Bureau of Reclamation Reservoirs and the Environment

O. A. DOLVEN AND CURTIS O. NESS

Division of Water and Land Operations, Bureau of Reclamation
Billings, Montana 59103

The purpose of this paper is to present a brief overlook or a 'state of the art' survey, as it were, in an attempt to bring into a common focus some of the accomplishments, problems, and needs relating to the construction and management of the man-made lake as experienced by the Bureau of Reclamation over some 68 years encompassing evolutionary needs and practices. This paper does not cover the far-reaching environmental impacts outside the dam and reservoir area.

Man-made lakes created by the Bureau of Reclamation have had a tremendous impact on the environments of the 17 western states. Totaling about 230 in number, these reservoirs have a combined shoreline of some 18,700 km, a water area of >688,000 ha, and 1.5 million ha of shoreline lands available for public recreational use. Locations vary from scenic canyons and foothill areas of mountain ranges to the Great Plains east of the Continental Divide. Sizes vary from about 80,000 to <40 ha of water surface.

In 1969 these reservoirs provided different forms of outdoor recreation totaling 54.5 million visitor days. The game catch included 21.7 million fish and 289,000 ducks and geese, and the game population was protected on about 235,000 ha of state and federal game refuge areas. Often, the conversion of a live stream to a lake with fluctuating water levels is not without some loss in the preservationist's point of view. However, compensating environmental benefits are or can be significant.

Environmental benefits now being realized are in a large measure provided by reservoirs justified by and built for other purposes. Although the early proponents of reclamation were conservationists, conservation relating to environmental preservation and enhancement evolved gradually as needs were recognized and the potentials of reclamation development to meet such needs became more fully appreciated. The total environmental quality goal has often been elusive owing in large measure to the difficulty in quantifying benefits, a requirement of the bureau's conservation development objectives. Incorporating these implied goals with old legislative tools was difficult. As a result the reclamation objectives for environmental quality originated to a large extent from two sources: (1) implicitly from a changing national concept of the quality of life and (2) explicitly from water resource managers who had to cope with specific goals not directly related to previously authorized objectives. Inescapably, disservices have been created by narrowly viewed developments, and potential benefits have been forgone. However, options available for the continued implementation of such narrow views have been substantially lessened by public interest in recreation and the environment.

Chronologically, the first environmental impact of the man-made reservoirs is the displacement involved in the acquisition of right-of-way. Although many early bureau reservoirs were located in remote and scarcely populated areas, the progressively narrowing list of potential damsites almost inevitably resulted in the displacement of some owners, tenants, and workers, the relocation of some sections of highway and railroads, and occasionally the relocation of an entire town. In accordance with the principle set forth in the fifth amendment to the Constitution it was long the policy of the federal government to pay the property owner the market value of his land. However, all other expenses and losses incurred by owners, tenants, and others, such as moving and relocation costs and sentimental values, were viewed by the courts as consequential damages and were not compensable. On May 29, 1958, however, Congress passed an act that recognized that payment of market value is not always enough and so authorized the payment of

expenses involved in moving the people, their families, and their possessions as a direct result of such acquisition.

The construction scars of borrow pits, construction trails, and construction campsites and the environmental compatibility of the new structure design were given only secondary consideration in the early history of the reclamation program. As more comprehensive congressional enactments permitted and as public awareness and interest in the preservation and enhancement of environmental quality advanced, the bureau has been in the vanguard of federal agency involvement. Current policy energetically supports a program that embraces planning, construction, and operation to preserve and enhance the qualitative virtues of the natural environment and the quality of life of all the people.

The multipurpose operation of its reservoirs is a practice that the bureau has lived with since the filling of its first reservoir. The public interest has demanded a vastly more efficient use of our water supply and of the physical opportunities for its regulation and enjoyment than was in many cases encompassed in the original plan. West of the 100th meridian, where most of the bureau reservoirs are located, the aridity of the country is such that streamflow fluctuates more violently and more complete control of streams and rivers is required. The total water supply is generally adequate for all consumptive uses in most of the areas that the streams and rivers serve, but storage must be provided for protection against floods, to generate power, to meet international treaty obligations, and, even on the great rivers, to assure an evenly regulated water supply for consumptive use.

FLOOD CONTROL

During the initial phases of river basin development when only a few major reservoirs are in operation, the flood control function involves different degrees of pool level fluctuations, since the flood control storage space must be evacuated to make room for the next flood. On Bureau of Reclamation reservoirs, flood control operations occasionally create such environmental problems as the flooding of nesting areas and interference with fish spawning or with recreational use at high-water and low-water stages. By timely cooperation with fish and game management agencies and the U.S. Army Corps of Engineers, which controls the flood control operation, potential fish and wildlife losses have been held to a minimum. As the number of reservoirs in a basin increases and therefore the fully regulated river approaches elimination of the flood hazard, flood control storage space becomes available for other uses as well. Although the Bureau of Reclamation has seldom reached this optimum objective in its comprehensive river basin development programs, by closely coordinated operations with other reservoir management agencies in the basin, it has approached this goal.

RECREATION

Some of the environmental and ecological significance of the recreational resources of the man-made lakes of the bureau is indicated by: a national recognition of the large permanent value of outdoor recreation for the health and well-being of the nation, the surging demand by whatever measuring rod (visitations, number of fishing license holders, number of boats in use, and so on) of an exploding population for outdoor recreation, preferably water oriented, and the average 0.57 ha of water surface provided to each person within the United States in 1850, which had decreased to 0.16 ha by 1950 and is still decreasing.

Against this background the resources of the bureau reservoirs range from resources of strictly local significance to those of such national importance as the Flaming Gorge National Recreational Area of the Colorado River storage project and the Bighorn Canyon National Recreation Area of the Missouri River basin project. In total they constitute a major factor in meeting the growing demand for water-based recreation. The National Park Service prepares a general development plan for the recreational areas, and qualified federal, state, or local agencies administer them. In a few instances the lack of funds has resulted in a lack of coordination between local administering agencies and a lack of success.

The bureau, acting as a custodian of public property, through its own program and by means of agreements with the recreational managing agencies establishes and maintains guidelines that are designed to provide unbiased recreational opportunities for public use. Such guidelines include: (1) unrestricted public access consistent with public safety and reservoir management needs to reservoir shoreline lands and water

areas, (2) balanced development to facilitate comparable opportunities among the various pertinent recreational activities, (3) time and space limitations on quasi-private recreational uses, such as cabin site and trailer use, to avoid preemption of potential public use areas by special interests, and (4) avoiding commitments that would provide special benefits or privileges not compatible with the public interest to nearby private landowners. Reservoir fluctuations due to flood control and drawdown for irrigation, power generation, and municipal and industrial water supplies are carefully controlled to minimize detrimental effects to the recreational activity.

The degree of fluctuation varies widely within reservoirs as it does between reservoirs, usually in an inverse ratio to the size of the reservoir. Although this fluctuation can have some minor adverse effects on the quality of the recreation provided, it apparently has little effect on the demand as measured in terms of visitor days.

Our experience with recreational development and public use of bureau reservoirs indicates that the recreational resources involved have a significant potential for meeting the future expansion of public demand if administrative practices reflect a cognizance of the need to protect environmental values and to insure development and management practices that are consistent with the public interest.

Most public health officials agree that recreation on water supply reservoirs under appropriate regulation presents no threat if the water is properly filtered and chlorinated prior to domestic use. Public health regulations and public sentiment usually prohibit body contact sports such as swimming and water skiing in domestic water supply reservoirs, but even swimming presents no special health hazard provided the water is completely treated before it is used for domestic purposes. Probably more important from a health standpoint is the installation and maintenance of on-site sanitary facilities for recreational users.

FISH AND WILDLIFE

The biota of the new reservoir becomes established in a very different kind of environment from that from which it evolved. River impoundment can upset the long-established balance of temperature, oxygen content, seasonal distribution, and energy flows in the biotic environment. Resulting changes occur in species composition, invertebrate succession, aquatic vegetation, and the biotic base that sustained them. The changeover, however, is from stability to dynamism. The big new man-made lake is the recreational hope of the future. Reasonably protected from major deleterious changes and broad enough to encompass the competing recreational pursuits of fishing, boating, swimming, and water skiing, it is deep enough to sustain a variety of fish and rich enough to grow them big. However, the state of the art of maximizing the fishery potential of reservoir impoundments has a long way to go. Nevertheless, some encouraging results have been realized when the controlled fluctuation of some bureau reservoirs has been used to facilitate fish spawning and nesting, to destroy the hatch of undesirable species, and to improve the feeding grounds for both fish and wildlife.

Most bureau reservoirs are used frequently by migratory waterfowl as resting and feeding areas. Some are important as nesting areas. Others, such as the Klamath project reservoirs in southern Oregon and northern California, are principal supporting components of major flyways. In addition, many reservoirs, such as those in the Great Plains states, complement state game management programs by supplementing scarce water areas for nonmigratory waterfowl and other wildlife management purposes.

SEEPAGE AND FLOODING

The question of whether the presence and operation of a reservoir can contribute to a seepage or high-groundwater problem in the adjoining land area and whether the presence of the reservoir at high stage, low stage, or in between can contribute to the severity or the frequency of ice jam flooding has been an issue on some bureau reservoirs. Although the preponderance of evidence is to the contrary, there is an element of doubt due to the lack of specific historical data from which a sharp differentiation between cause and effect and coincidence can be made.

EXPOSED BEACHES AROUND RESERVOIRS

Many bureau reservoirs are evacuated or drastically drawn down during the irrigation season. The drawdown exposes beaches, particularly at the upper end of the reservoir. The exposed beaches are unsightly and vulnerable to wind erosion. If the beach material is fine-grained

dust, blowing problems are common. If the beach material is sand, winds drift the sand onto the adjoining areas and oftentimes destroy the native vegetation. Although the problem is not widespread, it is difficult to correct.

Several dust suppression measures have been considered, and substantial experimental work has been performed or initiated including cultural practices oriented toward suppression of dust by either establishing a vegetative cover over the dust-contributing area or keeping the exposed soil wet or roughened. These practices have been successful at the higher reservoir elevations but have not solved the wind erosion problem in areas subject to prolonged seasonal inundations. Preliminary observations indicate that a diking program may be a more permanent means of dust suppression. However, the extent of the adverse effects of wave and ice action on such dikes is not known at this time; costs of repair or reconstruction following periods of inundation may be costly.

EVAPORATION

Reservoir evaporation ranges from <1% to about 20% of reservoir inflow. The average evaporation loss is approximately 5% of reservoir inflow. The feasibility of the large-scale application of monolayers for reservoir evaporation reduction has been investigated, but the conclusions of the study indicate that the average reduction in evaporation is only 12% because of significant film separation caused by wind action. The cost is approximately $0.02/m^3$ of water conserved.

SEDIMENTATION

Sedimentation rates as related to the life expectancy of the reservoir site are generally within design requirements. The maximum life is greater than a projection of observed rates of sediment accumulation, however, because the sediment storage capacity is greater than the water storage capacity and the current average specific weight of sediment is increased by compaction. Sediment storage capacity frequently changes turbulent silt-laden streams of low fishery values into streams of clear sparkling water and outstanding fisheries. Geodetic surveys show that the weight of water has caused minor subsidence of the earth crust.

WATER QUALITY

Most reservoirs bring about a dramatic change in the sediment load carried by the river. In 1930, for example, measurements indicated that 57% of the silt in the Yellowstone River came from the Bighorn River. Following completion of Yellowtail Dam and Bighorn Lake the Bighorn River below has become a clear sparkling trout stream with fishery value far in excess of original estimates.

There have, however, been increases in mineral content such as those found from the upper to the lower end of Lake Mead, the greatest increases being in the sulfates and chlorides of calcium and sodium. The location and operation of multiple outlets will affect the limnological regime of the reservoir and permit selection of the water quality to be served downstream. Related atmospheric control operations, such as cloud seeding for increased snowfall, can enhance the water quality.

NEED FOR RESEARCH

Sufficient management of water resources to meet the needs of an expanding population will require more fully developed systems of storage reservoirs to provide control of the periodic and seasonal fluctuation of streamflow. The number of potential reservoir sites in the nation is physically limited, and some are being preempted by incompatible development. A program for the reservation of storage sites on public domain has been under way, but no national program or policy exists with respect to the reservation of many other favorable sites that are privately owned. A study is needed therefore to consider (1) identification of potential sites for federal or nonfederal development, (2) restriction of future incompatible development through purchase, easements, land use contracts, or a combination of these means, and (3) reclamation through a long-term program at a limited number of key reservoir sites now encumbered or partially developed.

More research is needed in all phases of the environmental impact of the multipurpose reservoir. Since the current impetus is on the recreational, wildlife, and esthetic values of reservoir development and management, a great deal of the available literature is outdated, lacking in scope, and single-purpose oriented. The old concept of water use in terms of withdrawal needs to be replaced with a new concept of 'the duty of

water' for all purposes including the appreciation of social values and the national requirements for water of certain characteristics. The duty of water may have no relationship to the volume of water involved, but it has a very specific relationship to the way in which water must be distributed both geographically and in time within the total environment.

For reasons stated previously the scope of this discussion has been limited to what is essentially the 'take-line' of the Bureau of Reclamation reservoir, procedurally, those lands above and below the maximum flowage line needed for permanent structures, public access, and such current and future requirements of fish, wildlife, and recreational uses as may be authorized.

In no sense, however, can the Bureau of Reclamation multipurpose reservoirs be separated from their direct and indirect influence on the environment of the community and the nation that they serve. They have provided the means for making many areas of the western United States suitable for settlement. They have provided a frontier in which people could find opportunity for profitable employment and a feed base for the optimum use of the adjacent rangeland. It is in this sense that the environmental significance of the flood control function lies, for example, not so much in the inviolate storage space at specific elevations in the reservoir pool as in the property damage and loss of lives prevented downstream. It is only in that context that the full environmental impact of the Bureau of Reclamation reservoirs can be assayed.