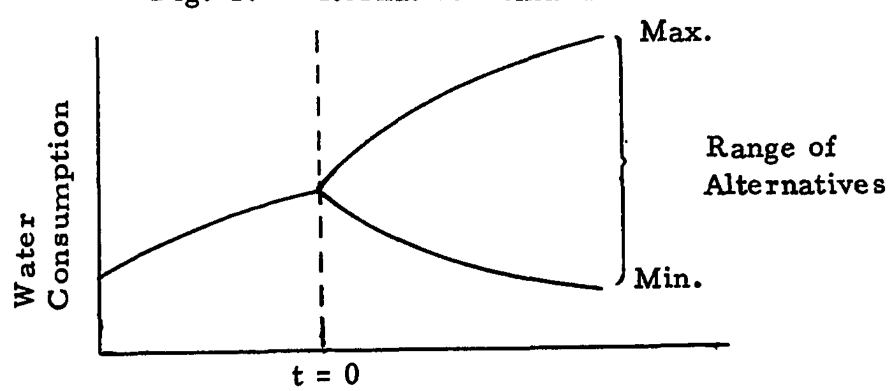

Table 1 considers the decomposition of average municipal use, illustrating the conditions where (1) all the water possibly needed is available, and (2) where re-use, recycling, and other alternatives are used. These are examples of factors relating to the socio-economic and lifestyle requirements of American culture.

TABLE 1.--Alternative Extremes of Average Municipal Use

	Alternative Extremes			
	Present (gcd)	Max. (gcd)	Min. (gcd)	Alternatives
Domestic	30	80	8	Re-use
Industrial	40	160	10	Recycle
Commercial	20	50	5	Air-to-air refrigeration
Public	10	20	0	Solid waste control
Irrigation	30	60	0	Artificial turf
Total	130	310	23	

Source: George W. Reid, A Multistructural Demand Model for Water Requirements Forecasting, A Report prepared for the Office of Water Resources Research, Department of Interior, Washington, D.C., January, 1970, p. 256.

If means could be found through design alternatives to reduce the per capita consumption of water to somewhere near the minimum requirement to sustain life, the water resources engineer would be concerned with a completely different set of ground rules for water resource planning. Suppose that, under the influence of technological planning, a new type of dwelling became available whereby individual water use could be greatly reduced without lowering the standard of living for the family. One immediate impact on engineering design might be the elimination of a collection and treatment system for human wastes, the primary purpose of which is to carry the abundance of wasted water from each dwelling.

Unfortunately, water resource engineers have not, up to this point, been allowed much room for visionary thinking, primarily due to their own primitive value system. Design criteria have been based on the past and have not allowed for predicted change in the future. Changes in the pattern of man's living must be made soon if man is to remain the dominant species on earth, changes which will very severely affect basic concepts for design.

The technological capability exists today to produce a family dwelling from which no environmental pollutants would be emitted, no wasting of the precious life support resources would occur, and living conditions and comfort could be enhanced. Moreover, a large portion of the American public is on the threshold of demanding exactly this ability to live within the ecological structure of nature. More pleas for clean water and clean air are coming from people, young and old.

Skeptics of such a scheme ask "Why bother when it is so simple to provide all the water anyone needs under present conditions and equally as simple to carry away the wastes?" Some data have been compiled in subsequent chapters of this study which will refute this attitude. If it is possible to impose a concern for future generations and welfare of the environment, the justifications are clearly delineated.

The individual home is perhaps one of the most remiss in fouling the environment and wasting its resources. The reluctance of water resources engineers to consider the individual home as a problem in water conservation is, no doubt, related to the practice of allowing private entrepreneurs to essentially control the housing industry. This segment of free enterprise may well be too costly to the environment to be allowed to continue.

The modern-thinking members of the architectural profession, which has for two generations completely ignored the challenges of individual housing design, are now raising their voices in support of a new dimension for housing. New architectural concepts include basic structures that will be a part of the social organism and will no longer be the hurried post and beam construction, look-alike houses in endless rows which have assaulted the cityscape. Water resources planning can have an enormous influence on the total success of a housing revolution. Solutions to water conservation problems can be found in providing alternatives in lifestyle and physical facilities design which require less consumption rather than increased consumption.

Unless some species other than homo sapiens becomes the dominant species of life on earth, modern man must come soon to (1) recognize the threat, (2) begin changes in attitudes and values, and (3) translate a new consensus into a structure capable of implementing it.

CHAPTER II

THE CONDITION OF THE CONTEMPORARY AMERICAN ENVIRONMENT

Technology and Environmental Quality

Because of the lack of technical ability to read it, the threat to man and his fellow earthly creatures posed by the absence of ecological consciousness has probably not been fully apparent until the present. Environments have been altered on a large scale by man, but in shaping environments, man has seldom foreseen the full consequences of his actions. With annoying consistency, man has misread many of the most conspicuous consequences of his impact upon the environment. Even with the data supplied by rigorous scientific study, the modern tendency has been to deal with environmental problems segmentally through specialists whose frequently conflicting judgments require compromise or arbitration. It has also been difficult to apply the competence of experts to comprehensive public policy. All too many administrators see policy in terms of their own immediate responsibilities and are not sensitive to the effect of their actions on a larger ecological scale.

The "Space Ship Earth" concept has given us an excellent projection model of the human conditions on the planet earth. There are, no doubt, many differences between life on earth and life in a space ship. However, each has limits as to the amount of stress it can tolerate without ceasing to be life supportive. The price for survival in outer space is the maintenance of this life-sustaining system on the space ship. On earth, man has behaved as if the terrestrial space ship were infinite in carrying capacity and in ability to absorb abuse. The fact that science has now given man a free hand to manipulate his environment with impunity has caused him to neglect the cumulative and long-term effects of his impacts on earth, convinced that technology can bail him out of any difficulty, and has eliminated his concern with preserving the viability of the environment. As the subsequent discussion will point out, this unceasing romance with technology may well be the very proverbial "straw" that, in the end, breaks the camel's back.

The accelerating demand on all resources resulting from technological advances; from increasing populations and their needs, expectations; and increasing demand for more production; is causing the more enlightened thinkers among our scientists to ponder these realities. They are beginning to realize that we have both the occasion and means to make bigger, more disastrous, and more irreparable environmental mistakes than ever before. They have seen the death, in effect, of Lake Erie. According to a recent report by a Committee of the National Academy of Sciences, within about twenty years city wastes are expected to overwhelm the biology of most of this country's national waterways.[1]

It has now been predicted by notable biologists that even the oceans may not be powerful enough to sustain the onslaught of technological abusiveness. Jacques Cosbeau, one of the world's most famous undersea explorers, has predicted the death of the oceans within the next half century unless industrialized countries "tame competition" and cooperate to save them.[2]

On the other hand, many of the capabilities that have enabled man to degrade and destroy his environment could, if applied with wisdom, enable him to manage the environment for the general welfare of man and his planet. "Wisdom" in the application of technology is the key to the future. However, the mere capability to solve our environmental problems does not insure that these problems will in time be solved. More laws on pollution are not the answer to total security of environmental welfare. A new insight into cause and effect must be conceived and accepted by society.

A new sensitized lifestyle, or "consciousness," as Reich describes,[3] must take place in the mind of the public before the momentum can be overcome. In Reich's concepts, Consciousness II people look at

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[1]Paul B. Weisz, The Contemporary Scene (New York: McGraw Hill, 1970), p. 294.

[2]News Release, "Death of Seas Predicted," Associated Press, October 18, 1971.

[3]Charles Reich, Greening of America (New York: Random House, 1970).

traffic congestion on the freeway as merely a factual event. Some, depending on the specialized character of their interests and perceptions, may see problems of urban design, metropolitan government, or public finance. However, to the Consciousness III person, the congested freeway also is viewed as a problem of man/environment relationships. Until an enlightened citizenry, the only effective originator of a coherent political philosophy for human needs, reacts in a positive way, no sound and lasting environmental policy can be developed.

Time is running out. " . . . Accumulating evidence records accumulative abuse of the earth to a point that requires prompt and effective ecological management if . . . [man's] . . . voyage through space is not to be drawn to an untimely end."[4] Environmental abuse is now at such a state of intensity that " . . . very little effective work can be done short of one to three generations. . . ."[5]

Unless a universal effort is made in the 1970's to redefine the ancient philosophy, ". . . be fruitful, and multiply, and replenish the earth, and subdue it; and have dominion . . . ,"[6] " . . . it will not matter whether man does or does not lead a meaningful life in a good society, and it will not even matter whether the races or nations do or do not make love or war; for there will not be enough left of man to worry about."[7]

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[4]Caldwell, Environment, p. 92.

[5]Weisz, Contemporary Scene, p. 292.

[6]Genesis 1:28. (RSV).

[7]Weisz, Contemporary Scene, p. 279.

We must bring the human population of this planet into balance with its resources and learn to avoid fouling our environment so that we make possible for every man, not merely an animalistic survival, but a life that permits the enjoyment of basic human values, the beauties of nature and art, and the flowering of individual creativity. One of the keys to coexistence in a conflicting environment is water. If we can clean up and maintain unpolluted waterways, many of the competing values will be eliminated.

Relations of Environmental Quality to Problems of Public Administration

With the preponderance of writings available on the ecological issues, it is difficult to remember that prior to the 1960's no clear-cut concept of public responsibility for environment existed. It therefore follows that concern for the quality of the total environment has been the business of almost no one in public life. It became evident during the decade of the 1960's that conditions of the environment were inevitably becoming issues for public responsibility. The Ninetieth and Ninety-first Congresses introduced and debated a number of bills which set precedence for accepting environment as a legitimate focus for public policy in the United States. The National Environmental Policy Act of 1969 signaled the beginning for government to provide a basis from which the environment could be legally enhanced.[8]

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[8]Caldwell, Environment, p. 10.

What was still lacking, however, was the popular consensus as to the direction public action would take. There was abundant activity among the more vocal segments of society as to how public responsibility should be implemented and how specifics, such as costs, should be allocated. Two basic viewpoints are involved in public decision-making regarding natural resources: the "market" view and the "ecological" view. The first view sees the relatively free play of economics and political forces as the most feasible determinant of environmental policy. The latter view sees the natural world, including man, as dependent for survival upon the maintenance of the delicate balance of nature.[9] Unfortunately, the operation of official bodies, whose decisions are usually charged with conflicting values and pressure from special interest groups, results in no acceptable guideposts for determining "public interest." Environmental issues which affect water, air, life, and natural resources are not exempt from political frailty. Because of these realities, public officials have made rationalizations and compromises resulting in decisions which jeopardized the public interest.

The environmental quality movement is and will continue to be very heavily dependent upon the aroused determination of organized citizens for its political strength. Unfortunately, the future prospects of environmental quality are still only vaguely perceived in the minds of most individual citizens. As with many propositions involving the pocket

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[9] Ibid.

book, there is a bias in defining the idea of "quality." Few citizens will readily support the strict requirements of "operational" environmental quality. When, for example, businesses are hurt from restricting roadside advertising or sales of speculative real estate, popular opinion for environment has notably diminished. Fortunately, there are indications of a change in American attitudes. Increasing knowledge regarding the disruption of natural space has kindled new attempts at planning and administration. The experimental new city projects and the new concern of the youth for environment are reassuring signs that public attitudes may eventually change.

The growth of sound environmental policy can take place only if two other developments evolve. First and foremost, the individual citizen must begin to see the comprehensive environment as a legitimate and necessary field for public action. Second, means must be found for more effectively organizing public institutions and agencies in relation to their responsibility to environmental quality. The second is not mutually exclusive of the first. We will not easily find the answers to positive environmental development and control until legislative, organizational, and administrative political efforts can be intelligently directed. The direction must come from the people. This is not an axiom of government; it is an axiom of life.

The City: Ecological Disaster Area

Following World War II, the ideas and values of the American public were self-centered and personal rather than social. The returning G.I. was ready to settle down with a good job, a house in a quiet neighborhood, good food, a share of the consumer goods, and a little leisure to raise his family. In retrospect, there were just two things wrong with this attitude: (1) it laid its main emphasis on personal satisfaction; (2) the exclusive preference for personal or private satisfactions over public needs insured that environmental quality would suffer. Result: autos, not balanced transportation systems; houses, not habitable close-knit communities; school buildings, not good instruction. Conscious and piecemeal selection of material things, which had been denied during the Depression, was more important than the larger interrelated system.

The uninspired political leadership in the cities was reflective of the apathy of the citizenry. The auto made it possible for the middle-class blue- and white-collar worker to live in the suburbs while the slow rot of the inner cities took place.

The plans and prophecies of Lewis Mumford were ignored.[10] The narrow perspective of the postwar conservative movement encouraged the urban sprawl and industrialization that would foul the air and waterways. The bulldozers, billboards, and factories were the banners of postwar progress in the cities. Easy assumptions were made that the

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[10]Lewis Mumford, The Condition of Man (New York: Harcourt, Brace and Co., 1944.

minorities in the inner city would remain content as second-class citizens and that a progressive and affluent country had to be filthy and polluted.

The postulation of Dansereau, known as the Law of Persistence, states: many species, especially dominants of a community, are capable of surviving and maintaining their spatial position after their habitat and even the climate itself have ceased to favor full vitality. The industrial cities of America are cores of human persistence.[11] There are environments in these cities which are conceded to be dangerous in many respects for human habitation, yet city government has not dealt with these areas ecologically. There has been increased police surveillance; insurance rates have increased; but the environment is accepted, and little effort is made to transform it. Urban renewal could be cited as an attempt to change human ecology, but no urban renewal project in America to date has successfully created a new environment without problems as severe as the old ones. Former problems have not been solved but merely displaced to some new locality. Local communities throughout the nation have been struggling with problems of housing, schools, water supply, waste disposal, transportation, recreation, and urban renewal. Still the decision-makers of the cities fail to think in environmental terms.

Economic "needs" are the most widely-accepted rationalization for justification of exploitive use of the environment in the name of progress.

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[11] Thomas R. Detwyler, Man's Impact on Environment (New York: McGraw Hill, 1971), p. 5.

The congested megalopolis exemplifies this nonsense of economic necessity. An example is the spiraling cost of real estate in the urban centers. There is no intrinsic value to the land in lower Manhattan. Its economic value is social. New York cannot afford open space or conservation of aesthetic amenities. On the other hand, one could argue that human needs for open space in the heart of a populous city could make the land too valuable to build upon, but society has no operational way of making this need effective.[12]

It become soberingly clear in 1965 that the persistence of the cities' industrial behavior patterns had brought about circumstances in which environment was to become a factor in public policy when, in the summer of 1965, for the first time since Sherman's march to the sea, our cities had been put to the torch.[13] The seeds of those hot summers that followed were planted by public policy to keep a whole race in an inferior state by approaches to economics that accepted poverty and slums as inevitable, and by national default of conscience that produced a degraded society and a destroyed environment.

Why has the greatest science-centered society in history not developed a science of human settlement? Why is our industrial complex able to send rockets to the moon, but unable to renovate the environment where we now live? And we wonder why our children do not accept our

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[12]Caldwell, Environment, p. 129.

[13]Watts, California, 1965.

value systems.

Such planning as has taken place has been dictated by the short-term economics of the market place and by engineers that do not consider basic human needs. Decisions on transportation, land use, and water resources have not exactly been quality-of-life centered.[14] The misuse of the water estates around the cities is a case in point. With the most superb water-based sites for cities in the world--San Francisco, New York, Seattle, San Diego, Chicago, Boston, St. Louis--the American push for economic progress has squandered these great assets. New York has more waterfront than any city in the world, but untreated sewage, misplaced highways, and rotting clutter have cut off New Yorkers from their own shoreline.[15] Moreover, the speculator-developer who carves up the countryside with planless urban sprawl is looked upon as an honored agent of "growth and progress."

As long as local government is dedicated to the proposition that any growth is acceptable, it will be extremely difficult for any new approaches to planning to be accepted. Even gas stations and drive-in restaurants have less problems getting zoning changed than new cluster development neighborhoods which do not meet the provincial ordinances.

In 1968, some noted demographers predicted that on the

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[14]Stuart L. Udall, 1976: Agenda for Tomorrow (New York: Harcourt, Brace & World, 1968), p. 48.

[15]*Ibid.*, p. 32.

bases of past growth, American population figures would reach 300 million well before 2020 and probably a billion by 2080. A great many government and business analysts unquestioningly accepted this assumption as a major factor for national planning. So widespread is this way of thinking today that it is taken as a fact of life. To suggest that there could ever be too many Americans is inviting suspicion of one's patriotism and faith in democracy.[16] To suggest that a new form of economics and a new view of life is possible is also preposterous. Only hippies and ecology freaks discuss such absurdities.

An Enlightened American Middle Class?

One interesting new viewpoint on society has been derived by B. F. Skinner, the world-famous Harvard psychologist. He has predicted a drastic cultural redesign for the American public. He postulates that citizens must be sensitized through the media to ". . . give up individual rights. . . ."[17] A vast system of behavioral controls will be designed to reinforce altruistic behavior and eliminate selfish behavior, which he claims is the cause of war, over-population, and pollution.[18]

Reich has identified societal characteristics in his Consciousness II level of human behavior which believes in the central ideology of

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[16] Ibid., p. 45.

[17] "Brave New Behaviorism," Newsweek, September 20, 1971, p. 95.

[18] Ibid.

technology, the domination of man and environment. Society functions best if it is planned, organized, rationalized, and administered.[19] Confront men of Consciousness II with any list of evils and the response is cheerful. They see signs of improvement. They compare the present favorably with the evils of the past which have been overcome. The problems of America can be solved with material progress, expanded technology, is their belief. They have heard it said by experts on television.

Both of these views of society see the corporate state running smoothly by means of willing producer and willing consumer, who desire what the state makes him want. The citizen is sensitized by television to believe what the state knows he should believe. Above all, produce, progress, and grow. No one is supposed to step forward to ask, "Who will determine what is best for me?" Everything in America today is designed for a white, middle-income male, age 18 to 25, exactly six feet tall, weighing 185 pounds.[20]

Suppose the values of technology and progress which have remained unquestioned are challenged. Suppose "progress" were to somehow be subordinated to the values of ecology and conservation. Suppose a significant segment of the citizenry suddenly became Consciousness III. Under such circumstances, the corporate state vanishes. People

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[19]Reich, Greening of America, p. 69.

[20]John Kenneth Galbraith, "The Economics Revolution," The Tulsa World, March 1, 1970, p. 12.

are no longer dominated by the machine. The change in consumer motive has a tremendous immediate impact. They buy only those things which satisfy real needs, not the needs invented by industrialists. The consumer regains power over what is produced.[21]

The national environment is being steadily destroyed by the works of man and a mere change of opinion or politics is not enough to reverse the action. ". . . If we decide that there should be more conservation, but at the same time believe in the basic value of economic and technologic 'progress,' no program for conservation will be effective; conservation will always be too expensive or contrary to public interest. . . ."[22]

The conflict of philosophy here is between authorities who preach greater control of individual freedom and those who believe that complete freedom is possible and desirable. The youth movement in the universities and colleges across the world has, perhaps, a significant role in generating this conflict. If the change to Consciousness III is not reversible, as Reich predicts, the maturing of today's youth may bring some interesting developments in American culture.

The Engineering System in the Public Sector

Scientists have no special qualifications for formulating goals

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[21] Victor Papanek, Design for the Real World (New York: Pantheon Books, 1971), p. 10.

[22] Ibid., p. 316.

for society. Their training and interests are exceedingly narrow. Their exposure to social/cultural problems is usually limited or nonexistent. Yet scientists and engineers play significant roles in determining what is feasible, what kind of knowledge is required, and what are the likely consequences of various courses of action.

Much of scientific research is governed by social needs. Knowledge of what these needs really consist should be defined in a much more sophisticated manner if science is to more adequately fulfill its social role.[23] More research should force consideration of basic value questions: what is a "good" environment, what kind of environment should be sought, what data are valid indicators of interacting effects on environmental factors and people?[24] Several criterion have been adopted by engineers in the determination of social needs, for instance, the "higher priority" criterion. The political power structure dominates in the case of military as opposed to civilian pre-emption of resources, and economics takes preference to industrial over individual considerations. The "multiple use" criterion seems a logical determinant for serving environmental interests, but here again the value variable in benefit-cost analysis is always associated with economic value. The "benefit-cost" system is a third criterion, but the method of calculating

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[23]Rene J. Dubos, "Scientists Alone Can't do the Job," Scientific Review, December 2, 1967, p. 69.

[24]Caldwell, Environment, p. 22.

costs and benefits is no more valid than are the analytical techniques which are incorporated. Intentional or inadvertent misuse or misjudgment of value is an inherent flaw in this system. Complete objectivity is impossible.[25] Engineers are often so intent in their self-made problems that they cannot detect problems of human life. ". . . Witness the kind of irrational justification given for the manned space program. This most sophisticated scientific-technological effort is, in fact, supported by a total rejection of reality. . . ."[26]

There is still another viewpoint on technology that was mentioned at the beginning of this chapter but has not yet been explored. Perhaps it is possible to create the intellectual atmosphere for the kind of complex ecological thinking that will be required if conservation is to become more than a sentimental word. The definition of ecological imperatives which can make conservation goals viable do require scientific knowledge, but not the kind of scientific knowledge our school systems presently develop.

The prospect of the eventual depletion of the natural resources of the earth could undoubtedly be well-served by a technology whose task would be to discover alternate designs which would affect a decrease in the use of these resources. At present, the educational system is tooled for teaching only the science of increasing production which requires more energy, water, air, space, materials, and stress.

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[25] Ibid., p. 10. [26] Dubos, Scientific Review, p. 69.

A revised goal for education would be to develop the kind of science that would help in preventing the destruction of environmental values with which human values are enmeshed.[27] It could, perhaps, prevent the day from coming when all the natural resources of the earth are gone.

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[27] Ibid., p. 71.

CHAPTER III

WATER USE IN THE AMERICAN CULTURE

The total amount of water used in the United States in 1900 for all purposes, including manufacturing, irrigation, food production, and human consumption, was about 525 gallons daily for each American citizen. In the first sixty years of this century, the total use of water per person nearly tripled to 1,500 gallons. At the present rate of increase, it is expected that water consumption will reach almost 2,000 gallons per capita by 1980. Roughly 50 percent of the consumption is for artificial irrigation and does not include use of rainwater by crops. Some 97 percent of the world's water is stored in the oceans and has a chloride content too high to make it usable for practical purposes. Of the remaining 3 percent, which is fresh water, almost 98 percent is tied up in the ice caps. Since freeing this water would not be feasible, there appears to be no practical way to increase the total supply of the worldwide water for consumptive use. Some of the water in the hydrological cycle is subject to reuse and is reused up to fifty times in some river systems. However, the huge amount of water required by living plants is returned to the hydrologic cycle directly and cannot be reused by man immediately.[1]

This rather small total supply of fresh water is now being reduced. Man is removing fresh water from the continents faster than the hydrologic cycle replaces it. It is estimated that North Americans take about twice what the hydrologic cycle returns to accessible reservoirs. Ground water reserves are being depleted at an increasing rate and will soon fall below that necessary to meet withdrawal demands. Similar shortages will occur in many areas of the world, and a number of notable scientists are anticipating a worldwide crisis unless alternative measures are taken.[2]

Even though the water demand does not reflect the disappearance of water, this over-use has other ramifications which are significant in the policy determination for water usage. It is impossible to remove all impurities under present treatment methods, and these impurities become concentrated as the water is used over and over. For instance, chemical and biological changes, known as eutrification, have occurred in all the Great Lakes except Lake Superior. These changes, characteristic of small lakes but remarkable for such large lakes, have come about over the relatively short time of fifty to sixty years. Man's activities clearly have accelerated the rate of eutrification. This acceleration has been greatest on the lakes near the largest population growth.

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[1] Paul and Anne Ehrlich, Population Resources: Environment Issues in Human Ecology (San Francisco: W. H. Freeman, 1970), p. 64.

[2] Ibid., p. 65.

Also, ground water may derive a wide variety of materials from man's waste-producing activity. Chemical characteristics of normal ground water may be increased in concentration from the degradation of organic solids in human and industrial waste, and from storage, transportation, and use of water for irrigation and industry. If fractures or fissures bypass the biologically active mantel of the earth and lead water directly from the surface to the ground water, micro-organisms may join the soluble chemical. The most serious current hazard of man's activities lies in the build-up of salinity in the ground water to levels which could render water useless to all the beneficial uses to which such water is put.

Under our existing state of food production technology, the giant users of water for life consumptive purposes potentially are still the most thirsty. Their ultimate demands upon available stores of water can be enormous. The most pressing factor limiting the capacity of the earth to support the spiraling population is the supply of food. However, there are many disparities between demands for water services and the water supply available, both locally and on a worldwide basis. It is toward the lessening of these disparities that engineers should be directed.

By examining the fundamental characteristics of water use, it will perhaps be possible to gain some insight into available alternatives for water consumption.

Historical Background of Water Development in American Cities

> The domestic use of water is universally classified as the most important beneficial use of that resource. Water is essential to life--the life of a city as well as the life of a human being. Without water a man dies. Without water a community faces the same fate.[3]

Suppose that through some strange act of sabotage, New York City or any other great city were to be deprived of its entire water supply. The results would not be instantly as horrifying as the explosion of a hydrogen bomb, but the eventual disaster would be almost as demoralizing to urban life. The complete confusion and fear into which a modern city would be plunged by the loss of its water supply is evidence of the peculiar dependence of the urban American upon the day-to-day delivery of safe and adequate water for his slightest whim. Yet, without it cities simply could not exist.

In 1790, American cities drew their water almost exclusively from springs, wells, and cisterns--sources that became steadily more inadequate as the population grew. By 1860, most cities had learned a great lesson. No longer could they depend upon internal sources of supply; at whatever expense or difficulty, they must impound the waters of outlying lakes and rivers and bring these life-giving streams through aqueducts and pipes into the very homes of their citizens.[4]

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[3]U.S., Congress, House Committee on Interior and Insular Affairs, The Physical Basis of Water Supply and its Principal Uses (Washington: 1952), p. 52.

[4]Nelson M. Blake, Water for the Cities, p. 2.

City life in the 1790's was not all profit and pleasure. The dangers of fire in the closely-built streets and alleys was a constant threat, and the activities of volunteer bucket brigades and primitive hand-pump engines were ineffective. Firemen were often badly handicapped when the fire occurred at a location where abundant wells or river water were not available.

The greatest threat to the lives of the city dwellers, however, came from disease. Epidemics of smallpox, yellow fever, and others were common long before the 1790's, but the great yellow fever epidemic of 1793 in which over 4,000 deaths occurred overshadowed all previous American experiences.[5]

After no less than three similar attacks of the dread disease in 1794, 1797, and 1799, the city became involved in the initial attempt at public health practices. Along with quarantines and other legal restrictions, city officials began to look at the dangerous accumulation of filth in the streets. In 1794, the city council ordered five water carts to be provided for the regular watering and cleaning of streets.[6]

Although primary importance was still placed on increasing the quantity of water, a few men began to insist that the water supply should be pure. In October, 1798, the Board of Managers of the marine

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[5]J. H. Powell, Bring Out Your Dead (Philadelphia: University of Pennsylvania Press, 1949), cited by Blake, Water for the Cities, p. 8.

[6]Blake, Water for the Cities, p. 9.

and city hospitals recommended that the city commissioners ". . . have the pumps frequently and copiously worked as the water is extremely offensive and unwholesome. . . ."[7]

Eventually, the American city dwellers grew suspect of the community wells located adjacent to cemeteries, cess pools, and stagnant ponds. A few attempts were even made to improve the public water supplies; one of the earliest was that of the Massachusetts General Court in 1652. This Boston enterprise consisted of the construction of a twelve-foot-square reservoir fed through bored logs from nearby wells and springs. In 1754, a group of colonists at Bethlehem, Pennsylvania, constructed a system of water works supplying every house with piped water. Later, a few of the colonists moved from Bethlehem on to Salem, North Carolina, and in 1786, brought water a mile and a half through conduits to its citizens.

In 1772, two private companies constructed a system of bored wooden logs to bring water from springs about a mile from town to the inhabitants of Providence, Rhode Island. In 1774, a very ambitious project was initiated to construct a system of water works for New York; however, before this could be accomplished, the British occupation of New York as a result of the Revolutionary War halted the project.[8]

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[7]Currie, Memoirs of the Yellow Fever, p. 108, cited by Blake, Water for the Cities, p. 11.

[8]Blake, Water for the Cities, p. 16.

The technical knowledge for building of water works was thus available. What was now required was for the city dwellers to abandon their traditional rural institutions and provide the more complex structure necessary for urban life.

During the first half of the nineteenth century, a great number of American urban centers began development of municipal water systems. By 1860, the sixteen largest cities of the nation, each having 50,000 or more inhabitants, were served with some kind of water works. Including the smaller cities, there was a total of 136 completed by that year.[9] In the largest cities--Philadelphia, New York, Boston, Baltimore--water consumption increased so rapidly that by 1850, citizens of each of these cities were again worrying about the adequacy of the community's supply.

The City of Boston had completed its great Cochituate aqueduct project in 1848 after opponents had argued that a plan for a daily consumption of 7,500,000 gallons was visionary. By 1853, the average daily consumption was 8,542,000 gallons. The problem was not increased users, but that each family used so much more than had been predicted. The Water Board complained that two-thirds of the water was wasted. Hoses and primitive toilets ran day and night. Especially wasteful was the habit of allowing faucets to run wide open all night when the threat of freezing pipes occurred. So widespread was this practice that during an especially bad spell of January weather, two inspectors were appointed

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[9] Ibid., p. 267.

to patrol the streets at night listening for sounds of running water in the house.[10]

In a day when water meters were practically unknown, the wasting of water could not be checked. In the long run, increasing urban consumption of water reflected not so much willful waste as higher standards of living. Bathtubs, shower baths, and water closets contributed greatly to the rapid increase in water consumption in the late 1800's. At the turn of the century, enormous quantities of water were required for the beginning of the Industrial Revolution. Introduction of modern household appliances such as washing machines, automatic dishwashers, garbage disposals, air conditioning, and the new practice of lawn sprinkling became an American way of life. The rate of consumption of water in America had no parallel in European cities. By the late 1930's, the average per capita use in ten major European cities was thirty-nine gallons per day. In ten similar American cities, the rate was 155 gallons per day.[11]

Boston, like most other large cities in their early expansion, annexed a number of smaller adjoining towns forming the Metropolitan Water District in 1895. After several attempts at developing sufficient water resources, the great Quabbin Reservoir, consisting of 74,886 acres covering twelve towns and three counties, was constructed. The new works increased the safe yield from 133 million gallons to 330 million.

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[10] Ibid., p. 268.

[11] Ibid., p. 270.

Baltimore constructed the Gunpowder River Dam in 1881, giving the city a supply totaling 150 million gallons a day. At the time, New York's supply was 100 million and Philadelphia's 50 million. By 1910, however, Baltimore required an even larger supply. In 1918, Baltimore annexed fifty-six square miles of adjoining suburbs. Steps were taken to enlarge the system, but the great drought that began in 1929 was almost disastrous. In 1943, the citizens finally voted a $12.5 million bond issue to increase the supply to 243 million gallons per day.[12] Philadelphia did not appreciably solve its water problems until the Delaware water project in 1945 increased the average supply to 500 million gallons per day at a cost of $285 million.[13]

The consolidation of the Greater New York City doubled the city's population in 1889 to three and one-half million persons with an average daily consumption of 372 million gallons. During the years between 1900-1910, immigration increase to the city alone was over one and one-fourth million. After a tremendous political battle and one serious water crisis after another, construction was begun on the Delaware Aqueduct in 1937. The work was still in its early stages when World War II halted construction. Citizens paid little attention to the mayor's appeals to conserve water until a serious drought in 1949 began to frighten them into action. Restaurants served water only upon request; automobile owners were forbidden to wash their cars; new regulations regarding air

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[12]Ibid., p. 274. [13]Ibid., p. 276.

conditioning and refrigeration were laid down; house-to-house inspections to determine leaky faucets were authorized. Friday, December 16, was proclaimed Dry Friday; consumers were asked to reduce water consumption to a minimum; men were requested to forego shaving. So successful was this experiment that Dry Thursdays were observed for the next six months. For the first time in history, the city's water consumption was actually reduced.[14] When the Delaware Aqueduct was finally completed in 1955, it stretched eighty-five miles and increased the safe yield to roughly 1.5 billion gallons per day.

The entire northern coastal region was experiencing difficulty in obtaining adequate supplies, and the ever-expanding population made clear the ultimate decision that a source of water supply must be planned on a regional basis. The Interstate Commission on the Delaware River Basin (INCODEL) was formed to develop a plan for providing the future megalopolis with water.

Stage one of the INCODEL plan was to build a reservoir in the Delaware Water Basin large enough to serve New York City and the cities of northern New Jersey, while releasing water during late summer and fall for low-flow augmentation. Stage two, which proposed three additional reservoirs on the Delaware and its tributaries, would serve Philadelphia, southern New Jersey, and also increase the available

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[14]*Ibid.*, p. 281.

supply for New York City.[15]

On the other side of the continent, the arid southern California country began to experience the same urban development problems. In 1913, the famous 233-mile-long Los Angeles Aqueduct began to serve that city. By 1927, Los Angeles had annexed over 250 square miles of adjoining territory and a water crisis threatened. It was this situation, together with the need for irrigation and hydroelectric power throughout the Southwest, that led to the great Hoover Dam project completed in 1936. The 242-mile Colorado River Aqueduct was built in 1941.[16] The Metropolitan Water District of Southern California totaled a 4,000,000-person jurisdiction covering 1,600 square miles by 1950. Distribution of water to many cities within the district increased the Colorado River Aqueduct to 392 miles, making it the largest in the world. The Los Angeles aqueduct now stretched a distance of 350 miles.[17]

These great public works, impressive as they are, still do not satisfy the tremendous rivalry for priority for water for irrigation and domestic use. Engineers are constantly debating the possibility of desalting, recycling, or milking the clouds. As early as 1953, Paul Baumann remarked:

> In 1950 consumption of potable water in the United States reached an estimated level of 170 billion gallons a day, or some fifty-eight cubic miles per year. During the same period

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[15]*Ibid.*, p. 284. [16]*Ibid.*, p. 286. [17]*Ibid.*, p. 287.

the usable volume of water produced by rainfall was only about fifty cubic miles.

This means that the water consumed in 1950 was 116 percent of the water produced, and this means our national water resources account was overdrawn. . .[18]

Classification of Water Use

Withdrawal Use

The minimum life-sustaining needs of humans for water are relatively small. An individual probably could get along comfortably on one gallon a day for drinking and cooking.[19] However, civilized life-styles demand much more. Table 2 shows how water is used in the average American city home.

TABLE 2.--Water Use for Domestic Purposes

Activity	Per Capita Use Per Day 1950	1965
Drinking, washing, laundry, face and hand, water closet	19 gal.	40 gal.
Three-minute shower	15	20
Other (car wash, lawn, garden)	16	30
Total	50 gal.	90 gal.

Sources: Compiled from Nelson M. Blake, Water for the Cities (Syracuse: Syracuse University Press, 1956), p. 622; George W. Reid, Lecture, "Water Supply and Sewerage," 1967, Table 1.

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[18]New York Times, March 17, 1953, cited by Blake, Water for the Cities, p. 287.

[19]H. E. Jordan, "The Problems That Face Our Cities," Water, The Yearbook of Agriculture, 1955 (Washington: Government Printing Office), p. 651.

In 1950, public uses, like fire control and street washing, added another ten gallons per person; commercial and undifferentiated industrial uses, twenty gallons per person more. System loss was ten gallons. Thus, the average urban dweller in 1950 was part of a household, public order, and trading system which demanded water at the rate of ninety gallons per capita per day. By 1965, this figure had increased to 150 gallons per capita per day.[20] Of this amount, only 10 percent actually disappeared; 90 percent was returned to water courses or to ground water.

The largest disappearance of water for life uses from concentrated supplies is for irrigation. Roughly 60 percent of the irrigation water is returned to ground water or stream flow after application to crops or pasture.[21]

The vast amount of water used by non-irrigated plant growth on farm land still may be much less than crop and pasture plants might use if they received the amount of water optimum to their growth. As agricultural methods and irrigation improve, this consumption and loss may greatly increase in order to feed the masses of eventual inhabitants of the earth.

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[20]Udall, 1976: Agenda for Tomorrow, p. 51.

[21]This estimate is a rough figure and the range of irrigation efficiency probably is somewhere between 50 and 70 percent. See K. A. Mackicham, Estimated Water Use in the United States, Circular No. 398, U.S. Department of Agriculture.

Few common industrial products are manufactured without employment of amounts of water which weigh many times more than the finished material itself. Water is used as a solvent or dilutent; as a medium of flotation, suspension, and heat exchange; and in many other ways. Except air, it is the medium of largest volume moving through factories. An applicable illustration is the volume of use in manufacturing the average automobile. The ton of steel requires 285 tons of water in its conversion from iron ore. About 115 tons more are used for processing plastics, textiles, other metals, etc. Thus, each automobile means the withdrawal of about 400 tons of water in its manufacture.[22] However, disappearance of water from industrial use is still far below irrigation in its demand from concentrated supplies.

Flow Use and On-site Use

The withdrawal uses are only part of the services given by water. Water requirements for navigation, energy production, support of fish and wildlife, recreation, and waste carrying constitute an important segment of the nation's water account. All of these water uses, except waste-carrying, occasion comparatively little water disappearance and very little change in quality. Energy production by nuclear reactors, however, may become significant from the standpoint of thermal pollution

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[22] P. Weir, "Public Water Supplies in the Future," Journal of the American Water Works (1956), 755.

in the near future unless innovative means are incorporated to improve this inefficiency.

Flow and on-site water uses are significant in water demand because they present certain aspects of conflict with consumptive uses. For instance, waste-carrying may make water unfit for consumptive use; the quality of water for domestic, industrial, recreation, and fish life may be decreased when a stream is used as a waste carrier.

Water's great versatility in use, therefore, gives its demand more dimensions not encountered in the demands for other commodities. Conflicting uses and disappearance through use of water present some challenges in determining alternatives for water use concepts and lifestyle changes. The potentiality for running out of water distinguishes it from most other economic production functions.

Demand and Supply

Timing Discontinuities

A number of important variables effect the demand for water which may or may not correspond to its availability. For instance, most water uses are not of continuously similar extent or intensity. The water level in surface or underground reservoirs may vary inversely to demand, causing shortages at different periods of need. Even under the most extreme drought situations, irrigation water is demanded only during the growing seasons. Of course, in the southern states this may be almost year-round. In Nebraska and Minnesota, it may be ninety days or less. Even within the growing season, water is not required over the entire priod of crop growth. Demand for other water services is, on the whole, more constant than irrigation. Domestic water supplies are needed in winter no less than in summer except for lawn and garden watering. Most industry seeks a schedule of continuous production. Demands for electric energy tend to peak in late autumn or winter. Use, as distinguished from demand, shows seasonal characteristics reflecting the unusability and tends to force adjustment of demand to availability.

Long-range discontinuities have been much more difficult to treat than seasonal discontinuities. The basic problems are forecasting any economic fluctuations and important recurrent but probable non-cyclical fluctuations in moisture precipitation. Even though techniques are improving for predicting incidence of demand and charting probable availability of water more accurately, these problems still occur.

The problems of discontinuity have been dealt with, for the most part, by attempts to improve supply. The affluent standard of living and greed for increased productivity have demanded this. Attempts at adjusting demand to meet supply have been few and only successful where regional conditions and other restrictions made availability of additional water resources impossible (such as space flight, for instance).

Quality Requirements

Problems of quality requirements have been greatly effected by increasing consumption in the technological society. There are essentially three methods of solving these problems: (1) improving quality by treatment of supply; (2) development of salt-tolerant uses, pairing of tolerant uses with low-quality supply; and (3) (least desirable politically) restriction of use to prevent quality deterioration. The various treatment methods are well-known, and no recent innovations have emerged to significantly change the nature of water treatment.

The pairing of tolerant uses and low-quality supply has long been practiced in agriculture; salt-tolerant crops and salt-tolerant animals have been paired with water supplies of relatively high dissolved-solids content. Industry also is using brackish water for cooling and cleansing.

Restriction of use to prevent quality deterioration has been applied with some success in the past decade. In addition, over 7,500 municipal and industrial sewage treatment plants have been constructed since 1952 in the United States. An important point in the construction of sewage treatment facilities is that seldom are all impurities removed which may be injurious to the environment. Especially in toxic industrial wastes, the build-up of dissolved solids over a period of time is becoming more crucial. Tertiary treatment of many wastes is an inevitability of the not-to-distant future. With the threat of higher treatment costs, cities and industries are beginning to consider methods of cutting back on water usage and reuse.

Problems of Quantity

Quantitatively, natural water supplies are unevenly distributed over the United States. Balancing these geographic inequalities has become an extremely important water-resource development over the past decade. These efforts have not only raised considerable economic controversy, but have had far-reaching ecological affects also. The transportation of water from concentrated supplies to localities of concentrated demand is best illustrated by the Imperial Valley irrigation project. Here, a fiasco of political, economic, and technical forces combined to rob the poor and pay the rich, while at the same time disrupting some of the most significant ecological systems in southern California.[23] One project proposed in Russia would have placed dams in the tributaries of every river basin, thereby allowing no runoff to escape into the ocean. Engineers and planners had made significant progress on development of the plan until concerned ecologists were able to convince the government of the profound environmental effect such a project would have.[24]

Conservational consumption is a means for satisfying demand

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[23] Caldwell, Environment, p. 46.

[24] Ibid., p. 62.

which has made little progress in the United States. Vast water resource projects to increase supply have been much more popular since they provide greater engineering and constructing challenges. Recycling of water in industry for cooling or other purposes has recently been somewhat successful, but no satisfactory means for recycling domestic water has been found in this country. Any modern technological developments for water distribution to cities have actually been designed to increase consumption since a major portion of municipal revenue is collected from water users.

Water conservation can be affected in other ways, such as substitution of other resources for water. Transportation, electric power generation, recreation, and waste disposal by other means are examples of how demand for water can be reduced. However, the trade-offs, both economical and in the depletion of other resources, must be accounted for when this is done.

Multiple use is also a form of conservation since it is making use of the same water to serve several forms of demand simultaneously. A key technique of multiple use is to eliminate or minimize competition between different demands and promote complementary use. The objective of multiple-use water resource projects is to maximize economic and social benefits compared to the investment, operational, and loss-of-land costs incurred.

One last notable feature of water supply and the hydrosphere as a whole is the great quantity of water stored on or within accessible parts of the earth's crust. A summary of estimated water available in the earth's hydrosphere is given in Table 3. Very large amounts are stored in the rocks below the root-zone of the soil. Nearly three-fourths of all the fresh water thought to exist in the hydrosphere is stored in the outer crust of the earth to a depth of about 12,500 feet. It may amount to more than eight trillion acre feet.[25] Finding how to use this tremendous amount of stored water is a task certainly to be undertaken by a number of scientists. The ultimate greater use of the oceans and acceleration of the hydraulic cycle are two other possibilities for increasing the supply of usable water for man. However, the one truly practical solution to man's inevitable future need for more fresh water would seem to be reduction of use. Of all possibilities, this is the one least likely to cause further disruption of the delicate ecological balance of nature for which water is such a vital requirement.

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[25]George O. G. Lof, Technology in American Water Development (Baltimore: The Johns Hopkins Press, 1959), p. 10.

TABLE 3.--Estimated Relative Quantities of Water Available Within the Earth's Hydrosphere

Item	Million Acre Feet	Index of Amount Relative to Soil Moisture	%/Total Est. Fresh Water Present
Oceans	1,060,000,000	51,960	---
Atmosphere, Earth's Crust,			
Fresh Water Bodies	33,016,084	11,618	100
Polar Ice/Glaciers	24,668,000	1,209	74.72
Hydrated Earth Minerals	336	0.16	0.001
Lakes	101,000	5	0.31
Rivers	933	0.046	0.003
Soil Moisture	20,400	1	0.01
Ground Water			
Fissures to 2,500'	3,648,000	179	11.05
Fissures 2,500-12,500'	4,565,000	224	13,83
Plants and Animals	915	0.045	0.003
Atmosphere	11,500	0.56	0.035
Hydrologic Cycle (annual)			
Precipitation on land	89,000	4.4	---
Stream runoff	24,460	1.4	---

Source: Based upon data given in C. S. Fox, Water (New York: Philosophical Library, 1952), cited by Edward A. Ackerman and George O. G. Lof, Technology in American Water Development (Baltimore: The Johns Hopkins Press, 1959), p. 12.

CHAPTER IV

FUTURE INFLUENCES ON WATER SUPPLY AND DEMAND

Technological Expansion

Industrialists would probably think of the future technological advances for water in terms of how more water can be produced so, in turn, more products can be produced. The economic conversion of salt to sweet water, new developments in rain-making techniques, accelerating the hydrologic cycle, or releasing the soil moisture, are their challenges to technology. The biosphere, which measures less than eight miles deep and comprises only a thousandth of the planet's diameter, is made up of a fabulously implausible set of circumstances which combine to form the environment. This thin envelope of air, water, and soil, incredible as it seems, is the only location in the universe which matches the correct set of circumstances to sustain the sensitive balance of life. No creature has, until very recently, had the power to effect it to any great extent.[1] It is now conceivable that man and technology could com-

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[1] Jack B. Graham, Water for Industry (Washington: American Association for the Advancement of Science, 1956), p. iii.

pletely change the whole chemistry and rhythm of this phenomenon of life.

In the early days of destruction of land and other natural resources for industrial expansion, people always had the luxury of good soil elsewhere. At some point in time, this luxury was no longer available. At that time, technology began exerting its forces toward the competitive struggle to control the remaining land and resources. Some relatively recent technical events impinging upon water resources development are of revolutionary scope in their potential effect on the biosphere. A prominent example is the impact of industrial use of nuclear energy materials. Man can make use of the energy of the sun, winds, falling water, and ocean currents without imposing thermal stress on the total earth environment. However, with nuclear or thermo-nuclear reactions, increased thermal stresses are imposed, constituting thermal pollution. Because a tremendous amount of heat is generated from nuclear reactions, a copious volume of water is used in the cooling process. As more nuclear power plants are constructed, warming of the earth's surface could take place. A 1° Centigrade increase would cause significant changes in plant life to occur. At the present rate of energy production, an increase of about 7 percent per year, this would take about ninety-one years. A rise of 3° Centigrade would melt the ice caps, raising the ocean by some forty feet and drowning all the major cities of the world. This would take about 780 years to achieve at present trends.

The earth would reach a state of uninhabitability if the mean temperature was raised to 30° Centigrade, requiring a period of 980 years.[2] The use of nuclear reactors for energy is probably the foremost technical event likely to affect the future use of resources.

Expanding the Range of Recovery Desalinization

The vast supplies of the oceans have been a challenge for man's beneficial use since exploitation of fresh water supplies has approached marginal costs (or at least since desalinization has been openly subsidized from the federal treasury). If any of the experimental desalinization systems become successful and economical on a large-scale basis, the effect could be far-reaching. Substantial use of demineralized water cannot be expected to have large effect on the use and development of other water resources. Its high unit-cost makes its applicability to larger existing installations prohibitive. Only in a few unusual circumstances, such as expensive water diversion from distant river systems, might large quantities of converted sea water be feasible for development. Even with the advent of desalinization, the spiraling water supply problem is still going unchecked.

Use of Untreated Sea Water for Industry

In recent years, improvements in corrosion-resistant alloys have led to major reduction in the corrosion problems of sea water.

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[2] Detwyler, Man's Impact on Environment, p. 220.

Developments in water treatment to reduce the growth of marine organisms in retaining ponds, pipe lines, and equipment, also have contributed to greater use of sea water for cooling purposes. Some progress also has been made in the use of sea water for flushing or washing operations, handling logs and wood chips in pulp mills, and for laundering. Where polyvinyl chloride or bituminous-lined piping is used, the corrosive aspect of sea-water use has been minimized. The problem of salinity in cooling water has been satisfactorily solved by use of cathodic protection. Because of these several methods of controlling corrosion, clean sea water is now cheaper than much of the "sweet" polluted water which requires considerable pre-treatment.

The results of use of sea water have not been appreciably effective in reducing the depletion of fresh-water supplies except in extremely water-scarce regions. Except in coastal regions, transportation of sea water would make its widespread use prohibitive. Under the present system of transport, duplicate water systems would have to be installed to handle any extensive quantities. However, in planning water supplies in coastal locations, critical evaluation of sea-water substitution should be undertaken, especially if fresh water is in short supply.

Recycling

The increasing application and extent of industrial water reuse probably constitutes the greatest potential for economic and ecologic efficiency. Most of the industries using large quantities of water have been located where supplies are ample, but with growth in industrial concentration in these areas, water shortage has developed. Capital requirements for converting to recirculated water systems have not been excessive in comparison with other service expenses or in relation to over-all investment. In many cases, the recirculated water has proven to be cheaper than the fresh-water supply.

Unfortunately, the justification for recycling in industry has not been a concern for environment or depletion of resources. Public relations may be a factor in certain instances; but in the long view even these decisions are based, at least partly, on the objective of maximum financial return to the manufacturer.

One solution to the problem of providing sufficient domestic water is that of recycling municipal water in a similar manner to industrial recycling. Windhoek, the capitol of arid South West Africa, has gained the distinction of becoming the first city in the world to use the complete recycling of its waste water directly to its drinking water system. The total affects of recycling on health are as yet unknown; however, there is known a potential hazard of viruses being concentrated by recycling. Experts feel that recycling water should not be used in the United States until health factors can be more reliably demonstrated.[3] Recycling is an advancement in water technology which could prove to be beneficial in the future. It does not, however, apply in the context

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[2]*Ibid.*, p. 201.

of the present study because it is a technological innovation which has not been promoted as a means for reducing use or accompanied with an innovation of ethics; neither has the apparently obvious panacean desalinization process described earlier.

Weather Modifications

Artificial precipitation of moisture from the atmosphere has been a tempting subject for scientific attention because the atmosphere is naturally the most mobile part of all the earth's water supplies. It also is attractive because recharge of water into the atmosphere is automatic, consequent upon the evaporation and transpiration effects of energy received from the sun. As in many of the more ecologically-pervasive events of the twentieth century, active interest in this subject did not significantly begin until the government began subsidizing experimentation.

Weather modification probably has merit, but not because of the possibility of basic change in rate of total moisture moving into or out of the atmosphere in the hydrologic cycle. Rather, its merit is in its potential for distribution of precipitation from the atmosphere, either geographically or in time.

The results of weather modification efforts have aroused some great scientific controversies. Weather modification contractors claim their activities have directly caused heavy increases in precipitation, while meteorologists feel that the effects of seeding, if any, are small.

Although there is now general agreement that positive effects can be secured and that precipitation can be increased under favorable circumstances, the limitations of the method, the quantitative results, and their prediction and control are not yet known with any degree of certainty. It is doubtful that the continued research efforts sponsored by the National Science Foundation, notwithstanding the definite benefits thus far derived, will lead to any significant relief to the total water resource problems of the world. Even though no dependable increases in water supply can be obtained, relief of drought and cultivation of additional agricultural lands in certain regions are definite benefits of weather modifications. In an expanding, productive economy with steadily growing water requirements, the development of all sources will certainly be justified. The undependable nature of this source is perhaps the most potent reason for concluding that it will not displace another more reliable source.

Reduction of Reservoir Evaporation Losses

The steadily expanding reservoir capacity of the United States is not all gain for water supply. The extended water surfaces that have been created have undesirable accompaniment in loss of impounded water by evaporation. In terms of total water lost, the national evaporation loss exceeds all municipal supplies. Losses of this nature represent major volumes in comparison with potential uses. The control of these losses has been seen as a tempting application of technological innovation.

Large raw-water lakes are not justified for costly structural covering, but minimizing surface area by increasing depth is advantageous. Underground storage in well-sealed natural formations is also a practical solution. Another possibility is the use of non-volatile immiscible liquid on the reservoir surface. Experiments with such liquids have been remarkably successful.

The advantages of evaporation control are numerous. In multipurpose reservoir development, recreational, fish and wildlife, navigation and flood-control functions will be uneffected. All flow and consumptive uses will be benefited. Hydroelectric generation will be increased in proportion to the added volume of water available; irrigation, municipal, and industrial users will benefit in similar degree.

Economics

Applications of technology to activities which use water and which supply water cannot be predicted independently of the set of policy and market incentives which stimulate the adoption of different techniques. The private developer is motivated by economics; his incentives stem from what will make a profit for him. The traditional stick house is doing it for him now. Furthermore, city officials, who possibly could demand some controls, are confused by the economics of progress and growth, the tried-and-true tests of a viable metropolitan setting. They somehow desire the "good" things of the great cities like Chicago, New York, and Pittsburgh. They continue to say, "Surely the blight and crime and congestion will not come to our town if we can just show continuous growth."

Recently, representatives of the Colorado State Industrial Development Agency took a trip to the east to recruit industry. As they stepped off the plane, they were surrounded by noise, polluted air, and masses of humanity. Enroute to their hotel they were enmeshed in three traffic jams. As they left their hotel for dinner, a man was mugged and robbed in the street. While eating, their hotel room was burglarized. After one uncomfortable night of restless sleep from the commotion of the city and flashing neon lights, the delegation decided to abandon their mission and return to the clean freshness of the Colorado mountains. These commissioners had learned an important lesson from their trip and came to a simple conclusion: they wanted no part of what "progress" could bring them.

This is an example of how economics plays the part of motivating the selection of particular processes and affecting change. Engineering planning for development traditionally has resulted from extrapolations made on the assumption that present policies and market conditions will continue indefinitely. This failure to reflect possible changes in such factors as population growth rate, demand, and social attitudes has resulted in a tendency to reject all alternatives simply because they are not "economically" feasible under present market conditions.

A recent study has investigated the possibility of reducing water use through installation of existing water-conserving devices within the home.[3] By following a breakdown of in-house water uses, it was determined that currently available technologies could permit water savings (savings in withdrawals) up to about 32 percent of present in-house use. This included about 9 percent on showers, 18 percent on toilets, and 5 percent on automatic washing machines. Installation of these water-saving devices could be accomplished without reducing the quantity of services yielded and probably without appreciably affecting the quality of services. The savings in water came at the cost of more expensive equipment.

If the savings in water costs more than offset the added capital costs, there would exist an economic incentive for adoption of these models. The costs of the following three strategies open to householders were computed through use of a mathematical model which determines present value of cost streams.

1. Do not replace existing equipment until normal replacement is called for. Then replace with the same heavy-water-use equipment.

2. Do not replace until normal replacement, then replace with water-saving model.

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[3]Charles W. Howe, et al., Future Water Demands (Springfield, Virginia: National Technical Information Services, 1971).

3. Replace immediately with water-saving model.

The present values of the cost streams are shown in Table 4.

TABLE 4.--Present Values of Cost for Three Equipment Replacement Strategies (Interest Rate of 10 Percent; Dollars)

Cost of Water per 1,000 gallons	Present Values 1	2	3
0.10	80	78	176
0.20	126	120	205
0.30	173	162	234
0.40	219	204	262
0.50	266	246	291
0.80	---------Break-even Point---------		
1.00	498	457	434
1.50	730	668	577
2.00	963	880	721
2.50	1195	1091	864

Source: Charles W. Howe, et al., Future Water Demands (Springfield, Virginia: National Technical Information Services, 1971), p. 8.

It is noted from this study that little difference exists between the present value of costs of strategies 1 and 2, especially in the plausible range of water costs extending up to $1.00 per 1,000 gallons. The third strategy becomes attractive only at water costs in excess of 80¢ per 1,000 gallons, which would be a charge for domestic water considerably in excess of the national average. It was concluded, therefore, that in most instances water prices would not rise high enough to stimulate economic motivation for homeowners to move toward water-saving devices under current or near-future conditions.[4] Even though this study

[4]Ibid., p. 12.

was drenched with impressive mathematical models and scientific calculations, the conclusions drawn were based entirely on economic conditions which were independent of the environmental considerations.

Another equally impressive engineering study to develop a state water resources planning model had as its immediate objectives the establishment of a systematic procedure for implementing the following: ". . . Plan specific methods of exploiting more effectively the state's water resources. . . . Determine . . . municipal, industrial, and rural water requirements based on increasing land use intensities and water consumption rates. . ."[5] The author had earlier proven mathematically that the state's water consumption rate was inceasing and would continue to do so. However, his formulation was based on historical data and did not allow for future variables (for instance, an ecologically-enlightened public which could result in a reduced water use).

Most engineers speak in terms of water demand and imply economic demand. This is a point which should be clarified since water economics do not comply with the postulates of conventional economic analysis.

The economic supply-demand framework consists of (1) a demand function which indicates willingness of customers to pay for

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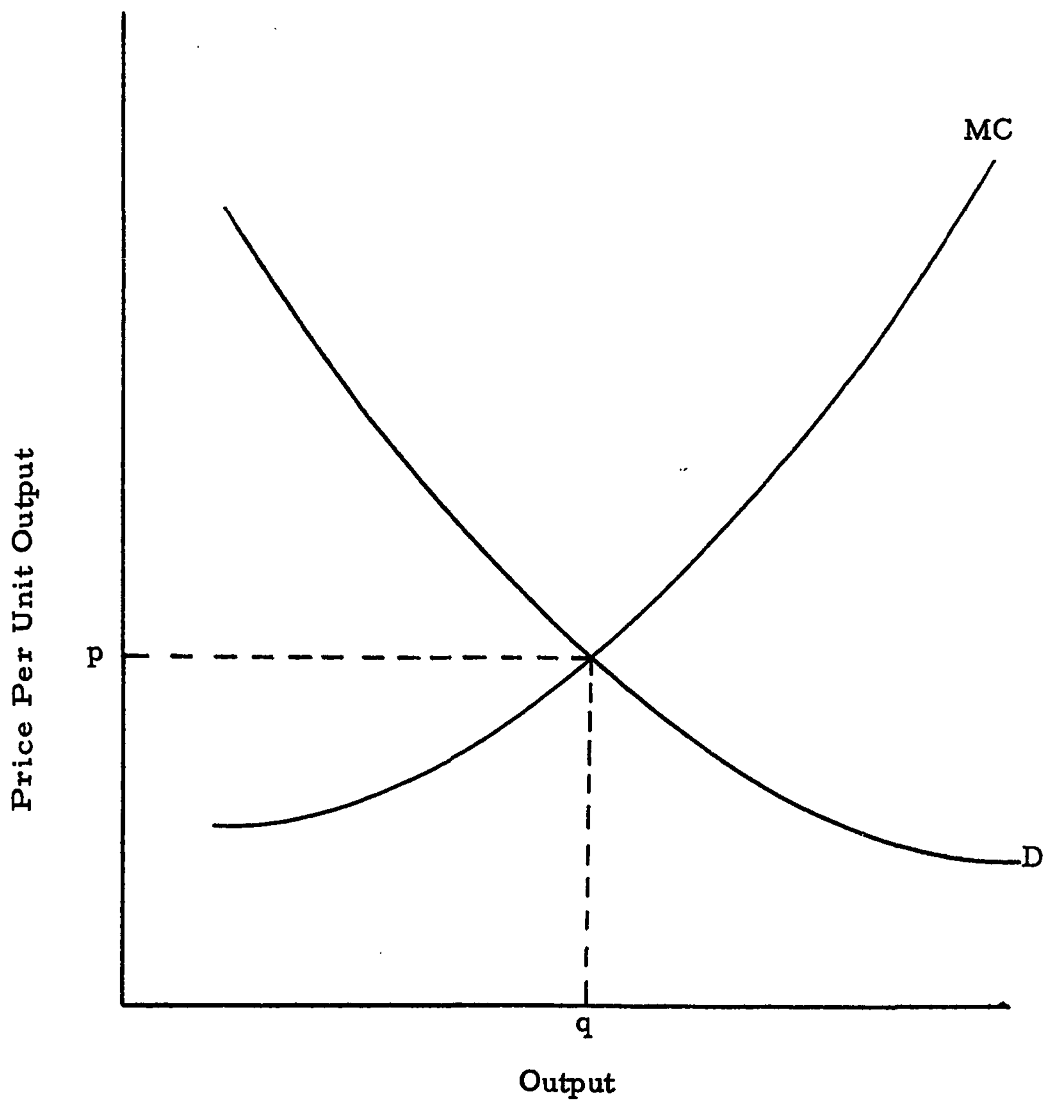
[5] Carl Richard Bartone,"A State Planning Model for Water Resources Development" (unpublished Ph.D. dissertation, University of Oklahoma, 1970), p. 14. Emphasis added.

different quantities of a product and provides an explicit measure of the benefits associated with having the product, and (2) a supply function which is in reality the marginal-cost curve. The supply curve indicates the additional cost incurred by producing another unit of output. The optimum quantity to be produced and taken by customers is that at which the marginal cost equals the incremental benefits as reflected in the demand function. When the supplier can determine the marginal cost (MC) and the demand (D), then it is possible to find the socially-optimal output (q) and the price to be paid per unit output (p). This concept is shown graphically in Figure II.

The application of this analysis is valid in water requirement forecasting when sensitivity of demand to price can be substantiated. Such a condition only occurs rarely where water is in such short supply that obtaining it requires allocation of a significantly large portion of the consumer's budget. However, if demand continues to accelerate, it is conceivable that the relatively low cost of water and the easily-obtained sources of satisfactory quality water are conditions which may not continue long into the future.

The problem in developing a demand function for forecasting population water usage is the difficulty in making estimates of price elasticities in the higher price ranges on the basis of existing relatively low price-range data. However, the overriding problem in this approach may be that even though prices were to rise, the demand for water may

Fig. 2.--Determination of Optimum Output



remain inelastic.

The price as a function of output (Figure 3) is an application which is useful in eliminating peak loads. The user is rewarded for maintaining a low-level, more constant flow. By cutting down on peak periods, more efficient design of the entire system could result, including storage, distribution, and energy requirements.

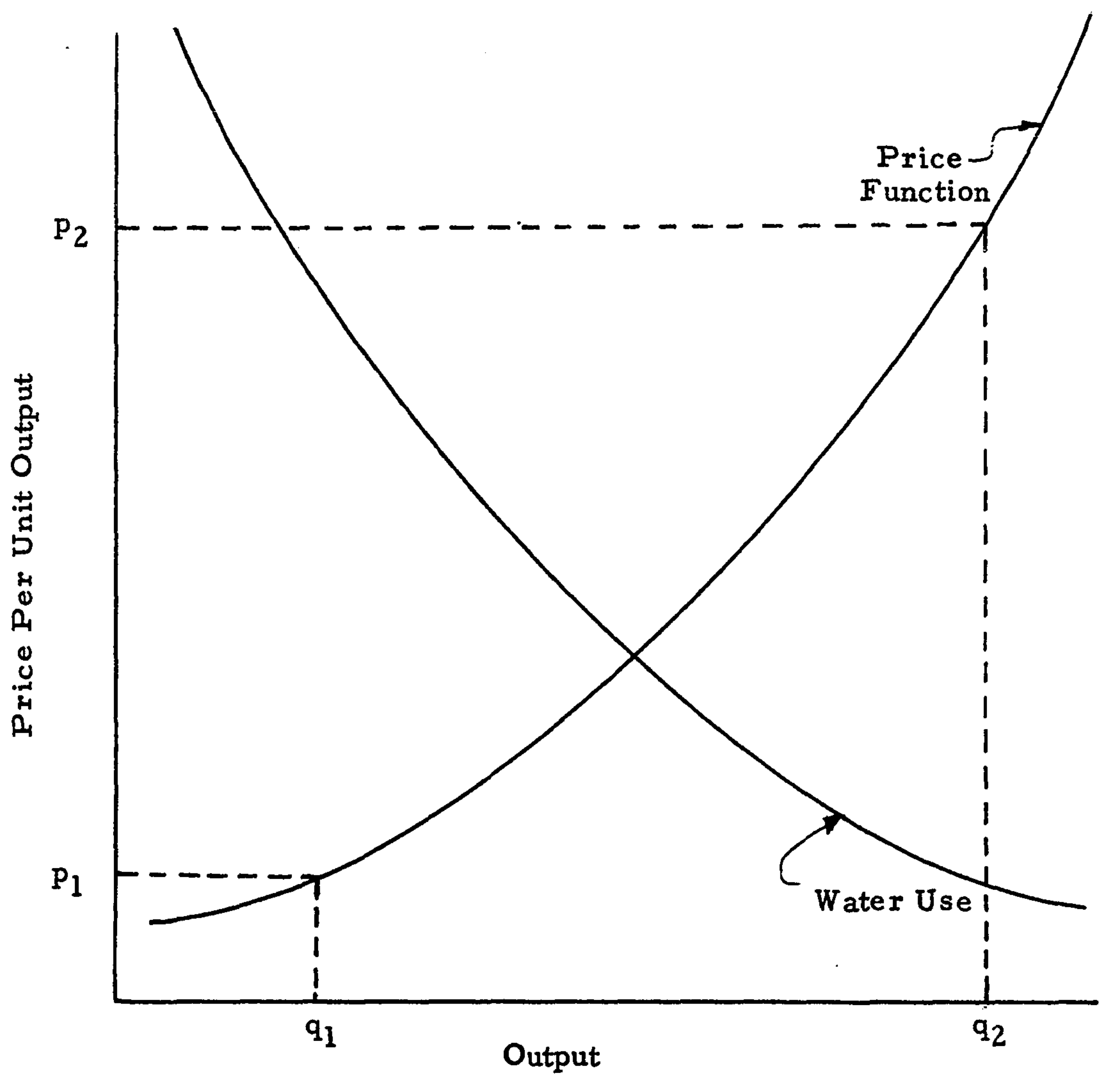
Pricing controls can be effective in maintaining quantity levels at a point in time. However, as a source of future supply, this method would not continue to serve as a meaningful measure. Since inflationary trends would apply to the analysis, future output would continue to reach higher levels and probably approach critical conditions. The need for more output capability would continue to be a problem of the future even though present demands might be satisfied to some degree. Future increase in demand could result in conditions more difficult to cope with than would have occurred under conventional pricing.

Population

The present rate of world population increase is adding close to 200,000 people per day, nearly six million every month or seventy million per year. This is approximately 132 persons per minute or more than two every second.[6] The world population in 1965 was estimated at 3.4 billion people, and this figure is expected to double by the

[6]Ehrlich, Population, Resources, Environment, p. 309.

Fig. 3 --Controlling Output Through Pricing as a Function of Output



NOTE: Small amounts of product (q_1) are inexpensive (p_1) or free; but as output increases (q_2), price per unit of output increases (p_2), making larger quantities prohibitive and water-use decreases.

turn of the century.[7]

It is undoubtedly impossible to determine precisely the number of people the earth can support. Various calculations have been made and the consensus of experts seems to be that the earth's ultimate carrying capacity may be somewhere between 10 and 30 billion people. At the present rate of growth, this figure would be achieved in about 100 years. In Thomas Malthus' "An Essay on the Principles of Population," he states that ". . . theoretically, populations increase geometrically while food increases arithmetically, causing a continuous struggle on the earth for food. Malthus applies this principle to human population, saying that when the population has reached the saturation point for food, then famine occurs and the population will be destroyed."[8] If the present population growth rate is projected into the future, the Malthusian saturation point for the world will be reached a mere century from now, either in our children's or grandchildren's lifetime.

> The explosive growth of the human population is the most significant terrestrial event of the past million millenia. Three and one-half billion people now inhabit the Earth, and every year this number increases by 70 million. Armed with weapons as diverse as thermo-nuclear bombs and DDT, this mass of humanity now threatens to destroy most of the life on the planet. Mankind itself may stand on the brink of extinction; in its death throes it could take with it most of the other passengers of the spaceship Earth. No geological event in a billion

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[7] Ibid., p. 290.

[8] Detwyler, Man's Impact on the Environment, p. 36.

> years--not the emergence of mighty mountain ranges, nor the submergence of entire subcontinents, nor the occurrence of periodic glacial ages--has posed a threat to terrestrial life comparable to that of human over-population.[9]

Dansareau has postulated his law of tolerance whereby "a species is confined ecologically and geographically by the extremes of environmental adversities. Modifications of environment by man have surpassed the tolerance of many species. The ultimate danger is that man's tolerance will be surpassed and man himself will become extinct."[10]

Any way we examine the future of man, even in the geologically miniscule span of the next century, the quality of life will be dependent upon, first and foremost, population size. Problems of food, water, raw materials, pollution, and space are all secondary to population size. The ecological plight is aggravated by the fact that it is a "quiet crisis."[11] As described in 1963, ". . . In the face of so many seemingly immediate socioeconomic crises, the ecologic one might be eclipsed and neglected, but though its time span is a little longer than that of the better known social problems, its ultimate impact is infinitely greater."[12] If man wishes to preserve his civilized way of life and avert a second Stone Age, he must not leave the ultimate control of population to a deferred process

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[9]Ehrlich, Population, Resources, Environment, p. 41.

[10]Ibid., p. 4.

[11]Stuart L. Udall, The Quiet Crisis (New York: Holt, Rinehart, 1963).

[12]Ibid., p. 4.

of natural selection. The quiet crisis clearly demands the attention of the best of many diverse talents, non-scientific as well as scientific, at the same time that other crises are being attacked.

The conclusion to this chapter must simply be that the spoil and movement of "progress" of an age gone by has failed abysmally. There are no more unspoiled places to claim, clear, and settle. The foresight needed to create garden cities within our now limited resources has not been forthcoming. We must now begin to examine our practices of resource husbandry and become cognizant of the fact that our wealths in land and people are inseparable.

We must dedicate ourselves to authentic conservation which maintains the productivity of our resource capital by wise use of resources and the maintenance of an environment that assures their continued full productivity. The more mature technology of tomorrow will find enlightened enterprise using the versatile talents of engineers and scientists within a framework that shows recognition of the fact that conservation is the real long-term measure of the wealth and security of a nation.

CHAPTER V

POSSIBLE ALTERNATIVES FOR WATER-CONSERVATIVE DOMESTIC LIVING UNITS

At a recent conference of environmentalists, the question was asked by a member of the audience, "Why don't environmental engineers come up with a water system that would eliminate wasting treated water for flushing toilets, watering lawns, washing cars, and other uses not requiring fresh water?" The answer from one of the "experts" on the program was the usual one given whenever this question arises. It went something like this: "The American public is so conditioned to having all the water needed that to change now would be impossible. We could provide a dual distribution system of treated water for drinking and cooking, and untreated water for flushing toilets and irrigation, but the people would probably not be careful to keep them separated. Eventually some child would drink the untreated water and possibly cause a suit against the city. For this reason we prefer not to rock the boat, so to speak, and continue the present method. The added expense of constructing dual water systems would probably be in excess of the present cost of treating additional water anyway." This attitude by experts who could, if so motivated, find a solution to the problem of wasting priceless resources, is the primary reason nothing is being done to solve resource problems. This is an obvious imperfection in our otherwise competent technical abilities.

The following discussion will attempt to outline some possible alternatives to the present practice of unrestricted wasting of treated water in the modern home. It will specify and evaluate a set of alternatives for domestic living units which will tend to minimize the use of water and, at the same time, decrease or eliminate the discharge of environmentally-degrading wastes.

The decomposition of domestic water in the home is given by category of use in Table 5. Two separate studies of in-house water requirements will be used throughout the discussion to show how water savings could vary in different sections of the country. One study conducted by Reid in 1967 places a large proportion of the total use for lawn watering. Since this study was conducted in the semi-arid southwest, it concludes significantly different results from the Akron, Ohio study which shows a rather trivial percentage of total domestic water used for irrigation.

After evaluating means of accomplishing water savings for the home, the various methods will be combined into appropriate alternative physical living units by type and applied to show the associated estimated costs for installation and total water and monetary savings. In calculating

TABLE 5.--Decomposition of Domestic Water Use by Category

Category of Water Use	Reid Study		Akron Study	
	Gal./day	%	Gal./day	%
Drinking/cooking	8	2.0	14	5.0
Dishwasher	15	4.0	16.5	6.0
Toilets	96	25.0	113	41.0
Bathing	80	21.0	102[a]	37.0
Laundry	34	9.0	11	4.0
Auto-wash	10	3.0	3	1.0
Lawn watering	100	26.0	8[b]	3.0
Garbage disposal	12	3.0	--	--
Wasted	25	7.0	--	--
Scrubbing/cleaning	--	--	8	3.0
Total	380	100.0	275	100.0

[a]A typical bath is 20 gallons, shower 5 gallons, per minute using 1/4-inch pipe.

[b]A 3/4-inch hose under 20 pounds pressure discharges 400 gallons per hour.

Sources: George W. Reid,"Water Supply and Sewerage," Lecture, 1967, p. 4; Jim Wright, The Coming Water Famine (New York: Coward-McCann, Inc., 1966), p. 59.

the monetary savings for water not used, the national average of 40¢ per 1,000 gallons will be applied.

Initially, the supposition was that the style or type of housing unit could be evaluated on a comparative basis for relative water use. However, further study revealed that the in-house use of water is primarily the same for single-family, multifamily, townhouse, or condominium. Unless some completely different conceptual lifestyle were to be developed (such as communal living), the quantity of water use for in-house purposes is not a function of the type of living unit. The use of water for irrigating lawns and gardens might be an exception since most individual homeowners pay little attention to optimum irrigation practices. In apartment housing, the usually quite low amount of grass per unit greatly reduces the per capita water requirement for irrigation. Condominiums usually include population density ratios somewhat similar to private homes, but the larger community open space is often irrigated from a well to cut down on the expenses of city water.

For these reasons, little emphasis is given to the variety of housing types except where savings in capital expenditures for water saving equipment can be shown. It may be possible to demonstrate a cost-effective distribution and collection system for an optimum number of living units under conventional water use requirements, but the purpose of this study is to discover some practical means for redistributing water within the household. It appears that all the water necessary to accommodate in-house needs can be contained within each individual home, thereby eliminating the undesirable factors of recycling water which has passed through several waste systems.

The total domestic consumption in the Akron, Ohio area in 1962 was approximately 17 million gallons per day, with over 40 percent of that amount being used for domestic purposes. This figure corresponds very closely with the findings in a Senate report which estimated domestic use, at that time, at 41 percent of all municipal demand.[1] In the semi-arid southwest, where more water is needed to maintain lawns, this figure is somewhat higher. Oklahoma City uses 45 million gallons daily, 20 million of which are required for domestic use for an average of nearly 45 percent of the total demand.[2]

Furth study of Table 5 reveals some additional facts which could be significant in developing the lower water-use habit. For instance, in both the Reid and Akron studies, a large percentage of the household use is devoted to bathing and flushing the toilets (Reid, 46 percent; Akron, 78 percent), both of which require less than drinking-water quality for practical purposes. Lawn watering is also significant in the southern states (Reid, 26 percent; Akron, 3 percent), for which non-potable water

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[1] Jim Wright, The Coming Water Famine (New York: Coward-McCann, 1966), p. 60.

[2] Leroy Turnpaw, Oklahoma City Water Department, private interview, December 6, 1971. Oklahoma City population, 300,000; total daily consumption 43-45 MG; domestic 2,000 gal. per person per month.

is satisfactory. With these uses comprising approximately three-fourths of the domestic use (Table 6), reductions in these areas would significantly affect withdrawal requirements.

TABLE 6.--Decomposition of Domestic Water by Highest Volume Categories

Category of Water Use	Reid Study		Akron Study	
	Gal./day	%	Gal./day	%
Toilets	96	25.0	113	41.0
Bathing	80	21.0	102	37.0
Lawn watering	100	26.0	8	3.0
Sub-totals	276	72.0	223	81.0
All other uses	104	28.0	52	19.0
Total	380	100.0	275	100.0

Sources: George W. Reid, "Water Supply and Sewerage," Lecture, 1967; Jim Wright, The Coming Water Famine (New York: Coward-McCann, Inc., 1966).

Total daily national water use breaks down roughly as follows: municipal, 5 percent; irrigation 60 percent; steam-electric power and cooling, 24 percent; manufacturing, 10 percent; and mining, 1 percent.[3]

While municipal water represents a relatively small part of total national consumption, it demands the highest priority when urban dwellers do not have enough for their needs. The truth and validity of the priority is obvious. Individually, a single drink from the faucet at home is as important (more so if you do not have it) as the vast power

[3]Wright, The Coming Water Famine, p. 60.

potential of billions of gallons of liquid packed up against Boulder Dam at Lake Head on the Nevada-Arizona border. The key word in this discussion is "needs." What are the needs of a city dweller?

We know that only a small amount is needed to sustain life, but, socially speaking, the need for water has greater significance. The well-manicured lawn, particularly in the mid- and southwest, is one example of strictly social water-demand. Critically speaking, the suburban lawn has little practical value. It gives merely an atmosphere effect to the home--provides a display area. Perhaps it symbolically fulfills man's needs for returning to the earth, his compulsion to grow things, and produce a crop as his ancestors once did. However, it provides no measurable play area for children, it cannot produce a significant amount of food, and it imprisons the homeowner every weekend when he could be spending his time more usefully. Yet it may consume a fourth of all the water available in a municipal domestic supply. Most homeowners convince themselves that they actually enjoy yard-work as a means of relaxation. However, if they ever find themselves in a situation where they are relieved of this drudgery for a period of time, most will never go back to that routine. The truth is that lawns are a status form in a class system culture. Rich people have gardeners and keep immaculately-groomed yards. The less affluent feel that they must possess what those higher in the hierarchy have attained. Thus, lives are spent as slaves to a patch of hybrid grass which is parceled into small enclosures.

Then vacations are taken where the land is wilderness and not spoiled by suburban "beauty."

Strategies for Domestic Water-saving

Interestingly enough, although the alternatives are numerous, few have been attempted on any significant scale. The following discussion will demonstrate the various possibilities of an urban environment which would significantly reduce the demand for water.

Lawns

Artificial Turf

Obviously, installation of artificial turf wouldprovide a solution to any water-shortage problem. If we insist on retaining the social "status" value of a showplace lawn, artificial turf, foliage, and flowers are very practical. It is doubtful, however, that this is an approach which would catch on except under extreme water-famine conditions since at approximately $30.00 per square yard, the average 70-by-140-foot lot would cost about $20,000 for installation. If this initial installation could be expected to last for the life of the home, say thirty years, the yearly amortized cost (including interest) would be $1,420. At present water rates of about 40¢ per 1,000 gallons, the yearly cost to water a conventional lawn is roughly only $14.60. Even the savings in labor and equipment for maintenance could hardly offset the difference in cost. On the other hand, the water-savings would be tremendous. This may be a practical solution for office buildings and other smaller areas.

Other considerations substantiate the argument for maintaining natural yards, however. Trees and shrubs filter out a surprising quantity of particulate matter in the air. Other pollutants, such as dust and pollen, will settle to ground level and are trapped in the grass. The combination of these living plants acts as nature's air cleaner.

Air must contain about 20 percent oxygen to support life as we know it; oxygen can only be supplied by green, growing plants. The average-size lawn can restore oxygen to the air for eight people. In the process it takes in and eliminates such other pollutants as carbon monoxide, nitrates of oxygen, and hydrogen sulfide.

Grass prevents wind and water erosion and holds precious water. It also acts as an absorption mechanism for noise pollution. Of the total amount of solar heat falling on a grass-covered surface, 5 percent bounces back, 5 percent is absorbed, and up to 50 percent is eliminated through transpiration. Large quantities of heat are retained by bare soil, asphalt, and, surprisingly, by artificial turf. A thermometer placed in the turf at the Orange Bowl registered 140° even though the air temperature was only 81°. At Michigan State University, tests showed surface temperatures on plastic up to 97 degrees, while nearby living grass registered only 80°. Professional athletes have found synthetic playing surfaces are so hot that their feet swell and the rising heat waves seem to lift a ball right out of the park. Temperatures to an unbearable 160° have been recorded in these arenas. Anything that reduces the temperature around the home by as much as 10° can make both day and night livable without air conditioning or reduced air-conditioning costs.[4]

Smaller, More Compact Lots

If the average homeowner uses 100 gallons per day for watering the lawn, reducing the lawn to half the size would unquestionably reduce the amount of water needed to fifty gallons, an appreciable savings. Further reductions would result in associated water savings (Table 7). Such a policy would necessitate additional land for a common open park area if acceptable population densities were to be maintained. Under existing practices, when this approach is taken, such as in the cluster developments in Columbia and Reston, the parks are kept in similar condition to traditional lawns and large amounts of water are still needed for irrigation. However, community-managed lawns would allow better control of timing, and off-peak hours would be utilized for watering. Well water or lake water is sometimes used for irrigation, but seldom is any attempt made to reduce the quantity of water.

More Efficient Management

Proper lawn care consists of a combination of optimum soil

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[4]Vernon J. Frye, "Trees, Shrubs, Grass Help Clean Air," Norman Transcript, January 2, 1972, p. 32.

TABLE 7.--Lowering Water Demand by Reducing Lot Size

Individual Lot Size	Grass Surface (sq.ft.)	Water Savings %
100 x 150	13,000	
60 x 90 (cluster development)	3,240	$100 - \frac{3240}{13,000} = .75$
30 x 80 (condominium)	500	$100 - \frac{500}{13,000} = .96$
Apartment complex	200 sq.ft./ living unit	$100 - \frac{200}{13,000} = 98.5$

conditions, nutrient treatment, and moisture application. A publication produced by the Oklahoma State University Extension Division outlining recommended lawn-care procedures suggests an irrigation system capable of supplying the turf with about three inches of water every ten days over a period of six months.[5] Even under these optimum treatment conditions, this authority on the subject of lawn care recommends an average of 760 gallons of water for average daily use.

Ecology/Husbandry

When land in suburbia is to be developed for individual housing, the first item of business for the contractor is to bring in bulldozers and other heavy earth-moving equipment. Then all natural

[5]Leland D. Tripp, Turf Management on Home Lawns (Stillwater: Oklahoma State University Extension Division, n.d.).

growth and trees are stripped off and the natural terrain is cut and filled to conveniently allow the largest number of rectangular parcels for individual ownership. This is done with little regard for natural beauty, drainage, accessibility, or conservation of resources, and certainly without regard for efficient water usage. Only as an afterthought, and usually only at the insistence of the governing agency, are schools, parks, churches, and shopping facilities considered in the private developer's scheme. Profit is the primary motivating force for producing the living environment for modern cities. This is not the living environment the people desire; it is merely what they have been made to believe they should want. Since no alternative is available, the citizens are without recourse. Even in many desert areas where housing developments have sprung up, such as in Phoenix and El Paso, where water for the poor people is simply not available, the middle class must have as lush a lawn as though they were living in Philadelphia or Louisville. No thought seems to be given to the fact that the water used to perpetuate an image could prevent some creature from an early demise or raise enough corn to feed an indigent family.

Some cities, such as Santa Fe, have adopted a policy of retaining the natural beauty of the land. Pride in a yard of cactus and mesquite in Santa Fe is just as valid as bermuda grass in Albuquerque. No precious water is wasted. Nearly all parts of the country have a unique terrain which could be displayed and carefully nurtured to take the place of current artificial landscaping. The variety and interest would be infinitely more pleasant to visitors than an instant replay of the previous stop. Scarsdale looks the same as Ft. Worth and Portland is another Omaha. The uniqueness of Santa Fe is attractive to visitors and presents an old-world charm.

If Oklahoma City homeowners were suddenly forced to stop watering lawns (which many would never consent to regardless of the emergency), the savings in water would be considerable--on the average of 10.5 million gallons per day during the summer months. This represents water that is nearly all lost since very little even enters the sewers to be discharged, treated, and used again. If new housing developments were to begin taking advantage of natural drainage and foliage indigenous to the vicinity where very little water was needed to maintain attractive surroundings, the future water demand would not look nearly as overwhelming. Also, since water use for lawns is seasonal, demand and pumping would be reduced during this peak period allowing for more efficient design of the water supply system.

In-house Use

The Water Closet

Another product of Victorian technology, which is still used in its basic form today, is the flush toilet. With the many great advances in science that have occurred in the last century, it is noteworthy that little change has taken place in this most common household device. Most environmentalists agree that it is wasteful and does not accomplish the purpose for which it was intended--disposing of human wastes. Each flush uses from four to six gallons of water which may constitute over 40 percent of all household water use. As outlined in earlier discussion, water-saving models are currently on the market which use approximately 60 percent as much water as ordinary models. The initial cost is slightly higher, but functionally they are not distinguishable from ordinary models. Water savings, which would compose about 18 percent of total in-house use, could, if water costs were high enough, offset this initial added capital cost and an economic incentive would exist for their adoption. The study by Howe, which was based on national average water prices, concluded that the incentive does not now exist for homeowners to replace present fixtures with water-saving models since the price difference could not be offset by water cost avoided.[6]

Regardless of the water necessary to make the toilet work, it still does not solve the problem of disposing of human wastes. It is simply a cosmetic cover-up which routes wastes, in great quantities of pure water, to sewage-disposal plants which are probably overloaded and incapable of treating the most troublesome pollutants such as phosphates and nitrates. The flush toilet, no matter how skimpy with water it can be made, is obsolete.

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[6]Howe, et al., Future Water Demand, p. 7.

This obsolete system should be succeeded by a system that requires each family to collect and completely dispose of its own body wastes. Such systems are possible and practical, and only wait to be developed and promoted for widespread use. One such system is already being tested in Sweden. With this advanced model, solid and liquid human wastes can be converted quickly and easily into humus-rich fertilizers. By mixing these wastes with bulky organic materials, like peat moss and garbage, in an enclosed chamber, the natural composting process will convert animal wastes into plant food. Unfortunately, these valuable plant nutrients are never allowed to fulfill the purpose for which nature intended them. Instead, billions of dollars are spent mixing these solid and liquid wastes with water in the conventional sewage systems and eventually flushing them into rivers, lakes, and oceans with their load of valuable nutrients largely intact. Paradoxically, instead of fortifying the life-sustaining nitrogen cycle, these wastes cause putrification, depleting oxygen in water needed for aquatic life to continue. Also, the good nitrogen, phosphorus, potassium, and humus so badly needed by the soil is lost in the process.

Why are human wastes disposed of in such a short-sighted and unscientific manner? It is indeed ironic that, in an age when technology is so advanced that a trip around the earth can be accomplished in a few short minutes, body excrements are allowed to flow untreated into natural waterways. Are we so concerned about the distasteful aspects of human wastes that all we can think about is getting them out of sight and smell as fast as possible, regardless of the environmental consequences? If the problem is fear of disease from the use of human wastes as fertilizer, check the current practice of shipping wastes by water to expensive and sometimes faulty sewage treatment plants. By comparison, this method is akin to emptying a chamber pot from the upper window into the street, as was the custom in the Middle Ages.

However, handling human wastes in a manner similar to Oriental peasants would be repugnant to even the most ardent American organic gardener. Composting of human wastes can be done automatically by use of the Swedish innovation called Clivus Dry Toilet. This mechanism mixes human wastes with household garbage in a unique way and eventually yields compost that is certified to be safe by the health departments of several Scandinavian countries.[7] The composting process puts the wastes in direct contact with the microorganisms that purify it, and no water is used in the process (Figure 4).

The water closet, the initial point in the developed water disposal system, is followed by large collection and treatment systems. Unfortunately, the trend is away from individual disposal and toward regionalized collection and disposal systems with enlarged treated effluents to be disposed of. There seems to be little effort to investigate

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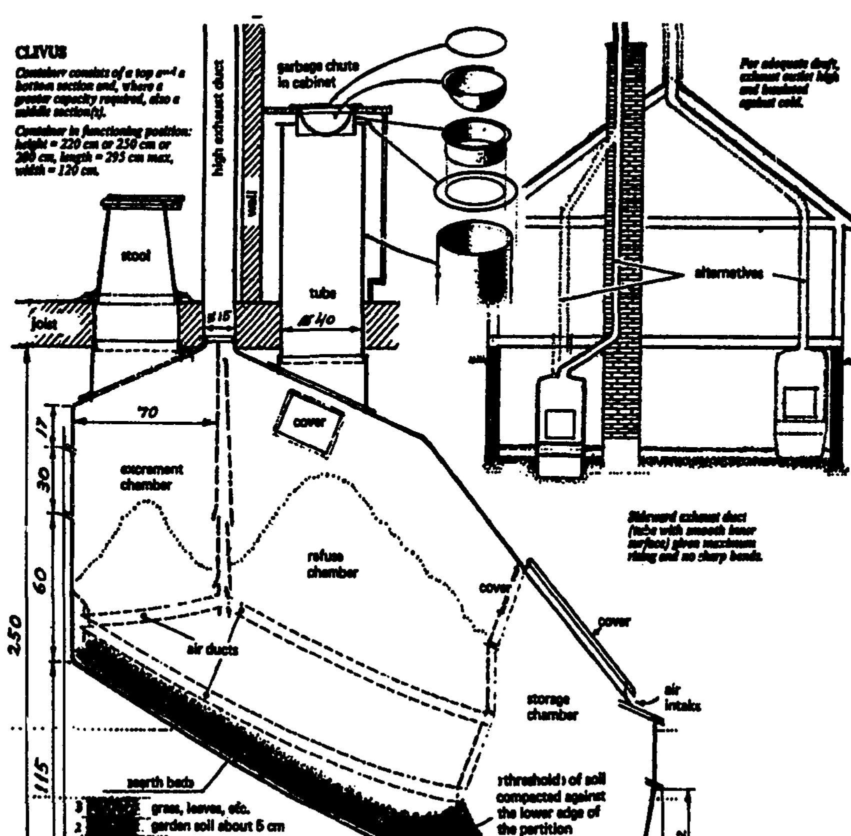
[7]Robert Rodale, "Human Wastes Can be Recycled," <u>Organic Gardening</u>, Vol. 19, No. 2 (February, 1972), 40.

Fig. 4.--Detailed Diagram of a Typical Clivus Installation



Source: Organic Gardening, Vol. 19, No. 2 (February, 1972), p. 138.

the most efficient way in which to treat and dispose of sewage originating from small installations consisting of homes, small apartments, factories, and restaurants. The time has come to review and re-evaluate the sewage treatment procedures for these areas.

On the other hand, the ground which is capable of treating sewage from septic-tank-like devices is rapidly diminishing and will be difficult to locate in the near future. Septic tanks and similar devices cannot provide proper or efficient treatment of sewage, as it is emitted from homes presently, to enable the continued discharge of anaerobic effluent to subsurface ground which is impermeable or in a high-water-table area. Realizing this, regulatory authorities and pollution departments are restricting building in areas beyond community sewage collection facilities. In addition, community collection facilities cannot be provided for more than the most populous areas of the country. It is simply too costly and inefficient to provide this type of treatment.

Beyond community sewage collection facilities, there are other ways to collect, treat, and dispose of small amounts of sewage. For instance, package plants or pre-fabricated plants, ranging from sizes of approximately 5,000 gallons per day to 500,000 gallons per day, are being marketed and are more economical than large treatment collection facilities. From a cost standpoint, individual systems for highly urbanized areas are most expensive. It can be easily seen from Figure 5 that diseconomies of scale and externalities are also working against the regional systems, and alternatives are becoming important. The current interest is in the modular or unitized unit. However, there are still viable uses for individual systems--special uses such as in marine craft, aircraft, railroads, trailers, and areas with water shortages. Another possible instance of practical use of the individual unit would be in a household which becomes independent of the community system, using its own recycled wastes for plant nutrients.

Further inspection of Figure 5 indicates that unit volume increases with size and at the individual level volume economies are also possible. In Figure 6, it can be seen that considerable savings on volume waste can be effectuated by shifting to dry disposal, disposal without water carriage, or to smaller or individual systems.

Perhaps it is not practical to attempt to toilet-train an entire culture. Adoption of the dry toilet is doubtful, but other alternatives for individual disposal are possible. Most homemakers would object to the aesthetics of the open pit of the Swedish version. They need water in the bowl to maintain stain-free, odor-free conditions at all times. However, the water need not be potable. Plumbing could be redesigned to make use of spent water (which has been used for hand-washing or bathing) for flushing. If the toilet drain were separated from all other household drains, the smaller volume of water collected could be more efficiently treated. Treatment could be accomplished by conventional means (such as activated sludge with digestor) by individual, neighborhood, or small

Fig. 5. --Representation of Scale Economies of Various Alternative Sewage Treatment Schemes

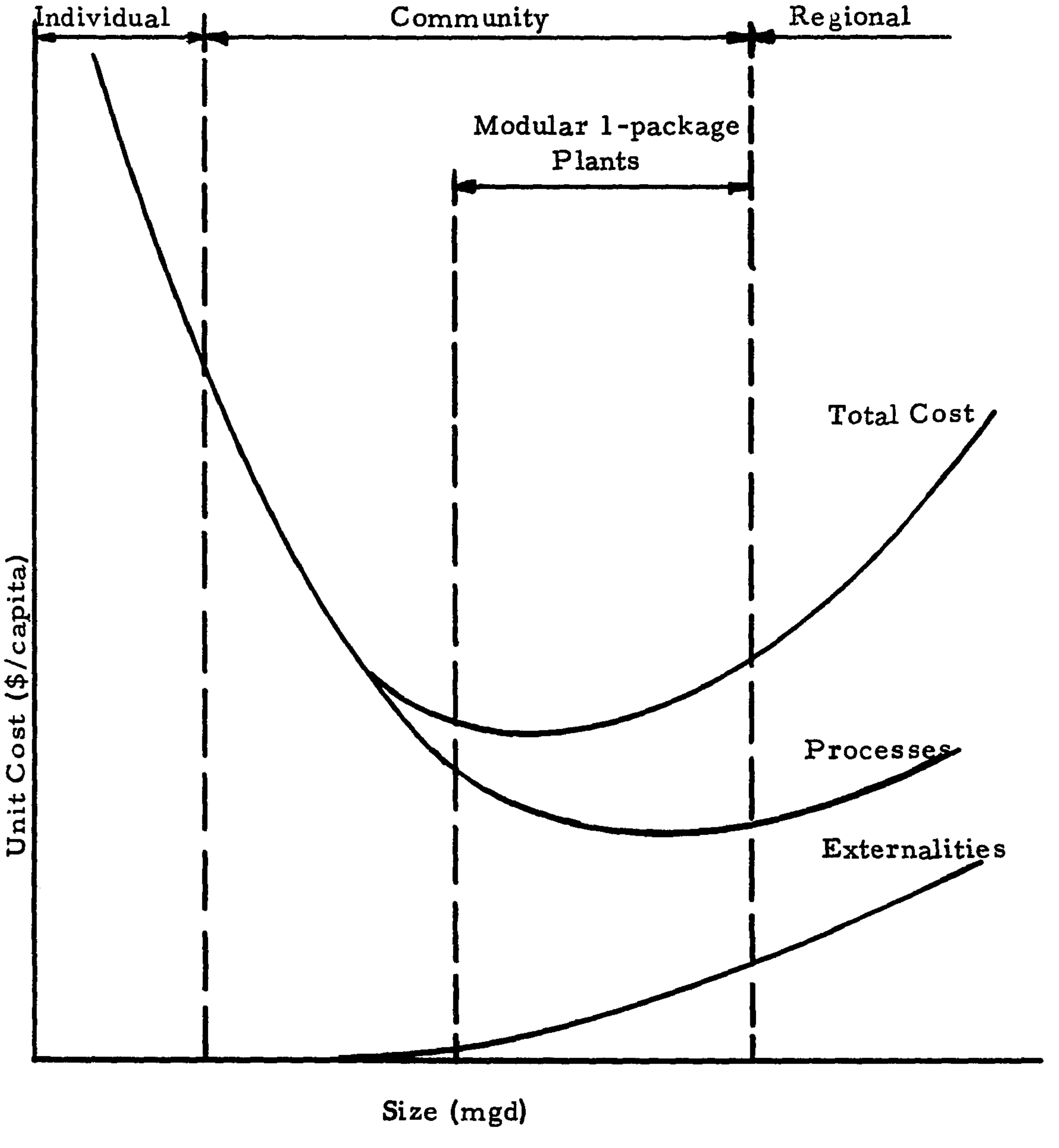
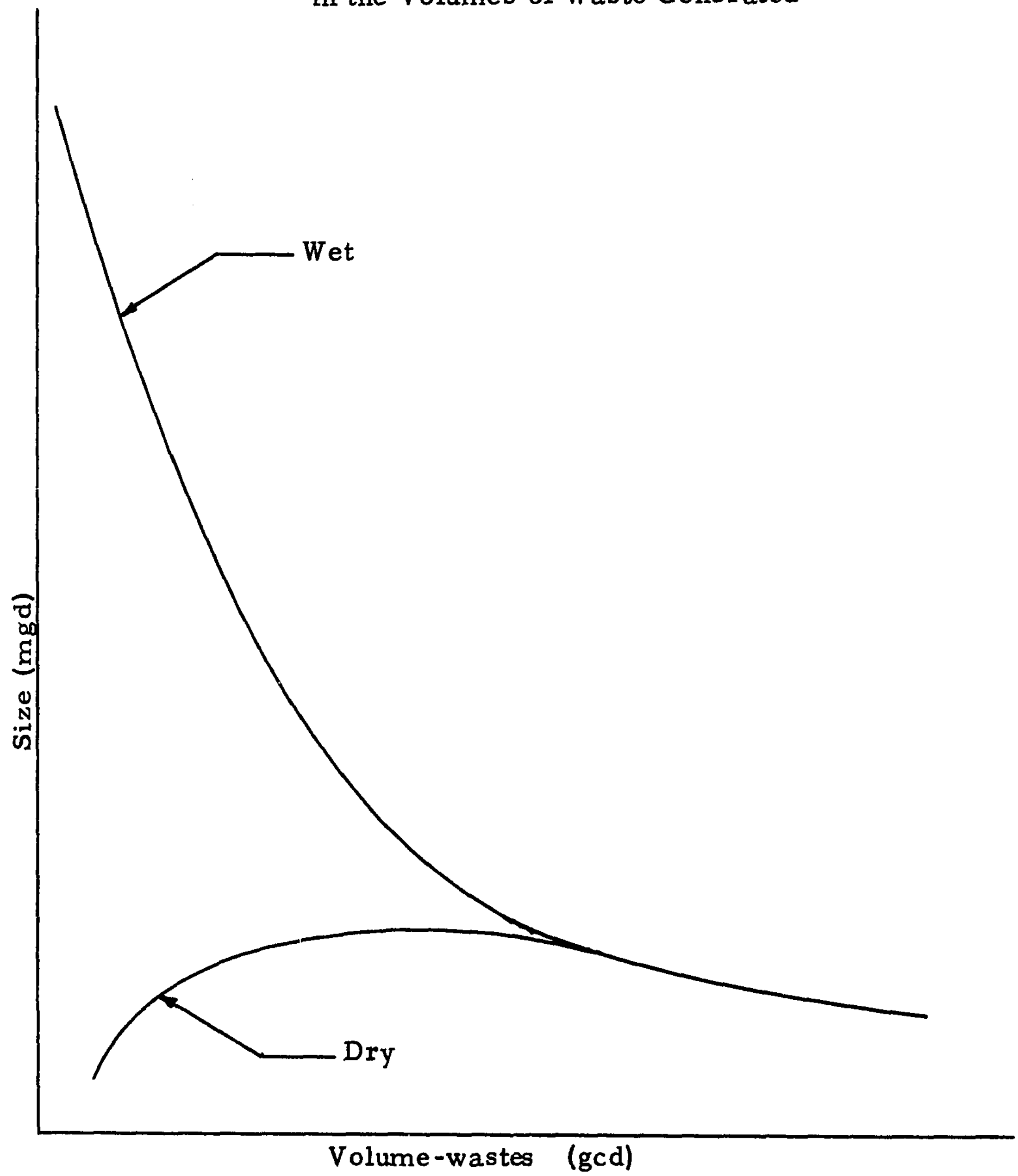


Fig. 6.--Comparison of Dry to Wet Disposal Methods in the Volumes of Waste Generated



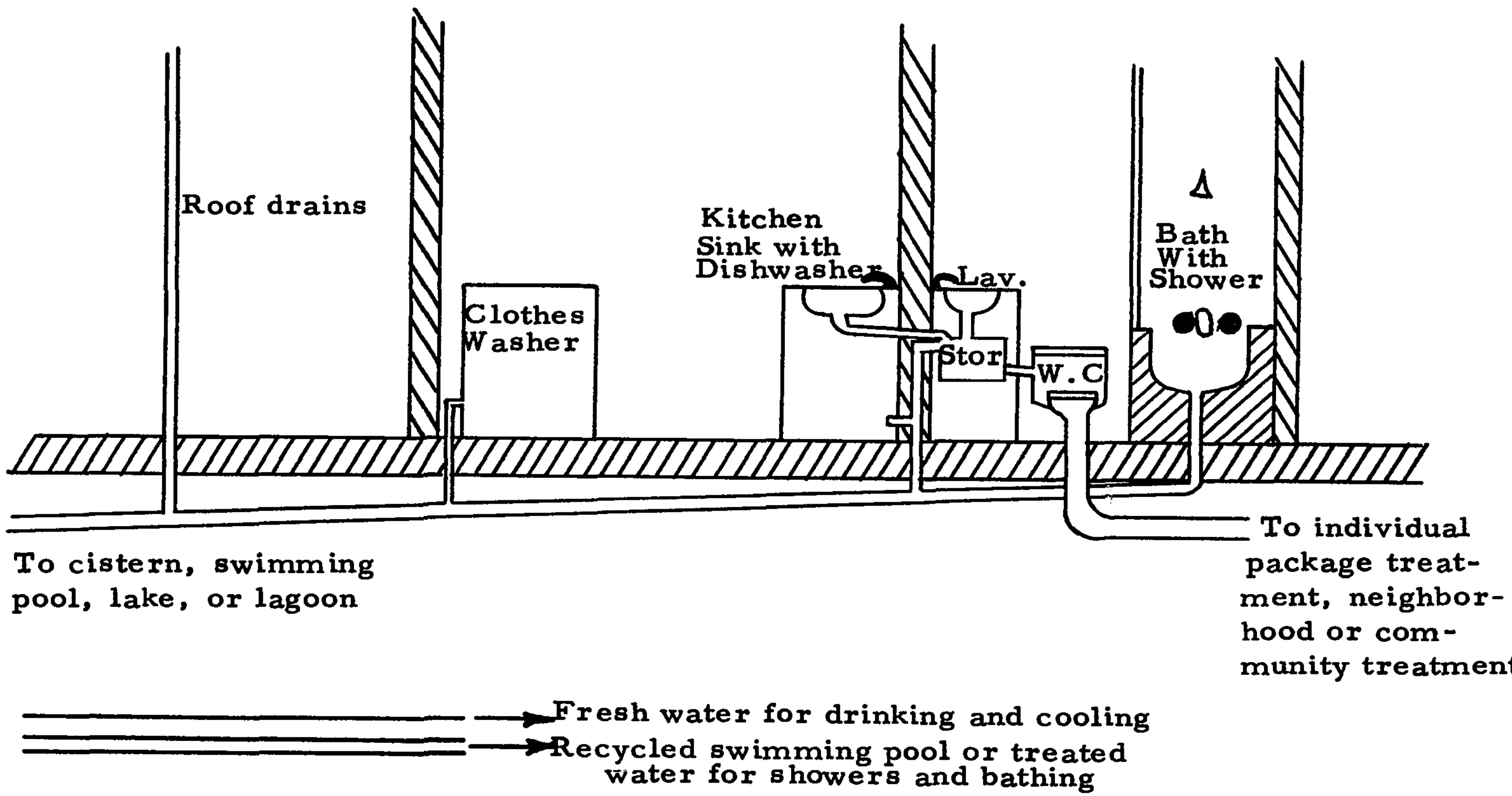
community installations. The drainage from other household uses could be handled separately by a number of means:

1. Recycled through small treatment plants
2. Stored and used for irrigation along with rain water (cistern)
3. Collected in neighborhood lake for boating, irrigation, recreation, and/or fire protection
4. Collected in a swimming pool-like reservoir for other nonpotable household uses

The diagram in Figure 7 illustrates possibilities for a plumbing system within an individual home. It is entirely possible that an individual treatment plant for body wastes only could be purchased and maintained for near the cost of larger community collection and treatment systems. This invention would require much less treated-water demand if none were required for toilets. If all irrigation water were obtained from the cistern supplied by the remaining waste lines, and bathwater drawn from the swimming pool, the major in-house uses would essentially be eliminated.

Timing discontinuities would be less of a problem under these conditions also. By further developing fire-proof construction for homes, which is a concept-making significant progress at present, the sizing of water-supply mains could be greatly reduced. Peak loading would be less a factor of design and more efficient supply systems would be possible. Small pressure-sensitive reservoirs could be installed in

Fig. 7.--Plumbing Diagram for a Home With Reduced Water-use and Waste-emission



houses which would fill only during periods of low demand. Table 8 shows the range of possible water savings with various alternatives.

The fact remains that the uncontrolled spread of Western culture to the entire world would be ecologically disastrous. There is exhibited an unrivaled concern for hygiene with daily bathing, shampooing, and armpit spraying. Yet, while we deodorize our armpits, our waste loads overcome the waste-receiving capacity of the natural environment. Our 6 percent of the world population produces 70 percent of the world solid waste.[8] In this respect, the aboriginal hunters must rank as cleaner creatures than American simply because they are unable to soil their living spaces to the degree that modern man can. Alternative life-styles and technology must be developed which will reverse these practices.

Bathing and Personal Hygiene

The amount of bathing necessary to maintain health standards will vary with location. Crowded conditions may necessitate more frequent bathing than open spaces of rural areas. Also, certain occupations require a higher level of personal hygiene. Bathing's contribution to health is one of the most controversial topics in health circles. Much of the controversy arises from the tendency to generalize about bathing rather than

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[8]Udall, The Quiet Crisis, p. 46.

TABLE 8. --Lowering Water Demand for Water Closets

Present Demand (gpd)		Installation of Water Savings Conventional Model				Installation of Clivus Dry Toilet			
Reid	Akron	Reid		Akron		Reid		Akron	
		Demand	Savings	Demand	Savings	Demand	Savings	Demand	Savings
96	113	58	38	68	45	0	96	0	113

to distinguish different types of bathing and their specific reasons. Cleansing baths are primarily to remove perspiration, odors, and other objectionable accumulations from the body surface. As such, the cleansing bath is of aesthetic value, though the contribution to mental health is not insignificant. There is also some protection against infection. Soap alters the permeability of the bacterium membrane so that the organism is permeable to water. As a result, the bacterium is destroyed by hydration. Excessive washing can remove the valuable natural oils and skin nutrients and cause numerous skin irritations.[9] Yet some 30 to 40 percent of in-house water use is devoted to bathing according to present information. It would be presumptuous to assume that that the habit of daily bathing could be broken in the interest of water savings. It is estimated that 60 percent of that amount (18 percent of the total) is used in taking showers. There are available today shower heads which restrict the passage of water, presumably without greatly affecting the quality of the bath. Wide-spread adoption of these units could save up to half the water devoted to showers, or up to 9 percent of the total in-house use, assuming that people do not extend the time-length of showering.

Even though shower baths are extremely popular, tub bathing is still preferred by many women and most smaller children. The individual bath requires approximately twenty gallons of water regardless of

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[9]C. V. Langton and C. L. Anderson, Health Principles and Practice (St. Louis: The C. V. Mosby Company, 1957), p. 97.

whether the bather is a small child or an adult. The bath water does not, however, require drinking-water quality since the water is contaminated as soon as the body is immersed. This fact may provide some capability for water savings through recycling. In the rural farm days, before modern conveniences were introduced, the weekly bath was a family cooperative. One wash tub of water was used by the entire family beginning with the children and finally the father. Each bather was allowed a fresh kettle of hot water on cold days to make up for the spillage, but the entire family bathed in approximately ten gallons of water per week. The Orientals consider bathing an important family event and provide a large pool to accommodate the entire family at once. In some cases, several families will share a bath together. Table 9 shows results which could occur by designing methods for conserving bath water.

A large number of American families are finding a private swimming pool within budgetary propriety. With proper design, this pool could serve as a reservoir for recycling bath water to an indoor bathroom. The pool could possibly be included as part of a larger bathroom where family bathing similar to Oriental procedures could take the place of individual baths. In this installation, very small amounts of makeup water would be the only requirement, and no discharge of wasted water would occur. The bathing pool water would serve a number of useful nonpotable purposes in the individual household, or larger installations would be practical for multifamily dwellings where recycled bathwater could be

TABLE 9.--Possibilities for Bath Water Savings

Present Demand (gpd)		Install Water-saving Conventional Shower Models				Recycling for Bathing			
		Reid		Akron		Reid		Akron	
Reid	Akron	Demand	Savings	Demand	Savings	Demand	Savings	Demand	Savings
80	102	86	24	71	71	0	80	0	102

shared by a large number of tenants.

Laundry

Laundering is becoming another major in-house water-use. Currently available automatic home washers exhibit a range of water use from thirty-two to fifty-nine gallons per eight-pound load. Water-saving attachments are also available on some models which reduce the water use to as low as fifteen gallons. These machines offer comparable performance, but initial cost is higher on the lower water-use models. Thus, unless water costs were unreasonably high, no economic justification for the waver-saver exists.

Laundry does not require a high-quality water for the wash cycle, and savings of both soap and water could be tremendous if laundry wash water were stored after each wash and used a number of times. Fresh rinse water could be added to the holding tank, displacing a small amount of the dirty water each time a wash cycle was completed. This dilution would maintain a satisfactory quality wash water with most of the soap already present. Since hot water is no longer necessary for washing, the only additive would be whatever bleach or softeners were needed for a particular load.

Another factor which might affect laundry habits is the new clothing styles the younger generation is promoting. The denim, all-purpose pants and shirts do not require as careful handling as the lacy, delicate clothing of past generations. As these styles become more prevalent, recycling laundry water will likely be more practical. Table 10 summarizes total savings in water under alternative clothes-washing methods.

Dishwashing

Very few new homes are constructed without automatic dishwashers. These devices do not require a great deal of water, and no water-saving model has been marketed to date. The dishwasher uses from five to eight gallons per load, depending on the number of wash cycles. Dishwashing does not require clean water to accomplish its purpose since the pressure spray and solvent properties of water are the cleaning mechanism. There is the problem of aesthetics since most mothers are suspect of dishes spreading colds and other childhood illnesses. However, a dishwasher could be developed which would recycle the wash water after screening out the solids. Rinsing could be fresh-water make-up, similar to the clothes washer. A third cycle, which has already been added to many models, could sanitize the dishes with steam heat to remove any remaining bacteria. Table 11 shows possible water savings if such a model were to be marketed for the home.

Drinking and Cooking

A relatively small amount of the total household use is needed for cooking and drinking. However, these are the only uses which require treated water. If the supply system could be designed so that each family

TABLE 10.--Water-saving Possibilities in Clothes Washers

Present Total Use		Install Water-saving Model				Recycle Wash Water Makeup Rinse Water			
		Reid		Akron		Reid		Akron	
Reid	Akron	Demand	Savings	Demand	Savings	Demand	Savings	Demand	Savings
34	11	20	14	6	5	2	32	2	9

TABLE 11.--Water-savings Possibility for Dishwashing

Present Total Demand		Recycle Wash Water/Fresh-water Makeup			
		Reid		Akron	
Reid	Akron	Demand	Savings	Demand	Savings
15	16.5	2	13	2	14.5

could obtain the fresh water needed for drinking and cooking, and untreated or recycled water could be used for all other in-house needs, the water demand for domestic use would be almost negligible compared with present and future requirements. A great deal of water is also wasted because of the habits of people turning on the faucet and letting it run to get a cool drink or while shaving or brushing teeth. For cooking, the hot water tap is turned on and the pipes are expected to drain in order to get hot water. The farther away from the water heater, the more water is wasted waiting for the pipes to empty water that has cooled. The water that is finally received is usually too hot and has to be cooled by mixing with cold water, causing all the more waste.

Several models of refrigerators and stoves are available which keep hot and cold water reservoirs full at all times. This produces water at the right temperature immediately and eliminates wasting the water of "undesirable" temperature which is in the pipes each time the faucet is turned on. If these devices were installed in all kitchens, nonpotable water could be used for kitchen activities other than drinking and cooking. The result would be a change in water-use criteria which involve the "kitchen sink," and alternative designs for the water-supply system would be possible.

An innovation which has not been investigated to this writer's knowledge is the use of microwave in heating water for household use. A device could be developed which would heat the water instantaneously as it passes through the pipes, thus eliminating the many problems with conventional electric or gas water heaters.

Garbage Disposal

The in-sink garbage grinder has been found to be a tremendous nuisance as well as a helpful kitchen appliance. Because of the increased organic loading to sewage treatment facilities, many cities have outlawed garbage grinders for domestic use. The rat population in sewers has been known to increase sharply where the appliance has been widely used. Water consumption in the home has, no doubt, increased also since garbage grinders have gained prominence. The water required to operate the grinder is not large, but the tendency is to turn on the water and grinder for continuous operation during the fifteen- to twenty-minute period required to clear the table and rinse the dishes. When this is done, a significant amount of clean water is wasted.

The new compacting device, which is gaining acceptance as a standard household necessity, is much more acceptable for many reasons. Not only does it eliminate the need for the garbage grinder, it also helps alleviate the solid-waste problems which are becoming more burdensome from domestic sources. With this new innovation just entering the household market, it is likely that garbage grinders will soon be a thing of antiquity. By eliminating garbage grinders, average daily water savings could amount to twelve gallons per day, applying figures from the Reid study. No data were compiled for garbage grinders in the Akron study.

Auto-wash

Nearly every suburban family in America now considers two automobiles to be a minimum requirement for survival. Even the youngest newlyweds will often possess two late model cars, especially if both the husband and wife are working. As the family grows, it is not uncommon for each teenager in turn to receive a car on the sixteenth birthday. Two-car garages are almost mandatory on all new homes and, in some cities, are required by city code. Apartment houses require at least two parking spaces for each living unit, and some require as many as two and one-half to three spaces per unit to take care of visitors and three-car families.

Automobile washing has thus become a significant water-use item. Private homeowners may wash the family auto as often as once weekly running the garden hose continuously for twenty to thirty minutes. Public car-wash facilities are often so over-crowded on the weekends that a thirty-minute wait in line is not uncommon. The amount of clean water used to wash and rinse an automobile will range from 20 to 100 gallons, with the runoff going to the sanitary or storm sewer. This is the most notable example of a recycling application since clean water has no advantage in obtaining a quality wash. Municipalities could afford to construct public, automated car-wash installations where nearly everyone would be encouraged to make use of the facility. Convenient locations and modest charges should nearly eliminate garden-hose car-washing, and only recycled water would be used in this practice. Using only recycled water would result in savings of ten gallons per day per person and three gallons per person day from the Reid and Akron studies respectively. A significant factor here is that this practice could be started immediately and would have almost unanimous acceptance in many urban areas. Table 12 shows a summary of possible water savings that could easily be realized in the urban centers.

TABLE 12.--Summary of Possible Water Savings for Homes Using Alternate Designs

	Present Demand			Possible Saving	
Water Use Category	Reid	Akron	Alternative Method	Reid	Akron
Auto-wash	10	3	Recycle	10	3
Garbage disposal	12	-	Compactor	12	
Drinking/cooking	8	14	none	0	-
Dishwash	15	165	Recycle	13	14.5
Laundry	34	11	Water-saver	14	5
Bathing	80	102	Water-saver	24	31
Toilets	96	113	Water-saver	38	45
Lawns	100	8	Natural irrigation		
Waste	125	8		0	0
Total	380	275		111	98.5

The Family Living Unit

The foregoing discussion on possible methods of saving water within each category of water use have no meaning unless they can be somehow combined into an appropriate family living unit. If this is done, it will then be possible to determine what benefit, if any, would be derived from initiating a program of water conservation. It has already been shown that, under current and near-future market conditions for water, there is little economic motivation for homeowners to move toward water-saving devices. In this absence of economic incentive, it would perhaps be appropriate to consider for the moment what water-saving affects would occur on the basis of a fixed or limited resource. If it could be assumed that, at existing rates of water use, all the available resources were being used and no additional family units could be established unless the existing families gave up some of their water, a new value standard could be applied to water conservation. Assuming there is some utility in gaining additional families to an urban area, some incentive might be shown for capital outlay on water-saving equipment for the home. Under this assumption, alternative plans for family living units will be developed, based on the discussion of water-saving devices presented earlier in this chapter.

Alternative A

The simplest means for initiating a water conservation program would be to install the existing water-saving devices for toilets, showers, and laundry washers in every home. It might be possible for city government to offer free plumbing assistance for every homeowner willing to purchase the new device. It might also be possible to cut yard watering in half through better turf management programs. The results of this alternative are shown in Table 13, using both the Reid and Akron studies of individual water-use as examples. For each family, a yearly water

TABLE 13.--Results of Installation of Water-saving Devices, Alternative A

Category of Water Use	Reid Study Present Daily Use (gal/daily)	Reid Study After Water-saving Device	Reid Study Total Water Saved (gal/daily)	Akron Study Present Daily Use (gal/day)	Akron Study After Water-saving Device	Akron Study Total Water Saved (gal/day)	Added Capital Cost Single Family	Added Capital Cost Multi-family
Drinking/cooking	8	8	0	14	14	0	0	0
Dishwasher	15	15	0	16.5	16.5	0	0	0
Toilets	96	58	38	113	68	45	40.	40.
Bathing	80	56	24	102	71	31	6.	6.
Laundry	34	20	14	11	11	5	30.	5.[a]
Auto-wash	10	10	0	3	3	0	0	
Lawn-watering	100	50	50	8	8	4	0	
Garbage disposal	12	0	12	-	-	-	0	
Wasted	25	10	15	-	-	-	0	
Scrubbing/cleaning	-	-	-	8	-	0	0	
	380	227	153	275	190	85	$76.	$51

[a]Based on 6 families per washer in apartment units.

savings of nearly 56,000 gallons would occur, according to the Reid figures, and 31,000 gallons would be saved according to the Akron study. Thus, a yearly saving of $22,40 or $12.40 would occur for each family, applying the national average of 40¢ per 1,000 gallons.

Alternative B

If, in addition to the water-saving devices of Alternative A, a city-wide policy of eliminating grass yards and installing artificial turf or low-water-use plants, no water would be required for yard-watering in the summer months. This might be especially desirable in mulfifamily complexes and condominiums where large natural land spaces could be set aside and advantage taken of the natural drainage patterns of the area for rainwater irrigation exclusively. In addition, garbage disposal units in the sinks would be replaced with garbage compactors, and temperature-controlled water reservoirs would be installed to cut down on the amount of water wasted. Also, public auto-wash facilities would use recycled water. Results of this alternative are shown in Table 14. With yearly savings of 80,000 and 36,000 gallons per family, $32.00 and $13.20 would be the yearly monetary savings using the Reid and Akron method, respectively.

Alternative C

One additional important water-saving measure will be assumed in this configuration; the water closet will be eliminated in favor of some

TABLE 14.--Results of Installation of Water-saving Devices, Alternative B

Category of Water Use	Reid Study			Akron Study			Added Capital Cost	
	Present Daily Use (gal/daily)	After Water-saving Device	Total Water Saved (gal/daily)	Present Daily Use (gal/daily)	After Water-saving Device	Total Water Saved (gal/day)	Single Family	Multi-Family
Drinking/cooking	8	8	0	14	14	0	0	0
Dishwasher	15	15	0	16.5	16.5	0	0	0
Toilets	96	58	38	113	68	45	40.	40.
Bathing	80	56	24	102	71	31	6.	6.
Laundering	34	20	14	11	6	5	30.	0
Auto-wash	10	0	10	3	0	3	0	0
Lawn-watering	100	0	100	8	0	8	0	0
Garbage Disposal	12	0	12	-	-	-	0	100
Wasted	25	5	20	-	-	-	100	0
Scrubbing/cleaning	-	-	-	8	8	0	0	0
	380	160	218	275	183	92	$176.	$151.

other method of disposing of human excreta. Table 15 shows results of this measure, bringing the yearly individual family savings to 101,500 gallons at $41.00 (Reid study), and 58,500 gallons at $23.40 (Akron study).

Alternative D

The final method shows how more than 90 percent of the water used for domestic purposes could be saved through recycling. For the single-family dwelling, recycling only the water used by the individual family, the increased capital cost would be significant since the method requires construction of a large pool and treatment plant. Many families today could afford this extra expense on a new home, and would, in fact, prefer the addition of a swimming pool. Poorer families could share a pool among several houses or in a multifamily complex of apartments or a condomium. If the initial cost were distributed among a number of family units, the small individual cost would be offset by the added recreational value the pool would bring. Under this method, only small amounts of water from the public system would be needed for drinking, cooking, and makeup rinse water for the clothes washing and dishwashing. For each unit adopting this plan, yearly savings would be increased to 132,000 gallons at $53.00 (Reid Study) and 94,000 gallons at $37.60 (Akron Study).

All four alternatives are displayed in the summary Table 17.

TABLE 15.--Results of Installation of Water-saving Devices, Alternative C

Category of Water Use	Reid Study: Present Daily Use (Gal/day)	Reid Study: After Water-saving Device	Reid Study: Total Water Saved (Gal/day)	Akron Study: Present Daily Use (Gal/day)	Akron Study: After Water-saving Device	Akron Study: Total Water Saved (Gal/day)	Added Capital Cost: Single Family	Added Capital Cost: Multi-Family
Drinking/cooking	8	8	0	14	14	0	0	0
Dishwasher	15	15	0	16.5	16.5	0	0	0
Toilets	96	0	96	113	0	113	200.	200.
Bathing	80	56	24	102	71	31	6.	6.
Laundry	34	20	14	11	6	5	30.	5.
Auto-wash	10	0	10	3	0	3	0	0
Lawn-watering	100	0	100	8	0	8	0	0
Garbage disposal	12	0	12	-	-	-	0	0
Wasted	25	0	25	-	-	-	0	0
Scrubbing/cleaning	-	-	-	8	8	0	0	0
	380	99	281	275	115	160	$236.	$211.

TABLE 16.--Results of Installation of Water Savings Devices, Alternative D

Category of Water Use	Reid Study			Akron Study			Added Capital Cost	
	Present Daily Use (gal/daily)	After Water-saving Device	Total Water Saved (gal/daily)	Present Daily Use (gal/day)	After Water-saving Device	Total Water Saved (gal/day)	Single Family	Multi-family
Drinking/cooking	8	8	0	14	14	0	0	0
Dishwasher	15	2	13	16.5	2	14.5	100.	100.
Toilets	96	0	96	113	0	113	200.	200.
Bathing	80	0	80	102	0	102	5000.	1250.[a]
Laundry	34	2	32	11	2	9	60.	10
Auto-wash	10	0	10	3	0	3	0	
Lawn-watering	100	0	100	8	0	8	0	
Garbage disposal	12	0	12	-	-	-	0	
Wasted	25	5	20	-	-	-	0	
Scrubbing/cleaning	-	-	-	8	0	8	0	
	380	17	363	275	18	257	$5360.	$1560.

[a]Based on a pool for each 20 units in multifamily. Initial construction cost $25,000.

TABLE 17.--Summary Results, Water-savings Methods

	ALTERNATIVE METHODS							
	a		b		c		d	
	Reid	Akron	Reid	Akron	Reid	Akron	Reid	Akron
Water savings, total gal/day	153	85	218	92	281	160	363	257
Yearly savings, 1000 gal.	55.9	31.	80	36	101.5	58.5	132	94
Additional lost, single-family	$76	$76.	$176.	$176.	$236.	$236.	$5360.	$5360.
Additional cost, multifamily	$51	$51.	$151.	$151.	$211.	$211.	$560.	$560.
Yearly Money savings	$22.40	$12.40	$32.00	$13.20	$21.00	$23.41	$53.00	$37.60
Equivalent new house-holds possible per family	0.40	0.31	0.575	0.33	0.75	0.58	0.95	0.94

CHAPTER VI

A NEW DEFINITION OF WATER DEMAND

Basis for a New Criteria for Water Demand

Water has always been considered a renewable resource by standards of scientific calculation. It is now becoming catastrophically apparent that this is not the case. Water supplies have finite limits. It is the demands of people on these supplies that apparently have no limit. Even with the unthinkable rate of population increase of about one percent per year for the world, the demand for water is increasing at an even greater 1-1/2 percent per year.[1] To intensify the problem of finding enough water to satisfy the ever-expanding population, nearly 95 percent of our aquatic assets are now being destroyed by the practice of using them to convey wastes away from our urban centers.[2]

Even if the rate of population growth in the United States could be adjusted to bring the growth-rate back to zero or to a declining rate, unless methods are discovered for reducing the tremendous appetite of the American public for destruction and consumption of the natural

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[1] Detwyler, Man's Impact on Environment, p. 76.

[2] Ibid.

resources, the tolerance of the ecologic equilibrium may be surpassed. As the "modern philosopher" Pogo so aptly put it, "We have met the enemy and he is us."

Fundamental overhaul on a social level of some of the most cherished tenets of an industrial society is the prerequisite for the future welfare of the earth's surface.

Feasible solutions to environmental problems are a complex blend of environmental understanding, politics, economics, social attitudes, and technological capacity.[3] The quiet crisis requires the attention of the best of many disciplines, non-scientific as well as scientific. For instance, in the past, large-scale water-resource development measures have been formulated and promoted by organizations dominated by engineers. Therefore, benefit/cost and other feasibility studies have been carried out under a rather technical/economical framework, and have generally failed to consider consequences of environment, ecology, and their related economical side-affects. The immediate economic interests of these groups have dictated an interest in short-run gains to be made from the environment without consideration of long-term consequences which are conveniently dismissed as social costs. When as much weight is placed on environmental and delicate ecologic systems as on the meeting of economic "needs," alternative, less spectacular solutions to water problems, not

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[3] Ibid., p. 6.

curtailing radical modifications of nature, may prove to be the wisest choice.

Notwithstanding the many calls for action to improve ecology, specific proposals seem too few and too negative: ". . . require India's population to practice mass contraception" or "make them eat their sacred cows." Unless the fundamental concepts of a culture are considered, specific measures may produce new backlash more serious than those they were designed to elevate.

In the case of water demand and consumption, a review of fundamental concepts reveals some surprising, yet simple, deductions. Benjamin Franklin was principally interested in disease prevention and sustaining life when he foresaw the urgency of public water-works installations in cities. These most basic needs of man had to be satisfied in a manner superior to the practices of the past. Today, the water-borne diseases are no longer of consequence. Diseased drinking water is seldom, if ever, considered a possibility, at least in America. Yet, as late as 1968, Charles Johnson, Administrator, Consumer Protection and Environmental Health Services Branch, Public Health Service, concluded: "The United States is rapidly approaching a crisis state with regard to drinking water and is courting a serious health hazard."[4]

A survey of the Public Health Service encompassing eight metropolitan areas from Boston to Riverside, California, and including

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[4] Ibid., p. 3.

Vermont, revealed that in several areas about 9 percent of the water samples indicated bacterial contamination. Pesticides were found in small quantities; the level of nitrates was too high in some samples; trace metals exceeded recommended PHS limits.[5]

Although the nation has invested $15 billion since 1952 in constructing 7,500 municipal treatment plants, industrial treatment plants, sewers and related facilities; a surprising 1,400 communities, including good-sized cities like Memphis, and hundreds of industrial plants still dump untreated wastes into the waterways of America.[6]

A dramatic example of just how much water pollution has increased in the last decade occurred in the summer, 1964, when the oily Cuyahoga River in Cleveland burst into flame. Not even the most virile mud worms and leaches are to be found in its lower regions. More and more United States rivers are becoming all too similar to this flammable sewer.[7]

How much more effective could these billions have been had they been spent in efforts to prevent the production of such huge amounts of wastes at their sources instead of attempting to clean them up just before they are dumped in the waterways of the nation?

The simple agrarian life of Franklin's day was short-lived as the industrial revolution changed so drastically the lives of the American public in the nineteenth century. The history of American

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[5]Ibid., p. 198. [6]Ibid., p. 196. [7]Ibid.

development illustrates the engineers' inability to anticipate this tremendous increase in per capita consumption by the American public. Each new attempt to solve the water demand problem for the urban centers proved frustrating when the expanded water supply became obsolete--in many cases even before it had been entirely completed--not simply because of the added population growth, but more because of the tremendous increase in per capita consumption which was a result of the ever-expanding affluence of the city dweller

The earliest engineering designs for individual water use promoted the unrestricted wasting of water. In 200 years of public works improvements, no one has devised a satisfactory system for limiting the use of water by individuals within the limit of the ability to pay. The American public has become so accustomed to the unrestricted use of water that any alternative restriction on water use seems socialistic, completely beyond the realm of sensibility, and contrary to the American standard of living (lifestyle).

Increased water rates do not lower the use of water to any appreciable degree, but by reviewing the fundamentals of water-works design further, there appears to be alternative structures wherein adequate and sufficient water could be provided for individual domestic use. These alternatives have one common requisite: a change in social attitudes which causes the majority of individuals to live within the ecological limitations of their environment for one reason or another.

Basically, the concepts for conserving water, which are the bases for this discussion, are to (1) develop a family living environment which is closely attuned to the processes of nature, and (2) design a mechanical system for the home which will effectively meet the needs of the home dweller without contributing adversely to the ecological system by making excessive demands for resources or dispelling harmful wastes.

One simple and feasible solution to the problem of water supply is to eliminate the ability of the homeowner to use more water than is necessary to satisfy his basic needs. As an example, the child who comes in for a drink of water turns on the faucet full blast under sixty pounds of pressure to let the water cool. Then he takes a large glass of water, pouring half of this down the drain, while the faucet continues its full deluge to the waste system. Even though the child requires only a few ounces of water to satisfy his thirst, the system design has caused him to waste several gallons of treated water in the process. Perhaps even more critical is the fact that, because of the completely illogical waterworks design, it has been necessary to greatly over-size the sewer systems in order to accommodate the abundant waste that each homeowner has taken for granted as the only manner in which he can enjoy the luxuries of modern living.

We can no longer afford the unrestricted use of water for either industrial or domestic purposes. The control of water use is very closely related to waste-producing habits of modern society. The practice of collecting all the liquid wastes at a single point for discharge back into the environment may have been logical in the smaller rural communities of bygone ages; however, for large metropolitan centers, it is as outmoded as the horse and buggy concept of transportation.

On the other hand, a return to the horse and buggy days may provide some practical solutions to our problems. (It is interesting to note that when horses provided all the motive power for society, some pollution problems existed which are much different from those under discussion here. In New York at the turn of the century, city officials had to contend with daily deposits of some two and one-half million pounds of manure and 60,000 gallons of urine on the streets. Scientists of the day hailed the development of the auto as a clean, quiet, and efficient means of transportation.)[8] In the earlier days, each family was responsible for providing its own water supply and waste disposal system. Until modern appliances and household kitchen aids made these primitive facilities outmoded, there was no shortage of supply or pollution problem. It was not a case of deficiency from the standpoint of fundamental principles; there was simply no attempt to adapt these principles to the new conveniences. It is time now to return to basic principles in searching for a better method of handling supply and waste.

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[8]"Technologies Seers," Newsweek, March 6, 1972, p. 69.

By a process of identifying each basic use of water in the household, it can be seen that practical engineering solutions can be found, such as an automatically-level controlled cold-water reservoir to restrict the child to drawing only the amount of water needed to quench his thirst.

The question can be asked, "Why bother? Very little water is actually lost in the process of filtering through the normal household." Though the question is well-grounded, it is this continuous reuse which adds more impurities that must be removed over and over through waste treatment and fresh-water treatment that does not make sense. It is the resources that are wasted in this repetitive process, and the "wearing out" of the water after it has been used by the populations of fifty cities that should receive more thoughtful consideration. Each time water is cycled through a city, more impurities are added, resulting in heavy concentration that eventually will cause problems with the balance of nature. The addition of tertiary waste treatment is proposed but this is throwing good money after bad.

There are other, more fundamental procedures to follow that require less spectacular public investments of wealth and knowledge. Even more importantly, there are alternatives that would require man to take only the amount of water needed to satisfy basic needs, rather than attempt to capture all the water in the hydrologic system at one time. By allowing the majority of the flow of water to continue in the channels supplied by nature, water could again assume its natural role as the most important medium of ecological balance.

It does require the assumption that an enlightened public has as the foremost aim to conserve the resources of the environment. A view of life that discards the egocentric concept of man as the dominant species over nature, replacing it with the concept of man as a co-partner with his ecological colleagues. The new approach to living becomes more than merely a lifestyle, but more of a religious, or moral concept where brother ant and brother fire are a part of the specter of life with brother man. Stated more realistically, the "change of mind" will have to do with man's attempt to structure his life according to the natural rhythms of the environment. He will renew the animal and plant habitats and take from the environment only that which he needs to sustain life.

Effect of a Balanced Ecology Lifestyle on Water Demand

There is no such thing as "waste" in the natural environment. The environment is prepared to dilute, degrade, and recycle by-products of energy and materials dissipation into life processes. The environment is thus dependent and structured for waste-receiving.

For most of history, man has lived in harmony and benefited from this ecological ingenuity. The vultures and bacteria have been equal to the feces and garbage, the carcasses and corpses. As man began to expand his expectations and his range of activities, anti-ecological forces were set into motion. He learned to resist disease and adapt to different environments until he became the most numerous of all large animals. Natural controls on man's population size which also served to control his waste-making have been surmounted. We now find ourselves adapting to waste rather than controlling it. The increasing drain on the capacity and capability of the environment to consume waste is forcing us to find ways to control our waste--and we must find ways to do it as swiftly and efficiently as possible. This may only be possible if we are willing to alter our behavior or lifestyle and give up some of the things we now consider important to a satisfactory life.

One possible change of lifestyle which would conserve itself with environment by restricting the use of water and generation of waste is that of the new Hippy-style communal living. It is not inconceivable that this type of societal form could become significant in the not-too-distant future. Already many of the characteristics of communal societies are being tolerated and even accepted in California. A recent exposition of over thirty bus-loads of communal dwellers made a pilgrimage to establish a "family" on a large eastern Nebraska farm which they had jointly purchased. Only after the local landowner observed with horror the consignees with whom he had been dealing and reneged on the contract did the caravan decide to return to its familiar and more tolerant California.

Government welfare subsidies are sufficient to support an individual and his family in the tradition of the communal hippy, and a number of "previously respectable and leading" citizens have chosen this way of living in their attempt to defy the inequalities and hypocrisies of the modern world. Perhaps the acceptance of this lifestyle will lead to a sanctioned means for solving many social problems: of the ghettos; the large numbers of unemployed; unproductive persons who cannot find a place in the normal society, such as emotional misfits, people with temporary emotional disturbances, or rehabilitated convicts before they return to the working world. There are any number of categories of human beings who are either by choice or by prejudice outcasts from the normal realm of society.

It is even conceivable that businessmen and professionals would take their vacations or extended leaves of absence to the commune in order to renew their vigor for facing the demanding pace of the working class. College professors who wish to spend their sabbaticals in an atmosphere of meditation and intercourse with nature would find a year or two of communal living to their satisfaction.

It is possible that 15 to 20 percent of the American population could be living in the commune at any point in time. Since the opportunity to spend time in this relaxed non-commercialized atmosphere where religious meditation (or supervised over-indulgence with drugs) would be considered a therapeutic reward for hard work. People would look forward to the opportunity to spend time in his favorite commune--living in a relaxed atmosphere with his "family" and doing only those things that interested him most. College professors would "rap" with electricians, and aerospace engineers would meditate with college drop-outs.

A basic change in societal values would be necessary for this occurrence, and public support would have to be both monetary and attitudinal. The result of the communal concept of lifestyle from the standpoint of enhancement of conversation would be a byproduct of the lifestyle. Since the basis for life in the commune would be complete and lasting relationship with environment, an ethic of ecology would prevail. A balanced system would exist where people would, because of their concern for nature and the environment, consume only the basic elements of air, food, water, and energy needed to sustain life. The new focus for living would be a calmness and serenity instead of the intense, violent life of the modern city-dweller.

The primary function of each man's activities would be to care for the components of nature of which man would become an integral part. The spin-off benefit would be that this conservationist attitude would carry over to the outside world, and life in general would be more pleasant and more responsive to the limitations of the environment. Even the cities would become quiet, attractive centers for pleasant community living with parks, playgrounds, and open space. Pollution would no longer be a problem since economic priorities would favor life rather than production.

The prospects of this form of lifestyle are not as remote as the older generation would conclude. Even now many intelligent college students are making plans to find a favorable location in which they can stay together after graduation. Each person would find work in the establishment system, but the homelife would be a form of the "extended family" where each individual would contribute what he does best for the group. This lifestyle will, if allowed to flourish, have some frightening effects on the corporate structure. No longer will it be necessary for each couple to have two cars, a boat, a camper, a swimming pool. These costly items can be shared as well as household items like washers and dryers, vacuum sweepers, and electric toothbrushes. The entire economy will be upset. Surely a law will be passed preventing this kind of criminal action against the system before it can be carried to the point of extreme.

Dr. John Todd has taken a look into the future and predicted that the homestead or small farm has the potential of being the cornerstone of the solution to the environmental crisis.[9] This twenty-first-century homestead will be ecologically complete, even to the point of generating its own power needs from non-polluting sources of energy such as the sun, wind, or gases that are the byproducts of sewage decomposition. Dr. Todd describes a number of techniques for producing energy, restoring soils, and producing foods by redirecting activities which formerly were destructive to or polluted the environment. New re-

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[9] John H. Todd, "The 21st Century Homestead," Organic Gardening, Vol. 18, No. 12 (December, 1971), 57.

lationships between plant diversity, soil fertility, and the ability to withstand the onslaught of pests and diseases are being sought. With increasingly productive organic food production, more land will become available for other purposes such as new crops growing in intricate combinations which also allows placing livestock on the land.

Already Oklahoma is offering ten-acre homesteads for fruit farming with guaranteed incomes of $7,000 per year. As part of an Economic Development project, the state will offer tools and training, as well as subsidies until the crop is able to maintain a level of subsistance for anyone who will work the land and remain on the farm.

Another feature of Todd's homestead of the future will be the sense of the land and forces of nature reflected in the places of human habitat. The houses and shelters will be environmentally sensitive, low cost, and individually built to satisfy the needs and tastes of each family.

A lifestyle conceptualized by others follows more the writings of Huxley and Orwell, which predict a futuristic technology unimagined by present-day standards. Predictive studies of a highly-advanced technology have been the most common among prognosticators of the future[10] and hold some interesting prospects for the conditions of conservation of resources. In this futuristic society many of the basic functions of man which require water, such as cooking and bathing, would be obsolete.

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[10] Sylvia E. Bowman, The Year 2000 (New York: Bookman Associates, 1958).

Food and liquid would be either in the form of pills or be given intravenously while sleeping. Dishes would no longer be required; the weekly quota of clothing would be purchased at the corner store and, after use, disposed of by some complete degradation process. One size would fit all people within an age group because of genetic advances and artificial diet control. The body and other household wastes would be immediately destroyed by some as yet uninvented process and would not require handling or transporting away from the inhabitants.

The entire food supply would be from artificial nutrients in tablet form. Bathing would not be necessary because of a dry vacuum process or chemical change which would instantaneously cleanse the body of all soil and bacteria. Lawns would not be necessary because of artificial turf. Cars would not be individually owned. A completely public transportation system would provide facilities for transportation from the individual's doorstep to any world destination. The only possible quantity use of water would be for recreational purposes in lakes and streams.

The final concept which, with a slight interjection of imagination, could provide a practical solution even within the present sociological setting. It would not require extensive change of lifestyle patterns. The primary requirements for this concept is a new design for individual living units. Since one segment of ecology cannot be considered in a vacuum, the home should also contain characteristics which will be intended as solutions to resource problems other than water. To begin with, the basic structure could be built of entirely non-flammable materials, including furnishings which will alleviate the necessity for traditional fire-fighting standards. Since the primary reason for the immense over-design of water systems is to accommodate fire-code requirements, a substantial savings would occur immediately. Eliminating the necessity for fire insurance ratings by the National Insurance Underwriters would also provide an economic advantage.

Some exciting new break-throughs are occurring within the architectural profession which would bear mention. The new theory of Ekistics, developed by environmental and urban planner, C. A. Doxiadis, is an approach to doctrine for urban and regional design which permits orderly and rational growth of cities.[11] It shows how all stages of growth may be accommodated to provide for the total environmental needs of human population. Ekistics is a multi-disciplinary science drawing on the substance of physical, biological, and social sciences for its basic content. It aim is "how to make a settlement so as to fill the two basic requirements of man, security and happiness."[12]

There is emerging a number of modern-thinking members of the architectural profession who seek a similar new dimension in "space

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[11] C. A. Doxiadis, Ekistics: An Introduction to the Science of Human Settlement (New York: Oxford University Press, 1968).

[12] Ibid., p. 9.

for living." Men like Paoli Soleri, Ian McHarg, and Lawrence Halprin are disturbed by the threat of society slowly devouring itself by building without consideration either for the land or for the real needs of people. Professor Vincent Sculy, Dean, Yale School of Architecture, says that ". . . the human act of architecture is the construction of the whole environment. The architect should concern himself with houses, trees, roads, and everything else in the environment."[13]

Ian McHarg has launched pioneer ecological studies for the architect at the University of Pennsylvania, calling for a study of the landscape--". . . the region will suggest its own form. . . ."[14]

Halprin argues that the most important element in a house or structure is technology, its capacity to cool, heat, prepare food, dispose of waste, etc.[15] Professor Knowles at the University of California has worked out an elaborate low-energy architectural system: buildings designed to conserve heating and cooling energy through location and placement to take advantage of sun, rain, and wind patterns. ". . . What we are thinking about is not an aesthetic of form, space, and structure; it is an aesthetic of survival. . . ."[16]

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[13]"New Architecture: Building for Man," Newsweek, Vol. LXXVII, No. 16, April 10, 1971, p. 79.

[14]Ian McHarg, Design With Nature (Garden City, New York: Doubleday & Co., Inc., 1969).

[15]Lawrence Halprin, The RSVP Cycles, Creative Progress in the Human Environment (New York: G. Braziller, 1970).

[16]"New Architecture: Building for Man," p. 87.

If the new urban scenes proposed by Halprin, McHarg, and others are any indication, the city of the future will welcome mixed diverse functions and residences, abolish the automobile, and establish open plazas where children can play. These plans are practical and probable, given some much-needed reordering of social, political, and financial priorities. Houses will be placed very close together in a cluster to conserve space for a large open "green" area which will be used for the mutual benefit of the neighborhood. This cluster design will center around the needs of children to play and learn in safety and in relationship with nature. The automobile will be de-emphasized as narrow streets will serve only the rear of the homes or be eliminated completely. Transportation within the neighborhood "green" will be by foot and bicycle, with provisions for small electric carts for aged persons. Exterior architectural design will be eliminated in favor of mechanical function and safety. Emphasis on beauty and style will be confined to the interior of the structure. Each unit will have a small private patio-yard for outdoor living.

Drainage for the entire area will be designed with gentle slopes to maximize the use of rainfall for irrigation of the green space. Runoff will be collected in small lakes to use for irrigation during the dry season. The green area will also be a balanced ecological system with plants and wildlife indigenous to the geographical area.

There will be no necessity for a collection system or waste treatment facility; waste from each family dwelling will flow through an irrigation and fertilization system to the family garden. A small water-treatment plant at a lake could provide for minute quantities of potable makeup water as required for each home water system. Water reservoirs within the home will be automatically level-controlled. These will provide hot and cold water for cooking and drinking. Connections from the public system to the house will not have accessible valves; thus no one will be able to regulate the flow of water into the home. Since no flammable materials will be used, only small pipes will be necessary to service the homes. Fire-fighting equipment will be needed only for using lake-water on possible grass fires in the green.

The home will be oriented so as to take advantage of natural wind and weather conditions to aid cooling and heating. The objective of the home mechanical system will be to explore the little-used, ancient, non-polluting forms of energy: sun, wind, rain, and water currents. While these forms of energy will not handle the needs of large cities, which are monstrosities incapable of incorporating ecological principles, it is possible to harness these old-fashioned forms of energy on a small scale. They may be the key to a form of rural revival within small communities. Windmills and solar generators for heating houses and cooking are possible on individual home installations. Domestic wastes will no longer go into sewers but will be a source of gas energy and fertilizers to be returned to the land.

If, as a nation, we were to spend half as much on creating low-cost single-family or small community-size sources of energy as we do on oil exploration or development of potentially dangerous nuclear generators, it might be possible to solve a number of environmental and social crises at the same time.

Use of water in the home could be very similar to that of present-day homes. However, each functional use of water will be isolated in self-contained equipment which will not allow mixing of the various impurities added to the water as it is used.

It should be noted that the one use of water in the home that does not lend itself to recycling with relative ease and safety is flushing body wastes. Garbage can be disposed of in a much more convenient and economical manner than the sink garbage disposal. Soaps can be applied in such low concentrations that their removal would present no particular problem.

By isolating the toilet waste water from the remainder of the system, and treating these wastes separately, the remaining water can be recycled through a simple treatment process. Many uses of water in the home require only swimming-pool quality for nonpotable use, so the task of treating the recycled water is made even easier.

Body wastes can be easily and completely treated by a simple aeration tank with the proper balance of water and air designed into a mechanical mixing tank. Small amounts of overflow draining to a tile field or reservoir can be used for lawn watering. Drinking and cooking require a very small amount of water proportionally, and thus could be supplied through the public potable supply to automatically-regulated reservoirs, providing a continuous and instant hot and cold supply to the kitchen. Overflow or waste from these faucets would be sufficient for make-up water to the system from the losses accounted to the waste treatment system. Peak demands would be non-existant as the hot and cold reservoirs would be pressure-sensitive and would not fill when an excessive load on the public system caused a drop in pressure. Instead, the reservoirs would fill during off-peak periods.

The water for bathing, washing hands, washing floors, and miscellaneous household use could be recycled through a large reservoir of 12,000-15,000 gallons. This pool would serve as a family bath and would be treated in much the same manner as a conventional swimming pool. The water temperature could be maintained for comfortable bathing since no high temperature water would be required in the recycling system. Clothes can be washed in cold water, and dishes would be steam-treated after being rinsed with the tepid water. Chemical treatment could be added to the system; however, very few impurities would be accumulated in the water that could not be efficiently removed by the filter, since no garbage, feces, or urine would enter the filter. A kitchen tap could provide non-potable water for routine cleaning, as well as a hot-water tap for washing surfaces for eating and preparing food.

The foregoing describes an alternative lifestyle that would not supplant the normal American cultural requirements drastically. Some desirable solutions to problems other than water shortage would also result from such a scheme. The aesthetics of recycling waste water would not be a factor since excrements are not recycled, and only the individual family's own water is reused rather than the community water. Any organisms, such as viruses which might survive the treatment process, would be confined to the occupants of the house and could not cause widespread epidemics. The simple water-treatment plant would become a routine piece of mechanical equipment for each new home, similar to the present furnace and hot water heater.

This plan does not, of course, provide a feasible means for converting existing housing, but the future population expansion would be assured adequate water since per capita use in the neighborhoods would be reduced to two to five gallons per day.

Further comprehensive study of fundamental changes in engineering design are needed that will attack the crisis of the environment. The individual home is one of the most obvious points of beginning, but unless the inhabitant has perceived that a crisis exists, results of these studies will be placed on the shelves of another university library to join the ghosts of other similar "intellectual" exercises. Nothing dishonors us more, or does more to limit the possibilities of genuine progress than the flaws in human nature that cause us to misunderstand the legacy of the past and misuse the opportunities of today.

CHAPTER VII

CONCLUSIONS

Proposal for a New Science: Soft Technology

Dying Lake Erie, the polluted air and rivers of our every industrial state, and the hideous slums of our big cities are the expressions of distorted values that permit us to demean and diminish so much of our continent. Daniel P. Moynihan, former Counselor to the President, wrote the preface to his latest book on the morning of the day of America's first lunar landing. The celebration victory in space was curiously muted, he noted, because intelligent Americans realized their failures on earth. Concern for the condition of life in the American cities produces a moment of thoughtful ponderance when we stop to think of what results might have been possible if a scientific and political coherence of effort were to be directed toward improving life on earth, as was done in the quest to conquer space.[1]

Realistic action, however, requires more than moralizing about the rights and wrongs of past years. Nor can the mistakes be

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[1] Daniel P. Moynihan, ed., Toward a National Urban Policy (New York: Basic Books, Inc., 1970), p. ix.

remedied merely by piecemeal actions that attempt to repair the depredation of the past without full commitment to put the welfare of people and land ahead of profits. Only if ecological planning is given the priority it deserves can the consumption and production standard in our society ever be reconciled with an environment-oriented standard. Only then can a marriage of technology, economics, and ecology occur.

Since the beginning of the industrial revolution, engineers and scientists have guided technology toward a produce, grow, expand, and compete objective. The resulting blighting and befouling of land and resources has been accepted as one of the costs of a progressive, powerful, industrial nation.

The manned space program has perhaps produced at least one measurable benefit to mankind. It has established an atmosphere of awareness of the finiteness of earth for everyone--astronauts, scientists, lawyers, plumbers, housewives, barbers, and young people. It has set the stage for a New Science--a science which has a technology which is moral, not money oriented; its goals are ethic, not economic, and its objectives are conservation, not destruction, of resources. This is the technology of an enlightened people, who recognize the fact that conservation is indispensable to the long-term wealth and strength of nations. It is a soft technology.

This new science could produce, instead of an industrial revolution, a conservation revolution. It will be applied to research for clean energy sources from the wind, sun, and falling water; recycling of wastes instead of searching for more metal and fuel deposits; public transportation rather than more cars with programmed obsolescence; organic agriculture, which causes no harm to nature from synthetic fertilizers and pesticides; and water-resource planning that will not kill the lakes and wildlife. It will give us the technical skills to redirect our enterprise system for the first time to enhance living values. It will accomplish this by the thoughtful design and location of its factories, by creating a fulfilling milieu for its workers, and controlling its processes and effluents. Most important, it can give us the skill to build beautiful living, and working, and playing environments for people.

Not until we saw a picture of the earth from the surface of the moon did it occur to us, in the headlong rush to produce more and more consumer goods to supply what was assumed to be an ever-increasing population, that our planet was finite. It has an environment which is fragile, biologically interdependent, and self-contained. All the resources we require, except the energy from the sun, must be found on earth and in its atmosphere. All the wastes we produce by transforming these resources into products and services, must be strewn or stored somewhere on earth, and most of these resources are irreplaceable.

The new science will go beyond the physical impairments of pollution and over-consumption. It will focus attention on the human psyche. It will fight for parks and walking paths and open space for children to play in safety. It will design new communities within the cities and take the fate of urban expansion out of the hands of entrepreneurs and private developers. It will place value on beauty, love, and peaceful places where wildlife can flourish. It will entail an application of the systems approach to the intricate system of life itself.

Objective of the New Science

Throughout American history, the municipalities which secured the building of public works always congratulated themselves on providing for the needs of their citizens for generations to come. Almost invariably, they underestimated future consumption. This eventuality is still predictable even with the most advanced techniques of planning for design, especially in water-resource projects and transportation systems. These are glaring illustrations of the engineer's inability to anticipate the tremendous increase in per capita consumption by the American public. Each new attempt to solve the demand problem for the urban center proved frustrating when the expanded systems become obsolete in many cases before they have been entirely completed, not simply because of the added population growth, but more because of the tremendous appetite for consumption which has resulted from the ever-expanding affluence of the city dweller.

In direct proportion to the over-consumption trends, particularly for water, is the great abundance of waste which is being carried away from the American home and deposited in the natural waterways of this country. The first objective of the new science would be to work toward a plan to reduce over-consumption and pollution of the water resources of the planet.

A strictly engineering approach to predictions of the future as a basis for design does not correspond to the ecologists' plea for a search for methods to reduce the tremendous appetite of the American public for destruction and consumption of the natural resources. The tolerance of the ecologic equilibrium, experts say, may be surpassed. It is the view of many writers today that fundamental overhaul on a social level of some of the most cherished tenets of an industrial society is a prerequisite for the future welfare of the earth's surface which is largely in the hands of man. Thinking man has the choice of how to influence future changes in his environment.

The soft technology will explore alternative approaches to the problems of predicting public water requirements for the future. The age-old premise that a capitalistic free society can only survive through increased expansion and accelerated production will be ignored for the moment. Instead of simply assuming "what has taken place in the past will continue, only more so, in the future," new criteria will be developed for planning based on the changes that could occur as a result of lessons learned from mistakes in managing the environmental resource accounts of the planet.

Planning teams will work together on projects effecting ecology to ascertain and articulate ideas involving not only physical but also cultural, economic, and social factors. These complex problems will require interdisciplinary teams of architects, engineers, sociologists, psychologists, anthropologists, planners, economists, lawyers, and managers bound together by a common commitment.

The soft technology will begin by developing a plan to allow each individual homeowner the opportunity to stop polluting the water. The objective of water-resource engineering will be to allow as much water in the natural channels of the land to continue in its unobstructed design of providing the lifeblood of the ecological system instead of capturing as much as possible for the exclusive service of man. Specifically, the planning will accomplish the following:

1. Identify factors and trends which contribute to the destruction and waste of environmental resources. Objectives will be concerned with the conflict around competing uses of and their associated destrictive qualities on water. This will produce a detailed priority list for the management of water resources based on relative polluting abuses.

2. Study the economic relationships of water use and water pollution for a range of alternative applications by comparing withdrawal, consumption, recycle, reuse, etc. This will show how economically feasible alternatives are possible which will reverse the progressively increasing destructive tendencies associated with water use.

3. Specify and evaluate a set of alternatives for family living consisting of single- and multifamily houses and public facilities necessary in a neighborhood cluster. This will include architectural and engineering designs for houses which will

require only minimum quantities of water without lowering the American standard of living and which will produce no water-polluting wastes. Included will be sociological, psychological, economic, and engineering analyses. All of the necessary functions of the family will be retained except the attitude that water is an unlimited commodity. New architectural concepts will be incorporated with a complete redesign of the mechanical systems of homes.

4. Teams of interdisciplinary professionals will develop and evaluate new designs to determine the desirability and practicality for promoting the concepts to public use.

5. A set of technical coefficients based on reduced consumption as a source of supply will be applied to predictive mathematical models to compare the large-scale measurement of demand based on present estimates of withdrawals to the "micro-level" approach of the new definition of water demand. This will illustrate the impact on water resources engineering which could result from the plan.

Future Directions for Water-resource Development

Water technology is concerned with the application of scientific knowledge and material techniques to the alteration or channeling of water demand to the production, storage, or transportation of water. Administrative policy is concerned with the application of social techniques to the same ends. Revisions in technology and administrative policy can provide some but not all solutions to the ecological problems facing future generations. Basically, the solution must be in the ethical realm. A majority of people must develop a sense of stewardship. This stewardship will involve a change from the exploiting I-it conflicting interaction between man and his environment to an I-thou concern, a change from the fragmented cultural division that we have largely been practicing, to an wholistic, integrated, and pluralistic culture. More significantly, any progress that is made must be made in the very short span of one to three generations.

There must occur a blend between technology, administrative organization, and morality in order to profoundly affect the course that water and economic development related to water will follow. Much scientific research follows directions that are governed by social needs. Development of a more sophisticated knowledge of these needs must be undertaken if we want science to fulfill its social role. In many cases, scientists are so interested in their own self-made problems that they tend to neglect the problems that are more meaningful for human life. In effect, scientists are practicing a form of intellectual masturbation. On the other hand, scientists alone do not have special qualifications to formulate goals for society; they can, however, and should play a role of unique importance in trying to determine what is feasible, what kind of knowledge is required, and what are the likely consequences of various courses of action.

It is possible to create a science in which the intellectual atmosphere and technology will be favorable for the development of the kind of complex, ecological thinking required if conservation is to become more than a sentimental word. Various philosophies of conservation have merit and can lead to the formulation of legitimate social goals, but the philosophies can be viable and the goals reached only if certain ecological imperatives are respected. The definition of these imperatives demands a new kind of scientific knowledge far different from what is presently being developed.

This discussion presents a paradox confronting the engineering professional ethic. As a student of the environmental resources of the planet, the engineer is aware of the destructive consequences of the productivity of his profession to the life support systems--air, land, water. Yet he is somehow unable to break away from political and economic forces which control the impetus directing his productive energies while at the same time a part of his moral fiber struggles with a solution to environmental degradation.

In the early days of man's destruction of his environment, he always had the luxuries of good soils elsewhere; the environmental wounds he left behind were sometimes healed by nature. Today this luxury is no longer available. As a result, the biosphere on which man's survival is dependent is literally in jeopardy. Man must begin to reverse this headlong plunge into environmental destruction and begin forming public policy objectives which will protect environmental quality.

An Ecological Model for Water Resources Planning

The complexities involved in achieving these objectives are formidable. In order to undertake the necessary solutions to problems of this magnitude, the systems approach must be applied. This will involve identifying and modeling the subsystems and determining their interactions before any effective evaluation of the accomplishment of goals can be undertaken.

On the other hand, the model should not be considered an end in itself. It is merely a means of attaining an end, and, as such, a technique to be used in modeling the problem should be made on the basis of objectives considered. Too often the modeler attempts to fit the problem to the tool rather than find a tool which fits the problem. The falacy with mathematical applications to complex situations is that we look for a simple coefficient multiplier to quantify the variables. Unfortunately, these coefficients, because they are simple to define and because they fit a mathematical formula, are considered factual. On the other hand, the model is essential because it provides a means for viewing the problem in its entirety rather than piecemeal and provides a means of realistically evaluating the results of an action. In recent years, the tools of systems analysis have been increasingly applied to the area of water resources problems. Specific examples of such applications are thoroughly discussed by Reid.[2]

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[2]George W. Reid, A Systems Approach to Urban Planning, A Report prepared for the Oklahoma Economic Development Foundation, Inc. (1969).

The primary outputs of most of these models are forecasts of economic and demographic characteristics which are then tied to water-sector requirements on a regional basis. The primary difference in modeling applications for the soft technology is that an additional, overriding characteristic will be introduced which will have precedence over the other two--the ecological requirements forecast.

Scope of Ecologic Model

The statement of the problem and definition of objectives are the first requirements of the systems approach. This hopefully has been accomplished in the first six and one-half chapters of this dissertation. The definition of the systems and subsystems which enter into the problem will now be described, together with their interactions. The final step in the solution of a problem is evaluation and analysis of results based on actual data. This will be left for future study.

Essentially, there are four major systems which will be considered applicable to this model:

1. Ecological System
2. Economic System
3. Hydraulogic System
4. Information

The fourth system relates to all three of the others and is required to supply data for the entire study. The interactions between the systems are shown in Figure 8.

The ecological system relates to the water quantity and quality requirements of the natural environmental balance for the specific region in question. The water needs for this system must be measured and carefully delineated since it constitutes the life-sustaining component of water demand. This includes not only man but all life which is necessary to a balance of life. These will be minimum or "most effective" demands determined through the most advanced technology in biotic and abiotic husbandry. There will be no cost allocation with this system since its demand will be met at all costs.

The economic system is concerned with all other uses of water. The requirements for this sector will be based on a value-cost priority basis whereby each subsystem will receive a value coefficient to be applied to the remaining water resources after the ecological system has been satisfied.

The Hydraulogic System is the most extensive system of the model containing many subsystems which interact within themselves, such as treatment capabilities and return flow or recycling quantities of the basic resources through transmission systems.

The information system consists of inventories or data collection procedures. This phase of the operation of the model will require the interdisciplinary approach to evaluate the basic systems and identify relevant data. This will include not only what is available, but what can

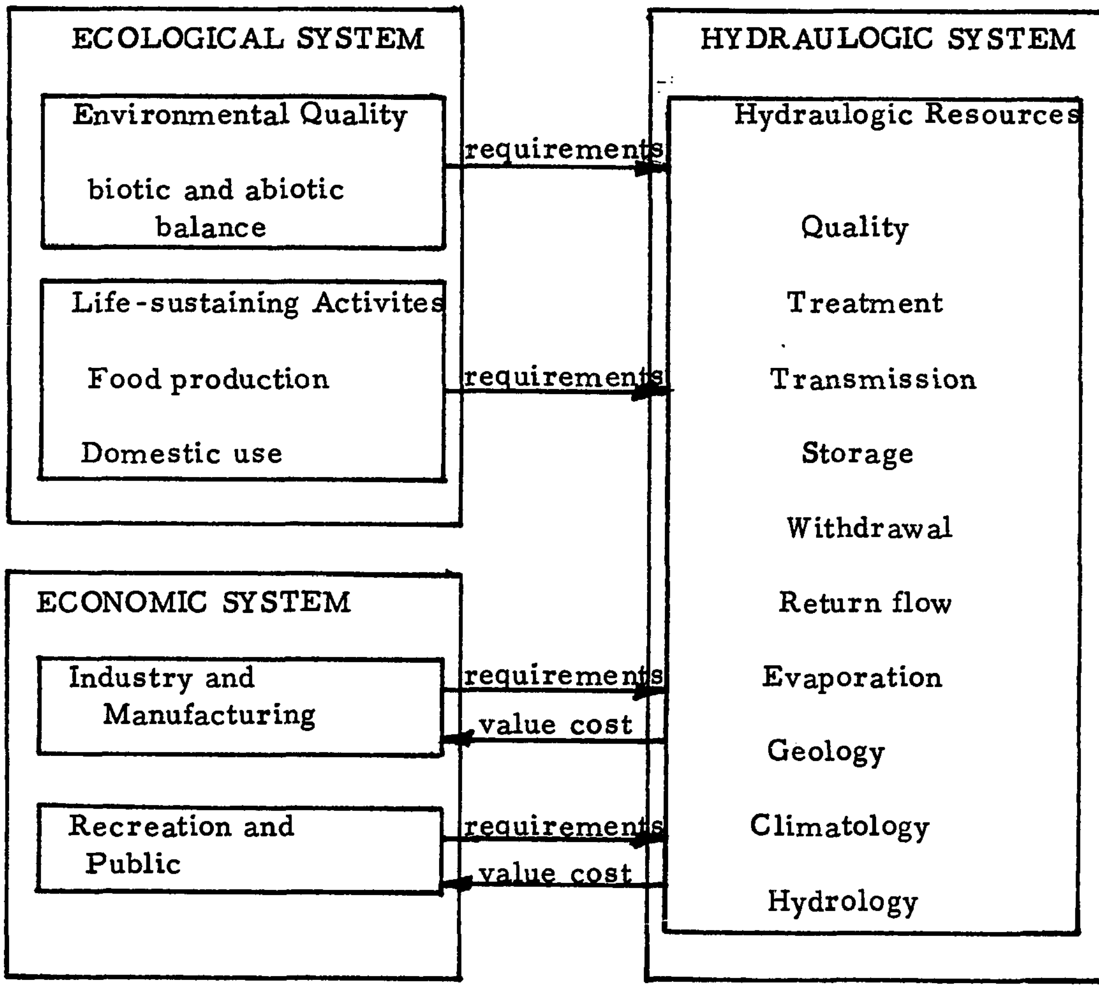

Fig. 8.--Major Systems of the Ecological Model

be done to reduce the requirements of the system to make them more ecologically efficient.

The time-frame for the planning model will include long-range occurrences, but will be based on feasible projections of the existing resources rather than simply on historical information and trends. Since design life-expectancy of public water-works facilities will not be a factor, 100-year projections will become normal practices.

The components of the model and their sequential arrangement are identified in Figure 9. The first step is to conduct the required inventories and data system. Next the projection of Eco-System parameters must be undertaken. Then, based on these projections, estimates of the total water requirements for a balanced ecology can be determined. Subsequently, a water system plan can be designed. Next, the remaining water available can be divided according to a value-cost priority system to satisfy regional development goals. Once the plan is developed and made operational, the evaluation in terms of ecological balance can be accomplished; if necessary, modification of the water plan can be made.

Summary

Before it will be possible to expect government to support research in this idea of a "soft" technology, it will be necessary to refute the contemporary fact of life that "he who controls the supplies of power, directs society." Deployment of a massive development of small pure-energy units would take power away from the relatively few.

Studies of new uses of water and energy should be enmeshed with ecologically-based agriculture and aqua-culture research. If this were to happen, the farms of the future would be organic and diverse and at the same time able to support large numbers of people. The basic axiom of organic gardening, namely the creation of superb soils and the raising of high-quality plants and animals, together in sophisticated poly-

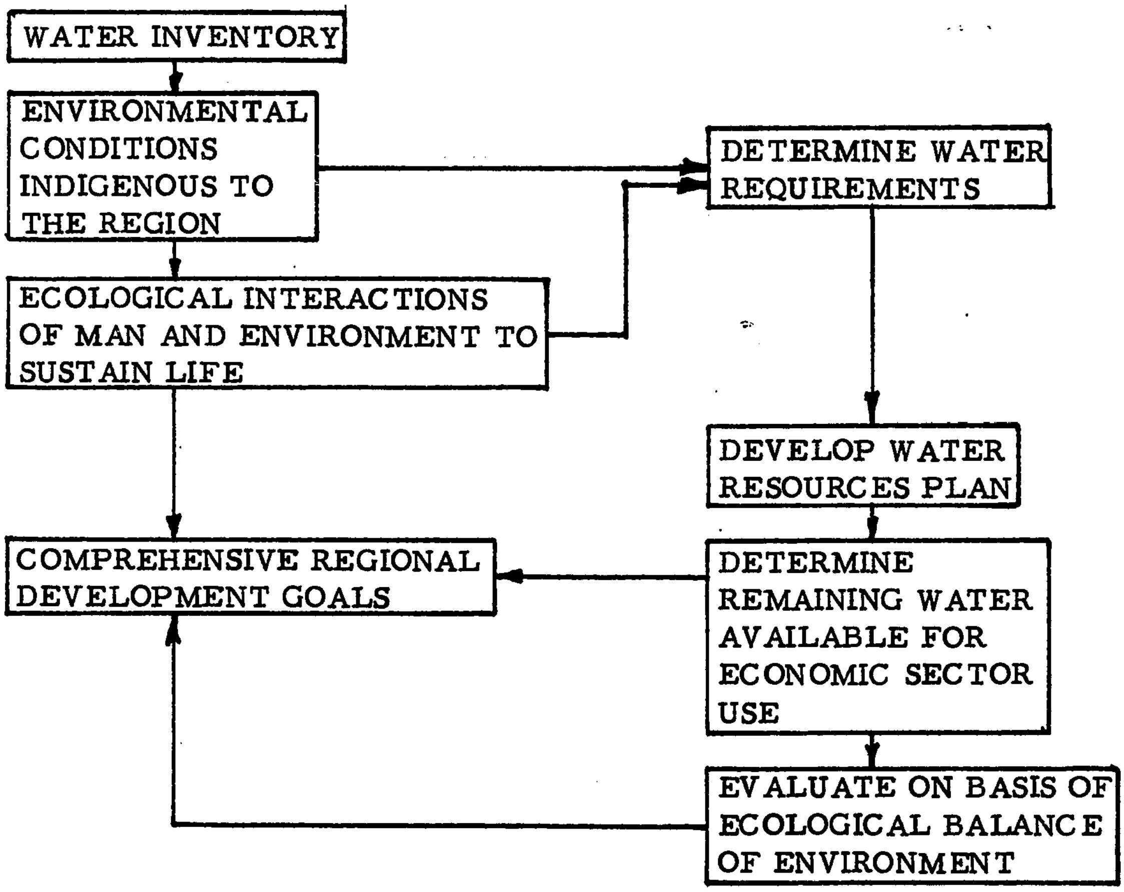

Fig. 9.--Organizational Planning Model

culture which imitate the processes of nature, will reverse the trend of artificial landscape which requires vast quantities of water and chemical fertilizer.[3]

The problem is finding support for this New Science to form a "soft technology"--a technology that would be risk-free and restorative to the environment. If this were possible, it might even be conceivable

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[3]John H. Todd, "Shaping an Organic America," Organic Gardening, Vol. 18, No. 10 (October, 1971), 83.

that a new source of human energies that could make the difference in the struggle to save the planet would be uncovered.

It is possible that rural and urban communities for the first time could make safety and sanity the norm, where men and children could walk unhurried to work and school, to see and touch nature and rub elbows with people like and unlike themselves.[4]

If we give ecology and population planning the attention and priority they deserve, we can and will reconcile the classic standard-of-consumption concept in our society with an environment-oriented index-of-living standard. New dimensions of conservation could then occur in which a merger of economics and ecology could occur.[5] To quote Mumford once again:

> During the past three years I, like many of my colleagues, have noted a new generation coming into the colleges: a generation trained perhaps more lovingly than their rigid and passive predecessors. They are no longer cagey conformists, no longer bent on dodging all the adventurous possibilities of life by an overemphasis on security, measured in income, or in status, measured only by the things money will buy. . . . Though they have grown up in an age of violence and totalitarian conformity, they now challenge its brutality and reject its compulsions;. . .[6]

No one can as yet determine whether the youth movement which Mumford observed in the early part of the last decade, and which

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[4]Udall, 1976: Agenda for Tomorrow, p. 91.

[5]Ibid., p. 101.

[6]Mumford, The Urban Prospect, p. 22.

has been vividly witnessed by all of humanity by now, will have an affect of change on the priorities of the nation. The so-called "hippy" commune has numerous interesting implications for an urban structure.

Perhaps some of these young people have recognized the threats and crisis and are beginning to set the stage for changing of values and priorities for living. Enough noted experts have convincingly predicted the enormity of changes in human determinations that must take place before real progress can be made to turn the tides. The youth of today show the only signs of anything resembling such a change.

It is by no means a simple matter of too little water, air, or food. How could one with faith dare to doubt that modern science could somehow solve these minor difficulties? Realistically, science can no longer carry the burden alone.

The primary problem now is to broaden the scope of public consciousness to include the whole nation and the whole world. It will be necessary to enlist the interest of all lawmakers and every citizen. More piecemeal plans geared to quantitative conventional programs for more jobs, better schools, improved welfare, accelerated housing, etc., will not arouse the people. These alone will not get the job accomplished. A dream of excellence and betterment to involve and excite every citizen is needed. Man has never dared to think and act on a scale that would involve each individual and every community across the land in a project for the betterment of mankind.

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