Achievement of Goals Subsequent to Construction of Water Resources Projects

By

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Introduction

History has shown that great civilizations develop where good quality water is abundant or can be made so by the efforts of man to meet the needs of man, and falter when usable supplies are inadequate or are grossly misused.

Most nations of the world, to the extent they have become involved in nationally sponsored and financed resource development activities, have historically given high priority to those functions and goals which lead to stronger national economic growth and stability. Currently, the goals of many nations, including the United States, are giving greater conscious emphasis to functions which contribute not only to economic growth but also to a better social and cultural quality of life for their people, and to protection and enhancement of the overall environment. All of these broad national goals relate directly or indirectly to a nation's resources and the projects that put those resources to work for the benefit of the people.
Resources

Water, land, and the atmosphere are the earth's three basic renewable natural resources from which all new wealth generates through the activities of a fourth all-important renewable resource—man. In general, all other resources are extractable and therefore exhaustible. Of the renewable wealth-generating resources, water is the most limited and variable. In addition to its wealth-generating capabilities, it is the catalyst in development of the earth's expendable resources. Water combined in use and development processes with land, coal, oil shale, other minerals, and other natural resources tends to stabilize and enhance rural and urban life in established areas, to stimulate rural and urban growth in new areas, and to promote general economic development and expansion with far-reaching benefits.

Planning and Construction

If a project is to achieve its goals subsequent to project construction, obviously it must have been formulated, designed, and constructed on a sound basis. Each of these aspects is an extensive subject in itself and cannot be covered in the limited time for this paper. Therefore, this paper deals only with achievement of goals subsequent to project construction and assumes, of course, that project formulation, design, and construction have been on a sound basis.

Multiple-purpose Projects

In most of the world, the day has long past when a nation can plan for single-purpose water development projects. The multiple-
purpose approach is essential to meet modern day needs and demands of society and it offers many advantages. Foremost among these of course is the opportunity to integrate and coordinate water uses for the several competing functions in order to maximize overall benefits for people. More specifically, the multiple-purpose approach offers the opportunity to share costs among several functions, to avoid costly duplication of facilities, to avoid costly modification of facilities for adding new functions after initial construction, and to minimize conflicts among project functional interests by setting up from the beginning long-range principles and criteria for coordination and integration of water uses.

Despite the advantages of the multiple-purpose project concept, there are inherent conflicts among the several purposes and these must be reconciled frequently by compromise. For example, the season of high-water use for irrigation occurs at about the same time that the natural flow of the river drops off. These circumstances often cause a rapid drawdown of reservoirs during the season of greatest recreational use of the reservoir area. This is offensive to the recreationist because the rapid drawdown leaves exposed shoreline mud flats, exposed boat ramps and piers, and a shoreline devoid of vegetation. Similarly, fluctuating water releases for hydroelectric power production for peaking purposes may create undesirable conditions for sport fishing downstream. Integration and coordination of water management operation to serve multiple functions become complex from the legal, technological, administrative, financial,
economic, social, political, and environmental standpoints. Management, to cope with these ramifications, is often beyond the capability of a local entity, particularly one oriented to a single function, and therefore must usually be dealt with under the broad authorities that prevail at the national level.

ORGANIZATION AND STAFFING

Organization

The type of organization required to manage a multiple-purpose project is usually established before the project is constructed. In the United States this may be a Federal bureau responsible for overall management of the multiple-purpose functions. Facilities serving single-purpose functions within a multiple-purpose project may be transferred, for operation and maintenance, to local or state organizations authorized to contract with the United States and with power to tax its members. If several such organizations are involved, a board of control or a joint operating organization of some type is established. If the project is international in character, the two or more nations involved must each be represented on some type of a joint committee or commission set up for the purpose of operating the project facilities pursuant to previously established guidelines and criteria. Such a board would employ an experienced manager, supplemented by a technical staff to the extent necessary to conduct the operation and management functions.

Staff

To achieve project goals, the manager and his top professional staff must represent technical expertise in all disciplines associated
with the various project purposes. The number and classification of employees in each professional category will vary according to the operation and maintenance functions to be performed for each project purpose. Many irrigation districts in the United States have found it desirable to publish a handbook for their directors and staff which describes in some detail the project goals, its physical facilities, the Board's legal responsibilities, its policies and standards, its management philosophy, and its programs for operation and maintenance.

MANAGEMENT OF STORAGE AND CONVEYANCE SYSTEMS

Operating Criteria

Operating criteria may be defined as the long-range guide for operation of reservoirs, powerplants, and related facilities in a river basin consistent with the laws of the river so as to facilitate water regulation for the benefit of present and future water resource development in the basin including protection and enhancement of the environment. Individual reservoirs in a basin development should not be operated as independent units or features. An integrated, or at least coordinated, operation of all units is essential to achieve the highest multiple-purpose use of the water resource and the greatest benefits for the greatest number of people. This requires promulgation of carefully worked out operating criteria.

Input into governing criteria must represent contributions from national, state, and contractual interests. Legislative, compact, treaty, and contractual restraints must also be observed. Parochial positions must give way to equitable treatment. The views of all interested parties must be given full recognition.
Criteria should be flexible with provision for periodic review among interested parties, and for revision if desired.

An annual report describing the actual operation for the preceding year and projected plan of operation for the current year should be a requirement.

Operational Techniques

The primary authorized functions of a reservoir usually dictate the management procedures for its operation. However, under a multipurpose concept, this can become quite complex because of the different requirements for meeting competing interests and objectives. For example, the desire for empty storage space to insure flood control, the desire for a full reservoir to provide maximum irrigation and power generation benefits, and the desire for a nonfluctuating reservoir water level to maximize recreational benefits are basically in conflict. A compromise plan including proper priorities of interest is necessary. Although these conflicting interests are recognized in the planning process, those responsible for actual operation of a complex system are often subjected to pressure from special interest groups for modification of reservoir operation to enhance or give precedence to a particular function at the expense of another. Frequently there is some flexibility in operations to recognize peculiar circumstances and to modify operations on a temporary basis to meet unusual or emergency conditions. However, the rule of operation must be fair and equitable treatment of all concerned in the light of authorized functions and established limiting operational criteria. Success in these operations requires good
public relations which, in turn, requires complete explanation to the users involved, the news media, and the public in general, as to the reasons behind operating decisions, the goals in mind, and the accomplishments obtained.

**Water Quality**

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**Review of Maintenance**

Periodic inspection of all operating facilities is a necessity. Inspection should be made at predetermined intervals by a team of experts in the maintenance of the particular facilities involved, whether they be dams, powerplants, pumping plants, canals, or mechanical systems related thereto. The purpose of such inspections, of course, is to discover, identify, and evaluate all deficiencies
Water Quality

The success of many functions served by a multipurpose water project are dependent on good quality water. Conversely, these same functions may have adverse effect on water quality.

In a complex multipurpose river development, the greatest cumulative negative effect on water quality usually develops through the use and reuse of water as it moves progressively downstream from one reservoir to the next. Paradoxically, the greatest positive economic benefits from a given water supply are derived by the same use and reuse. By knowing the effects of various operations upon quality and the seasonal water quality demands for each multipurpose, many operations can be adjusted to provide maximum benefits from a limited water resource.

For example, an irrigation project located on marine shale parent materials may have two negative effects, i.e., (1) a concentrating effect on total dissolved solids through evapotransformation; and (2) a "loading" of the drainage return flow with new salts leached from the parent material. Lining canals and laterals would decrease seepage, and increased farm irrigation efficiency would decrease deep percolation, both of which would otherwise leach salts from the soil and parent material.

Similarly, it is often possible to hold return flow of poor quality in a separate regulating reservoir and either use it for purposes where quality is not important, return it to the stream during periods of high flow, or return it to the stream when it will have the minimum adverse effects. For example, highly saline water for late season irrigation of cotton appears to have
little adverse effect, while the same quality water would totally destroy a salt-sensitive crop at germination time.

Release of storage water in the late irrigation season usually provides good quality water at a time when river flows would be low and of poor quality without the benefit of storage regulation.

The temperature of water in a stream below a dam to meet various purposes can be controlled within rather wide limits through the use of multilevel outlets.

The rate and timing of discharges from a reservoir have an important influence on the biodegradation assimilative capacity downstream. Large releases and increased flow velocity may so reduce the travel time to move a given organic pollutant downstream that it does not have time to undergo biodegradation. Peaking power releases may be particularly troublesome in this respect.

These few specific examples are cited to emphasize that to achieve project goals, each operation for a given project purpose should be made with a full awareness of its effects on other project goals.
in maintenance or operation and to establish schedules for their
correction. The long-range objective is to insure effective,
efficient, and safe performance of the facilities for their intended
purposes.

IRRIGATION

Sustained High Production

The broad long-range objective of irrigation development is
to establish a firm dependable base in support of local economies
out of which will grow numerous secondary benefits, both economic
and social with far-reaching effects. The immediate objective,
however, is agricultural production. Realization of the broad
irrigation objectives depends upon the extent to which agricultural
production is in fact developed and sustained at a high level.
Experience of the Bureau of Reclamation has clearly revealed programs,
tools, and aids which are very helpful in reaching both the immediate
and long-term objectives.

Drainage

Ground-water levels associated with the irrigation of project
land must be watched carefully in order that proper and timely cor-
rective steps can be taken before serious drainage problems occur.
A buildup of the ground-water level may drown the plant roots, and
accumulation of salts in the root zone may occur when there is
insufficient drainage to carry saline drainage water away or when
insufficient water is applied during irrigation to leach these salts
out of the plant root-zone.
The main source of salts is the irrigation water itself. It may contain from one-half to three tons of salt per acre-foot, and many areas require irrigation applications of from 4 to 10 acre-feet annually. Another source is the salt in the soil brought up to the root zone from lower levels with a rising water table or by piezometric pressures.

Drainage problems may occur a year or two after an area is first irrigated or they may develop slowly and not become critical for many years after initial irrigation. This is determined by the quality of the water used for irrigation; the type of irrigation system and irrigation practices which determine the quantity of water that percolates to the ground water; and the soil and subsurface characteristics of the area which determine the capacity of subsurface aquifers to hold water and to allow water to move away under natural or existing conditions.

Drainage problems are often so complex they cannot be completely predicted or planned for in the project planning stage. On projects where drainage was studied as part of the project planning effort, information may be available on the original depth to the water table, the hydraulic permeability of the soils, and other soil characteristics, the depth to an impervious barrier, the topography, and outlet conditions that make it possible to predict what drainage problems may be anticipated.

Ground-water observation wells should be installed and read periodically to keep track of changes in ground-water conditions.
It is preferable that these wells be installed at least 2 years prior to the initiation of project irrigation, in order to record preproject conditions. In areas with significant seasonal rainfall, the rainfall data should be collected and correlated with groundwater conditions.

Periodic plotting of groundwater data is necessary to determine changes in conditions. This may be done by the preparation of maps and charts showing depth of groundwater and seasonal changes in groundwater conditions. A good topographic map with contour intervals of about 1/2 meter or less is usually essential as a base for the preparation and layout of the data.

Information on soil and geographic conditions is essential to predicting the requirements for drains, determining drain locations, and estimating their effectiveness when installed. This includes information on the permeability of the soils and the depth of permeable material that overlies a drainage barrier. While it is necessary to have a general idea of soil permeability of an area, the best measurement can be made by bailout-type tests conducted under high water table conditions.

Proper drainage can be accomplished only with the knowledge of the source of the water that is causing the problem. Modified irrigation practices to reduce deep percolation and lining of canals to stop seepage are often cheaper corrective measures than installing drains.
Settler Assistance

Engineering. Often the irrigators on new projects are inexperienced. Help that can be given to them in preparation of their farm units and in managing them will help in attaining high crop productivity in the initial stages of development. It will prevent the considerable expense and loss of productivity that occur when crude systems must be rebuilt after the farmers find out that they are ineffective and inefficient and therefore must be redone.

The proper layout of the farm unit is essential to maintaining high productivity, providing good control of irrigation water, and in keeping the farm labor requirements within reason. The design of farm fields depends on the type of irrigation to be practiced. In gravity irrigation, consideration must be given to the head of water available, the slope of the fields, and the length of the irrigation run so that water can be applied in proper amounts to the soil root-zone for the need of the crop being grown without wasting water, eroding the soil, or causing high labor requirements.

In sprinkler irrigation systems, less consideration need be given to topography in the farm layout, but peak water requirements of crops, labor requirements in moving the systems, and cost of providing the pressure to the sprinkler irrigation system are of prime importance.

The design of farm ditches to deliver water to farm fields and surface drains to carry off excess water needs to be considered in
the development of the farm unit. The proper slope, capacity, and elevation of the water level in ditches as related to that of farm fields is essential to the control of irrigation water.

**Agronomic.** The change from dryland agriculture to irrigation often involves training and education of farmers in farming practices. These usually are considerably different from those under dryland farming conditions.

Proper irrigation practices are essential. It is often difficult, even for people who have had irrigation experience, to understand the soil-plant-water relationships that are necessary for proper irrigation. Farmers need an understanding of the capacity of the soils on their farms to hold moisture, the conditions under which plants extract moisture from the soil, and what happens when excess water is applied.

As compared to dryland farming, new crop varieties often provide higher production under irrigated agriculture. In the United States information on these can be obtained from agricultural experiment stations. Often the availability of water allows for changes in planting dates or may permit for more than one crop to be grown during a year.

To accomplish desirable agronomic adjustments the Bureau of Reclamation frequently, as part of its project costs, arranges to employ or finance the employment of skilled agronomists and irrigation engineers to assist farmers individually in farm unit layout, cropping patterns, and irrigation methods.
Financial. Full production from irrigation agriculture can be obtained only if financing is available for farm development, farm equipment, and farm operating costs. Farm development costs are usually beyond the financial capacity of the farmer. Loans, grants, or other methods of making money available from Government or private sources is usually necessary to the farmer.

The farmer will also need to finance the purchase of proper equipment for the most effective planting, cultivating, and harvesting. Often it is not feasible for farmers to own individually all of the needed specialized equipment. Thus, arrangements should be considered under which several farmers can share equipment, possibly through cooperatives or equipment pools so that farmers can obtain the use of needed equipment at reasonable costs.

Development Farms. Development farms are an effective tool in settler assistance. Their principal value is during the early years of a project to demonstrate to new settlers and project water users practical irrigation methods and agronomic practices best suited to local conditions. The farms also provide a centralized location where all interested local, State and Federal agencies can cooperatively carry on needed research and experimentation concerning specific problems of the project. To accomplish this, it is imperative that the sites selected represent the principally prevailing project conditions and, at the same time, represent specific problems of the project.
Research conducted under such conditions usually is under the direct supervision of agricultural experts supplied by the State or Federal government. However, an advisory committee composed of interested Federal and local interests usually participates in the operation of demonstration farms for Reclamation projects. The demonstration farm may be on land in a project area and farmed by the landowner or tenant, in accordance with the plans of the supervisor and committee; or it may be on Federal or State land and operated by a contractor, also under technical supervision.

Frequent demonstrations, to which local settlers are invited, are held at the field level to illustrate improved irrigation and farming methods. The Bureau of Reclamation has found from experience that demonstration farms are extremely helpful in expediting the attainment of irrigation project objectives.

HYDROELECTRIC POWER

General

Electric power is derived as a byproduct of Reclamation's western multiple-purpose river developments. Being a byproduct, power generation is determined by the amount of water passing through the storage system. The Bureau of Reclamation's involvement in the power field is largely for the purpose of financing those reimbursable costs of other multiple-purpose functions of water resource projects that are beyond the ability of those functions to repay. Power managements' objectives are comparable to those of any other business, that is, to perpetuate the organization so that its mission and financial objectives can be achieved. Because of the Bureau of
Reclamation's mandate and desire to run its electric system in the most economical manner possible, efforts are continually made in evaluating all possible economies that might be achieved by adopting new practices, new procedures, new products, and new technology, not only in the planning of new power developments but also in the redesign, operation, and maintenance of older plants.

There are few, if any, manufactured products or processes that reach a greater number of American consumers than electric power. Because of this, the industry is subjected to microscopic examination by the public, the press, and other communication media in addition to regulatory agencies. This became particularly pronounced when the Northeast sector of our country suffered from an extensive blackout in November of 1965. This marked the start of a period in the industry when the key word became "Reliability."

Reliability

Translating reliability from the word to action has required installation of much new equipment and establishment of many new procedures. A new emphasis on reliability has also resulted in the formation of coordination councils and organizations which now display a degree of cooperation that has not previously prevailed in the industry. The Bureau of Reclamation has taken a leading role by coordinating the operation of its interconnected power system through development of relay and control devices for improvement in interconnected power system operation and have joined all available reliability and coordinating councils in which we can contribute
our expertise. We are an active member of the Western Systems Coordinating Council which serves 36 million people with an electric power demand of approximately 49 million kilowatts.

Implementation of Goals

The Bureau of Reclamation is facing and meeting the challenge to provide reliable, high quality, low cost electric power for the ever increasing demands for our customers by numerous means. Now under construction is the "third powerplant" at Grand Coulee Dam on the Columbia River in the state of Washington. The existing generating capacity at Grand Coulee Dam is about 2 million kilowatts. The six units to be initially installed in the new plant will add 3,600,000 kilowatts, with an anticipated ultimate capacity in the third powerplant alone of 7,200,000 kilowatts. The Bureau of Reclamation recently participated in the construction of extra high voltage ties between the Pacific-Northwest and the Pacific-Southwest. Those ties are in the 500- to 750-kv. range and involve d.c. as well as a.c. transmission.

Peaking Power

Hydro powerplants are uniquely well adapted to generation of peaking energy. Since the power industry by its very nature is one of growth and change, the Bureau of Reclamation is exploring opportunities to maximize use of all hydro installations for peaking power production to augment the thermal power baseloads of the West. The Bureau of Reclamation is also investigating the further development of so-called pump-back storage for hydro peaking capacity to make the maximum use of our water resources.
However, even with all the new developments in systems analysis and control, the formation of large power pools, combined operating areas, the construction of extra high voltage ties and high capacity generation, and the greatly improved computer capability and use, the human element cannot be overlooked. Personnel understanding and guidance must be thoroughly geared to the achievement of the goals being sought.

FLOOD CONTROL

Under the multiple-use concept most reservoirs are now planned and constructed to provide flood control by allocation of some storage space, either exclusively or jointly, to the flood control purpose. Even when this is not one of the primary objectives the incidental flood control benefits in connection with other uses such as irrigation and power are often quite significant.

Flood Operating Criteria

In order to obtain maximum flood control benefits operating criteria based upon rule curves as related to snowpack surveys, runoff forecasts, seasonal temperatures, historical records, and other meteorological information are necessary. These often are developed in the planning stages, and should be revised as operating experience indicates is necessary or desirable.

Communication

The efficiency of flood control operations is enhanced considerably by complete and fast communication of the latest
hydrological data within the drainage basin of the project. As many interests, both Government and non-Government, are concerned with flood control activities cooperative arrangements among such interests are often used in obtaining and relaying current rainfall data, river stages, and other information useful in flood control operations.

RECREATION AND FISH AND WILDLIFE

Through desirable combinations of water, land, and aesthetic resources the storage features of water development projects usually have high potential values for recreational use. Because such projects usually utilize public lands, public waters, and public financing, the resulting recreational benefits should accrue to the general public, rather than to special interest groups. Accordingly, recreational management responsibility should be assigned to a qualified governmental entity.

The first requirement to be met, in connection with recreational interest in project features, is to protect the project from damage incident to public use and to provide at least minimum facilities for protection of the health and safety of the public. Such facilities are clearly the minimum required and usually are highly inadequate to accommodate the full public recreational potential.

To maximize public benefits, consistent with other project requirements and needs for environmental protection, development and use of a reservoir area for recreation should be undertaken.
in accordance with a soundly conceived development and management plan which brings together in one document, information needed to coordinate all pertinent reservoir needs and uses. Such a plan can be updated as necessary to meet changing needs. It contains a ready source of information to provide guidance to all appropriate interests.

Fish and wildlife values of a project fall into two readily identifiable categories, i.e., (1) those that provide direct recreational benefits (such as hunting, fishing, camping, picnicking, and nature study) in the project area, and (2) those requiring use and management of project features or facilities for mitigation of losses or enhancement of fish and wildlife resources.

MUNICIPAL AND INDUSTRIAL WATER SUPPLIES

Water is the lifeblood of a country's cities and industries. Therefore, it can be expected that municipal and industrial water usually receives priority over all other uses as to both quantity (the sharing of water shortages) and quality. However, the degree to which this is done is usually spelled out in the operating criteria.

Water quality, including taste and odor as well as salt concentration, is extremely important. Every effort should be made to keep the reservoir and distribution system (including open canals and pipelines) from becoming polluted. Pollution can occur from the action of man, animal, or nature. Controls must be exercised to prevent the detrimental effects of sewage and indiscriminate use of pesticides adjacent to water supplies. Heavy use of an area by
wildfowl can result in undesirable concentration of nitrates or biological pollutants. Flood runoff into canal systems serving municipalities may result in turbidity and siltation problems.

Federal and local health and environmental control agencies often are helpful in policing M&I water supplies to keep out pollutants. They also can control the activities of the project system operators. Therefore, a good working relationship with personnel of the agencies is essential. They can compel operators to take certain safety precautions as well as limit them in the use of chemicals to control algae, insects, or weeds in a water supply area. The Bureau of Reclamation has found that in some instances fish and wildlife agencies prohibit use of copper sulphate to control algae causing undesirable taste in water because the CuSO₄ kills fish in the reservoir. In other instances, public health service agencies will not allow the use of DDT to control mosquitoes or 2, 4, 5-T to restrict certain plant growths around water supplies because of possible ill effects on water users.

Conclusion
In conclusion, CONCLUSION

In conclusion, may I emphasize that the fundamental objective of any water resource development project must be to improve the quality of life for people. Accomplishment of that objective requires more than mere construction of the physical facilities for water control and delivery.

It requires skilled management and a technically competent operation and maintenance staff that fully understands the short- and long-term effects and relationships of operations among and between the several project purposes; it requires carefully developed ground rules to assure equitable integration and coordination of all authorized project functions; it requires adequate and sound advice, assistance, and financing for project water users; it requires continuous review and updating of operating procedures and criteria to keep them fully, efficiently, and effectively responsive to the basic objective of maximizing social and economic benefits.

It is common knowledge that water is basic to the very existence and survival of man. Therefore water resource development must be conceived, constructed, and operated for the benefit of mankind, not only those of us now living but also for generations yet unborn. Like government itself, both philosophically and actually, and appropriate motto would be that water resource development for maximum benefits must be "of the people, by the people, and for the people."