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WATER RESOURCE PROBLEMS OF ENERGY PROJECTS IN THE COLORADO RIVER BASIN

Norman H. Brooks
Robert C.Y. Koh
E. John List
James P. Quirk

Principal Investigators

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Water Resource Problems of Energy Projects in the Colorado River Basin

INVESTIGATORS: J.P. Quirk, Professor of Economics
N.H. Brooks, Director, Environmental Quality Laboratory; James Irvine Professor of Environmental and Civil Engineering
R.C.Y. Koh, Research Associate in Environmental Engineering
M.S. Isaacson, Research Engineer, Environmental Quality Laboratory
E.J. List, Professor of Environmental Engineering Science
H.S. Burness, Visiting Associate in Economics*
E. Hoffman, Graduate Student, Economics*
N.H. Al-Adhadh, Graduate Student, Economics*

The successful development of western coal and oil shale deposits is dependent, to a significant degree, on the availability of adequate water supplies. EQL is involved in a study of the aggregate effects of various energy activities in the upper Colorado River Basin on downstream water quantity and quality. These activities will tend to reduce the available water in the river, and could increase its salinity, which is already so high as to interfere with downstream domestic and agricultural use.

The study in progress has four essential components. The first of these is an understanding of the river system and probabilistic nature of the natural water flows. Research concerning the first phase is found in Publication 4a and an earlier EQL report, Publication 4b. Publication 4a by Burness and Quirk is a background document describing the institutions, water law, legislation, litigation, rights allocation and historical pattern of water use along the Colorado River. Publication 4b by Jensen gives a computer simulation for predicting both water quantities and quality for the Colorado River System with stochastic

*Former investigator who has left Caltech.

inputs from the tributaries. With uncertainty about future river flows, the model allows probabilistic investigations of various alternative policies for water withdrawals and returns with various operating rules for release of water from the major reservoirs.

The second component (which was the main effort in FY77 and FY78 and is now essentially complete) is the study of the legal, economic and institutional aspects of water use and the definition of alternative water allocations. Due to the level of utilization of the Colorado River, the additional water necessary for energy activities is most likely obtainable in two ways, assuming no importation from other basins: (a) alteration in the current allocations of water, and (b) reductions in evaporation losses, such as through reduction in reservoir storage levels. With respect to possibility (a), it is shown in Publication 4c that the doctrine of appropriative water rights, adopted by all of the Colorado River Basin states, leads to economic inefficiencies due to current restrictions on transfer and sale of water rights. The introduction of competitive markets in water rights would eliminate many inefficiencies and provide the possibility of water for energy activities. Moreover, the appropriate pricing of water would limit certain overuses and provide a source of water for higher valued use in energy activities, Publications 4d and 4e. There are, however, natural barriers, in the form of return flow externalities, to the transfer of water rights. This problem is analyzed and solutions to it are suggested in Publication 4f.

The other possibility of obtaining water for energy activities through reductions in reservoir storage levels and the associated evaporation savings, while technically feasible in the short-run (as shown by Jensen) has been found infeasible as a long-term solution, Publication 4g. This is because, when the river is fully appropriated, the current implicit Bureau of Reclamation (Burec) policy of releasing the expected value of streamflows and limiting aggregate water uses to the same, results in a greatly reduced expected value of storage.

On the other hand, this does not rule out the possibility of an interim solution based on reduced reservoir storage, which could make available as much as 1.0 to 1.5 MAF yearly over a thirty year period until the steady state is attained.

The question of optimal storage is also examined on economic grounds in Publications 4h, 4i, 4j, 4k and 4l. While stored water could be used currently, it also functions to ensure against future shortages. The publications discuss the derivation of optimal release policies as a first step in attacking the problem of arriving at the determination of an optimal "insurance premium" to pay to avoid shortages.

The third component is the estimation of water use and residues resulting from different kinds of energy activities. This component was scheduled for FY 79, but due to the late arrival of FY 79 funds, no work could be done during the past year.

Estimation of water usage and residues from various energy activities is now scheduled for FY 80. It will be accomplished primarily through the results of a literature study. This is the third project component listed above.

Synthesis of the first three project components to predict the aggregate effects on the Colorado River system of various energy development scenarios is the final project component. In it the water demands and residues of various energy developments will be incorporated into the computer simulation model. During this phase of the study, active participation on the part of DOE will be sought in terms of possible energy development scenarios in the Colorado River Basin.

In order to facilitate running the computer simulation model for many possible energy resource development scenarios, the model, which is currently structured for use on an IBM 370 computer will be restructured for use on the Environmental Quality Laboratory's dedicated PDP 11 computer facility.

In addition to water quantities, salinity transport in the Colorado River system will also be studied. The operation of the U.S. Bureau of Reclamation's Colorado River Simulation System (CRSS) Model will be analyzed with emphasis on the salinity modeling. The Caltech model will then be modified in order to correctly determine river salinity.

As a final step, the model giving information on both quantity and quality of river flow could be used in conjunction with the results of the economic analysis to determine possible outcomes of energy development scenarios and how different market arrangements for water rights might influence the outcomes.

An additional activity related to this project element carried out at Caltech in FY 79 was the sponsoring of a conference on western water issues. The conference was held on May 17 and 18, 1979 at Caltech and was attended by over 200 people, primarily from California and the southwest. It was supported in part by a special grant from the Office of Environment of the Department of Energy. Although funding for the conference was outside of the institutional grant framework, many of the presentations dealt with the issue of water supply for energy development which is the focus of this project element. A report on the conference was published and is listed below as Publication 4m.

PUBLICATIONS FROM PROJECT ELEMENT NO. 4

4a. H.S. Burness and J.P. Quirk, "Colorado River Project Phase I; Water Rights and Allocations," Open File Report 77-10, Environmental Quality Laboratory, California Institute of Technology, Pasadena, California, December 1977.

4b. A.R. Jensen, "Computer Simulation of Surface Water Hydrology and Salinity with Application to Studies of Colorado River Management," Caltech Ph.D. Thesis, June 1976 (also Report no. 12, Environmental Quality Laboratory, California Institute of Technology, Pasadena, California, June 1976.

4c. H.S. Burness and J.P. Quirk, "Appropriative Water Rights and The Efficient Allocation of Resources," appeared in American Economic Review, March 1979. Also presented at Econometric Society meetings, June 1977, Ottawa, Canada. (Also Social Science Working Paper, no. 157, Revised, Division of Humanities and Social Sciences, California Institute of Technology, Pasadena, California, March 1978.)

4d. H.S. Burness and J.P. Quirk, "Economic Aspects of Appropriative Water Rights," to appear in the Proceedings from the Conference on Natural Resource Pricing and Use Rates, August 1977, Trail Lake, Wyoming.

4e. E. Hoffman, "Survey of Southern California Water Companies Residential, Single Family Water Rates, Average Production Costs, Excluding Capital and Depreciation Rate Policy Questionnaire," Open File Report no. 77-6, Environmental Quality Laboratory, California Institute of Technology, Pasadena, California, September 1977.

4f. H.S. Burness and J.P. Quirk, "Water Law, Water Transfer and Economic Efficiency: The Colorado River," submitted to Journal of Law and Economics. (Also Social Science Working Paper no. 228, Division of Humanities and Social Sciences, California Institute of Technology, Pasadena, California, August 1978.)

4g. H.S. Burness and J.P. Quirk, "The Theory of the Dam: An Application to the Colorado River," to appear in a volume in honor of E.T. Weiler, Purdue University Press, 1979, eds. G. Horwich and J. Quirk. (Also appeared as Social Science Working Paper, no. 227, Division of Humanities and Social Sciences, California Institute of Technology, Pasadena, California, August 1978).

4h. H.S. Burness and J.P. Quirk, "Water Rights and Optimal Reservoir Management." Presented at the Econometric Society Meetings, June 1977, Ottawa, Canada. (Also as Social Science Working Paper, no. 165, Division of Humanities and Social Sciences, California Institute of Technology, Pasadena, California, June 1977.)

4i. N.H. Al-Adhadh, "Chance Constrained Model of Water Reservoir: Bounds on the Long-Run Distribution of the Water Stock," Social Science Working Paper, no. 217, June 1978, and "Chance Constrained Dynamic Programming Model of Water Reservoir with Joint Products," Social Science Working Paper, no. 218, California Institute of Technology, Pasadena, California. Based on Chapter 1 of N.H. Al-Adhadh's Ph.D. thesis, "Essays in Economic and Political Choice," Division of Humanities and Social Sciences, California Institute of Technology, Pasadena, California, May 1978.

4j. H.S. Burness and J.P. Quirk, "Optimal Water Storage Policy with Applications to the Colorado River," presented at the American Economic Association meetings, December 1977, New York, New York. Also to be published as "The Colorado River: A Case Study in Optimal Water Storage Policy," in Grants Economics of Water Resources, K. Boulding and J. Horvath, eds., Prager Press, 1980.

4k. E. Hoffman, "Optimal Capacity Choice and Inventory Policy for a Storable Good Subject to Random Supply" (Chapter 5) and "Optimal Resource Allocation Under Appropriative Water Rights" (Chapter 6) appearing in "Essays in Optimal Resource Allocation Under Uncertainty with Capacity Constraints," Ph.D. thesis, Division of Humanities and Social Sciences, California Institute of Technology, Pasadena, California, September 1978.

4l. E. Hoffman, "Deviations from Optimal Pricing of Lower Colorado River Water," presented at 1978 Annual Meeting of the Association for the Study of the Grants Economy; also to appear in revised form in Grants Economics of Water Resources, K. Boulding and J. Horvath, eds., Prager Press, 1980.

4m. M.S. Isaacson and T.C. Fall (eds.), "Report on Conference on Western Water Issues," Memorandum no. 22, Environmental Quality Laboratory, California Institute of Technology, Pasadena, California, September 1979.