The economics of alternative uses of water in the Yellowstone Basin

by John Riley Snyder

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in APPLIED ECONOMICS
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Abstract:
This study resulted from an anticipated increase in water consumption in the Montana portion of the Yellowstone Basin. This anticipated increase was due to coal development in the Fort Union formation and was expected to decrease the income of irrigated agriculture. Standard linear programming techniques were used to maximize the returns to irrigation under six levels of coal development, ten different years of natural flow, and five levels of minimum flow constraints (to simulate necessary levels to maintain the ecosystem). The results included the expected marginal value of water to irrigated agriculture and the expected income reduction of irrigated agriculture resulting from diverting water to coal development or using it to satisfy minimum flow levels.

The empirical results suggest the potential conflict for Yellowstone Basin water is more serious between requested Fish and Game Department minimum stream flows and irrigated agriculture than between coal development and irrigated agriculture. Water diverted to coal development would have been worth approximately $1.30 per acre-foot to irrigated agriculture at the margin. In contrast, the water needed to satisfy 50 percent of the minimum flow levels requested by the Montana Fish and Game Department would have had a marginal value of up to $75.00 per acre-foot to irrigated agriculture. In fact, the minimum flow requirements at 50 percent of the Fish and Game Department's request could not be met during some of the flow years.

This study indicated a need for research to determine the value of water in the stream, both for the ecosystem and recreation.

Finally, the estimated value of water in agriculture under present conditions was too low to validate the justification of a dam on the upper Yellowstone on the basis of its value to either irrigation or coal development.

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A thesis submitted in partial fulfillment
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ABSTRACT

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Chapter 1

INTRODUCTION

When a society has a plentiful supply of water, it treats it as a free good, that is, it is used to the point where the value added by the last unit used approaches zero. As this water becomes more scarce (decreasing in quantity and/or quality), conflicts between users arise, and pressure to change the rules allocating the water increase. Recently, conflicts between potential users, environmental groups, and representatives of the state have increased awareness of the problems of allocating Montana's water resources. While the conflicts will be resolved, the solution requires that the people in the decision making process be supplied with information enabling them to allocate water supplies to increase the benefits to society. This study should provide a part of that information.

BACKGROUND

The Yellowstone River rises in Yellowstone National Park, in the northwest corner of Wyoming. From there the river flows north into Montana. Fifty miles north, the river turns east-northeast and flows this general direction until it enters the Missouri River a few miles inside North Dakota. Major tributaries to the Yellowstone River include the Clark's Fork, Big Horn, Tongue, and Powder Rivers.

> "Streams in the basin contribute the major part of their annual runoff in the spring and early summer months. It

> is not unusual for perennial streams in the mountains to contribute over 90 percent of their annual flows in the months of May, June and July . . . Streams which originate in the plains and foothills are commonly intermittent and flow only in direct response to precipitation."[1]

Runoff is usually greatest in May and June, but crop needs are greatest in July and August. Several reservoirs store water for these high water consumptive periods, but the irrigated acres in Montana's Yellowstone Basin use over a million acre-feet of water per month in July and August. Usable storage capacity in all these reservoirs is less than a million acre-feet. Other major water uses in this basin include municipal supply, electric power generation, recreation, ecological systems, and thermal electric power generation.

Ecology of the Yellowstone Basin

The Yellowstone Basin lies in both the Rocky Mountains and the Great Plains. The differences (varying water supply, temperature fluctuations, soil conditions) between these two areas and the inter-lying transition areas naturally define various habitat: such as alpine peaks, forested mountains, sagebrush-grassland plains, badlands and desert. Man's use of water from the Basin directly affect the

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[1]Stevens, Thompson, and Runyon, Inc., Yellowstone Regional Assessment Study, Preliminary Draft, (The National Water Quality Commission, 1975, p. VII.)

ecosystems within the Basin. These effects depend on the severity of water quantity and quality changes combined with the adaptibility of the food chain organisms.

Three major life zone areas in the Yellowstone Basin in Montana show the following characteristics:

1. Rocky Mountain - steep mountains, forests, heavy snowpack and long snowmelt, and swift flowing, gravelbedded, cold water streams.
2. Northern Great Plains - flat grassland, light snowpack and sudden snowmelt, and large, turbid, warm water rivers and reservoirs.
3. Transition area - characteristics of both with interaction between the biotic communities of both.

The Rocky Mountain life zone contains the more sensitive cold water aquatic organisms. Stream flow depletion, resulting in higher stream temperatures, and organic pollution (sediment-laden discharges) may lead to habitat deterioration.

> "The major environmental problem in the study area may be defined as loss of habitat. In cold water areas, this loss is primarily a function of increased siltation. In warm areas, this loss is primarily a function of stream flow regulation."[2]

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[2]Ibid. p. IX.

The Montana Department of Fish and Game in an apparent attempt to preserve the present ecological balance in the Yellowstone River -- prevent a further habitat transition and the accompaning change to silt-dependent and silt-tolerant aquatic species -- applied for a reservation of flows in the Yellowstone River. This application requests setting aside about 1.5 million acre-feet of water.

Coal Development in the Yellowstone Basin

In Montana the coal mining industry is presently undergoing change. Influenced by the oil embargo of 1973 and 1974, and other national-international events, coal mining, in the low-sulfur Fort Union formations in Eastern Montana, has flourished. Presently, large quantities of coal are being transported out of the region to power plants in the mid-west and south. Two 350 megawatt coal-fired generating plants are presently coming on line and more are planned. In addition, coal gasification or liquification plants may become economically feasible by the year 2000.[3]

While providing an additional source of energy, coal production also produces potential water problems. It may damage or alter underground storage and aquifers, increase erosion and sediment in runoff

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[3]Stroup, Richard, and Walter Thurman, "Will Coal Gasification Come to the Northern Great Plains?" Montana Business Quarterly, XIV (Missoula, Montana: University of Montana, 1976), p. 33-39.

into rivers, and create competition between mining and agriculture for available water supplies.

Strip mining operations use 6 to 15 gallons of water per ton of coal mined[4] -- primarily for controling dust and washing coal. Besides its use in the mining process, (34 billion strippable tons in the Yellowstone Basin)[5] estimates place water consumption by gasification at 70 to 160 gallons of water per million cubic feet of gas[6] and by thermal electric power generation at up to 19,200 acre-feet per year for each 1000 megawatt plant.[7]

Irrigation in the Yellowstone Basin

Currently, irrigated agriculture consumes most of the water in the Basin: 99.9 percent of the Basin's 525,000 irrigated acres use water from surface supplies at a rate of around 3-1/4 acre-feet per acre per year -- about two million acre feet of water per year. In

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[4]Project Independence Report, (Federal Energy Administration, 1974), p. 304.

[5]Montana-Wyoming Aquaducts, (U. S. Bureau of Reclamation, 1972), p. 13.

[6]U. S. Department of the Interior, Bureau of Reclamation, "Report of Resources of Eastern Montana Basins" (Billings, Montana: 1973) p. 43. Derived

[7]Townsend, Stuart, and James Van Lanen, An Economic Analysis of Alternative Technologies for Cooling Termal-Electric Generating Plants in the Fort Union Coal Formation, (Bozeman, Montana: Montana State University, 1974), p. 15.

addition to current irrigation, another 150,000 acres in the Basin is potentially irrigatable.[8]

HISTORY

Since the first settlers came to Montana over a hundred years ago, Montanan's have failed to set up a system of stable and enforcable water rights. While definite, defensible, stable property rights in land developed quickly, Montana's water laws have undergone many changes. What influenced Montana's water law changes? Why aren't property rights specified more clearly for water? In answering these questions we must look at Montana's development.

Many of Montana's first ranchers and lawyers came from the East. They saw that Montana needed some sort of water law. They knew a type of stream property rights known as the Doctrine of Riparian Rights. So, in 1865, when they adapted the laws of the East to Montana, they included the riparian doctrine.

The Doctrine of Riparian Rights, developed in England and the eastern U.S. during the first half of the nineteenth century, contains three basic characteristics: First, restricting the use of water to riparian owners -- people who own land on the bank of the

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[8]Northern Great Plains Resource Program, Draft Report, 1974, p. II-2 to II-4.

river (Ripa, a Latin word, means bank of the stream). Secondly, each owner shares equal rights to the water. And, finally, the stream must remain in its natural flow -- undiminished in quantity or quality.

In their study, The Evolution of Property Rights: A Study of the American West, P. J. Hill and Terry Anderson state, "Establishing and protecting property rights is very much a productive activity toward which resources should be devoted. But, like any other activity, the amount of this investment will depend upon the marginal benefits and costs of allocating resources to these endeavors."[9]

Before 1865 farmers and ranchers in Montana, in spite of Montana's arid climate, found water supplies adequate relative to demand. They devoted few resources to the development of property rights for water.

At about the same time, gold was discovered, and miners swarmed to Virginia City, Helena, and Diamond City. Miners found water important here, for they used it to increase the returns from gold mining. Following Hill's and Anderson's theory, miners would invest more resources in defining water rights since they had more to gain. As squatters on public domain, the miners applied to their land and

[9]Anderson, Terry and P. J. Hill, "The Evolution of Property Rights: A Study of the American West," Journal of Law and Economics, XVIII, 1.

streams the rule of the U.S. land laws that priority of appropriations gives priority of right. This gave miners the right to appropriate water for their own use regardless of whether their claim bordered a stream or not. Just as these laws restricted claim size to what he could work in a reasonable time, they restricted the amount of water a man could appropriate to what he could use beneficially. Although some of the placer miners felt that the streams should be equally divided, these rules gradually became law through the miner's courts.

In 1865, the Bannack Assembly adopted both "the common law of England", and some statutes from Colorado including the doctrine of prior appropriation. A conflict arose. The conflict went to court in 1921 and the Montana Supreme Court declared, "Our conclusion is that the common doctrine of reparian rights has never prevailed in Montana since the enactment of the Bannack Statutes in 1865, and that it is unsuited to the conditions here."

From this time on Montana accepted the Doctrine of Prior Appropriation as its basis for water allocation. This doctrine gives legal right to use water according to the following rules:

1. Water may be diverted from the stream for use in riparian and nonriparian lands regardless of the diminuation of its flow.
2. The first appropriator has first right to the amount of his appropriation.

3. The use must be beneficial.

4. When use ceases the right ceases.

5. The water right is a property right and its owner cannot be deprived of it without due process of law.

In 1939 the Montana Water Resources Survey began. Essentially a historical research program brings the water rights registry up to date. A majority of our counties now have published records from this research. Applying the theory of property right evolution we would expect something of this sort as our population increased.

Since we face coal development in Eastern Montana and possibilities for increased demands on water supply, it would seem the activity in property rights related to water would increase. Beginning July 1, 1973, a new water law became effective. It specified that all water claims will be brought up to date, recorded and regulated. In addition to updating our water rights system in the courts, the state has funded research to anticipate future demands on water supplies and waters' value to alternative users.

JUSTIFICATION

Obviously the increase in activities concerning the availability and use of water in Eastern Montana indicates that water is becoming more and more a scarce resource. At the time this project began, studies estimated the future demand for water for industrial purposes at 2.6 million acre-feet[10] annually from the Yellowstone Basin. Without building additional storage facilities, water supplies may become inadequate to meet the demands of both those and present water users in dry years. Allocation of the water in the Yellowstone Basin to maximize benefits to society, depends on knowing the value of water in each of the competing users. Stuart Townsend, James Van Lanen[11] and Richard Stroup[12] determined the value of water in wet and dry cooling in the coal industry, but similar studies are necessary for the other coal-related projects, agriculture, and recreation. In addition, one alternative method of obtaining water rights by industry may be purchase from the irrigated agriculture sector.[13] The North Central Power Study[14] mentions purchase of irrigation land and the accompaning water rights as a potential source of water for

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[10] Montana-Wyoming Aqueducts, Op.Cit., p. 31.

[11] Townsend, Stuart and James Van Lanen, An Economic Analysis of Alternative Technologies for Cooling Thermal-Electric Generating Plants in the Fort Union Coal Region, (Research Report #49: Montana Agricultural Experiment Station, 1974), p. 17.

[12] Stroup, Richard and Stuart Townsend, An Economic Analysis of Alternative Cooling Technologies, (Bozeman, Montana: Montana State University).

[13] As of 6/1/76, water rights can be sold from one user to another if approved by the Board of Natural Resources and Conservation.

[14] North Central Power Study; I (Department of the Interior, 1971), p. IX-9.

a proposed thermal-electric generating plant in Colorado.

The "Utility Siting Act," Section 16, Part 3(g), indicates the need for this study in stating the responsibility of the Montana Department of Natural Resources and Conservation to investigate the effects of other users due to changes in the quantity and quality of water brought about by power plants. We designed this study to fulfill part of this responsibility by building a simulation model for water and its economc uses within the Yellowstone Basin of Montana. Using this model, the change in income from irrigated agriculture was measured by simulating diversions of water into various uses: coal-related projects and minimum flow requirements. Thus, this study measured the economic effects on irrigated agriculture from changes in the quantity of available water brought about by power plants and/or ecological demands and provides a basic model for measuring the effects on other users.

OBJECTIVES OF THE STUDY

This study has two basic objectives: 1) To build a linear programming model which has the capabilities to estimate the value of water in irrigated agriculture, and 2) to estimate the value of water in irrigated agriculture. As the value of water varies, depending on its scarcity, the model can be used to estimate the value of water for several different scenarios. The scenarios should include the range of pojected water diversions to the energy production sector and possible reservations within the stream for ecological and recreational purposes.

PRESENTATION OF THE STUDY

Chapter two reviews related literature, and based on that review, linear programming was picked as the appropriate model to accomplish the objectives of the project. Chapter three develops the model. Data for the linear programming model is presented in Chapter four. Finally, the results are tabulated and conclusions presented in Chapter five.

Chapter 2

REVIEW OF RELATED LITERATURE AND DETERMINATION OF AN APPROPRIATE MODEL

Economists use several methods to measure the economic value of water. They can find no consistent "best" method: depending on the type of value desired and other objectives of a study, an economist can combine or alter various methods.

PROBLEMS

Several economic and physical problems exist, making valid and consistent values of water difficult to obtain. For instance, a typical river basin or subbasin contains several other uses of water, such as fishing or mining, besides irrigation. Some of these users may affect the others through any or all of the quantity, quality, time, and location dimensions of the water resources. "In the language of price theory, these effects may be expressed either in terms of positive or negative externalities. These types of interdependencies cause acute problems in valuing the resource on a single purpose basis."[15]

Besides that, the stochastic nature of water supplies results in less efficient production decisions by farmers than under conditions

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[15] Young, Robert A. and S. Lee Grey, "The Value of Water in Alternative Uses with Special Reference to the Great Plains," The Role of Water Resources in the Economic Development of the Great Plains, #54 (Denver: Great Plains Agriculture Council, 1971), p.87.

of accurate water supply forecasts. The productivity of water at the farm adds additional factors which must be taken into account -- for instance, water must be used in combination with fertilizers, etc. to increase yields. Others include transportation costs of water to the farm, cost of taking the farm goods to market, soil, climatic conditions and irrigation methods. Such things, over a time, change the demand for water.

An economist, determining the value of water, must also pay attention to the time frame: A farmer may pay a higher price for water after planting his crops (short run) than before deciding what to grow for the year (long run).

Also, water users view irrigation water values differently. The private firm ignores externalities, but society estimates water's total value, including all benefits as well as all costs. So an economist must determine whether the county, state, or nation represents society's views.

Valuation in the Absence of Market Prices

If a free market existed for water such as exists for wheat, that is if potential users could buy water from potential sellers, the market price of water in its alternative uses would be readily available. Efficient users would bid the less efficient ones off the market, and water would then be employed in its most efficient uses. No such market for water exists in Montana. In part, public agencies and organizations allocate water among the host of users -- in addition, water rights belong with land holdings unless the sale is approved by the Board of Natural Resources and Conservation. The estimate for the value of water arrived at in this study should closely approximate the "market value".

METHODS OF ANALYSIS REVIEWED

For the most part farmers do not bid for control of the water -- they appropriate. Where water has been abundant, farmers consistently use it to the point where its marginal productivity approaches zero. This intensive use reflects the low marginal cost often associated with water.

As water has become increasingly more scarce in many agricultural areas, economists have been called upon to measure its marginal value product (MVP). Some of the methods they developed include production function analysis (regression analysis), input-output analysis, inputed land values (regression analysis), and partial farm budgeting using linear programming (called residual imputation by Young and Grey).[16]

Production Function Analysis

The production function can lead to a marginal value function

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[16]Ibid.

for water, given specific assumptions about other variable inputs and product prices. Miller, Boersma, and Castle of Oregon State used this approach in their study on water values in the Willamette Valley.[17] Using a Cobb-Douglas production function they found that the yields of corn and beans are closely related to total water applied. Hoszar, Skold, and Danielson has similar results in an experiment with corn production in Eastern Colorado.[18]

A variation of this approach was pioneered by Ruttan[19] and has the advantage of being relatively inexpensive since the data has already been collected and tabulated. The problems arise with sampling and estimation. Brown and Beattie[20] felt that Ruttan, in an effort to overcome problems attributable to multicollinearity,

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[17] Miller, Stanley, Larry Boersma and Emery N. Castle, Irrigation Water Values in the Willamette Valley: A Study of Alternative Valuation Methods, Bulletin #85 (Corvallis, Oregon: Oregon Agricultural Experiment Station, 1965).

[18] Hoszar, Paul, Melvin D. Skold, and Robert Danielson, Evaluations of Irrigation Water and Nitrogen Fertilizer in Corn Production, Bulletin #107 (Fort Collins, Colorado: Colorado Agricultural Experiment Station, 1970).

[19] Ruttan, V. W., The Economic Demand for Irrigated Acreage - New Methodology and Some Preliminary Projects, 1954-1980, Baltimore, John Hopkins Press, 1965.

[20] Brown, William G., Bruce R. Beattie, "Improving Estimates of the Marginal Value Productivity of Irrigation Water Using Ridge Regression, Unpublished Paper.

omitted variables which could tend to distort estimates of the value of the marginal product. They then modified the Ruttan model in an attempt to avoid some of the estimation difficulties. They used a more homogeneous study area, converted county data to a per farm basis, and then used ridge regression.

Production function analysis lends itself to a micro approach to estimating water values. As the project objectives included modeling the entire Yellowstone Basin in Montana, this method was not appropriate for this study.

Input-Output Analysis

Input-output analysis estimate the effects on regional and state income levels of alternative water allocations among sectors, i.e., alternative allocations of water between agriculture and industry. Using input-output analysis in his study in New Mexico, Wollman[21] found that value-added per acre foot ranged from $28-$51 in agriculture to about $1,300-$4,000 in manufacturing and mining.

H. Craig Davis and P. H. McGauhey of the University of California at Berkeley used input-output analysis in the fifth part of their

[21] Wollman, N., The Value of Water in Alternative Uses, (Alburqueque, New Mexico: University of New Mexico Press, 1965).

economic evaluation of water in the Western United States.[22] In their study they encountered major problems in interpretation of the results, which they felt would be reduced if more recent and accurate information on gross trade flows were compiled.

> "Input-output analysis can be developed from secondary data, but the most accurate studies required extensive primary data. The method is flexible but requires careful interpretation and analysis of the results. It is particularly useful for an aggregate analysis of value of each sector of the economy. It is probably not too useful when trying to allocate particular amounts within alternative uses."[23]

Since the objectives of this study are to estimate water value while allocating it to users in several different hypothetical situations, input-output analysis was not deemed an appropriate tool.

Inputed Land Values and Other Transactions Relating to Water

Due to problems mentioned earlier and state water laws, transactions in the market involving water are rare, but in some cases they do exist. These usually involve "renting" water unless the land to which the rights pertain are transferred too. Both Anderson[24] and

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[22] Davis, Craig H. and P. H. McGauhey, "Part V Multiregional Input-Output Techniques and Western Water Resources Development," Economic Valuation of Water (Berkeley, California: University of California: 1968).

[23] Lindeborg, Karl, Economic Values of Irrigation Water in Four Areas Areas Along the Snake River in Idaho, Bulletin #513 (Moscow, Idaho: Idaho Agricultural Experiment Station, 1970) p. 4.

[24] Young, Op. Cit. p. 93, citing Anderson, Raymond L., "The Irrigation Water Rental Market, A Case Study," Agricultural Economics Research,

Gardner[25] did studies on water rental markets and found that in most cases prices reflected the short-run demand.

Based on the rationale that land prices reflect the capitalized value of returns from crop production on that land, Anderson and Hartman estimated the average value product of water (AVPw) in northeastern Colorado. They used data on land prices and water delivery rates found in public records. Anderson and Hartman concluded that regression analysis of farm sales data provided reasonable estimates of water values that would be reliable for resource development and water conservation planning.[26]

Linear Programming

Linear programming is the most widely used method for determining the value of the marginal product of water in agriculture. In linear

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8(2), (1961) p. 54-58.

[25]Gardner, B.D., and H. H. Fullerton, "Transfer Restrictions and Misallocations of Irrigation Water," American Journal of Agricultural Economics, Vol. 50, #2 (Menasha, Wisconsin: American Agricultural Economic Association, 1968).

[26]Hartman, L.M. and R. L. Anderson, Estimating Irrigation Water Values: A Regression Analysis of Farm Sales Data from Northeastern Colorado (Fort Collins, Colorado, Colorado Agricultural Experiment Station, 1963).

programming sets of farm budgets are constructed which compare revenues and costs with and without irrigation water supplies. The increment to the net value is inputed to the increment of irrigation water.

In his study in Idaho, Dr. Karl Lindeborg used linear programming to compute the price users can pay for an additional unit of water.[27] His linear model expressed the complexities of land, water, and crop rotation.

Whittlesey,[28] Kelso,[29] and Hartman[30] all found it necessary to make assumptions like Lindeborg's[31] in setting up their various models.

Typical assumptions include:

1) Farmers grow the combination of crops which maximize net revenue;

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[27]Lindeborg, Op.Cit.

[28]Whittlesey, Norman K. and Thain H. Allison, The Value of Water Used in Washington's Irrigated Agriculture, Bulletin #745 (Pullman, Washington: Washington Agricultural Experiment Station, 1971).

[29]Kelso, Maurice M., William E. Martin and Lawrence E. Mack, Water Supplies and Economic Growth in an Arid Environment, (Tucson, Arizona: University of Arizona Press, 1973).

[30]Hartman, L. M. and Norman Whittlesey, Marginal Values of Irrigated Water, Bulletin #70 (Fort Collins, Colorado: Colorado Agricultural Experiment Station, 1960).

[31]Lindeborg, Op.Cit.

2) Technology and methods are the same on all farms in each model;

3) Production costs are constant;

4) Water is optimally allocated on the farm;

5) Farm sizes are the same as the representative farm;

6) Each farming area has the same soil and climatic conditions.

When using this method an economist builds farm models representing "typical" farms in the study area. Assumptions vary from model to model.

> "Where there are numerous crop alternatives or where it is desired to approximate a nonlinear production function with piecewise linear segments, formulation of the problem within the linear programming framework has proven particularly advantageous."[32]

Most of the studies done in this area derived a step function which approximates the annual demand for water. If the researcher adjusted for overhead costs and subsidy payments, this method may be useful for evaluating the long-run demand for water.

CONCLUSION

Only one method of analysis seemed suited for the needs of this project. First, the objectives required a simulation model of the

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[32]Young, Op.Cit., p. 97.

water flows within the Yellowstone Basin. Second, this model needed the capability of estimating the value of water to irrigation - primarily as an alternative to use in coal related projects. In addition, data availability was considered in choosing the method of analysis.

Linear Programming (L.P.) met all three criteria. Past studies have used L.P. in both simulation models of watersheds and for estimating the value of water in irrigated farms. Since the Montana State Cooperative Extension Service has partial farm budgets for much of the Yellowstone Valley and the Montana State University Department of Civil Engineering built a state water planning model the third criteria of data availability was satisfied.

Chapter 3

THE MODEL

SIMPLE VALLEY

Building a mathematical model which simulates the economics of water in Montana's portion of the Yellowstone Basin requires a marriage of engineering and economics. That is, mathematical equations representing the monetary returns from the various uses of water in the basin must be joined with equations representing the physical constraints of the hydrological basin.

The Yellowstone Basin model developed in this project grew from a river basin system developed by Robert Dorfman and Arthur Maass called "simple valley." Applying this simple valley concept to the Yellowstone Basin results in Figure 3-1. With this concept a river basin is broken down into major irrigation areas, tributaries, dams, industrial users of water, and the mainstream. This model divides the Yellowstone Basin of Montana into five irrigation and runoff areas, one dam, and on coal project, two main tributaries from Wyoming, and the Yellowstone mainstream.

Water originally enters the basin from Wyoming. After runoff flows originating in Montana are added to the stream, diversion to irrigation project 1 occurs. Further downstream, more water enters from Wyoming and as Montana runoff. Shortly thereafter, the model diverts water for irrigation project 2. Meanwhile, water flowing