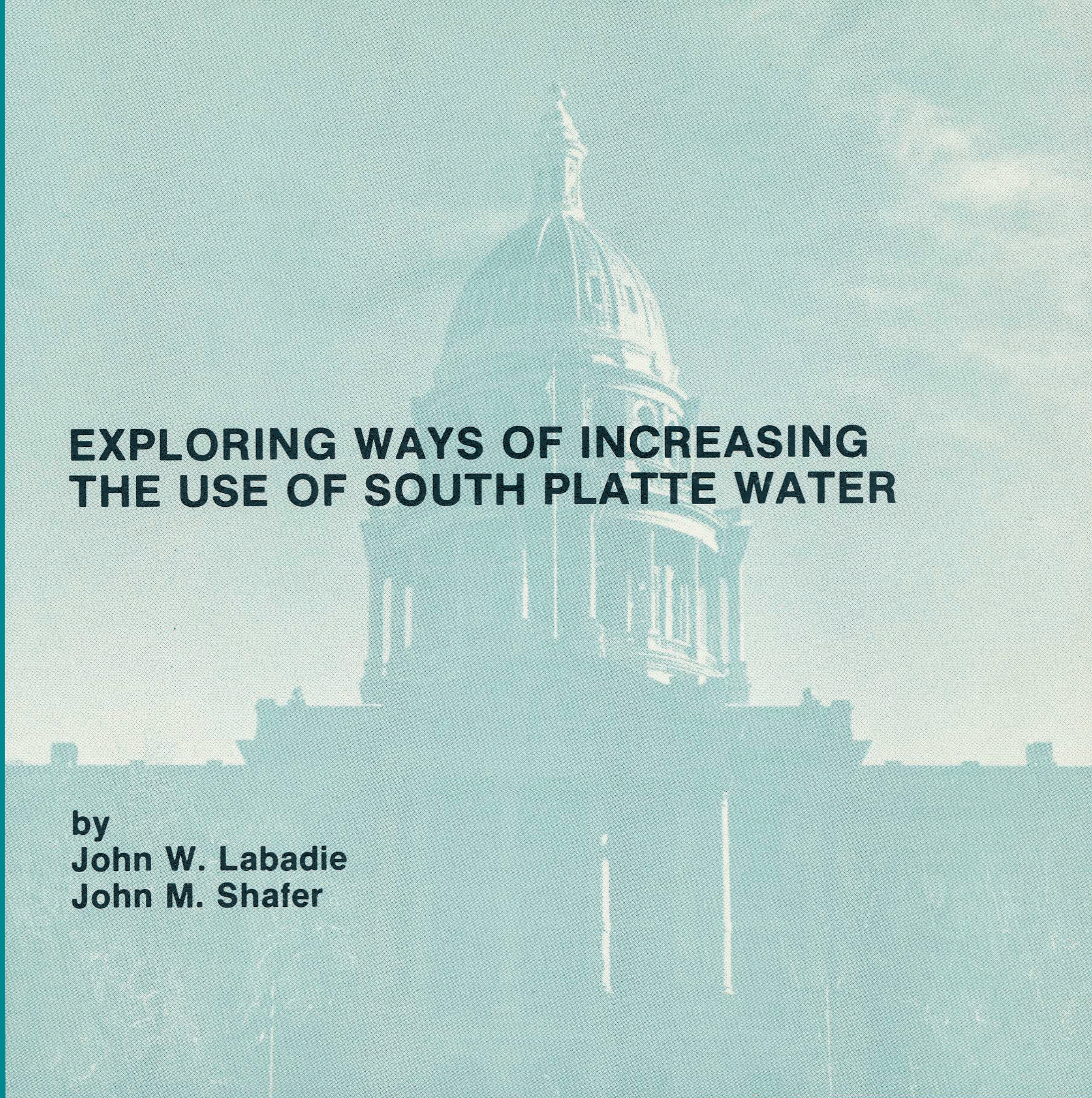

EXPLORING WAYS OF INCREASING THE USE OF SOUTH PLATTE WATER

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COLORADO WATER RESOURCES RESEARCH INSTITUTE

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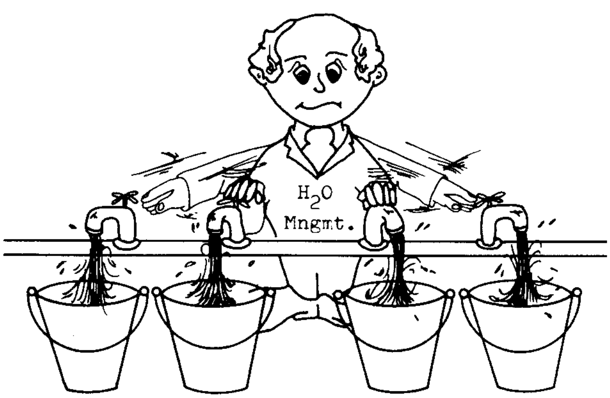
The full report covering this technological development is in Technical Report No. 16, available from the Institute ($5.00).

EXPLORING WAYS OF INCREASING THE USE OF SOUTH PLATTE WATER

INTRODUCTION

Increasing population along Colorado's Front Range presents an ongoing challenge for water managers. These managers must find ways of maximizing the uses of available water to meet requirements of water users without damage to water-right owners. Efficient management of water is imperative to meet the ever-increasing demands of municipalities, industry and agriculture.

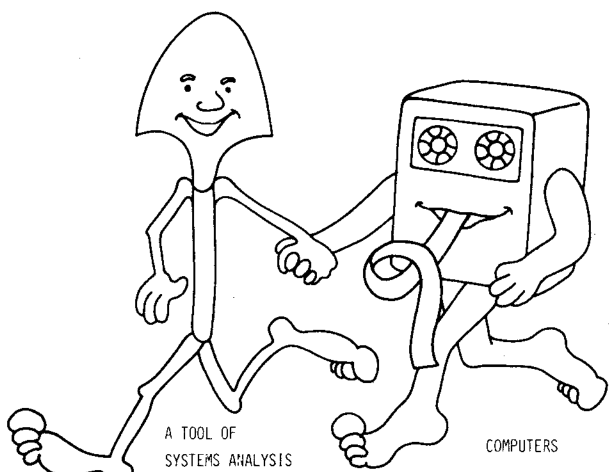


A system of storage reservoirs in combination with interlocking rivers and canals is a complex network that offers many options for skillful water management. To examine these options water managers are advised to raise "what if" questions that might conceivably lead to better use of the available water resource.

Addressing "What If" Questions

What if storage water rights were satisfied by flexible delivery from any reservoir in position to make delivery? Such a question leads to examination of a possible water management option different from prevailing practice.* It may or may not be a viable option. Statutory requirements for water rights administration may be one reason. Unwillingness of water-right holders to pool their waters and accept the flexible-delivery scheme is another likely constraint. But if the option is physically possible, and if it offers to water-right owners sufficient advantages in improved water supply or other incentives, the constraints may be relaxed by appropriate statutory or voluntary changes.

An important tool for answering such "what if" questions is a simulation model of the water system. This is made possible by the modern high-speed digital computer. A simulation model is no more than a computational procedure, but so many calculations are required that without a computer the task would be impractical. The model and computer go hand-in-hand, each depending on the other.



To properly address water management questions, a simulation model must be able to trace the life cycle

To a limited extent, river commissioners of the Colorado Division of Water Resources do now administer storage rights and direct flow rights with flexibility to accommodate exchanges agreed upon by water-right owners.

of a given volume of water as it is stored, transported, distributed and reused. The model also must be able to simulate each of many possible combinations of reservoir releases that could physically satisfy existing and projected demands, including instream flow. It also must be verified as an accurate and reliable model by duplicating the historic behavior of the real system.

MODEL SPECIFICATIONS

The model should be capable of simulating a complex river basin system by monthly time increments over a period of several years. Monthly increments provide sufficient accuracy for planning purposes and monthly hydrological data are readily available. The purpose of the model is to provide state and local water planners or managers with an easy-to-use tool for evaluating the effects of water management options and changes in system operation for their effects on water availability at all critical locations in a basin. Existing or planned priorities (including legal) among various beneficial uses of water must be carefully preserved. Special training or skill in computer operation should not be necessary in use of the model.

RELIABILITY OF MODEL

To explore possibilities of maximizing water usage of sub-basins in the Colorado Front Range, a computerized hydrologic computation (simulation model) was developed, using the Cache La Poudre River as a case.

The strong advantage of a model is that . . . options can be tested without disruption of the actual system.

An extremely important step in simulation is model calibration. If the model can reasonably duplicate the behavior of the real system, confidence is developed in its reliability. Computations that result in river flow which reasonably match historical records of flow indicate the model will correctly predict the impacts of changes in reservoir operation. The strong advantage of a model is that operational options can be tested without disruption of the actual system. The expense of developing and using a simulation model is negligible compared to the expense of cut-and-try changes in the real system.

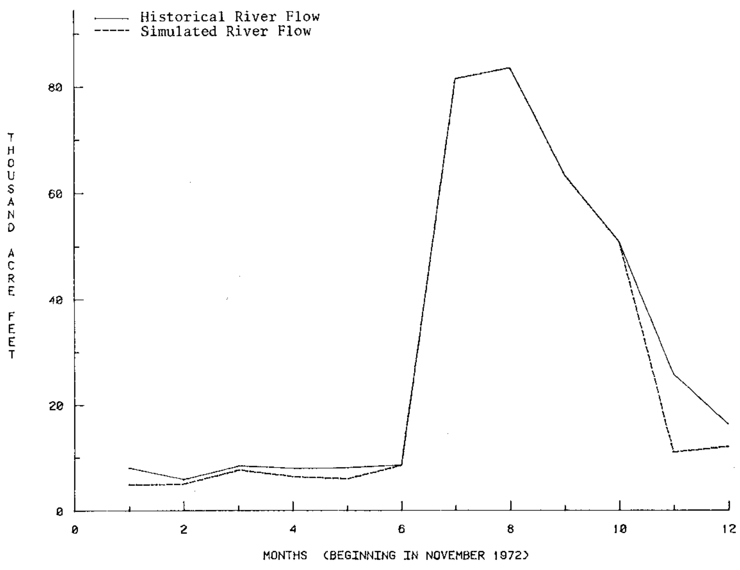


Figure 1. Computer Simulation Flow vs. Historical Flows after Model Calibration.

Figure 1 shows a portion of the calibration results for the model after it was fully developed. It shows that this computer-simulation model matched historical gaged records of river flow very closely since results for other years used in the calibration turned out even better than this one.

To test its utility, this model was applied to the Cache La Poudre River Basin. Specific features of the upper basin that were used in this study are shown by diagram in Figure 2. Factors that must be accounted for in the model include:

- the physical complexity of interrelated water storage, transport, distribution and reuse;
- all possible combinations of reservoir release policies that could physically satisfy the final demand but are subject to
  - constraints on system operation due to water rights; and
  - constraints on system operation due to locations of final demand.

The model is reliable in accounting for all these variables.

MODEL APPLICATIONS

Application of the model was tested on two real water supply management cases where changes in system operation might potentially increase utilization and benefits of the limited water available to the basin. In the first case, options for managing releases from high-country storage reservoirs were explored. Increasing public pressure for high-country recreation opportunities as well as for maintenance of instream recreational values make this a practical question to examine.

The second case was not as hypothetical as the first case. It involves the need for cooling water supply to the Rawhide Power Plant being constructed north of Fort Collins, Colo., by the Platte River Power Authority (PRPA). The problem in this case was to test potential options for getting water delivered to the site without negative impact on other water-right owners.

Enhancing Recreational Potential of Reservoirs

High-country storage reservoirs often are closed to the public or are so severely drawn down during

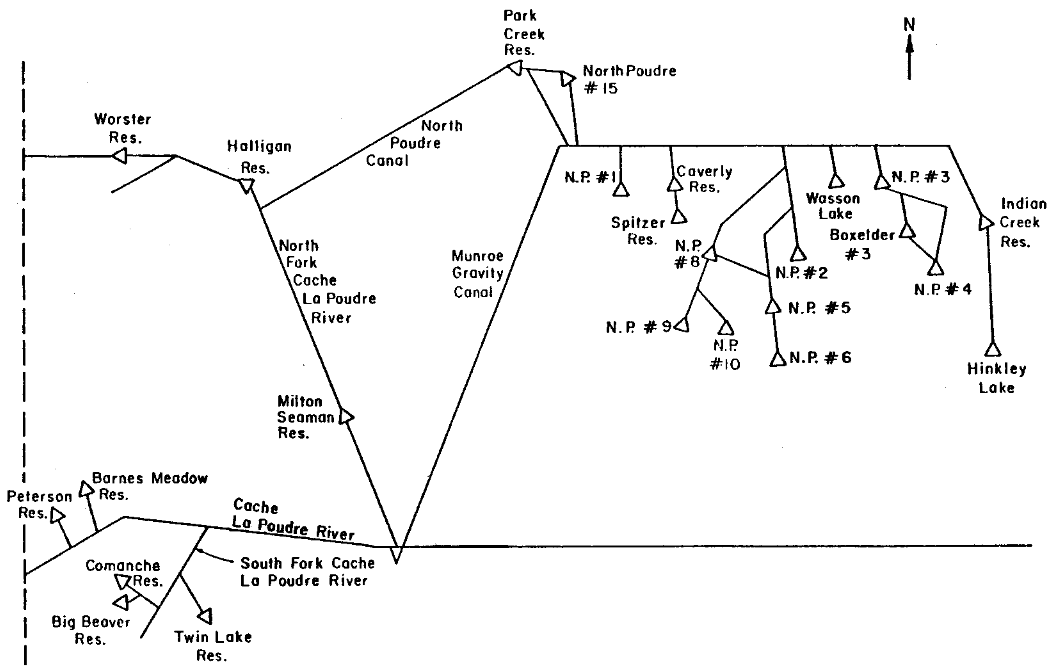


Figure 2. Schematic of the Greeley-North Poudre System.

prime recreational seasons that it is virtually impossible to maintain fisheries or use the reservoirs for recreational purposes. Recreation pressure on mountain areas during the summer could be partially relieved if it could be shown that, under alternative management, water could be held longer in certain reservoirs while owners of reservoir water would continue to receive their legal water rights without damage.

On the other hand, reservoirs on the plains are under somewhat less pressure for recreation. Perhaps some of these could be drawn down before the high-country reservoirs so that water remained stored longer in some of the high-mountain reservoirs. Of course, during periods of severe drought the mountain reservoirs would necessarily be exhausted as the situation dictates.

Would it be possible from a hydrologic and a legal standpoint to maintain high water levels in . . . the reservoirs through . . . the recreation season?

To test the model on a real system where historical data are available, a set of six high-mountain reservoirs under single ownership was selected. Five of these reservoirs, in conjunction with a system of plains reservoirs, constitute the water supply system for a major irrigation company. Of the five high-mountain reservoirs, two were judged by recreation specialists as possessing outstanding recreation potential. The question raised for study was this:

DATA REQUIREMENTS FOR MODEL
1. Physical characteristics of the basin
2. Operational criteria for the reservoirs
3. Virgin water supply
4. Imported water
5. Delivery demands
6. Reservoir evaporation
7. River water losses by sections

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Any alteration from traditional operating policy must occur in such a manner that historical water demands are satisfied with no injury to any water-right holders. It also is desirable to know the impact of any change upon instream flow conditions. Using a three-year test period of past record including both a wet year and a dry year, it was found that three of the mountain storage reservoirs could be maintained at relatively high levels throughout the three-year period.

The model . . . proves that improved recreational conditions on some high-mountain reservoirs could be achieved without injury to water-right owners.

The other two reservoirs were drawn down to a greater degree and were essentially empty by the end of the test period. These two reservoirs in conjunction with several plains reservoirs that were drawn upon more heavily than had been done historically met the total demand. Figures 3, 4, 5, 6 and 7 show both the historic water-levels in the five high-mountain reservoirs (solid lines) together with the water levels resulting from modified operation of the reservoirs in conjunction with plains reservoirs (dotted lines).

The model simulation indicates that improved recreational conditions on some high-mountain reservoirs could be achieved in most years without injury to water-rights owners. However, there are legal issues that must be dealt with before such a plan of operation could be implemented. In particular, storing water out of legal priority for certain reservoirs would need to be allowed.

The foregoing changes in reservoir operation caused relatively small changes in monthly volumes of flow in the stream system. A decrease in monthly flow of more than 1 percent was experienced in only two out of 12 months (August, 9 percent; September, 13 percent). Even with these decreases, the stream flow remained higher during those two months than it

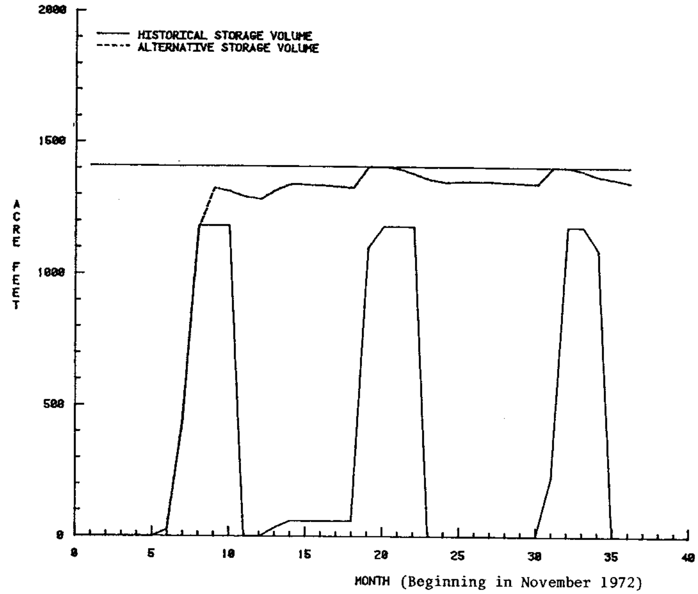

Figure 5. Peterson Reservoir.

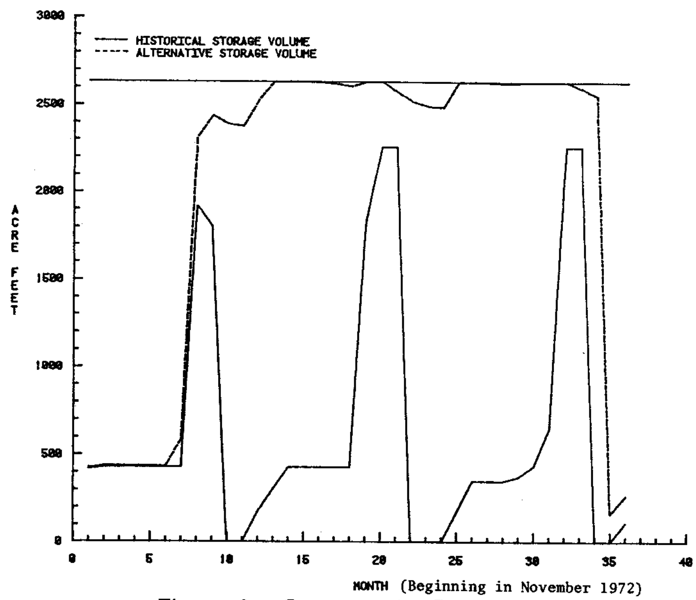

Figure 6. Commanche Reservoir.

probably would suffer somewhat. However, a reservoir does not necessarily need to be totally full to be attractive for recreation and to maintain a fishery. The model would allow many "trade-off" runs between instream and reservoir uses to be made.

Rawhide Power Plant Supply

The PRPA has negotiated with Fort Collins to divert to the 13,000 acre-foot Rawhide Power Plant cooling pond an amount equivalent to a portion of the city's

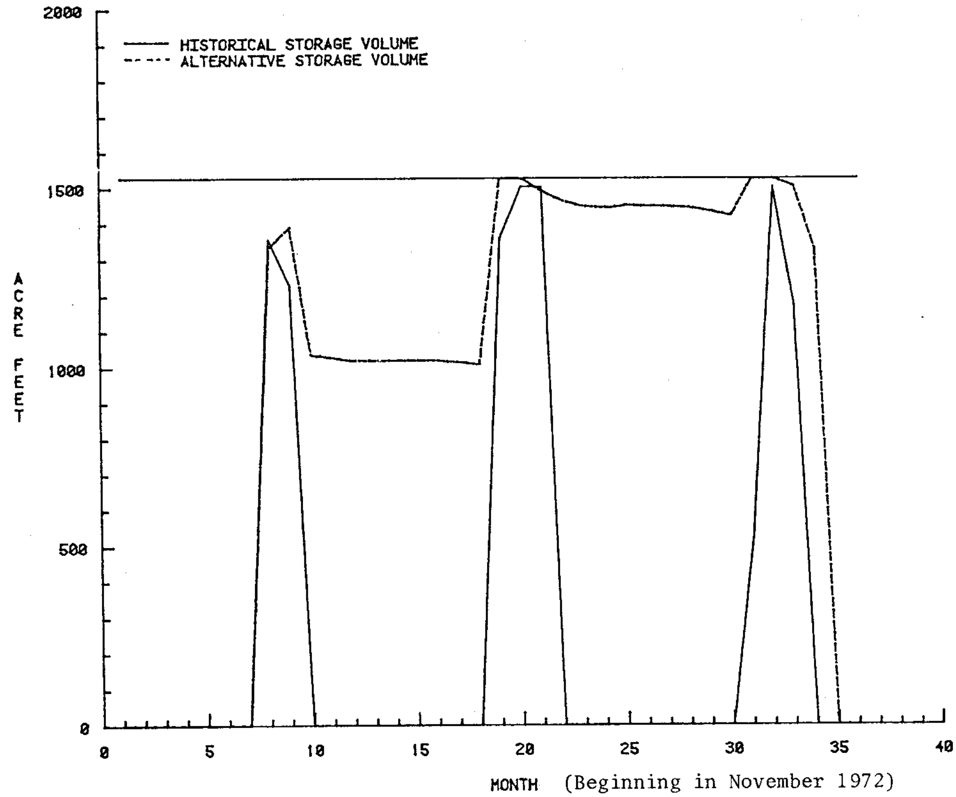

Figure 7. Big Beaver Reservoir.

treated sewage effluent. This scheme depends upon previously unappropriated waters imported from outside the basin being used by the city and then being made available for reuse downstream of the city sewage treatment plant for diversion to the power plant. Exchanges of water between the city and reservoir company are key to the plan.

. . . water exchange agreements must be made among various direct-flow and storage-right owners to maintain uniformity in water delivery to the cooling pond.

The question examined by the model included: Can treated sewage effluent be managed to supply by 1985 the initial filling of the cooling pond, and can this treated water supply a minimum of 4,200 acre-feet to the pond annually? For this case study potential water supply includes direct-flow river water, Colorado-Big Thompson project water, reservoir storage water within the basin and all transbasin diversions into the basin. Borrowing or water exchange arrangements must be made among various direct-flow and storage-right owners to maintain uniformity in water delivery to the cooling pond. After the pond is filled, a stable pool elevation within reasonable limits must be maintained.

Figure 8 shows the main components of the basin system which are involved in the exchanges and routing necessary to accomplish delivery of required amounts of water from the treated sewer effluent to the cooling pond.

Simulation results show that, assuming repetition of approximately the same weather sequences experienced in the past 25 years, the pond can be filled by 1985 without injury to other water-right owners as shown in Figure 9. Further, the model gives integrated reservoir operating rules to keep the pond full thereafter. An integrated approach to reservoir operations is important to the success of this scheme.

An advantage of computer simulation is that one can test various hydrological sequences that possibly could occur in the future, including extensive drought sequences, and could predict how the supply to the pond would be affected.

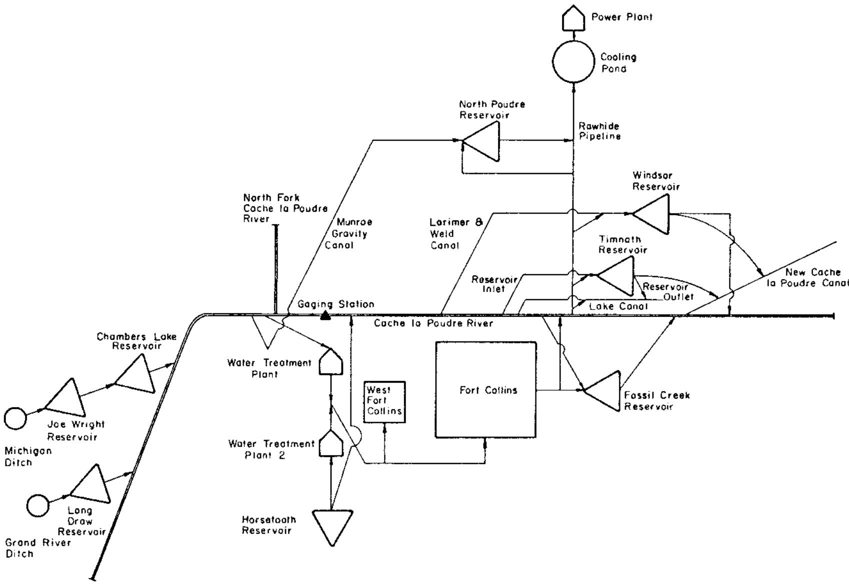

Figure 8. Components of the Rawhide Case Study.

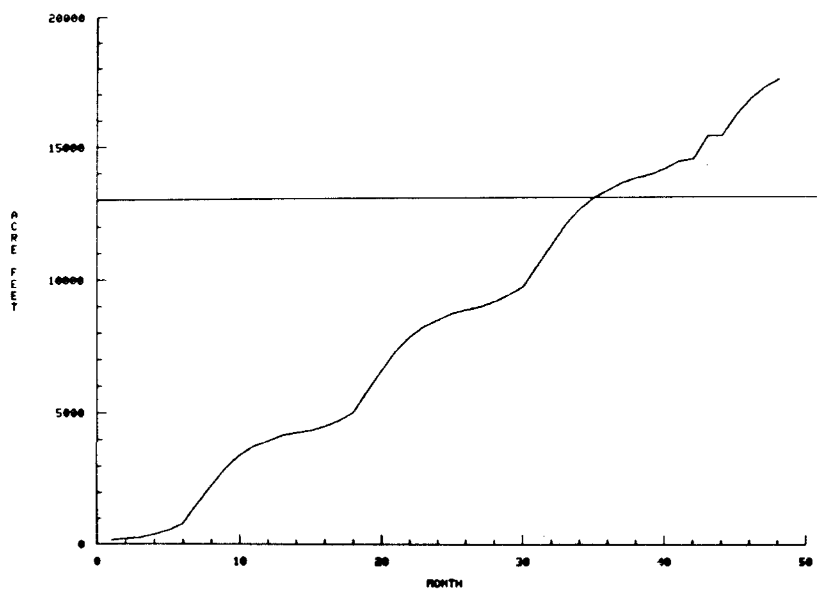

Figure 9. Accumulated Reusable Effluent Deliverable to Rawhide Cooling Pond.

These Information Series reports are designed to provide information on how the natural water system works and how it can be reconciled to the complex demands placed on water today. It was prepared by the Colorado Water Resources Research Institute to assist legislators, other policy makers and water resources planners and managers in better understanding specific water problems and issues.

The most predictable feature of water policy at the present time is change. Changes are occurring in the demands on water supplies, in the values people place on water resources and also in the institutional and legal foundations of public water administration.

This era of change emphasizes water resources administration and management. The focus is upon *improving management* of existing water supplies because new supplies are scarce. The Institute's purpose is to provide new technologies and new tools for water managers and planners to use in meeting the growing water demands.

Norman A. Evans, Director
Colorado Water Resources Research Institute