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The Outlook for Water

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BOOK REVIEWS

THE OUTLOOK FOR WATER

By

NATHANIEL WOLLMAN AND GILBERT W. BONEM

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In 1960, Wollman forecast for the Senate Select Committee on National Water Resources water supplies and uses for 22 water resource regions of the Nation. Briefly, Wollman's procedure was as follows. Major uses, referred to as requirements, were projected by region to the year 2020 based on extensions of contemporary economic trends for each region. Economic supply schedules for water were also developed for each region, based on the costs of development necessary to guarantee different levels of flow. Finally, the least cost combination of waste dilution flow and treatment of wastes required to maintain a specified level of dissolved oxygen was calculated for each region. The least cost solution was compared with maximum treatment-minimum flow and maximum flow-minimum treatment options.

In 1971, Wollman in collaboration with Bonem revised the earlier study to correct an error[1] in the hydrologic input and to account for improvements in the other input data. The flow-storage relationships in the earlier study understated the required storage and costs of storage for relatively high levels of sustained flows. This understatement was especially important for the water-scarce regions of the West. In 1966 Lof and Hardison developed the hydrologic inputs for the present study. Also, the revision includes the results of further studies by Reid and associates of the flow requirements for alternative BOD waste loads and costs of treatment for alternative levels of BOD removal. In addition, the revised analysis includes an evaluation of the water recirculation rates required in steam-electric power generation to keep the water temperature in each region from increasing more than 5.4°F. Further revisions include the following:

1. The following minor errors were found by the Forecast Division of the National Water Commission in its use of the Wollman-Bonem model: (1) The Wollman-Bonem model assumed primary treatment of wastes discharged to estuaries, but in the model a treatment level between primary and secondary was used; (2) the factor allowing for increased efficiency over time was not included in calculating the manufacturing losses for textiles, leather, rubber and plastics, stone, clay and glass, lumber and wood, and other industries; and (3) the Y(m) factor in the BOD dilution flow equation did not vary with time—second equation 8, page 211; and Table D-21, page 219; page 178; and Table B-13, page 180 in the Wollman-Bonem study.

(1) substantial decreases in the projected requirements for swamp and wetland uses, (2) increases in municipal losses by charging as loss all intakes by municipalities which discharge into coastal or estuarine locations, (3) further delineations between manufacturing intakes of brackish and fresh water, and (4) decreases in storage investments by taking credit for storage already in place.

In the Wollman-Bonem study, solutions were computed for three different levels of economic-demographic growth in each region. High, medium and low levels of growth were assumed. The high alternative reflects a set of conditions which would be expected to give relatively high levels of water use—high rates of growth in factors such as population, economic productivity and electrical power demands. Similarly, the low alternative reflects a set of conditions which would be expected to give relatively low levels of water use—low rates of growth in population, etc. The medium alternative basically reflects an extension of contemporary trends.

In spite of the revisions, Wollman and Bonem found the following implications of the projections to be the same as in the original study: (1) the Southwest will be a hard-core water shortage area; (2) costs of treatment will dominate future outlays for water if streams are to be kept aerobic; (3) a relatively large amount of flow will be required to dilute wastes even if treatment is increased two-fold; (4) because of required dilution flows for waste dissemination, water shortages will spread eastward; and (5) unless large-scale interbasin transfers of water are undertaken in the West, future water expenditures will be largely for waste treatment and flow regulation in the East.

To indicate the types of specific conclusions that may be derived from the Wollman-Bonem model, the following sample is provided:

(1) In industries making heavy use of water for cooling, as in thermal electric power production, water withdrawals may be decreased by as much as 80 percent by the imposition of effluent standards restricting increases in the stream temperature to less than 5.4°F;

(2) BOD wasteloads discharged by industries and municipalities will increase four to seven-fold in the next 50 years;

(3) industrial waste loads which presently represent 70 percent of the total for industries and municipalities will increase to 85 percent of the total by 2020;

(4) the food, paper and chemical industries discharge around 60 percent of the BOD wastes of all industries and municipalities;

(5) BOD waste discharges of the chemical industry will increase 12-fold in the next 50 years if present trends continue;

(6) industries and municipalities presently discharge to the estuaries and oceans 40 percent of their BOD wastes; they are not given more than primary treatment;

(7) secondary treatment of wastewaters before discharge to the estuaries and oceans would increase treatment costs by about 25 percent;

(8) if water quality standards would be increased from 4 to 6 milligrams of dissolved oxygen per liter of fresh water, treatment costs would increase by 50 percent;

(9) the water problems of the Southwest will continue to be primarily agricultural in origin;

(10) in the 17 western states except California, the predominant agricultural use of water will be for the production of irrigated forage and grain crops to feed livestock; they will represent over 50 percent of all irrigated agricultural uses and be at least three times the municipal and industrial consumptive uses of water in the water scarce regions of the Lower Colorado, Rio Grande, Great Basin and Arkansas-White-Red;

(11) in the Northeast, particularly the Delaware-Hudson, Ohio, and Great Lakes Regions, there will be significant water quality degradation due to heat and BOD waste discharges unless present trends and policies are changed significantly.

This provides a sample of the conclusions that may be drawn from the projections of the Wollman-Bonem model. They clearly indicate the importance to the Nation of modifying policies influencing water use (consumptive) in irrigated agriculture in the Southwest and policies influencing industrial heat and BOD discharges in the Northeast. The agricultural problems are an excellent example of the importance of indirect policy effects, they are heavily influenced by farm price support programs.

Several strengths of the Wollman-Bonem model are noteworthy. First, the model provides a systematic integration of the hydrologic, engineering, and economic factors which underlie the development of regional economic supply schedules for water. The integration gives the supply costs for each level of annual flow. It further shows the rapidity at which the incremental costs of supply increase as the point of maximum regulation is approached. Thus, there is a limit, short of desalting, to which future water shortages can be resolved by investing in water resource development; it is going to become increasingly important to look at the demand side and consider possibilities for reallocating the limited supply. Second, the Wollman model projects BOD waste loads, treatment costs, and quantities of water used, and shows the rapidly increasing costs of treating the wastes of increased production, which are also affected by the law of diminishing returns. Thus, significant improvements in waste treatment (and production) methods will be necessary to offset the rapidly increasing costs of treating the wastes of the Nation's increased production. Third, using the supply functions and treatment cost functions, the costs to maintain a given water quality by maximum treatment and minimum use of dilution flow, minimum treatment and maximum use of dilution flow, and the least cost combination of treatment and dilution flow may be analyzed for each level of water quality and level of economic-demographic growth. Fourth, since a computer program was developed, the sensitivity of the different assumptions in the model may be easily studied. This possibility is important today in view of the rapidly changing attitudes toward economic growth and environmental protection.

In addition, the model lends itself to a number of extensions. National and interregional input-output models may be used to provide an improved economic-demographic input. It is further possible to extend the model to project the BOD wasteloads of concentrated forms of livestock production and the costs of treating these wastes.

In comparison, the Water Resources Council in its First National Assessment estimated available flows without reference to the costs of developing them; they give little emphasis to water quality; and they did not provide an analytical system for sensitivity analysis. The Council, in effect, virtually ignored the contributions made by Wollman in 1960 and by Lof and Hardisen in 1966. They missed a great opportunity to extend the Wollman analysis and to begin to measure the economic demands for water in 1968. Fortunately, we now have an expanded and more refined analysis of the water resource problem by Wollman and Bonem. It needs to be extended to include estimates and analyses of the economic demand schedules for water in the important uses.

The primary weakness[2] of the studies directed by Wollman and, for the sake of the record, all of the national studies was the projection of all important water uses—withdrawal, consumptive, disposal and recreational—as "requirements." Basically, water use coefficients were estimated for each use and multiplied by an extension of a contemporary economic (or demographic) trend to give projected requirements. Thus, the economic demand for water—quantity used as a function of price—was not taken into account. Instead, the quantity of water used was implicitly assumed to be totally independent of price and to have an unlimited, or infinite, value in all uses. This ignores the principle of substitution. The results of many

2. Wollman and Bonem were not unaware of this weakness. The following discussion is for purposes of emphasis as well as direction. It seems to be badly needed.

studies show that differences exist in the incremental (or marginal) values of water in different uses across the Nation. With increasing scarcity, as forecast in all of the studies cited above, the *effective price* of water will increase; and the quantity of water of a given quality used will decrease. This will result in reallocations of the limited supply among the highest marginal valued uses to the point where the effective price is just covered by the lowest marginal valued use. Clearly, a sound basis for policy formulation and plans must include measures of the economic demands for water as well as the economic supplies of water.

Measurement of the demands for water will require analytical descriptions of the production functions including water and waste treatment processes for the following important water uses—chemicals, pulp and paper, primary metals, petroleum refining, electric power generation, agriculture, and food and fiber processing. Particular emphasis must be given in the development to the quantities of water withdrawn and consumed, the costs of water treatment, the quantities of different residuals generated, and the costs of treating the residuals or disposing of them in alternative ways.

The production functions developed by Heady and associates (at Iowa State University) for land resource analysis and extended by Heady (under contract with the National Water Commission)[3] for land and water resource analysis need to be further extended to account for the waterborne residuals generated by agricultural production. This extension needs to include the development of waste treatment functions and practices to abate agricultural pollution.

Using the production and water treatment processes, the incremental values of water in consumptive use may be derived for each given level of water quality. These schedules of incremental values will provide the consumptive demand functions—the quantity of a given quality of water used as a function of price. Similarly, using the production and waste treatment processes, the incremental values of water in disposal uses may be derived.[4] They give the disposal demand functions for water and show the quantity of a given type of waste that would be discharged by an industry (or all industries) in a region at each proposed level of an effluent tax.

Estimates of the demand and supply functions for water would provide a basis for developing equilibrium price-quantity-quality re-

3. The National Water Commission Contract No. NWC 70-013 with the Center for Agricultural and Economic Development, Iowa State University, Ames, Jan. 25, 1972. The forthcoming report will include partial measures of the economic demand functions for water in irrigated agriculture.

4. It is interesting to note that demand functions for waste disposal may be derived from the waste treatment functions in the studies directed by Wollman. Hence, equilibrium levels of effluent charges for a given region may be deduced.

lationships for water use. This basis would allow analysts the opportunity to study the economic inefficiencies of present allocation systems and the implications of changing policies to alleviate these inefficiencies. The original work of Wollman and the more recent work of Wollmand and Bonem provide measures of the costs of development and treatment. This work needs to be supplemented with estimates of the values of water in consumptive, disposal, and recreational uses.

Another major weakness of the earlier studies was the implicit assumption that policy developments in the future would follow the trends imbedded in the historical data. This approach will probably continue to be necessary for a long time to come with regard to many indirect policies which have only secondary effects. However, for policies having strong direct and indirect effects, every effort needs to be made to get away from the use of trends as soon as possible. The reasons are as follows. We are presently witnessing rapidly changing attitudes toward economic growth and environmental protection. New legislation reflecting these attitudes will probably change significantly the previous economic-demographic trends. Policy makers need informational aids that show the effects of different alternatives. For example, they need to know the effects on water use of varying different policy-related variables. How much will water use decrease with a 10 percent increase in the price? How much will water quality improve with the imposition of certain effluent taxes? How much will irrigated water use in agriculture in specific regions be affected by the removal of farm price supports? It is answers to questions like these that policy makers need. Trend extrapolations will not provide this information.

In summary, both values of water in use and costs of resource development are needed to provide a sound basis for formulating policies and plans. Wollman and Bonem have measured and analyzed an important subclass of these fundamental relationships. The implications of the analysis will serve as important aids in the present reevaluation of priorities. This analysis needs to be extended as soon as possible to include measures of the economic demands for water. Lack of this knowledge is at the core of the raging controversy between the environmentalists and the capitalists. Its development should be given the highest possible priority in water resources research.

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