ECONOMIC AND ORGANIZATIONAL ISSUES IN ALASKA WATER QUALITY MANAGEMENT

Gregg K. Erickson
Resource Economist

and

Arlon R. Tussing, Ph.D.
Associate Professor of Economics

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R. Sage Murphy, Director,
Institutes of Water Resources

Victor Fischer, Director,
Institutes of Social, Economic and Government Research

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INTRODUCTORY NOTES

The first draft of this paper was produced in late 1969 for the Institute of Water Resources at the University of Alaska as a final completion report to the Office of Water Resources Research, Department of the Interior. The original title of the paper, and the title of the project grant, was, "Water Resource Utilization Conflicts in Cook Inlet; Some Economic Considerations." Since the time of the first draft, public attention has been focused upon the hazards of crude oil spills from tankers and terminal facilities associated with the proposed pipeline from Prudhoe Bay to Valdez. The University's Institute of Social, Economic and Government Research, with which both authors were affiliated[1], determined that parts of the Cook Inlet study would be of sufficient public interest in the form of the occasional paper found herein.

This paper has been condensed and revised and is devoted principally to the institutional alternatives for water quality management in Alaska. Very little of significance from the original version of the paper has been deleted, although the total text has been considerably shortened. The paper does not purport to introduce any novelty in analyses or policy, but presents some of the current thinking of economists regarding pollution control in the Alaskan context.

[1] Gregg Erickson is presently a staff member of the Alaska Legislature's Joint Pipeline Impact Committee. Professor Tussing continues to be associated with the Institute of Social, Economic & Government Research at the University of Alaska.

WATER QUALITY MANAGEMENT: WATER AS A DISPOSAL MEDIUM

Rivers, streams, bays and inlets are often the most efficient vehicles for disposal of unwanted materials and energy--the residuals or waste products that are an inevitable result of any human activity. However, the ability of each body of water to transport, disperse, and degrade wastes is finite. When the utility of water resources for uses other than waste disposal is reduced, the waste products involved are regarded as pollutants. The object of water quality management in particular, and water resource policy in general, is to attempt to balance the benefits from routine waste disposal and other uses at the margin, thereby maintaining the mix and intensity of resource utilization that optimizes the total net benefits received by society.

If the various costs and benefits, their sources and interrelationships are well understood, it is possible to pursue this optimal balance through the apparatus of centralized decision-making authority. Social norms, existing patterns of water resource utilization, the projected pattern of future demand, and political realities should all be considered. A "comprehensive water resource utilization plan" can then be adopted, calling for this or that modification of existing patterns of use and specifying in greater or lesser detail the most advantageous directions for future development. Usually, water quality management has become institutionalized incidentally to some other need for resource planning, such as hydro power development, navigation improvement, irrigation, flood control, or some combination of these.

Centralized Pollution Control

Public Law 660, "Water Pollution Control Act Amendments of 1956."[2] and subsequent legislation authorized comprehensive management of water quality in interstate waters and have not been implemented with increasing frequency in recent years, usually only after problems of chronic pollution have begun to seem intolerable. With a few notable exceptions, such efforts have been greatly successful in the United States. Usually, the desirability of collectively institutionalized control of the water resource management function was not recognized or generally accepted until streams and estuaries were so loaded with pollutants that the costs, public and private, of disposal appeared extraordinarily high. As long as the estuarine and riverine waste disposals systems were working at less than capacity, there was little need for centralized control, and, even after such needs became apparent, there remained strong ideological commitment in favor of decentralized decision-making and economic individualism. European experience has apparently been more successful, perhaps partially because of a contrasting willingness to submit to centralized management.[3]

Not even perfect knowledge and unlimited authority in the hands of wise men can be expected to bring about an immediate rationalization of water resource utilization. Such a rationalization can so disturb the existing patterns of production and distribution as to create costs that are larger than those originally being attacked. For instance, short run opportunity costs associated with idle

[2] 70 Stat. 498.

[3] See Kneese, (1964[6])

plant and equipment may make the immediate closure of an existing industrial activity undesirable, even where hindsight clearly indicates that the facility should never have been established in the first place. And, as a practical matter, the economic interests of established industries are generally well protected, both politically and legally.[4]

Management agencies typically have single or limited purposes and powers under their legislative authority; they also tend to have specialized private constitutencies who resist granting them mandates to consider more complex sets of objectives. Even complete jurisdiction over human inputs into the water system would not assure the ability to balance the benefits of alternative river and estuary uses according to the agency's own view of the public interest. To do so would require influence over all aspects of future regional development. Water management authorities generally have no power to prevent the construction of high value structures in flood plains, nor over paving and removal of vegetation in the runoff basin.[5]

Lack of knowledge presents the greatest single barrier to centralized management of water pollution. A most obvious requirement is for complete information regarding the degree to which beneficial uses of a watersource are curtailed as a consequence of various types and levels of pollution. For instance, lacking pollution controls of any sort, downstream users would still want to understand the physical and/or biological relationships between pollutants and "water quality" as they define it. Although there are many difficulties in obtaining such complete information, they are not unique to control of pollution under a central authority.

A more serious problem, however, arises in determining the "benefits" of pollution, and the costs involved in prohibiting or restricting it. These costs and benefits are likely to be intimately associated with the cost and revenue structure of each individual polluting firm, as well as the technological constraints under which it operates. The profit margins available to pay for pollution control, the reduction in pollution obtainable from a given expenditure, and the importance of waste disposal services in relation to the firm's other productive inputs are all factors that will be different for each polluter, and upon which the optimum level of effluent discharge will depend. Most questions regarding the most efficient means of producing a given product or service are decided in a decentralized manner. That is, individual firms make the decisions, and there is no existing institutional structure for channeling necessary information to a central authority. In addition, there may be difficulty in obtaining the cooperation of various firms, because in many cases the polluter or would-be polluter will have an interest in seeing that the pollution control authority is misinformed or poorly informed on some or all of the relevant questions.

Another problem of centralized control is that this individualized control of individual firms is required for efficient resource management. An alternative method of waste disposal, or a process

[4] See Pennsylvania Coal Co. vs. Sanderson 113 Pa., 126, 6A (1886) and discussion in Sax 1968 (pp. 442 et seq.)

[5] James A. Crutchfield has called the authors' attention to the fact that development of the Puget Sound area has diminished the region's salmon resource far more by urbanization's elimination of small spawning streams than be either overfishing or pollution as usually understood. Ironically, both sport and commercial fishing interests have concentrated all their attention on the last two influences.

or product modification that reduces residuals production, may be easily available for one polluter, whereas another may find such alternatives either very costly or totally unavailable. Very few benefits will be foregone by the former operator because of his ability to utilize other methods of waste disposal or control; similar restrictions on the latter operator will have a much more serious effect on the benefits flowing from his operation, and may even be severe enough to eliminate what would otherwise be a socially and economically viable enterprise. If the pollution created by each operator is of the same magnitude, and causes the same loss of utility to downstream water resource users, then considerably more stringent restrictions on the first operator will be necessary to balance out these benefits than would be appropriate for the second operator.

For instance, suppose that two firms, A and B, produce a similar product, earn about the same profit, are located near each other on the same river, and are each dumping twenty units of the same pollutants into the river each day. If firm A finds it much less expensive to provide alternative methods of dealing with residuals than does firm B, any arbitrary restriction on the amount of pollution permissable will have a more severe impact on firm B. In the case of the cost functions shown in Figure 1, an arbitrarily imposed restriction of ten units of pollution per firm per day would cost firm B $500 per day and firm A $100 per day, for a total private expenditure of $600 per day. Such a restriction would be desirable if the 20 units per day reduction in the pollution load increases the stream's utility to downstream users by an amount equivalent to more than that $600 per day. In principle, the optimum restriction is that level at which the firms' costs from a small reduction in the quantity discharged just equal the gained benefits.

Because of their ease in enforcement and administration, many authorities concerned with pollution control have attempted to set arbitrary limitations on the quantity of pollution allowable from individual firms.[6] These are generally referred to as "quality standards" rather than quantity limitations, although control of both parameters is usually implicit in the actual limitations.

The attractiveness of this method of water management is mitigated, however, by its inefficiency. This inefficiency is illustrated by reference to the prior example, where $600 of private expenditure purchased a remission of 20 units per day in the pollution load. The respective slopes of the cost functions in Figure 1, however, show that a much greater reduction in the amount of pollution could be obtained by shifting more of the $600 per day expenditure to firm A. If the reduction in river pollution from firm B is graphed against the reduction from firm A, as in Figure 2, the resulting curve represents the "reduction possibility function" for $600 per day of private expenditures. The point at which a 45 degree line is tangent to this curve is the point at which a dollar of pollution control expenditure by firm A purchases exactly the same reduction as the same dollar diverted to firm B. Figure 2 indicates that a shift in either direction from this point would result in a smaller reduction in the total amount of pollution obtained with the $600 per day rate of private expenditure, and as a consequence the tangency represents the optimum operating point for this level of expenditure.

[6] Kneese (1964 [b], 1965) discusses the nature of these standards and examines their economic implications in detail. Also see Senate Document No. 97, 87th Congress, Policies, Standards and Procedures in the Formulation, Evaluation and Review of Plans for Use and Development of Water and Related Land Resources, (1962).

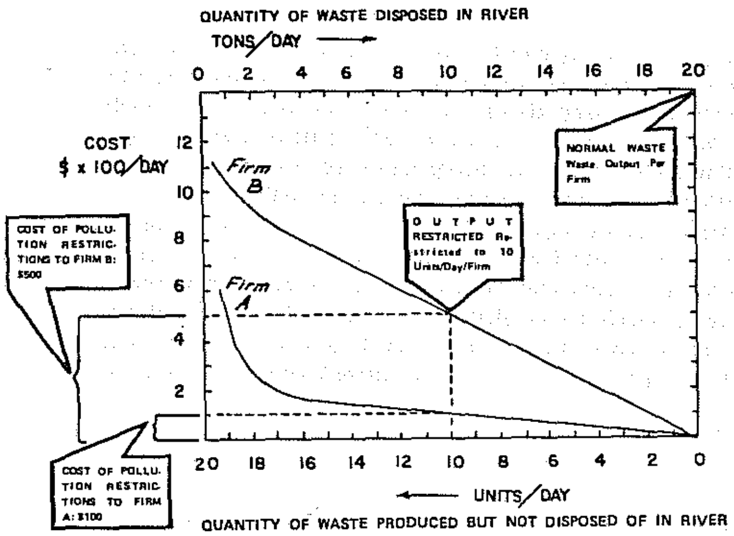

FIGURE 1 If each firm is prohibited from dumping more than ten units per day, the total reduction in pollution will amount to twenty units per day (ten units cutback for each firm); total cost in the private sector will be $100 + $500 = $600 per day.

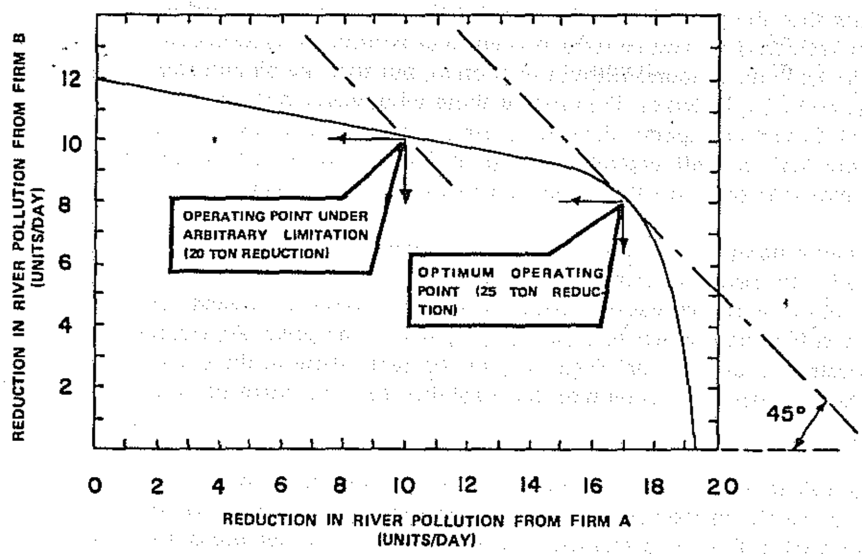

FIGURE 2 Pollution reduction possibility function. Combined pollution control spending of $600 per day by firms A and B will reduce pollution by an amount dependent on expenditure split between the two firms. Curve traces the various relationships between reduction in A and B's pollution, giving total private spending of $600 per day.

Various techniques are available for estimating the aggregate benefits accruing to downstream water resource users from abatement of a given quantity of pollution, and similar methods can be used to estimate the total (private) costs of bringing about that reduction; but because such techniques depend on the law of large numbers, their usefulness is contingent on there being a sufficiently large number of individual units in the group being measured, so that individual differences effectively cancel one another. As a consequence, the policy maker engaged in pollution management can set overall "water quality standards" specifying the aggregate level of pollution allowable in any given river or estuary, with fair confidence that overall marginal costs and benefits are capable of being balanced at or somewhere near that level. He does not however, have the information or the methodology to decide which elements of the private sector will pay what part of the private costs. In such an instance there is little way to assure the public that pollution control is being exercised fairly except on the basis of some formula or rule that is both readily understood and easily applied.

Decentralized Pollution Control

One way of circumventing this difficulty would be to decentralize the decision making process itself. At the extreme, the entire control activity might be referred to some sort of self correcting market system. Under such a scheme the "right to pollute." and the right to be free of pollution, would be bought and sold in a market in which prices would be determined by the interaction of supply and demand. Ideally, such a system would eliminate the need for government participation in the decision making process.

An obvious difficulty in this solution is that such a market is very difficult to create or maintain because of "externalities," the fact that the goods involved are "public" goods and are enjoyed or consumed collectively rather than individually. Assume for a moment that petroleum wastes could be disposed of in Cook Inlet or Prince William Sound without restriction, but that the oil industry offered, for a price, to curtail its polluting activities. Presumably those who would benefit from such a curtailment -- commercial fishermen, sports fishermen, etc., -- would consider such a proposition, but unless one individual or well organized group of individuals is sufficiently interested in seeing the pollution abated to pay the whole price, this price will not be paid.

Because there is no way to prevent non-payers from enjoying the benefits of freedom from pollution, they cannot be coerced into assuming a share of the cost. As a practical matter, the abatement offered for sale in the above example would probably never be purchased because no potential buyer is likely to realize sufficient benefits to justify paying the asking price. An equal difficulty is that benefits of unrestricted disposal privileges are, in the same sense as the costs, enjoyed collectively. For example, how does one determine the eligibility for, and share of, any payment for not doing something.

Some sort of collective action is called for in cases of this sort. The appropriate form for this collective action will depend at least partly on the political-legal situation and the existing patterns of resource utilization. If an individual, a firm, or a municipality has been enjoying free use of an estuary or watercourse for the purpose of waste disposal, it is likely to view its access to the disposal medium as a property right, inalienable except by due process. The vested interests supporting this view may be so powerful as to render unrealistic any pollution control scheme that does not recognize these "grandfather" rights. In Alaska, at least, no such legal right exists unless such right was freely exercised prior to statehood, except insofar as such rights may have been granted by the state through permit, lease, or patent.

Allowing existing sources of pollution to continue unchecked can work in several ways to deflect a region from the optimum growth path. Particularly, some aspects of outdoor recreation may find it difficult or impossible to develop in the face of polluted water. Downstream users of water may find it necessary to devote an inordinate amount of their resources to securing an adequate supply of the proper quality water.[7] Finally, the existing level of "grandfather" pollution may make it necessary to impose excessively strict limits on the quantity and types of wastes that industrial newcomers may dispose of in the public waters.

Even where the balance of political power and legal opinion is not biased in favor of the "historic" polluter, economic efficiency is a pivotal consideration that often argues against "changing the rules" after the game is well under way. Where waste disposal services are an important factor of production, considerable fixed investment may have been made on the assumption that such services would be available essentially without cost. A change in the rules, by increasing the costs of waste disposal, may make a firm's or industry's operations unprofitable, and thereby cause all or part of that investment to be lost. The cost to society of this disinvestment may be greater than the costs of allowing the waste discharge to continue for the remainder of the investment's economic life. Subsidies, either paid directly to the affected firms or in the form of low interest loans for pollution control investment, have been suggested in these cases. The misallocative effect of such devices can be demonstrated by the same line of reasoning that was used above with regard to arbitrarily invoked standards.[8]

When a long established pattern or industrial or municipal waste disposal suddenly becomes objectionable because of a change in public tastes and perceptions, it poses a political and legal problem; as such, economics provides only partial insight to its solution.

Imposing the Cost of Pollution on the Polluter

The logical alternative to allowing free access to or use of a resource is to place a price on that access. The use of the public waterways for purposes of waste disposal imposes costs on society. The proper price for such use of a river or inlet is the charge which produces just enough revenue exactly to compensate for the losses and/or the unpleasantness that must be put up with as a consequence of that use. He who would use the public's river as a sewer should pay the public's price for putting up with his sewage.[9]

[7] However, recent studies (Davis, 1966), (Ayers and Kneese, 1969) indicate that very little in the way of abatement effort can be paid for from the savings in treatment costs realized by downstream users. In a sufficient proportion of industrial and municipal uses, (boiler feed water, domestic water supply) some sort of treatment will be necessary at the intake regardless of the actions of upstream users. Within broad limits, the costs of bringing water up to usual standards of purity do not vary greatly in response to changes in the initial quality of the water. The most conspicuous economic effect is a result of offenses to recreational opportunities and aesthetic perceptions.

[8] Cf. Kneese (1964 [b], chapter 8) and Kamien, et al. (1966).

[9] An excellent survey of the issue of effluent pricing is found in CF Letter, "Should we now turn to effluent charges – another weapon available for the war against pollution," June 1971. Washington: The Conservation Foundation.

Control of pollution by means of a pricing mechanism is superior in many ways to the traditional authoritarian methods. It explicitly takes into account the fact that the appropriate level of residuals discharge will vary in response to changing conditions, including the economic conditions under which the waste producer operates. Use of a pricing system allows abandonment of the tenuous assumption that water quality is a matter of only two states, the acceptable and the unacceptable, which the enforcement of "water quality standards" generally imposes. A schedule of charges can be constructed that reflects the more appropriate assumption of a continuous, directly increasing relationship between the pollution load of a stream or inlet and the externalities--the costs which do not show up on the polluter's balance sheet.

Stripped to its basic elements, the use of a pricing mechanism leads to the simple equilibration of supply and demand. Being sold are waste disposal services. The demand for these services is derived from considerations such as the availability and cost of substitutes, the factors' relative importance in the productive process, the demand for the final output of that process, etc. The supply function on the other hand describes the "bribes" that the polluters must offer society to obtain their permission to dispose of each particular level of waste.

The system described above is a hybrid, requiring centralized control and a political determination for its supply function, but permitting decentralization on the demand side. The conspicuous advantage of such a system is that at any given level of total private spending for waste disposal, expenditures both on differing methods of disposal within a firm can improve its position by shifting any expenditure from providing alternative means of waste disposal to the purchase of dumping rights from the public pollution authority or vice versa. As a consequence, private costs are minimized. Since costs eventually become charges for the final outputs the public purchases, and/or lower incomes for producers, minimizing these also minimizes the ultimate price paid by the public for any given level of abatement.

Effluent pricing is particularly appropriate to and feasible in the "competitive" case, where there are many heterogeneous sources of discharge. In these instances, the response to price changes will be continuous, allowing the use of small rate changes to approach and maintain the desired levels of water quality by trial and error. Technical rigidity and indivisibilities will make the adjustment process less efficient in "monopsonistic" or "oligoposonistic" cases, i.e., where the demand for waste disposal services is dominated by one or a handful of firms; here, fees are likely to be negotiated rather than finding their own way to the desired equilibrium value. If the intended level of pollution appears relatively harmless, and the permit is granted, a more subtle question arises. By what course of action does the management authority serve equity and efficiency when, after the plant is in operation, another firm proposes a similar facility and demands equal access to environmental waste disposal services? What, indeed, is to be done if the effluent from one plant is socially costless, but a doubling of that output brings about a dramatic qualitative change, raising pollution to an intolerable level?

Treatment of waste disposal as a publicly marketed service allows these questions to be addressed in a familiar context. Almost all firms purchase their raw materials and other factor inputs in markets where the parameters of supply and demand are constantly shifting. If the supply of a factor of production is relatively unresponsive to changes in the quantity demanded, and if the level of demand is likely to increase (for instance, because of new firms entering the field) the factor price is likely to rise. The successful firm will consider these possibilities and plan to minimize the internal dislocations caused by fluctuations of this sort.

In the case of waste disposal service, the government would presumably first set the price of disposal rights at a low level, reflecting the correspondingly low cost that the initial level of pollution imposes on society. Rational managers would not expect this state of affairs to be permanent, and would anticipate future public and administrative attitudes toward higher levels of pollution. With an assessment of the probability of new firms establishing themselves nearby and thus increasing the demand for disposal services, managers would make the necessary guesses about future costs of pollution in the same manner as for other costs.

There are comparable issues about who should conduct, and who should pay for, the necessary information acquisition. In one sense, the requirement for information is a social cost of the proposed investment, and its burden ought to be on the beneficiaries of that investment (i.e., its owners and the consumers of its output). On the other hand, the party controlling the information output will understandably tend to withhold or release data selectively in order to bias the actions of others. It follows, therefore, that the government should be very cautious about accepting the scientific or technical presentations of anyone applying for a pollution permit without having some independent means of verification.

WATER QUALITY MANAGEMENT: EPISODIC POLLUTION

Preparing for the Unpredictable

The preceding analysis has shown how it may be useful to think of water pollution questions in terms of waste disposal services as a scarce factor of production, the use of which is in competition with other valuable uses of the disposal medium. In many of the most important cases, however, such services are not a normal and easily measured input to some productive activity. These cases are marked by long periods during which the demands for waste disposal services can be easily met by the assimilative capacity of the body of water, punctuated by sudden and unpredictable episodes in which the resource is called upon to dispose of massive quantities of discharge over a short period of time. Pollution of this sort is usually unplanned, the result of an operational human error, mechanical misfunction, or the physical failure of some system component. Breakage of underwater petroleum pipelines and oil tanker groundings are two familiar examples of such causes.

Management of this type of demand for waste disposal services tends to be more complex due to its unpredictability and infrequent occurrence. Assessing the "costs" of a pollution "incident" after the fact is complicated by the necessity of reconstructing a sequence of events from limited and often conflicting observations. When observing the effects of a continuous discharge of effluent, an investigator can repeatedly return to the field to fill in gaps in his data; with episodic pollution phenomena, the investigator must necessarily wait for the next incident, which may not come for months or years. A "similar" incident may never occur. Moreover, since the victims of these incidents can not be identified nor the magnitude or distribution of costs assessed in advance, there is no satisfactory way of compensating potential losers for the hazards to which they are exposed. Nevertheless, efficient utilization of water resources will not be achieved unless techniques can be found for evaluating the probability and both the magnitude and distribution of the social costs of such events.

This is especially true in Alaska, which has few problems with chronic industrial discharge. On the other hand, episodic pollution is well-known. From 1960 through the first half of 1968, there were 111 known crude oil spills in Cook Inlet. Submarine pipelines carrying crude from offshore platforms to shore stations have on several occasions leaked or been broken. Marine tankers bringing refined products up the Inlet to Anchorage and picking up crude have been the proximate cause of several types of pollution incidents. Overflows or valving errors during oil transfer operations have occasionally resulted in spills, and, finally, tank rupture due to collision with underwater hazards or other vessels has, in three known instances, resulted in serious episodic pollution.[10] Twelve of the known spills resulted from pipeline failures, 12 from tanker operations, 58 from drilling platforms (37 of them in 1968), 17 from oil drill rigs and service boats, and 12 traceable to onshore oil facilities.[11] The Inlet has been spared a blowout disaster of Santa Barbara proportions or a really large tanker spill.

That spills have not caused much harm is mainly a result of the exceptional mixing and biodegradation that take place there,[12] but it also appears to be due, in part, to the very short periods of the year in which wildlife are vulnerable to such hazards. Between 1960 and 1969, there was only one incident in which wildlife is known to have been killed because of oil industry. This case involved the loss of between 50 and 2,500 ducks as a consequence of what is presumed to have been a several hundred barrel spill from an unidentified tanker. The only other incident with a significant wildlife effect involved a moored drilling vessel in Seldovia Bay, which apparently discharged fuel oil into the harbor. The extent of wildlife loss, if any, from this incident is unknown.

Thus far, the platforms themselves have not been the immediate source of any serious pollution accidents. Nevertheless, they probably represent one of the more important hazards due to the quantities of crude that might be discharged if storm, ice impact, ship strike, fire, or other force were to cause a massive failure in a platform's structure.

Rounding out these episodic hazards posed by the oil industry activity are those connected with drilling operations, whether conducted from a permanent platform or drilling vessel. Even in the development drilling of thoroughly understood formations, it is not possible to be wholly certain that high pressure fluids contained in rocks tapped by the well bore can not somehow find their way uncontrolled to the surface. The danger of such a blowout or an unexpected "kick" is naturally more severe during exploratory drilling; one such event has actually occurred in the Inlet.

[10] In this context "serious" has been taken to mean more than 100 barrels.

[11] From authors' inspection of records in Anchorage office of FWQA.

[12] See Kinney, Button, Schell, and Robertson, 1970.

Fortunately, it was possible to burn off the natural gas and natural gasolines that vented uncontrollably over the many months that it took to plug the blowout. Had the higher pressure fluids included significant amounts of heavy crude oil, this blowout might have become as infamous as the 1969 incident in the Santa Barbara Channel.

While the presence of petroleum operations in the Inlet has not imposed significant costs on other users of the resource, the existence of those other users has significantly increased the costs of operations to offshore oil drillers. The exact magnitude of these costs is difficult to estimate because many of the pollution control expenditures produce ancillary benefits to the operator in terms of safety and operatonal efficiency. For instance, of several operators contacted, all said the installation of the wellhead and downhole pressure control devices would have been required even if pollution hazard control had not been a design consideration. Other facilities, such as skim tanks, are primarily for pollution control, but also increase the quantity of crude oil recovered, thus partially paying for themselves. Total capital costs of these items are probably in the neighborhood of $100,000 per platform.

Three Approaches to Episodic Pollution

No blanket theory can be given for managing water resources in the face of these threats. In most cases, there seems to be three distinct approaches to developing formalized management.

Engineering

The first of these might be called the engineering approach, since it relies heavily on the engineering expertise of the government authority. Most cases of episodic pollution are not completely unexpected, even if it is not possible to predict the time and place of their occurrence. Steps can be taken during the design and construction phase of such facilities as pipelines and offshore platforms to reduce the probability of future episodic pollution. Regulations regarding cementing of wells, the placement of valves on offshore pipelines, depth of burial, thickness of pipe, and types of inspection procedures to be used during construction are examples of such steps.

One disadvantage of relying on this method is that there is almost never any effort devoted to justifying the additional effort that these regulations require on the basis of the protection they purchase. Regulations and requirements are usually adopted or rejected on the basis of their absolute effectiveness in maintaining a given level of water quality, rather than their cost-effectiveness. In these circumstances, the management authority will ordinarily tend toward overprotection.

Since there are no institutionalized channels for feedback of cost information into the decision process under the engineering approach, the regulated industry or interest group, particularly if it is cohesive and well organized, will tend to have *ex parte* means of bringing its influence to bear. This can result in the capture of the management authority by the interest which is ostensibly being regulated. The highly technological nature of hazard control questions makes their *ex parte* consideration more likely, since the industry may have a monopoly or near monopoly on the necessary expertise.

Fines, Penalties and Civil Liabilities

The second approach toward management of episodic pollution is through the levying of fines or charges against those who generate it. Prior to permitting any activity which constitutes a threat to the environment or to any beneficial interest in a resource, the management authority would specify the various hazards and the penalty to be paid if harm materializes. Hazards would thereby become private hazards, to be contended with by those who are best situated to control them. This method has the advantage of placing the responsibility for prevention on the shoulders of those who are best situated to judge the cost-effectiveness of particular measures and to implement them. Disadvantages associated with the approach are the necessity of maintaining constant surveillance and the difficulty of measuring the dimensions of each incident so that charges can be levied. There is also the problem of identifying the victims and determining their proper compensation. A further problem may arise if the potential sources of large scale pollution incidents are relatively small firms. In such cases, the hazard is created by an autonomous decision making unit that may be too small to internalize expectation of the social costs generated by its activities. To take an extreme example, an undercapitalized wildcatter might drill a well in a location where a blowout could cause a large scale pollution incident. From the point of view of such a promoter who fully expects his firm to be bankrupt at the conclusion of drilling if he does not make a major discover, the extra costs of blowout protection may not be worthwhile.

In a different context, one of the authors of this paper has compared the engineering and penalty approaches:

> There are two ways in which we can look at the effectiveness of environmental stipulations--do they provide the maximum protection in exchange for a given level of additional engineering expense? Or, do they contribute some given level of protection at the lowest possible cost?
>
> It is simply not rational to spend a million dollars to preserve a $50,000 resource. Nor is it rational to spend a million dollars to avoid a 10 per cent chance of a million dollar accident. On the other hand, some kinds of damage or risk of damage cannot be avoided by any kind of stipulation if oil is to be produced or a pipeline is to be built at all.
>
> Putting a value on intangible and latent resources and assigning dollar numbers to different kinds and degrees of risk are complicated issues . . . Many of the same difficulties are encountered regularly in appraising and insuring private properties, and the same principles can be used as in ordinary business practice with a greater or smaller degree of error.
>
> There will obviously be a great deal of arbitrariness in assigning dollar values to such things as the violation of wilderness or the degradation of scenery. But even arbitrary appraisals are superior to their alternatives--the assumption that these things are either worthless, in which case we should forbid development under any circumstance. Assigning prices affords a way of ranking different values, so that the greater effort is expended to protect more important things rather than the less important. The greatest advantage of this approach, however, is

> that even prices which are wholly "wrong" give [the pipeline company] a continuing incentive to reduce damage--an incentive which is absent if they are told exactly where and how to proceed.[13]

The analogous private remedy to penalties levied by the government is the civil damage suit. Federal legislation and international agreements have undermined this remedy by limiting maximum liability for any one spill, but states apparently may authorize broader liability within their internal waters. In the absence of specific legislation providing for "absolute" liability, however, the burden may be upon the complainant to prove negligence. Moreover, maritime law does not impose liability on the owner of the cargo for damages arising from its transportation. This fact encourages oil companies to use chartered vessels, or to incorporate each vessel in their petroleum carriage separately, in order to avoid liability in excess of the value of this ship and its cargo.[14]

The argument for unlimited absolute liability--that is, responsibility for damages not limited to some maximum, nor contigent on proof of negligence--seems to be unassailable from the standpoint of economic efficiency and equity. Similarly, liability ought to be extended to owners of hazardous cargoes. By choosing, for instance, to ship crude oil on commonly owned (or "unowned") waters, a petroleum company imposes a risk of damage to other parties, even if there is not legally recognizable negligence. This expectation is a cost, as is any individual instance of damage. These costs of transporting the product properly ought to be upon its beneficiaries, the consumers of petroleum products, and recipients of petroleum profits and rents. Anything less than absolute and unlimited liability shifts part of the expected costs to others--commercial fishermen, coastal residents and landowners, tourists and recreationists. The assertion that those who bear the risks are incidentally consumers of the same petroleum products, or beneficiaries of the revenues of the government captures these activities, is not necessarily true, but if it were, the point would remain that the costs are being distributed entirely independently of the benefits.

A serious obstacle to reliance upon the civil law to deter polluters and to compensate its victims is the difficulty in assigning losses in the case of unowned assets, such as stocks of fish, or even estimating their magnitude where the asset damaged is both unowned and unmarketed, as is the case with the scenic attributes of public lands and waters.[15]

[13] Statement by Arlon R. Tussing on the "Application of the Trans-Alaska Pipeline System for a right of way to construct a pipeline from Alaska's North Slope to Valdez, Alaska" before the U. S. Senate, Committee on Interior and Insular Affairs. In U. S. Senate, "The Status of the Proposed Trans-Alaska Pipeline," Part 2, Committee on Interior and Insular Affairs, 1969.

[14] A. R. Thompson of the University of British Columbia School of Law has prepared a Comparative Table of Statutory Provisions Regulating Oil Pollution of the Sea (April, 1971). Also see Thompson, 1971.

[15] Douglas Clarke (quoted in Dales, 1968) offers an instructive contrast between the legal vulnerability of "common property resources" in North America and the treatment of privately owned angling right in Great Britain. Where these rights are owned and marketable, damage to them by pollution can be dealt with like any other injury to private property. According to Clarke, the Angler's Cooperative Association in Britain is usually successful in actions to prevent or abate pollution.

Collective Insurance

The third approach toward episodic pollution might be called the collective insurance method, for it involves regular payments compensate for the exposure to the hazard, instead of sporadic payments associated with particular incidents. This arrangement is appropriate provided that adequate measures already exist to reduce the risk of incidents. The insurance charges collected from private operators would (in theory) just be enough to deter those operations whose activities fail to produce social benefits in excess of public hazards.

Where the state (which collects the insurance payments) is also the owner of the exploited lands, as in the case of offshore petroleum development in Alaska, the required payments would offset part of the rents (principally in the form of bonus payments) accruing from those lands. At the point where payments soak up the whole potential rent, so that the present value of a lease is negative, the lands simply would not be leased. From the point of view of allocative efficiency, those hazards over which the operator has direct control should be internalized through penalty charges or the like. Since insurance type schemes reduce the operator's incentive to take technically feasible precautions, they are most usefully employed where the risks are essentially beyond control, but where one function of the insurance charge is to determine whether--given those risks--the venture should be undertaken at all.

WATER QUALITY MANAGEMENT: ALASKA

The preceding discussion has been a cursory treatment of economists' ways of looking at problems of water quality. The literature of water resource management and environmental economics from which it is drawn is addressed primarily to the problems of regions that are already highly developed; its very existence as a specialized area of inquiry is a consequence of measurable property damage and of expressed feelings, ranging from uneasiness to outrage, of people living where the free use of waste disposal capacities of water bodies has already reduced their utility for other purposes.

The body of knowledge that has recently developed in response to this stimulus should be the intellectual foundation for any systematic effort to attack the problems of water resource allocation in any undeveloped area in Alaska or elsewhere. Nevertheless, it is necessary to give emphasis to the striking contrasts between the physical, economic, and (to a lesser extent) social environment of most of the rivers and estuaries of Alaska and the examples which one finds throughout the literature of water resource economics.

Alaska's greatest waste loads, domestic or industrial, are concentrated in Cook Inlet, but there is little concrete evidence to indicate that any beneficial use of the Inlet has been reduced or restricted as a consequence. The major potential source of pollution, oil industry activity in Cook Inlet, has been discussed above. Despite the popular concern for the Inlet's and Alaska's fish and wildlife resources in the face of industrial and municipal development, these resources and their values, however measured, have not been seriously reduced.

Program Planning for Water Quality

Inasmuch as Alaska has at present very little demonstrable damage because of water pollution, Alaska's water quality management plans must concentrate on identifying resource utilization conflicts that can be expected to develop in the future, rather than emphasizing the resolution of existing conflicts. Already, most existing and proposed pollution control measures for this region are designed to prevent the development of conflicting uses. In such a context, the questions that must be answered deal with the probability that a conflict will develop, the actual cost of such a conflict should it develop, and the costs of its prevention. It may very well be that prevention is more costly than cure, or even that both are unnecessary.

Identifying future resource utilization conflicts will require an information base adequate to estimate the economic and demographic directions of the region. It is logical that this information should be in hand prior to intensive work being undertaken toward evaluating the physical and biological aspects of possible conflicts. This does not mean that investigation of the physical and biological characteristics of the water should be ignored, but rather that investigations should not specialize on the relationships between particular parameters until economic information indicates that human activity will either affect those parameters or be affected by them.

No objective criteria can be laid down to guide the decision maker in choosing the information relevant or important to his tasks. Much, of course, will depend on how the tasks and priorities are defined. Nevertheless, the following observations and policy suggestions may be useful to understanding and–where appropriate–making use of economic ways of examining problems of water resource management in Alaska.

From the point of view of resource allocation, the services provided by a body of water should be distinguished one from another in two functional ways: First, the provision of such service requires the water to possess specific physical and biological characteristics. Second, services can be classed according to the manner and degree to which their provision modifies the nature of water. These requirements can be thought of as inputs, and the modifications as outputs, of a service providing process.

In the more developed areas, it has been found useful to stimulate these inputs and outputs in a model of the water body under study. Such a model may be a very complex mathematical structure, but the idea behind it is very simple: rather than speculating blindly about future contingencies, it is often more productive to introduce the event in question into an artificial system and observe the results. It is possible to extract much useful information at a small cost from such a model, even when the physical relationships are poorly understood. Models may be as simple or as complex as desired; depending on objectives, they may be inclusive as many inputs and outputs, and relationships among them, or just a few.

Modeling techniques can be applied to many of the present problems of water quality management in Alaska, including for example, the assessment of the pollution hazards of large tankers using Prince William Sound. Data from Cook Inlet, the English Channel, the Persian Gulf, and other areas of high density tanker movement, could help illuminate the relationship between traffic volume and weather conditions, and the probability of oil spills from collision or grounding. Historic Prince William Sound weather patterns and expected traffic movements to and from Valdez can be combined with existing knowledge about the manner in which tidal and other currents would transport any spilled oil to infer the probable size, location, frequency, and dispersal of oil spills. This information, even in a probablistic form, will assist scientists in determining priorities in applied research. For instance, with adequate cooperating inputs from marine biologists, such information might indicate whether the principal hazards from the tankers were to bottom fish and invertebrates, waterfowl, or salmon.

Another use of modeling would be in evaluating the effectiveness of alternative navigation systems in an area such as Prince William Sound and its approaches. In each system the expected frequency and size distribution of position errors is generally known in advance. In many cases a small reduction in the magnitude and frequency of navigational errors can be obtained only at a great cost in additional system capacity. Whether the cost is justified can be evaluated by comparing the number of groundings and collisions that would occur in several hundred years of experience simulated by the model for alternative systems.

Administrative Innovations

On the whole, existing agencies are not organized to seek out this kind of information on benefits and costs, nor to use it in allocating the services and values available from Alaska's water resources. Formulation of legislation to restructure institutions in this direction requires consideration of factors that go beyond the scope of this study. On the basis of economic theory, however, it is possible to identify some general organizational innovations that might improve allocative efficiency in water resource utilization.

The advantages to charging polluters for their use of the public waters have been discussed above. It was suggested that these charges should be based on an analysis of the benefits foregone as a consequence of the pollution under consideration; it was pointed out that such charges should be increased or decreased in response to the changing opportunities for beneficial use of the water resource and the level of demand for services it provides.

Regardless of the political and social constraints taken into account in developing governmental structures to handle these matters, their determination requires a degree of technical expertise. As Alaska continues to be industralized and to become more populous, conflicts related to water resource allocation will become more frequent, and the demands for their resolution will exceed the capacities of any non-specialized legislative or judicial organization.

Under the administrative structure that prevailed until 1971, effluent discharge permits were issued by the Department of Health and Welfare. On the federal level, comparable authority rests in the Army Corps of Engineers. The state's water quality control functions have now been transferred to the newly created Department of Environmental Conservation. Future legislation might mandate the new agency to conduct a benefit/cost analysis for each permit requested, and require the department to establish such fees or charges as may be necessary and appropriate to allocate the limited waste carrying capacity of the waters in question.

An alternative solution might be to establish a Water Resources Evaluation Board within the new department. Such a board could be appointed by the governor in staggered terms and be composed of people with varied professional backgrounds representing diverse interests; for instance, a five member board might be specified, containing a biologist, an engineer, an economist, a businessman and a recognized "conservationist."

Another alternative would be to pattern the board after the Alaska Oil and Gas Conservation Committee, with its membership being representative of the various executive agencies having concern with water pollution and resource allocation problems. These would include the Department of Fish and Game, the Department of Health and Welfare, various divisions within the Department of Natural Resources such as Parks, Petroleum, and the Department of Environmental Conservation.

Anyone wishing to conduct activities that would alter certain well defined characteristics of the public waters would be required by law to submit an application to the Department of Environmental Conservation. The Department would prepare a water utilization impact study attempting to identify all possible adverse effects of the proposed use. If the anticipated impact exceeded a certain prescribed measure, a public hearing would be called after publication of the study and the passage of a reasonable digestion period. The board would determine on the basis of the application, the utilization impact study, and the hearing record, whether the proposed discharge should be allowed and, if so, the appropriate charge. That charge could be as high as the board might determine appropriate, but in order to emphasize the fact that the permitee is purchasing a productive service from the public, there would be a minimum fee--perhaps $10 per year. The criteria to be used in setting these fees would be laid down by the legislature, but in general could follow the lines discussed above.

The fees could be assessed per unit of effluent, suspended particulate matter, biochemical oxygen demand (BOD), the degree to which such measures as temperature, pH, or dissolved oxygen content of the waters are altered, or any other measure of utilization or degradation considered appropriate. Once established, a fee schedule would remain in force until reviewed. Review might be initiated by public request, the applicant's request, by submission of a revised impact study from the Department of Environmental Conservation, the Board's own motion, or automatically on receipt of an additional request to use the same waters for a similar or competing use.

This particular governmental structure has been presented in detail for the sole purpose of illustrating the implementation of the abstract but basically simple concepts discussed earlier. Political and social factors have been deliberately ignored in order to focus attention to these concepts, but even from a strictly economic viewpoint the institutional structure outlined here can probably be improved.

The heart of any such reorganization, however, is legislation to permit the use of the price system, at least in those cases where the equity and efficiency of the market solution is not in doubt. Clearly this includes those cases where the waste carrying capacity of a water course has been limited to what a pollution management authority declares as acceptable, and this limited capacity must be rationed among several competing commercial firms and/or domestic sewer systems. Such a reorganization might go further, formalizing the collection of information on both benefits and costs, requiring the distribution of such information, and encouraging its careful analysis, with the final result of a general--but not slavish--commitment to the use of the market system as a tool of allocating the benefits of water resource use.

Arguments and Counterarguments

Even if the concept idealized above were embodied in legislation, attainment of the management goals discussed in Part I would be by no means assured. An essential prerequisite is that policy makers and the electorate have an intuitive grasp of the logic of decentralizing some of the decision making authority in water resource management. Despite Alaska's outside reputation for "development at any cost," it has been the authors' experience that the Alaskans are at least as aware as Americans in general of the environmental degradation that has taken place elsewhere; on the whole they are genuinely committed to preventing similar degradation in Alaska. Many people who are most concerned with environmental quality feel that the loss of air and water quality in the other states has been associated with and a consequence of rampant capitalist "free enterprise," that is, of decentralized decision making based upon the price system. An understandable inference is that society must forbid individual economic units the authority to dump waste either in the water or the air, and must concentrate this authority in the hands of the government. In this context, the proposal advanced here to decentralize a part of the decision making goes against the grain of the public's newly mobilized environmental conscience.

Conservationists increasingly have an ambivalent or hostile attitude both toward the price system and toward the economics, whose resort to numbers and apparent desire to put a price on "priceless" resources is an anathema. It is sometimes argued that the disposal of any residuals in the public waters is contrary to the public interest. The implication of this position is either that society derives no benefits at all from directly inexpensive waste disposal, or that the benefits derived from the pristine character of any watercourse are so great that they outweigh the benefits related to waste disposal efficiency from the tiniest increment of impurity.

A less doctrinaire conservationist position accepts the relativism of environmental "quality" and the appropriateness of the cost-benefit principle to issues of pollution. It is argued, however, that the successful implementation of the ideas outlined here depends upon a governmental responsiveness to the public interest that is not obtainable. The critics suggest that narrowly based economic interests exercise a disproportionate control over the political process; as a consequence, policy makers charged with the responsibility for setting pollution charges will consistently be biased towards fees that are too low.

This contention is neither categorically refutable, nor satisfactorily dealt with exclusively by economic analysis. Not all those who advance the line of reasoning start from the same assumptions. Those conservationists who do not basically distrust the judgment of the citizens, no matter how effectively expressed by the political machinery, base their argument on the belief that government responds effectively only to those political interest groups that can mobilize concentrated economic power in support of their positions. It follows, they contend, that such interests will control the fee setting process. However, other arrangements for water quality management–such as absolute prohibitions and prescriptive engineering specifications–are also patently vulnerable to manipulation and corruption. Their formal inflexibility in the face of varying economic circumstances inevitably creates instances where administrators--or courts--decide against enforcement, or permit long delays in enforcement. The absence of a continuous schedule of charges scaled to the social costs of pollution makes the penalty to the polluter for compliance a drastic one, and enchances his rewards from manipulating the system through political pressure or litigation.

On the other hand, much of the political resistance to establishment of authoritative agencies for environmental management is based on a fear on the part of industrial and municipal interests that the mechanism will be biased in favor of environmental fundamentalism, that the concentrated political power of the conservation movement will determine water quality standards. It is further feared that the management institutions and the courts will be used to harass and delay any development, however beneficial, which uses water bodies for waste disposal.

The fears of both sides in this debate are realistic, and are supported by a considerable body of experience with regulatory agencies in various fields. Ideally, an allocation mechanism should not be vulnerable to capture by any one group of users, in this case by industrial interests, domestic sanitation systems, riparian landowners, or outdoor recreationists. The choices for water quality management in Alaska are not, however, between corruptible mechanisms and those that are wholly invulnerable to concentrated economic or political power. Among the imperfect alternatives, we believe that social options are most nearly approached with arrangements which use the physical, biological, and economic information that is available, in a formal system of analysis and decision whose criteria are uniform and objective. Yet the system ought to be one that is continuously responsive to the various natural characteristics of and human demands upon water resources, both among places and over time.

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