INFORMATION BULLETIN NO. 3

Economics of Water Quality Control Measures

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WATER
for
IDAHO

Water Resources Research Institute
University Of Idaho
Moscow, Idaho
January, 1970

ECONOMICS OF WATER QUALITY CONTROL MEASURES

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Given at the
R. N. Irving Chapter
Soil Conservation Society of America
Annual Meeting
November 21 and 22, 1969
Holiday Inn
Boise, Idaho

ACKNOWLEDGEMENTS

The author wishes to acknowledge the contribution of the following persons. Dr. A. T. Wallace, Associate Professor of Engineering at the University of Idaho; Mr. Wayne Haas, Assistant Director and Mr. H. Tom Davis, Environmental Engineer, both of the Idaho Water Resource Board staff. These gentlemen provided considerable background and data and information relating to the general setting of water quality problems in Idaho.

ECONOMICS OF WATER QUALITY CONTROL MEASURES

Idaho depends on its natural resources for economic growth--air, soil, and water serve as basic raw materials for agriculture and industry. These same resources are also used to receive and dispose of the waste products created by industrial, municipal, and agricultural activities. This waste disposal role of our natural resources has created severe problems for both private and public sectors of the economy. Some say that we are approaching the point where our ability to pollute the environment may ultimately affect our ability to survive on earth. At the present time we don't have enough information to make such a statement, it is necessary, however, to recognize the potential threat of pollution to our environment and to put it into proper perspective. The major threat of pollution is that of destroying large segments of the environment which presently enhances or could enhance the quality of life of the people of Idaho. The magnitude of this problem of pollution needs to be determined both on the local, state, and national levels.

Water quality control is a broad problem in water resource management. Water quality control is a very complex problem and one which requires a broad framework for analysis. This problem is affected by the use water is put to, the location of the user on the river or lake in question, the number of water users, the number of waste disposers. In addition, water rights and other legal problems enter the picture. For these reasons, it is necessary to look at a basin wide water quality control program. This approach has many ramifications for present users and future users. Who should pay for water quality control; who should be allowed to pollute and what kind of treatment or control is necessary? The remainder of this paper will be devoted to these problems.

DEFINITIONS

The specific topic I wish to discuss is the economics of water quality control measures. Let us begin by defining water, water quality, and water quality control.

Water

Water in its chemical form is H_2O. This chemical formula indicates that it consists of two parts of hydrogen and one part of oxygen. The water flowing in our lakes and rivers is far more complex than this formula. It includes many dissolved chemicals, soil particles, and debris.

Water is a unique natural resource instrumental to all forms of life, and also to many industrial processes. Generally the federal and state laws indicate that water is a common property resource owned by the State. It also has a characteristic unique to common property resources because an individual can establish the right to use the water flowing past his farm, mine, or industrial plant. He may also acquire a quantity of water for some legally defined beneficial use. In Idaho the beneficial uses of water are for domestic water supplies, irrigation, mining, and manufacturing.

Another type of water use or right which is not as clearly written out in the legal framework is the right to pollute water. It appears to be an established practice, that any beneficial user of water also has the right to discharge waste water into the same body from which he obtained his clean water. At the present time a joint federal-state effort is being made to rectify this situation and hopefully this effort will define what waste loads will be tolerated in our rivers and streams.

Water Quality

What is water quality? The Water Quality Act of 1965 allows the various states to formulate water quality standards:

> "to protect the health or welfare, enhance the quality of water and serve the purpose of this Act. In establishing such standards . . . shall take into consideration their use and value for public water supplies, propagation of fish and wildlife, recreational purposes, agricultural, industrial, and other legitimate purposes."[1]

[1]White, Gilbert F., "Strategies of American Water Management". The University of Michigan Press, Ann Arbor, Mich., 1969, p. 59.

This definition of water quality is ambiguous to say the least. Even so, there is much to recommend a broad concept for defining water quality, because it allows flexibility to consider the various uses of resources and conditions of water resources in the United States. Water problems tend to be different in the various states. The availability of adequate municipal water supplies tends to be a problem for the northeastern states with the large populations, while adequate supplies of irrigation water are needed in the west. These uses of water have far different water quality needs.

Pollution

Pollution is also defined in an ambiguous fashion, because almost every stream is polluted to some degree. The types of pollution range from turbidity to low levels of dissolved oxygen. When the multiple use concept is applied to water, then that which is polluted water for one use may not be polluted for another.

Water Quality Standards

What are water quality standards? A water quality standard is a quantifiable indication which is used to describe the condition of water. Standards are generally set in terms of TDS (total dissolved solids), DO (dissolved oxygen), or levels of coliform bacteria present in water. The type of standard used depends upon what use the water is to be put to. If the water is being used in an industrial process TDS may be the appropriate standard. DO is used to measure the effect of polluted water on aquatic life. The coliform bacteria standard is used to determine whether or not the water is potable. These standards all set some minimum level of pollution which will be tolerated. They do not provide any incentive to decrease the level of pollution above that set by the standard.

It appears that the lack of support for the water quality standard is related to the difficulty of measuring the benefits to be obtained from water quality. It is impossible to estimate the benefits because of two problems. First, water is a non-priced good in our world. This means that we do not buy and sell water on a market basis and therefore there is no demand for water in the traditional economic sense. Wheat is a market commodity which has a price but water is not. Secondly, multiple use of this resource also complicates the picture. The same water may be used for domestic, irrigation, and industrial purposes. This variety of uses creates problems in management which are related to a priority ranking of these uses, and generally this information is unavailable. For these reasons water quality standards are necessary. The standard provides a working level goal which can be implemented to set levels of water quality and to this extent it is useful.

WATER QUALITY PROBLEMS

In Idaho there are three basic uses (agricultural, municipal, and industrial) in which water quality is important to continued economic growth The water quality problems which affect these uses depend upon where the water is and what it is to be used for. Location is a real and meaningful factor related to water quality problems. If a pulp mill is upstream from a municipality then the waste water discharged by the pulp mill will create a water quality problem for the municipality if it expects to obtain its potable water from the same river.

Agricultural water quality problems consist of mainly turbidity caused by irrigation runoff, erosion of non-irrigated cropland, siltation resulting from timber harvesting, runoff of organic materials from feedlots, and the runoff of fertilizer and chemicals from cropland.[2] Another primary source of agricultural pollution is the concentration of animal populations in specific areas. For example, about half of the cattle in the Snake River Basin are clustered in three areas: (a) along the Snake between Lake Walcott Reservoir and the confluence of the Big Wood (Malad) River, (b) in the lower Boise River Valley, and (c) in the central basin between Adrian and the head of the Brownlee Pool.

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[2] Contrary to popular belief, the pollution caused by fertilizer--particularly with reference to increased nitrogen levels in water--has not been found to be significant. There are many other sources of this nitrogen not the least of which are the effluents from municipal waste treatment plants and food processing plants.

In these regions there are about 800,000 head of cattle and significant numbers of other farm animals[3]. The drainage from manure piles constitutes a significant source of bacteria in the river. This drainage also increases the nutrient load of the river contributing to depletion of dissolved oxygen. Excessive depletion of dissolved oxygen has been largely responsible for the numerous fish kills of the Snake River Reservoirs.

The municipal water quality problem has two sides. First it is necessary to obtain a clean source of potable water. Secondly, the municipality needs to dispose of the waste it generates. The waste disposal problem focuses on the dumping of raw sewage into the rivers and lakes. If the waste load becomes large enough, the dissolved oxygen levels may decline severely and most forms of aerobic aquatic life will disappear.

Industrial water quality problems are primarily of three types. The first type consists of effluents which pollute rivers by depositing chemical and organic matters directly into these bodies of water. Paper mills, food processing plants, and chemical plants contribute to this type of pollution. The second problem is that these firms may have to treat polluted water (before making use of it) if they are located downstream from another user who is discharging waste. The third type of problem is that of thermal pollution created by impoundment, condensation of steam, and metal fabrication.

These types of pollution all have characteristic impacts on water. The first type consists generally of the discharge of large quantities of acids, phenols, and other chemically toxic materials which create a hazzard to aquatic and higher forms of animal life including humans. When the waste discharge takes the form of organic matters and proteins from food processing plants, the problem becomes one of maintaining adequate levels of dissolved oxygen to maintain aquatic life. A high concentration of organics tends to promote rapid bacterial growth as long as oxygen is available to support aerobic forms of life. When the oxygen supply is depleted anaerobic forms of life take over, the river tends to become lifeless and takes on undesirable odors and colors. This type of change eliminates many if not all of the aesthetic qualities a river or lake may have.

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[3] Federal Water Pollution Control Administration, "Water Quality Control and Management--Snake River Basin", September, 1968.

Ground Water

A problem that is very important in Idaho is that of ground water waste disposal wells. The practice of drilling drain wells and discharging wastes back into the underground aquifer is a relatively common one. If these waste discharge wells are located near the wells used to provide potable water the very nearness of these wells can create serious water quality problems. There is really only one practical solution to this problem and that is, do not discharge waste water back into the underground aquifer, develop an alternative waste disposal procedure.

WATER QUALITY CONTROL MEASURES

It is important to recognize that water has two particular characteristics affecting water quality control. The first is that water has an ability to renew itself. Water is a resource which is replenished on an annual basis, i.e., a new supply of clean water is available each year, a result of the hydrologic cycle. The second characteristic is that water has a natural ability to oxidize and stabalize organic wastes on a continuous basis. This latter characteristic leads one to the conclusion that many water pollution problems may tend to be local in nature instead of general. A river may be polluted for 10 miles or so downstream from the waste discharge point, depending on the flow of the stream, and beyond this distance no significant pollution problem may exist. In other words, many water pollution problems may not be basin wide in nature, but rather local. This conclusion materially affects the type of control measures one may choose to control water pollution.

Eventually a time comes when the waste load of a stream is too great and the natural ability of the stream to assimulate waste is exceeded. At this point, there are basically four alternative methods available to control water pollution. These are: (a) low flow augmentation, (b) prevention, (c) treatment, and (d) recycling of effluents.

If waste discharge is seasonal or if stream flow is seasonal, so that the waste load of a stream becomes temporarily greater than the natural ability of the stream to assimulate its waste load, low flow augmentation may be the most feasible solution to the pollution problem. This alternative is particularly attractive where upstream storage already exists. The stream flow can be regulated by setting up a schedule for necessary water releases to insure an adequate flow.

If the waste problem cannot be solved by increasing the flows, either because the storage is unavailable or limited, the next most feasible method may be to prevent waste from entering the stream. This alternative is appropriate for agricultural pollution. Turbidity can be controlled by using approved soil conservation practices, drainage from feed lots can be reduced by terracing feed lots and fencing to keep the animals away from the river, lagoons for manure disposal can be used where terracing will not work effectively, and the final step would be to go back to putting feed lot manure on cropland to build up productivity and organic matter. Another method used to dispose of waste water by industries and municipalities would be to use irrigation sprinklers to spread effluent on waste land.

The alternative low flow augmentation and prevention are first order types of solutions for relatively minor water quality problems. Basically these techniques work best for small pollution such as small municipalities, small isolated industrial plants, and agriculture. When the waste disposal problems cannot be handled by these two methods the next alternative is treatment. Waste water treatment is primarily used by wet process industries and large municipalities. In either case the production of either chemical and/or organic wastes, or raw sewage is so large that the receiving body of water would be overwhelmed by the waste load. In these cases waste water treatment to remove solid and biochemical demanding substances is necessary.

There are four general types of treatment that can be used to solve the waste water problem. In cases where the total dissolved solid load is low, organic load is high, and dissolved oxygen levels critical aerating the stream or lake may be sufficient treatment to solve the problem. This is a relatively low cost method where air is pumped into the water through pipes positioned in the bottom of the river. This technique does not reduce the waste load of the river, but it effectively increases the natural ability of water to assimulate wastes. The second alternative is begin treating waste before it is discharged into the river. There are three general types of treatment; these are: (a) primary treatment which removes from 35 to 50 percent of the BOD (biochemical or biological oxygen demanding substance) (b) secondary treatment which removes from 50 to 85 percent of the BOD, and (c) tertiary treatment that removes from 85 to 97 percent of the BOD.

The final alternative for pollution control is recycling of effluents. This alternative is a combination of prevention and treatment. The effluents in a production process are treated and then recycled. As industrial development increases this technique may be come very important. The choice of any of the above methods to control water quality depends on the magnitude of the waste load a river or stream receives, the location of the waste discharges along the river, the waste load carried by the river and the quantity of waste water each disposer has to discharge into the river. Several of these control measures may have to be used to achieve effective water quality control in a river, particularly a river like the Snake River which receives wastes from many sources. Low flow augmentation will be used in conjunction with treatment as a standard practice to supplement the latter practice. This combination will significantly improve the water environment for aquatic life in our rivers. It may be that new technology both in industrial processes and treatment will have far reaching effects on water quality in the future.

ECONOMICS OF WATER QUALITY CONTROL

The economic problems created by water quality control are a legion. Fundamentally the problem breaks down to the following considerations. We need an economic framework which will help us maximize the satisfaction of human wants from the use of water on the one hand, and which will also allow us to minimize the costs of achieving these satisfactions. The concept of a public optimum may be appropriate at this point. The optimum allocation of water among uses and users that will result in the maximum satisfaction of people's wants over time would be an ideal public optimum. The difficulty faced with a public optimum is that we have no good way to measure benefits. In an economic sense there are two characteristics of water quality that create problems. First is that of the variability of the water supplies, and second is the differentiation of demand for water of various qualities according to uses. In addition the magnitude of the waste disposal problem, the characteristics of the stream carrying the waste load, and the type of water quality standard used must be considered.

Another real problem related to water quality control is that benefits are difficult to identify and almost impossible to quantify. For these reasons the major economic interests revolve around the costs of control measures. The costs of water quality control measures are highly variable depending on the type of control. If prevention is used, the costs of terracing or building lagoons or installing a sprinkler system are relatively minor. Low flow augmentation in itself may be inexpensive but an area of real conflict may exist in the alternative uses of this water. Economists refer to this as the alternative cost or opportunity cost of water. In Idaho irrigation would be an important example of this type of conflict. If the low flow augmentation water requirement came during mid summer the cost of this water would be very high if this resulted in curtailment of irrigation.

If the water quality problem is such that treatment or recycling is necessary the costs of water quality control become very high. The relationship of cost to treatment is shown in Figure 1. The dollar values are hypothetical and are only used to indicate relative magnitudes of change in cost for the various levels of BOD removal. The relative increase in costs moving from primary to secondary treatment as indicated on the graph, would be 18 percent. The increase moving from secondary to tertiary treatment would be 45 percent. This indicates that the costs of treatment tend to accelerate rapidly as the level of BOD removal increases. If we add recycling to this, costs tend to be high because tertiary treatment is generally required for recycling of effluents.

Ultimately, we need to ask, what is water quality control worth to society and what is society willing to pay for water quality control? This eventually leads to the question who should pay? The firm or municipality doing the polluting? The public? Some combination? These questions are difficult to answer because we first have to identify who the polluters are, and next what the water quality requirements of the downstream users are. When these questions are answered we generally find that there are both small and large polluters. Every firm which discharges effluent is involved as is

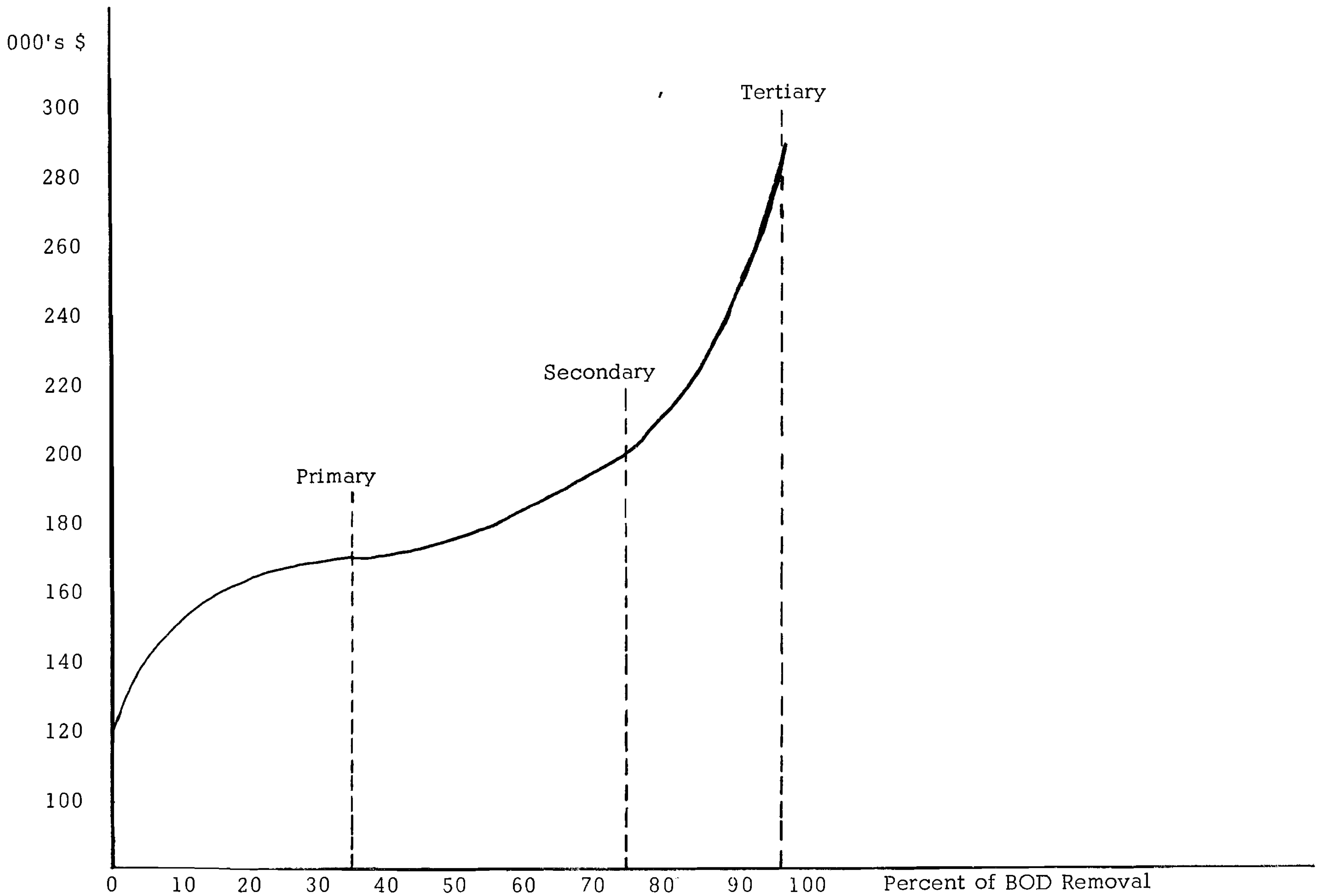

Figure 1. Relationship between Costs and BOD Removal by Waste Water Treatment

every household that has running water and indoor plumbing. The objective way to solve the problem is to charge everyone. This raises the problem of how much to charge each polluter and now the difficult part of the problem comes into focus. If the public is to pay for water quality control should it pay more than the amount necessary to clean up the direct pollution it is responsible for? By direct pollution I am referring to that pollution generated by households. In the past the public has admitted to some interest in helping to clean up more pollution than it directly creates. The public has an interest in clean water for domestic use, recreation, and esthetic values. And, it has spent tax dollars at both the federal and state levels to solve some pollution problems which otherwise would not be solved.

Another question exists which also needs to be answered. That is how much should the industrial polluter pay to clean up the effluent he is producing? Some people say he should return the water to the river or stream in as good a condition as it was when it was taken. This argument is highly idealized compared to practice. The questions which are raised concerning the control necessary for a particular industrial plant relate to (a) what the downstream water quality requirements are, (b) what the natural ability of the river is to assimilate waste, and (c) what the waste load of the river may be. Another question which often comes up is what portion of the cost should the public bear for treating industrial wastes? There is no good answer to this question because there are too many unknowns which we need to specify. The federal government has set a precedent by providing some money to start the clean up process, but this program may not last forever. The new water quality regulations leads one to conclude that in the future water quality control will largely be paid for by the people who create the problem. Of course, this does not mean that there will not be federal money available for water quality control measures, but the form of this money may change from direct grants to long term low interest loans which eventually have to be repaid.

While discussing the problem of who should pay, a few historical facts and some future cost projections may be of interest. Stepp and Macually in "The Pollution Problem"[4] indicate that in 1958 the total expenditure for water pollution abatement was $40.9 billion. Of this amount, 5.5 billion or about 8 percent was federal money. Looking ahead to 1980 the new investment in water treatment facilities required from 1958 to 1980 was $57.9 billion. Of this

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[4] Stepp, J.M., and Macaulay, H.H., "The Pollution Problem". American Enterprise Institute, Washington, D.C., October 10, 1968.

amount $6.7 billion or again about 8 percent was federal money.

The total amount of non-federal money amounted to $35.4 billion for waste water treatment in 1958. Of this $25.3 billion was spent for municipal waste treatment and $10 billion for industrial waste treatment. From 1958 to 1980 the required new investment was $51.2 billion, of which $31.2 billion were for municipal waste treatment and $20.0 billion for industrial waste treatment. These amounts of money were expressed in terms of 1958 dollars. In terms of todays money considerable larger amounts would be necessary.

The final consideration related to what the federal government should pay for in terms of water quality content relate to the many dams that already exist and that will be built in the future. These costs are not reflected in the data presented above, yet each of these structures has a function in improving water quality in the river it is controlling. Many billions of dollars have gone into and are committed to new construction to aid in this program. Much of the impact of these structures relates to controlling thermal pollution of the rivers which affects the navigation and the fishery, and they also are used in low flow augmentation programs.

Another important factor is that in the absence of any type of governmental control, the free enterprise does not create any incentive for the firm to clean up its own water unless it happens to own another plant or facility downstream. The public has an interest in the water quality problem because it wants to encourage industry to develop production processes which are competitive. If a competitive environment is to be maintained some form of governmental coordination or water quality at the federal level is probably necessary. This is important because if the states are allowed to compete on the basis of water quality, then those states without any water quality control will tend to have a competitive advantage over those who do have stringent water quality control requirements. A state like Idaho which has relatively high water quality standards might tend to lag in its industrial development compared to some other states with a similar resource and population base. This would not only be undesirable from the local point of view, it would also be undesirable from the national point of view. Finally if such a situation were allowed to continue indefinitely the economic pressures would tend to result in a general lowering of water quality standards nation wide. This result would be counter to the goals of the present water quality program, and the general public would be considerably worse off than it is now in terms of the quality of the environment.

In conclusion let me say that the economics of water quality control are extremely complex. In order to come to grips with this problem a resource management approach is required which describes the problems, sets forth goals and timetables for achievement to devise a management program. We need to define water quality, know the location and number of waste dischargers, and what water quality control measures are feasible. It is at this point when the problem is adequately defined that engineers, economists, and other research workers can develop control procedures which will solve the problem in an optimal way.

Water pollution like most other problems we face is a people problem. What we need to do is inform ourselves as to the nature and complexity of this problem and then start doing those things which will help support a program to improve the condition of our water. It is our water, we want to use it in many ways so lets do all we can to develop patterns of use which permits industrial development, agricultural uses, recreational uses, fisheries, and all other types of use we see fit. Water is a precious resource which we need for our very life. None of us wants to see it degraded to the point where it becomes an undesirable part of our environment. With the proper controls and regulation we can have agricultural, industrial, recreational, and domestic use of this resource. It is up to us!

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