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The level of general public interest in the way the nation's natural resources and environment are being exploited is increasing. Questions are being raised among public policy makers and academia about the wisdom of the rate at which public funds are being invested in resource, and specifically water resource, development, and about the efficiency of those investments. The purpose of this thesis research is to step back and take a critical look at a particular part (e.g., irrigation) of a small watershed project in operation, to determine how it actually has performed. Such an _ex post_ evaluation may provide useful information to all parties interested in water resource issues. The study is part of an overall research program designed at Oregon State University at the request of the Douglas County Board of Commissioners in association with the Oregon Association of Conservation Districts, to evaluate the performance of small watershed projects completed in Oregon in the last 20 years.

The Wolf Creek Watershed Project located in Union County represents the study area. The data used were obtained through direct interview and

mail survey of the irrigators in the project area. The results of the analysis show that the irrigation program of the Wolf Creek Project has significantly contributed to an increase in and stabilization of irrigator family incomes as well as other household incomes in Union County. In fact, it is estimated that the Wolf Creek Project generates annually an additional $674,372 in net income for irrigator families and $719,976 for other households in the local economy -- or a total of $1,494,348 increase in final net income to Union County residents. The irrigation program of the project has also contributed to water and energy conservation. The overall project results in flood and erosion control as well.

Primary & Secondary Irrigation Benefits in Small Watershed Projects: An Evaluation of an Oregon P.L. 566 Project in Mid-Life

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CHAPTER I

INTRODUCTION

Public Involvement in Small Watershed Development Projects

Historically, issues related to water and related land resources have occupied a dominant place in the preoccupations of societies. In the United States, as reflected in the body of legislation on water and related resource use, policies and regulations affecting the allocation of these resources have passed through various stages with attendent controversies.

During the settlement of the West in the 19th century, federal land was transferred to private ownership by awarding the property right to any settler able and willing to clear 160 acres of land and establish a farm. "Under the Homestead Act of 1862 which authorized the transfer, approximately a billion acres passed into private ownership" [Johnston and Kilby, 1975].

At the turn of the 20th century, the federal government deepened its involvement in resource development by investing directly in irrigation projects. Through the Reclamation Act of 1902, a special fund was established for this purpose,[1/] and the Bureau of Reclamation was entrusted with the responsibility to initiate and build water projects

[1/] Reclamation funds, finaced by the sales of public lands were established. Prior to the Reclamation Act, the Desert Land Act and the Carey Act also had provided federal support for irrigation development.

prior to actual agricultural development in the project area. Farmers simply were required to sign contracts to repay construction costs in ten annual payments subsequent to their settlement in the area. Later, the repayment period was extended "to forty years and need not begin until [after] a development period of ten years; also, agreements to repay construction costs [are] no longer [to be] signed by individual settlers but by irrigation districts which have been given the power of taxation over a project's beneficiaries" [Eckstein, 1958, p. 192].

In 1954, the Watershed Protection and Flood Prevention Act commonly known as Public Law 566 (P.L. 566), authorized local organizations (water districts, or combinations thereof) having authority under state law, to address problems of watershed protection and development of water resources in small basins less than 250,000 acres in size. These local groups, assisted by the Soil Conservation Service (SCS), were to initiate the project, carry out feasibility studies, and receive financial assistance from the federal government for their construction.

As the extent of federal involvement in water and other natural resource development projects, as well as the demands of local populations for the use of natural resources to sustain the momentum of growth increased, so did the demand for federal assistance for watershed development. However, the federal budget for P.L. 566 projects did not keep pace with increasing demands for these public expenditures. The federal government, operating under budget constraints, began to select only those projects that were the "best" among many proposed water investments. However, the lack of accepted federal guidelines for the evaluation of alternative public investments made comparisons among competing projects very difficult, and as a consequence the allocation of federal funds among alternative projects become controversial.[2/]

An additional, but chronologically later source of controversy was the environmental impact of resource development in the last two decades. The general public has become increasingly concerned about the trade-offs between environmental quality and economic growth. The public has challenged resource economists, other natural and social scientists, and other professionals to answer questions on whether or not the benefits that accrue to society as a whole from these uses actually outweigh the consequent costs to society; and whether or not knowledge in the general area of resource development and project evaluation is generally adequate.

In the course of the debate over the trade-offs between environmental quality and economic growth, the federal government has had to revise its policies to account for the emerging concerns and new approaches to the identification and measurement of project impacts. New regulations for the evaluation of water resource development projects that can qualify for federal assistance have been proposed.[3/] At the state and local levels, which have a substantial economic stake in water and related resource development endeavors, the new regulations shed a cloud of uncertainty on future economic growth. Considerable interest has arisen in these communities in the reappraisal of their development strategies,

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2/ Although the "proposed practices" published in 1950 were the first attempt to set the standards on project evaluation practices, the first truly comprehensive federal guidelines for water project evaluation were published in 1973 by the U.S. Water Resources Council [U.S. Water Resources Council, 1973].

3/ The most recent guidelines and regulations for the assessment of the impacts of federal water development projects were proposed in 1979 by the Water Resources Council in response to the President's Memorandum of July 12, 1978 [U.S. Water Resources Council, 1979].

the development of new legislation related to resource use planning, and the assessment of the performance of projects already completed in order to generate relevant information for future planning and resource use decisions.

Background to the Research

The present thesis is part of an overall research program requested by the Douglas County, Oregon, Board of Commissioners in collaboration with the Oregon Association of Soil Conservation Districts. The request was made for Oregon State University to do a study of the P.L. 566 projects already in operation in order to generate data on their performance, and on the benefits local communities have derived from them in comparison with the costs incurred.

In Douglas County, and elsewhere in Oregon, 13 small watershed (P.L. 566) development projects have been completed in the last two decades. County and Conservation District officials have been concerned and uncertain about the adequacy of project evaluation assumptions and techniques. They also have been in need of the "best" possible information on benefits and costs of water development for use in future economic planning.

Three of the small watershed (P.L. 566) projects completed in Oregon in the last 20 years were selected for *ex post* evaluation or after-the-fact (see Figure 1). The three projects evaluated in the course of the study include: (1) the Sutherlin Creek Project located in Douglas County, southwest Oregon, in operation since 1968, with main objectives of flood control and recreation; (2) the Skipanon River Project located in Clatsop County, northwest Oregon, and in operation since 1966

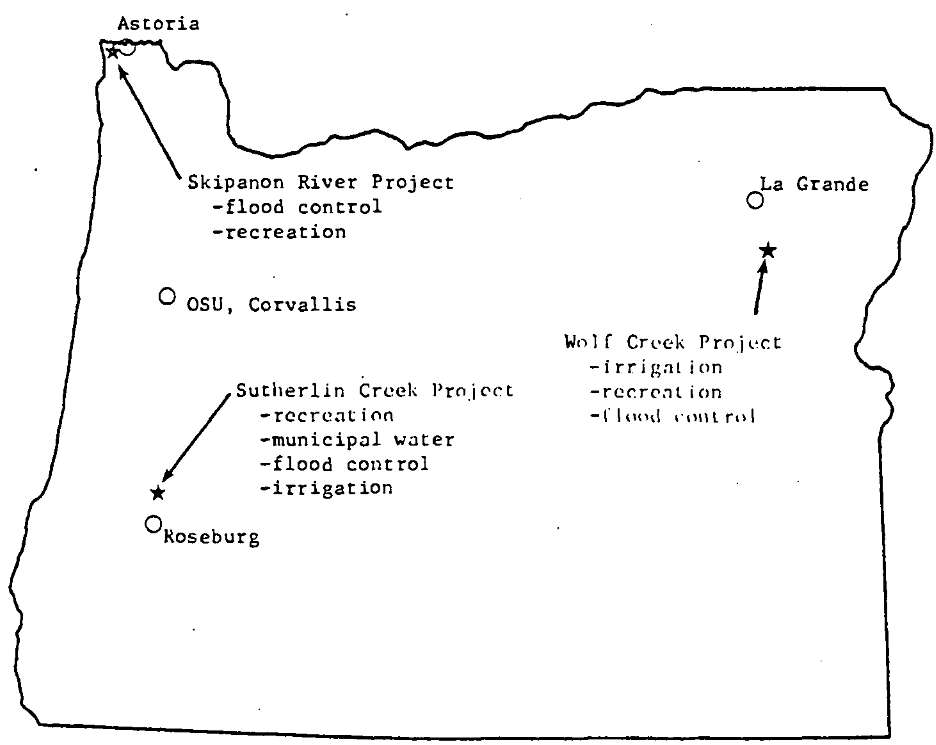

Figure 1. Site of Three Small Watershed (P.L. 566) Projects Studied in Oregon in Conjunction with the Ex Post Evaluation Project. [Source: Kraynick, et.al., 1980.]

with primary objectives including recreation and flood control; and (3) the Wolf Creek Project located in Union County, northeast Oregon, an irrigation and recreation project in operation since 1975.

Considerations guiding the choice of these projects included (1) the geographical dispersion of the selected project areas, (2) the differing purposes of the selected projects, (3) the availability of county input-output models, and (4) the cost sharing arrangements. To be meaningful as decision making tools, the results of the study would have to be representative of the different climatic regions in the state, cover more than one of the several purposes of water resource development, and feature the different cost sharing arrangements available to project sponsors.

The proportion of local cost share in water development projects varies with the primary purposes of the project and the sponsoring agency. For example, while farmers participating in SCS irrigation projects have to bear 50 percent of the construction costs (see Table 1), those participating in Bureau of Reclamation (BR) and Army Corps of Engineers (CE) projects pay variable shares of the project costs.[4/]

Because of the direct involvement of local people in the development of small watershed (P.L. 566) SCS projects, the sponsors of the research program thought that the determination of the extent to which the local community has been benefited in comparison to the actual costs it has experienced could provide valuable information for future decision

4/ Farmers' cost shares in Bureau of Reclamation (BR) and Army Corps of Engineers (CE) projects are variable because these two agencies use a basin account system to transfer power and water revenues to cover the costs of irrigation which reduces the costs that must be paid by the users of irrigation water [Marshall, 1970].

Table 1. Maximum Federal Cost Shares for Water Resources Projects.

Purposes	Agency[a]	Percentage of Costs by Cost Category: Construction	Land Rights	Operation, Maintenance, and Replacement	Relocation and Alteration of Utilities
Irrigation	BR	Variable	0	0	0
	SCS	50	0	0	0
	AE	Variable	0	0	0
Water Quality	SCS	0	0	0	0
	AE	100	100	100	100
Recreation: Fish & Wildlife	BR	50 & 100[b]	50	0 & 100[c]	---
Improvement	SCS	50	0	0	---
Development	SCS	50	50	0	---
	AE	50 & 100[b]	50	0 & 100[c]	---

a/ BR = Bureau of Reclamation; SCS = Soil Conservation Service; AE = Army Corps of Engineers.

b/ The maximum federal share of separable and joint costs is 50 percent and 100 percent respectively.

c/ The maximum federal share of separable and joint costs is 0 percent and 100 percent respectively.

SOURCE: Marshall, 1970.

making, and especially future cost-sharing arrangements. Thus, assessment of the magnitude and distribution of local benefits and costs attributable to small watershed projects constituted the general problem explored in the *ex post* evaluation project.[5/]

Selection of the Wolf Creek Watershed Project

The Sutherlin Creek, Skipanon River, and Wolf Creek small watershed projects evaluated in the Oregon State University study are multipurpose in nature. Each is comprised of a different mix of flood and erosion protection, irrigation, recreation and municipal water supply objectives, as may be seen in the anticipated *ex ante* impacts reported in Table 2 below. The impacts generated by each purpose have been the subject of separate research programs conducted under the general auspices of the *ex post* evaluation project. The present thesis is concerned with the benefits and costs of only one of the multiple project purposes: irrigation. Because the Wolf Creek Project is the only small watershed project among the three studied to have irrigation as the most important purpose, the northeast Oregon project area became the area of study for the detailed evaluation of the local economic impacts attributable to irrigation and the focus of this thesis research.

There are about 30 growers in the Wolf Creek Project service area where 13,407 acres are being irrigated.[6/] The water is delivered to most of the farm land through gravity pressurized pipelines, making it possible for these farmers to sprinkler irrigate their crops without

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5/ Overall results for the *ex post* evaluation project are given by Kraynick, *et.al.* [1980].

6/ There are only 349 acres irrigated in the Sutherline Creek Project service area and practically none in the Skipanon River Project area.

Table 2. Expected Annual Primary Benefits by Purpose and by Project: *Ex Post* Evaluation Project.

Purposes	Skipanon Creek[a/]	Sutherlin Creek[b/]	Wolf Creek[c/]
	Percent of Total Expected Annual Benefit by Project		
Irrigation	---	12	82
Flood Control	52	40	6
Recreation	48	42	12
Municipal and Industrial Water Supply	---	6	---

a/ U.S.D.A., Soil Conservation Service. Watershed Work Plan, Skipanon Creek Watershed. Clatsop County, Oregon, 1958.

b/ U.S.D.A., Soil Conservation Service. Watershed Work Plan, Sutherlin Creek Watershed. Douglas County, Oregon. 1963.

c/ U.S.D.A., Soil Conservation Service. Watershed Work Plan, Wolf Creek Watershed. Union County, Oregon. 1966.

incurring any pumping energy costs. In contrast to the irregular water supply experienced before the project, farmers in the project service area also benefit from a year-round water supply made possible by the project storage reservoir.

Evaluation of benefits that accrue to irrigators and other households in the Wolf Creek Project service area and the surrounding local economy as a result of the development of the project constitutes the specific problem in this thesis. Other dimensions of the present research topic include (1) the validity of the assumptions relative to the future composition and value of agricultural production as used in *ex ante* benefit-cost evaluations, and (2) the accuracy of predicted versus observed project costs and benefits.

Objectives

The objectives guiding the thesis research as reported here are three-fold:

(1) To develop a theoretically appropriate methodology that can be used in the evaluation of irrigation impacts of small watershed projects on a local economy.

(2) To estimate the impacts of the Wolf Creek Project at the farmers' (primary beneficiaries) level, and at the level of the local economy (secondary beneficiaries).

(3) To explain the discrepancies that may appear between the observed and the expected economic impacts.

The first objective is achieved by reviewing the literature on project evaluation and adapting existing techniques and assumptions to small economy (i.e., county) conditions. The irrigation benefits are measured by the change (with versus without the project) in farm family income as revealed through crop budget analysis. The secondary benefits or impacts that accrue to local households other than service area farmers are estimated through the use of a Union County input-output model. The results estimated using this approach are compared with those projected in 1966 when the Wolf Creek Project work plan was prepared. When disparities appear in the two sets of results, a rational explanation is found to account for the observed differences.

Organization of the Thesis

Each of the above objectives is dealt with in the next four chapters. The second chapter is devoted to a brief overview of the literature on project evaluation and related issues. Special attention is given to the rationale of government intervention in the marketplace and the role of agriculture in the economic growth of rural communities. In the third chapter, a methodology for estimating the primary and secondary local economic impacts attributable to irrigation is developed. In the next chapter the methodology developed previously is used to evaluate the irrigation benefits of the Wolf Creek watershed project. The first section of this chapter contains a description of the existing physical and economic conditions in the Wolf Creek watershed and the characteristics (structural and nonstructural measures) of the Wolf Creek Project. The next two sections deal with the investigation procedures used to collect the data and the estimated results. The last chapter is used to summarize and rationalize the major findings, to acknowledge the limitations of the thesis, and finally to suggest implications for future research.

CHAPTER II

THEORETICAL FRAMEWORK

In this era of uneasiness about government intervention in the private sector, it is not unusual to hear people claim that public investments, especially in water resource development, are "pork barrel".[1/] It also often is apparent in the criticism of water resource development projects that a major reason for public investment in unjustified projects is the misinterpretation and/or misapplication of evaluation procedures. A project analyst can avoid procedural errors through a better understanding of the theory, assumptions, and attendant limitations that underly the evaluation techniques.

The purpose of this chapter is to clarify an appropriate approach to project evaluation. This is accomplished by reviewing the theoretical framework within which the *ex post* evaluation of small watershed projects (or of any specific attribute of such projects) is founded. In addition to the conceptual issues involved in project evaluation, the rationale of public investment in a more general sense is addressed. The purpose is to determine whether or not public investments in water resource development may be necessary in a competitive market economy.

Rationale of Public Investments in Water Resource Development

In a competitive market economy, the price system is considered the most efficient mechanism for allocating scarce resources. For the system to be operational and efficient, a set of assumptions related to the structure of the economy and the behavior of the economic agents (producers

[1/] A project is referred to as pork barrel if its "objective" benefits are anticipated to be less than its objective costs [Hanke, 1980].

and consumers) that interact in the market must be satisfied: (1) The individual consumer must be a rational being who makes consistent decisions concerning the allocation of limited resources to meet his preferences, given a set of market prices. The preferences are assumed independent of the purchases of others, and the desire to substitute one good for the other as market conditions change diminishes as the extent of substitution increases. (2) The individual producer also is assumed to be a rational being who seeks to maximize profit, given the market conditions, by producing with the least cost alternative to the point where marginal costs equal marginal revenues. The production processes of different firms (producing units) are assumed to be physically independent (the productivity of one firm is not affected by the outputs of other firms), and are subject to the law of diminishing return as output levels increase. (3) The structure of the product and factor markets is such that every participant (buyers and sellers) has perfect information, and is so small as to be unable to influence existing market conditions; that resources are mobile and responsive to changes in price; and that only marketable goods (i.e., those with a price tag) are produced and exchanged.

In those cases where actual conditions violate these assumptions, the price system fails to function efficiently. Either market structure and/or market behavior assumptions may be violated. One common, and sweeping, violation of underlying assumptions is the exixtence of an external economy. "The effect of [this failure on the] external economy is to cause divergence between private and social cost-benefit calculations" [Bator, 1958], and in order to harmonize private production decisions with public welfare, some form of government intervention may be necessary.[2/]

Some economists (Coase, 1960; Buchanan and Stubblebine, 1962) maintain that even with externalities, market solutions still can lead to the efficient allocation of resources if liability rules are defined and transaction costs are nil or very small. Kneese (1971) and Randall (1972) argue that market solutions to externality are adapted or adaptable only in the two party case because in practice liability rules are complex and difficult to define, and transaction costs are very high. This is probably why large scale externality problems such as those involved in water resource development are handled through government intervention (regulations or public investment).

Characteristics of Water Resource Projects

The products of water resource development effectively violate the market assumptions outlined above. Quite often, when considering water development alternatives, private production decisions will not necessarily maximize public welfare. For example, the consequence of some kinds of basin development (e.g., flood and erosion control) may be equally available to all residents in the project area such that it is impossible to exclude anybody in the area from its consumption. Since the reduction of flood hazards and erosion control resulting from development of a river basin are public goods and consequently not valued in the market, private profit maximizers are unlikely to allocate scarce resources to the production of such goods. Hence, the price system may not maximize public welfare.

2/ In the Economics of Welfare (1946) Pigou suggested taxation of benefits to subsidize the losers.

Another example in which private decisions may not maximize public welfare may be the case of water quality control. In fact, private production decisions can result in pollution of a river basin, representing a cost to society. But yet, the market valuation of the output produced from the polluting activity may not necessarily account for the accompanying social cost causing, therefore, a discrepancy between the private and social optima.

Yet a third reason why the price system may fail to maximize public welfare is the immobility of resources in rural communities. Resource immobility limits the opportunity for communities to share proportionally in the allocation of the nation's resources or wealth -- unless there is some type of government intervention, usually in the form of public investment in water resource development or irrigation projects.

These kinds of investments can stimulate economic growth in rural communities because, according to economic base theory "the rate and direction of growth of a region or a city is determined by its function as an exporter to the rest of the world" [Bendavit, 1974]. And since agriculture constitutes the major export sector in most rural communities "providing a net flow of capital to finance a considerable part of the investment requirement for infrastructure and industrial growth; ... the growth of farm cash income associated with structural transformation means increased rural demand for inputs and consumer goods that can provide important stimulus to other local sectors" [Johnston and Kilby, 1975]. In other words, given the "dragging effects" agriculture has on local economic development coupled with the resource immobility characteristic of rural communities, public investment in water resource development that contributes to the increase in productivity in agriculture (through irrigation, flood or erosion prevention) may initiate the process of growth and development in rural areas.

There generally is little debate among economists and public decision makers about the need for or role of these forms of public investment.[3/] The major controversies involve instead the questions of eligibility and choice of the projects to be implemented.

Public Investment and Cost-Benefit Analysis

To respond to the need for accepted criteria for determining the eligibility of development projects for public investment, a new type of economic logic was required. Resource economics evolved during the 1950's making substantial contributions to the economic literature on project evaluation. Of special significance was work on issues related to efficiency and equity in water resource development projects. Books and articles were published on the problems of resource conservation [Ciriacy-Wantrup, 1952]; on the theory of public expenditure [Samuelson, 1954]; on questions related to discount rate and opportunity costs of public investments [Haveman, 1974]; on project appraisal and planning in developing countries [Little and Mirrlees, 1974]; and on environment improvement [Freeman, 1979], just to name a few.

As far as cost-benefit analysis (evaluation) of water resource development programs (irrigation, flood control, recreation, hydroelectricity) is concerned, however, Otto Eckstein's book Water-Resource

3/ There is, however, a debate over whether or not water diverted for irrigation purposes is an efficient investment. In the short run, the opportunity costs of the water diverted for irrigation may be quite high, suggesting that such investments may be inefficient [Whittlesey and Gibbs, 1977]. However, this has not been conclusively demonstrated [Obermiller, 1978].

Development: The Economics of Project Evaluation remains the major contribution. Even though Eckstein did not invent cost-benefit analysis (CBA) which actually is "a generic term embracing a wide range of evaluative procedures which lead to a statement assessing costs and benefits relevant to project alternatives" [Sasson and Schaffer, 1978], the book is seminal in its clarification of the theoretical concepts and assumptions that underly the project evaluation techniques.[4/]

A water resource development project must be considered feasible and eligible for implementation only if the resulting benefits exceed the costs or said differently, if the benefit-cost ratio is greater than one. "The benefit-cost ratio can be stated equivalently as the present discounted value of future benefit and cost streams or in terms of average annual costs and benefits" [Duffield, 1980]. The latter form is the one commonly used in project appraisal. Benefits are generally expressed in terms of annual returns and the costs in terms of annual payments.

Correct estimation of benefit and cost ratios depends first of all on the proper identification and measurement of benefits and costs that are relevant to the project. It is necessary (but not always simple) to distinguish between the effects (benefits and costs) that accrue directly to the primary participants (irrigators in irrigation projects) and those that accrue to the society or local community as a whole. In addition to the identification problem, there may be difficulties in obtaining the economic information or selecting the appropriate procedures needed to measure the benefits and costs. Not only the magnitude of these

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4/ The first formal document on cost-benefit analysis known as "Green Book" was published in May 1950 by the Federal Inter-Agency River Basin Committee, Subcommittee on Benefits and Costs. Its formal title was "Proposed Practices for Economic Analysis of River Basin Projects".

effects, but also their distribution among people, sectors, and regions need to be evaluated. Further, the timing and duration of the effects must be known [Obermiller, 1978].

Many applications of cost-benefit analysis have failed to recognize some of these problems. In particular, there has not been sufficient concern for the distributional effects of resource-use decisions. Related to the difficulties involving distributional issues are problems encountered in attempting to measure welfare brought about, in part, by the lack of accepted working definitions of welfare. Also difficult and controversial is the choice of the discount rate to be used in calculating present or annual values. One basic idea behind the discount rate is to find an interest rate that is the appropriate exchange ratio for any commodity at two different points in time. Because in the modern economy there are many such rates, the problem is to find the one that is most appropriate for water resource project evaluation.

Voluminous literature has been devoted to the subject of choosing a discount rate and there does not yet seem to be a definitive answer. However, the concept of using the social opportunity of capital (foregone returns to the funds if invested in an alternative use) as the correct rate is dominant in the literature.[5/]

The difficulties encountered in projecting future impacts of water development projects (*ex ante* evaluation) may or may not apply to evaluation of after-the-fact effects (*ex post* evaluation); depending on whether the latter involves a completely terminated project. However, other difficulties and obstacles need to be overcome for the *ex post*

5/ The discounting procedure used in the overall *ex post* evaluation study is reported by Kraynick, *et.al.*, Chapter VII.

analysis to make economic sense and to be effective in improving the decision-making process. These obstacles relate to (a) the dynamics of the economic system in contrast with the static approach used in cost-benefit analysis; (b) the stochastic nature of some of the expected outputs of a water development project; and (c) the time horizon during which the effects are expected to occur. A detailing of the implications of these obstacles can be found in Haveman (1972).

In either *ex post* or *ex ante* evaluations, cost-benefit analysis will be as effective for public investment decision-making as the analyst is objective and aware of the possible flaws in the techniques. The analyst's awareness of possible flaws can be gained only through a good understanding of the concepts of micro- and welfare economics that form the basis for the analysis of public investments and cost-benefit analysis. Relying on the concepts reviewed in this chapter, a methodology for evaluating irrigation benefits in small watershed development projects is subsequently elaborated.

CHAPTER III

METHODOLOGY FOR EVALUATING IRRIGATION BENEFITS

Introduction

One objective of this thesis is to elaborate a methodology for evaluating the irrigation impacts of small watershed projects. In pursuit of that objective, identification of irrigation benefits relevant to the development of small watershed occurs immediately below. The following section is concerned with the measurement of those benefits.

Benefits of Irrigation Water Supply

The value of an irrigation project to farmers, just like the value of any other good or service to its users, is measured by the farmers' willingness to pay for the supply of water. But irrigation water is not a final consumer good. It is an intermediate good, use of which can induce an increase in agricultural output or a reduction in the cost of production. Hence, it is reasonable to think that for farmers, the water will be valuable only to the extent of its contribution to the increase in production or reduction in cost.

The expected change in net income to the irrigator will be the direct measure of value for his supply of water. In addition to the direct benefits that accrue to farmers, an irrigation project will generate other benefits in a community. There will be: (1) secondary or indirect benefits that accrue in other sectors of the economy as a result of the increased production in the agricultural sector; and (2) public benefits (any benefits other than the direct and indirect benefits) that accrue to the community as a whole.

Primary Benefits

Primary benefits are those project effects which count from the standpoint of the individual irrigator. They can be classified as increases in either/or net farm income and other farm prequisites. Net farm income is the difference between gross farm income and production expenses. Gross farm income is the revenue from the sale of crops, livestock and livestock products. Production expenses include all cash expenditures, a charge for depreciation, and interest on farm investment. Other farm perquisites include such items as the value of farm products consumed by the family and the increased rental value of farm dwellings.

Secondary Benefits

Secondary benefits represent the impacts of the project on the economy beyond the farm. They arise in two ways: (1) "induced by" benefits, or benefits that accrue to all enterprises in the economy under consideration from supplying goods and services to farmers for living and production expenses; and (2) "stemming from" benefits, accruing to all enterprises between the farmer and final consumer, and attributable to handling, processing, or marketing the outputs from the project.

Because of the nature of secondary benefits, it is important in their evaluation to specify the level of economy (national, regional, local) at which they are occurring. At the national level, secondary benefits are generally discounted by economists. Secondary benefits are not viewed as value added to the nation's stocks of goods, but rather as a change in existing income flows. It is argued that, given the basic assumptions of cost-benefit analysis, the investments in natural resources are made in a framework of economic balance and stability. Any increase in secondary economic activities in one region will result in displacements of resources in other regions of the economy in such a way that the overall secondary effects will be nil or very small. The assumptions of economic balance and stability also imply that resources (labor and capital) are mobile and are utilized in the most productive way.

However, in reality it is not unusual to find cases of resource under-utilization due to immobility and other social constraints, especially at the regional and local levels. Under these conditions, secondary benefits arising from the improvement in unemployment and other resource uses as a result of a project will not necessarily create offsetting effects elsewhere. They will contribute to the improvement in national efficiency as well as to the "regional economic development which is an important policy objective and perhaps the main rationale of irrigation programs" [Eckstein, 1958].

From a strictly regional or local economy viewpoint, secondary benefits are important regardless of the state of resource uses. Of immediate concern to regional planners are the effects of the project on their respective economies. Similar offsetting effects that occur elsewhere in the overall economy are not directly relevant to them. Hence, from a local perspective and especially for programs involving local cost sharing, secondary effects play an important role in the evaluation of water resource development projects.

Public Benefits

Public benefits represent any improvements in the local or regional economy that are not captured in the two previous categories of benefits. For example, if due to economies of scale the realization of the project results in community developments that could not have been undertaken before, public benefits can be credited to the project. Public benefits may also arise in cases where irrigation projects help prevent a long-term deterioration in agricultural land productivity through erosion control. However, it should be kept in mind that there also may be public costs associated with this kind of benefit, and that the former cannot be claimed while ignoring the latter. The proper approach is to identify all public benefits and public costs, and then derive the net public benefits to be credited to the project.

Benefit Evaluation Procedures

Given the local interests that underly this study, the impact evaluation is limited to the local economy (e.g., county). The "with versus without" principle is used to derive primary and secondary benefits. These benefits consist of the increase in economic returns to farmers (primary) and other households in the community (secondary) resulting "with the project" as compared to "without the project".

Measurement of Primary Benefits

The computation of irrigation primary benefits generally is handled through farm budget studies which identify production costs and revenues. Production costs include all cash and non-cash expenditures the farmer has to incur to make his products available for sale. Cash costs include all the actual expenditures made in purchasing factors of production such as fertilizer, seed, and pesticides; in operating farm equipment; or in using custom operators. The operating costs of farm equipment are comprised of the expenses for fuel, lubricants, repair, and maintenance.

Inputs that are purchased in large quantities and stored during the season are valued at their purchase price plus an allowance for the cost of storage.

Non-cash costs include the cost of using the farmer's own capital and labor in the farm business. In family-oriented type businesses, most of the labor inputs used in the production process are provided by the farmer and his family. A cost evaluation that does not include these labor costs underestimates actual production costs. Doing so assumes that family labor has no long-run opportunity cost. The history of American agriculture has shown this not to be correct. Farmers can out-migrate and seek employment elsewhere.

The farmer's own capital employed in the farm business should also be charged at the opportunity earning rate in alternative usage. For example, the cost of owning farm equipment should include the amortization of the initial investment and a charge for taxes and insurance. An allowance for building costs also must be considered if the equipment is sheltered.

Gross farm revenue is the proceeds from the sale of farm products such as crops, livestock, and livestock products. In addition to these products that are directly exchanged in the marketplace, gross farm revenue must include the goods and services that are consumed on the farm. By subtracting production costs from these gross farm revenues, one will derive the net benefit or return to the relevant factors of production. The difference between the net benefits with and without the project will yield the primary benefit of the project.

Measurement of Secondary Benefits

Among the various techniques available to regional economists to measure secondary benefits, economic base analysis and input-output studies are most frequently used. These two techniques are summarized below.

Economic Base Analysis. The fundamental concept of economic base analysis is that the rate of growth of a region is a function of its exports. The industries or economic sectors that contribute to these exports constitute the economic base of the region, and together they comprise the basic sectors [Bendavit, 1974]. The non-basic sector is made up of all the supportive activities necessary to service the basic sector.

The assignment of economic activities to the basic or the non-basic sector may vary from one economy to the other. For example, a service sector including motels and restaurants, which is generally considered as non-basic, can be a basic sector in an economy in which tourism is a major exporting industry.

When the demand for the outputs of the basic sector (exports) increases, the non-basic sector also will expand to accommodate the increased service requirements of the basic sector. The ratio of the change in basic sector to the non-basic is called base ratio (BR). A base multiplier (BM) is computed by adding one (1) to the reciprocal of the base ratio ($BM = 1 + \frac{1}{BR}$). For example, when the base ratio is equal to one-half ($\frac{1}{2}$), the total impact or base multiplier equals three (1 + 2). An equivalent statement is BM = (Base + Non-base)/Base. Impacts can be expressed in terms of employment, income, or any other economic measure.

Expressing the above example in terms of employment means, when basic employment increases by one, a total of three new jobs, including both basic and non-basic, will be created. In impact analysis, once the change in basic employment (or income) is determined, the total change in the region's economy can be computed by multiplying the former by the base multiplier.

For the problem at hand, namely the evaluation of secondary benefits from irrigation development, agriculture is viewed as one of the basic sectors. Changes in output as a result of the irrigation project lead to increases in exports. Their impacts are then evaluated within the economic base methodology.

Input-Output Analysis. To perform an input-output study, the economy is generally divided into sectors or industries. Each industry sells to and purchases from other industries. The interindustrial exchange is expressed in terms of direct and indirect coefficients. The sum of these coefficients for a given sector or industry determines the change in business output in the economy for a unit change in the sales to final demand by the respective sector. This latter coefficient is sometimes referred to as the "business income multiplier". In addition to that multiplier, other specific multipliers such as household multipliers can be derived to show the effect of change in final demand on other sectors of the economy.[1/]

The difference between the "business income" and the "household income" multipliers is, the latter measures the change in actual payment

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1/ For a more detailed explanation on the nature, derivation, and another application of input-output models in Oregon, see Stoevener, et. al. (1972).

received by households within the county (or the region), in compensation for the primary factors of production which households supply; while the former (business income multipliers) measure the total increase in business activity in the county, as a result of an increase in the sales to final demand by the respective sector. The "business income multiplier" does not really indicate how much of the increase in activities result in net income increases to local inhabitants but the household income multiplier does provide this information.

In input-output studies, households are usually treated as exogenous, meaning that household consumption is a part of final demand. Household incomes do not generate any additional rounds of expenditures in the economy. The use of this procedure results in a low estimate of the induced change in household income, especially in small economies (e.g., the county). However, "by closing" the model with respect to households, induced changes in household expenditures are permitted to interact with other sectors. Increased wage payments will result in higher incomes to employees which further will increase business sales to households in the county. Household income multipliers derived from "closed" models (households endogeneous) are typically larger than those derived from the "open" models (household exogenous). Treatment of households as endogenous adds a degree of realism to the depiction of a local economy.

The (static) input-output model is more descriptive than predictive. The model is built on linearity and constant technology assumptions. The linearity assumption implies that, to increase output by a given proportion, all inputs must be increased by the same proportion. The constant technology assumption is that the structure of the economy depicted by the direct coefficients remains the same over time. This means input substitutions, made possible by new technology, will not be reflected in the model which is a description of existing economic conditions at a given period in time. For example, if a water resource program results in the construction of new processing firms or the emergence of new sectors, these effects cannot be captured in the existing model. Nevertheless, static input-output can be rendered useful in tracing out project's impacts on local economy by adjusting the model to account for the changes.[2/]

While input-output models are superior to economic base techniques in project analysis, considerably more data is required to construct an input-output model. However, an input-output model already has been derived for the region of interest here (Union County). Hence, secondary benefits are determined using that input-output information.

Use of the Input-Output Model in Determining Irrigation Indirect Benefits

The input-output model is by definition a "demand-side" approach to structural analysis which implies that a change in final demands (principally exports to outside areas) results in an immediate response by the local economy. Direct and indirect changes in transactions among (economic) sectors in the local economy are induced. The impacts of changes in final demand on local household incomes are measured by the product of the change(s) in final demand and the household coefficient(s) of the relevant sector(s). The input-output system measures two kinds of effects of a change in final demand: (1) direct effects and

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2/ For more detailed treatment of these adjustment procedures, see Carroll [1980] and Johnson [1980].

(2) direct and indirect effects. The residuals between these two household income effects represent the secondary benefits.

Direct Plus Indirect Effects of a Change in Sales to Final Demand

Given a "direct plus indirect" coefficients table also known as the "Leontief inverse" matrix, the element ($b_{hh,j}$) in the household row and the j^{th} column (e.g., household payments in the agricultural sector) represents the total addition to local household income due to a \$1 increase in sales to final demand by sector j (agriculture). Thus, for any increase in sales to final demand by the agricultural sector (ΔY_{ag}), the local economy would experience a total (direct plus indirect) change in household income equivalent to:

$$\Delta B_{hh,ag} = (b_{hh,ag})(\Delta Y_{ag}), \tag{1}$$

where

$\Delta B_{hh,ag}$ = total change in local household income as a result of a change in sales to final demand by agriculture;

ΔY_{ag} = change in sales to final demand by agriculture; and

$b_{hh,ag}$ = element in the household row and agriculture column of the "direct plus indirect" coefficients table.

Direct Effects of a Change in Sales to Final Demand

The direct payments effects of a change in sales to final demand by the j^{th} sector are represented by the income that accrues to the households that supply the primary factors of production to sector j. The relationship inherent in input-output models for estimating these direct effects is based on the product of change in total gross output (instead of change in sales to final demand as in the case of direct plus indirect effects) and the element in the household row and the j^{th} column of the direct coefficients table. Thus, the direct effects of a change in sales to final demand by the agricultural sector is equivalent to:

$$\Delta A_{hh,ag} = \alpha_{hh,ag} \cdot \Delta X_{ag} \tag{2}$$

where

$\Delta A_{hh,ag}$ = change in direct household payments by agriculture;

ΔX_{ag} = change in agriculture's total gross output; and

$\alpha_{hh,ag}$ = element in the household row and agriculture column of the direct coefficient table.

<u>Indirect Effects of a Change in Final Demand</u>

The residual between the total (direct plus indirect) change in household income ($\Delta B_{hh,ag}$) and the direct payment to households by agriculture ($\Delta A_{hh,ag}$) represents the secondary impacts that accrue to households in the local economy other than those associated with agriculture. Thus,

$$\Delta D_{hh,j} = \Delta B_{hh,ag} - \Delta A_{hh,ag} \tag{3}$$

where

$\Delta D_{hh,j}$ = change in payments to nonagricultural households in the local economy resulting from a change in sales to final demand by agriculture;

$\Delta B_{hh,ag}$ = total (direct plus indirect) change in local household income as a result of a change in sales to final demand by agriculture; and

$\Delta A_{hh,ag}$ = change in direct household payments by agriculture resulting from a change in agriculture's total gross output.

Adjusting Input-Output Parameters for Observed Discrepancies

The use of the above relationships and procedures to determine secondary benefits would seem to be a fairly straightforward undertaking. However, difficulties may arise in the evaluation of irrigation project secondary benefits, particularly when there is a discrepancy between the estimate of the direct effects ($\Delta A_{hh,ag}$) using the input-output system and the returns to farm households (ΔR_{hh}) as determined in farm budget studies. When the discrepancy occurs, as when for example the return to farm households in farm budget studies is greater than the estimate of direct effects from the input-output model ($\Delta R_{hh} > \Delta A_{hh,ag}$), the secondary effects ($\Delta D_{hh,j}$) estimated by using the approach described above underestimate the true secondary impacts of the project; and the procedure must be adjusted in order to account for this discrepancy.

Possible Reasons for Discrepancies. It will be recalled that under the farm budget procedure primary benefits are derived as the difference in net farm incomes with and without the project situations. The increase in net incomes on farms with irrigation water arises in part because of disproportionate increases in factor use on the affected farms. While farmers commit the so-called associated costs together with the irrigation water to bring about the increase in agricultural output, the increases in agricultural net incomes are possible largely because less than proportionate increases are required for certain inputs (e.g., land and labor).

The input-output methodology in which the household impact reflects both primary and secondary effects assumes, as mentioned previously, that the primary benefit component of the household impact is derived from strictly proportionate changes in farm input requirements as agricultural output increases. To the extent farm output changes are the result of disproportionate increases in input use, the resulting primary benefit estimates may be lower under the input-output system than they would be if the enterprise budgeting procedures were used.

In addition to the effects of the disproportionate use of some inputs, the primary benefits from crop budgets (ΔR_{hh}) may be higher than the direct benefits estimated from input-output models ($\Delta A_{hh,ag}$) if the two estimates do not represent the returns to the same factors. In fact, in the present study, contrary to the direct effects as estimated by the input-output model, the primary benefits as measured in the budget analysis include the return to water in addition to the returns to capital (land) and management. In order to meaningfully compare the "budget primary benefits" to the "I/O primary benefits", the two results must be expressed in terms of the same variables.[3/] More specifically, a charge for water must be deducted from the budget primary benefits to make them more nearly comparable to the I/O primary benefits.

A possible third reason for discrepancies in the two measurements

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3/ To avoid confusion in terminology, "budget primary benefits" will be used to refer to the primary benefits estimated using the farm budget procedure and "I/O primary benefits" will refer to the direct household effects derived from the use of household technical coefficients from the input-output model.

lies in factor and product price changes. When the two types of estimates are not derived at the same point in time, changes in price relationships may cause the two estimates to differ from one another.

The effects of general price level changes can be overcome by deflating the value of the final demand estimates by the prices received by farmers' index. Thus final demand would be expressed in terms of the same price level as prevailed during the year for which the input-output model was constructed. After deriving the secondary benefits, the consumer price index could be used to inflate the results back to the current year.

<u>A Suggested Solution</u>. To deal with the apparent impasse of the inconsistent benefit measures stemming from the use of the two methodologies, it is necessary to draw the line sharply between the two appraoches. The derivation of farm budget estimates of primary benefits is logically superior to and empirically more reliable than an estimate of primary benefits from the input-output model. Therefore, the irrigation primary benefits or return to irrigator households (ΔR_{hh}) are measured using the farm budget approach.

The estimate of secondary benefits can be derived relying only on the input-output model as shown in equation (3). The procedure restricts use of the input-output model to a purpose for which it is most suited; tracing out the indirect effects of an economic change to which the local economy has been subjected. At the same time, determination of the primary benefits is left to a methodology which can cope with the details of farm production cost and revenue changes which necessarily need to be taken into account in the evaluation of irrigation benefits, but which are beyond the capabilities of an input-output model.

One drawback remains with this procedure. If the primary household impacts on the agricultural sector(s) are actually greater than those portrayed by the input-output model, the estimate of secondary benefits will be too low. The effects of household expenditures induced by the higher real level of farm household incomes will not be reflected in the secondary benefits estimate. Hence, a consistent adjustment of the secondary benefits estimate is needed.

If it may be assumed that the difference in primary household incomes ($\Delta R_{hh} - \Delta A_{hh,ag}$) would have the same effect upon the local economy as would an increase in final demand upon the household sector, secondary benefits could be augmented by adding to the above estimate the product of the "excess income" (EI) and the appropriate household coefficient ($e_{hh,hh}$). The actual excess income available for household expenditure would be the difference between the budget primary benefit compensated for the water charge and the I/O primary benefits: ($EI = \Delta R_{hh} - \Delta A_{hh,ag}$). Indeed it is not too unrealistic to assume that farm families benefiting from the project would have similar expenditure patterns and hence would affect the rest of the economy in a similar manner as would other families living in the county but earning their incomes elsewhere.[4/] The actual indirect effects of these expenditures would be equivalent to:

$$\Delta E_{hh,hh} = e_{hh,hh} \cdot EI \qquad (4)$$

where

[4/] Allowing for the possibility of measurement errors, the secondary benefits arising from excess income perhaps should be evaluated only when the excess income is greater than some arbitrary portion, say five percent, of the demand change in the agricultural sector.

$\Delta E_{hh,hh}$ = additional secondary household income generated in the local economy from a change in sales to final demand by the household sector;

EI = direct payment to households by agriculture not accounted for by the input-output estimate of direct effects (assumed equivalent to a change in final demand facing the household sector); and

$e_{hh,hh}$ = element in the household row and household column of the direct plus indirect coefficients table.

Since the water charge is paid to an irrigation district within the county, the impact of the expenditure of the funds received by the district on household incomes also may be considered. While a major part of the irrigation fund received by the district (from farmers) is used to repay the principal and interest on the federal loans, it is likely that a part also will be spent locally. If it is assumed that the money spent locally by the district results in an increase in final demand faced by some sectors of the local economy, a secondary benefit can be claimed for the irrigation charge (irrigation fund) paid by the farmers to the district. These secondary benefits are once again equal to the product of the final demand (proportion of the irrigation fund spent locally) (ΔW_j) and the direct plus indirect household coefficient(s) (diminished by the technical coefficient) of the relevant sector(s) ($f_{hh,ij}$) OR

$$\Delta F_{hh,j} = \sum_{j=1}^{n} f_{hh,j} \cdot \Delta W_j \qquad (5)$$

where

$\Delta F_{hh,j}$ = secondary benefits due to changes in sales to final demand by sector j;

ΔW_j = change in local expenditures for output of sector j by water districts; and

$f_{hh,j}$ = j^{th} sector direct plus indirect household coefficient diminished by the same sector's technical coefficient.

The total secondary benefits generated by the irrigation project in the local economy is therefore equal to:

$$\Delta G_{hh,j} = \Delta D_{hh,j} + \Delta E_{hh,hh} + \Delta F_{hh,j} \quad (6)$$

where

$\Delta G_{hh,j}$ = change in indirect household payments resulting from a change in sales to final demand by sector j, adjusted for discrepancies between the estimates of "I/O" direct benefits and the primary benefits of farm budget studies; and

$\Delta D_{hh,j}$, $\Delta E_{hh,hh}$, $\Delta F_{hh,j}$ are as defined previously.

Public Benefits

In addition to the private benefits (primary and secondary) that accrue to households in Union County, the Wolf Creek project is expected to contribute to a reduction in energy consumption and erosion of agricultural lands in the county. These forms of benefits can be evaluated on the basis of a comparison to an alternative system. The approach consists of measuring the costs of an alternative and feasible system that can be used to provide the same service (e.g., erosion control). The least cost method for implementing such a system would constitute the benefits generated by the project. The actual valuation of the benefits hinges upon the accurate identification of the alternative system.

For example, in the case of energy-saving benefits the alternative system should consist of an energy-consuming system that would replace the present gravity pressurized system. Since farmers would have several options about the manner in which they would apply the water (if they did so at all) under the new system, the cost of that alternative system would depend on its design features. Its feasibility would depend on how farmers would be affected by the costs and how they (the farmers) would appraise the benefits and costs under their own individual circumstances given the various irrigation schemes available to them. Detailed engineering and economic studies would be required to determine the possible outcomes of such alternative systems.

Sources of Data

The accurate valuation of irrigation benefits hinges on the measurement of some key variables such as cropping pattern, crop yield, inputs used in production, factor prices, and output prices. The data required to quanitify these variables can be either primary or secondary.

Primary data consisting of "first-hand" information can be obtained from farmers either through direct interview (a typical farm study approach) or mail survey or both. The typical farm study approach consists of getting data that do not represent average production costs but instead reflect the consensus of opinion of one group of experienced, commercial producers using generally accepted production practices in the project area.[5/] The mail survey can be used to collect additional information and/or to double-check the data obtained by using the typical farm approach.

[5/] For more detail, see the enterprise data sheets prepared by Farm Management Specialists in the Department of Agricultural and Resource Economics, Oregon State University.

Secondary data consists of any information gathered from published or unpublished sources such as technical bulletins. This information can be used as a benchmark in checking the accuracy of or supplementing primary data. Price information generally is from a secondary source.

Summary

The computation of irrigation primary benefits is best handled through the crop budgeting approach. The data for the crop budgets is obtained by interviews with groups of representative commercial producers using generally accepted production practices in the area. The budget must be established for conditions "with and without" the project. The difference between the net benefit with and without the project (returns to land, management, and water) represents the increased income of the irrigator family or primary benefits.

The secondary benefits can be derived using county-level input-output models and projective change(s) in the final demand(s) of the relevant sector(s). These benefits can be expressed in terms of income flows to county households, suppliers of the local primary factors of production. In the next chapter these various principles are applied to the Wolf Creek Project in order to quantify the impacts it has had on the local (Union County) economy.

CHAPTER IV

EMPIRICAL ANALYSIS

Introduction

The purpose of this chapter is to present the actual *ex post* evaluation of the irrigation benefits of the Wolf Creek Project. In the first section of the chapter, a brief description of the characteristics (structural and non-structural measures) of the project, and the physical and economic environments within which it is operating, are given. These descriptions help to understand the importance of the installed structural measures. The next section of the chapter covers the procedures used in the study to collect the needed information, the data actually collected, and finally the estimated irrigation benefits of the Wolf Creek Project.

Environment and Characteristics of the Wolf Creek Project

Physical Environment

The Wolf Creek Project is located in the Wolf Creek watershed, a sub-basin of the North Powder River Valley which extends over Union and Baker Counties in northeastern Oregon (see Figure 2). The watershed is entirely located in Union County, "15 miles south of La Grande (Union County seat), ten miles north of Baker (Baker County seat) and about one mile above the confluence of the North Powder River and Wolf Creek" [Soil Conservation Service, 1966].

The Wolf Creek watershed, like many other areas in eastern Oregon, is characterized by cool and relatively moist winters, and warm and dry summers. The annual average precipitation measured in the watershed is

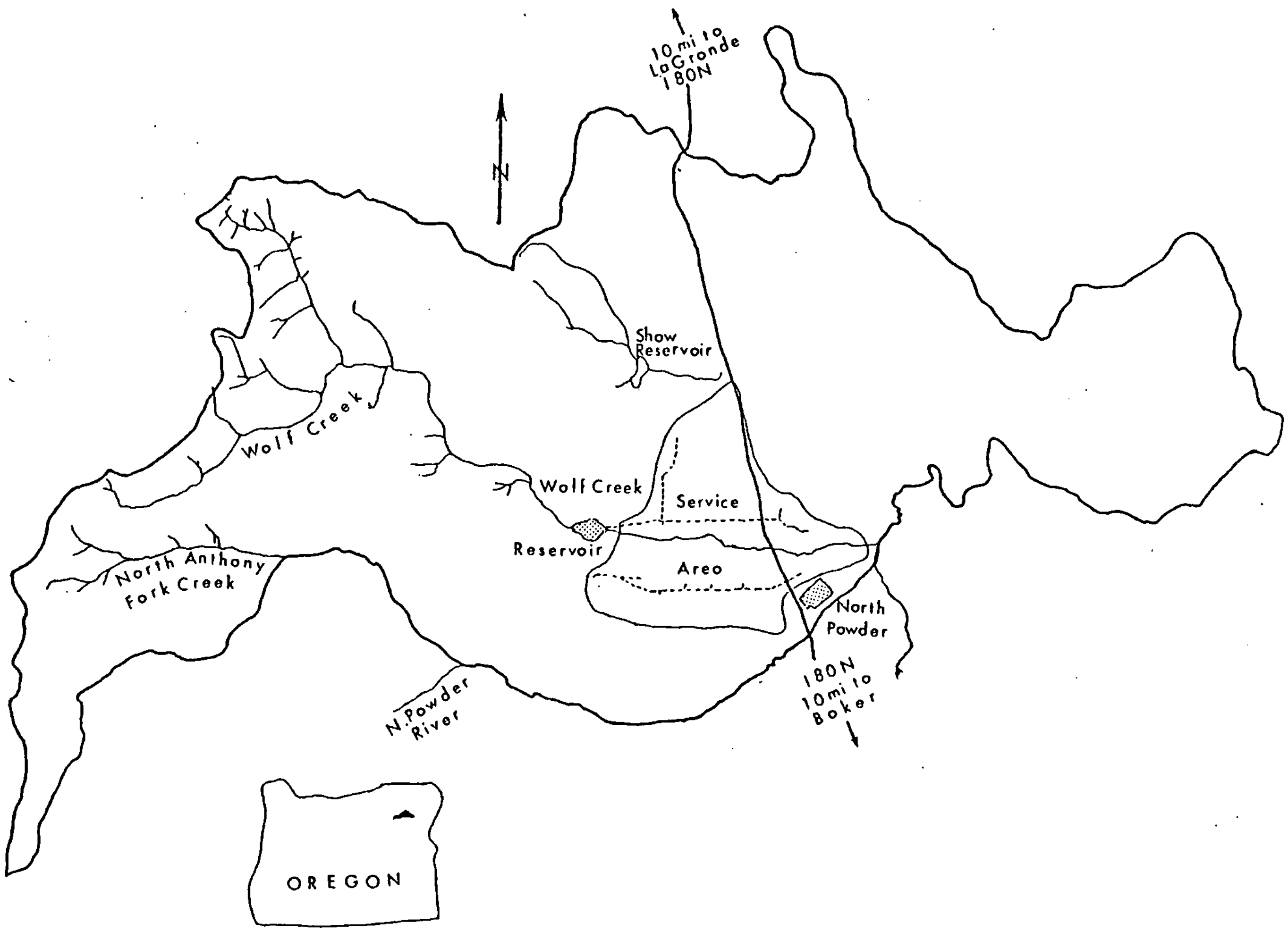

Figure 2. Location Map: Wolf Creek and Related Drainages - Ex Post Evaluation Project. [Source: Kraynick, et. al., 1980.]

17 inches, of which only 24 percent occurs during the growing season. Besides the low rainfall, the growing season also is characterized by a very high rate of evaporation (15 percent of the annual rate) which reduces even further the availability of disposable moisture necessary for agricultural production in the watershed.

The general water resource situation in the North Powder River Valley is one of water availability from surface as well as from ground sources. The surface waters, product of the melting snow in the Elkhorn Mountains, are discharged via various streams all of which are characterized by high flows in the winter and spring but low flows from late June through the fall. The irregular runoff pattern limits the reliability of the natural flows of the surface water as year-round irrigation water sources. The average runoff distribution of Wolf Creek on which the project dam is built is given in Figure 3. Groundwater well production in the area ranges from 800 to 3,000 gallons per minute (gpm) per well with an average lift of 90 feet. Only a few wells were established in the watershed before the project was built.

Economic Environment

Union County is characterized by a low population density. It contains 2,034 square miles and an estimated 1979 population of 24,000 or 11.80 people per square mile. About one-half of the county population (11,250) is in La Grande, the county seat; and 430 persons live in North Powder, the only town in the watershed [Population Research and Census Center, 1980]. Employment statistics for the last ten years show that the civilian labor force is consistently growing in Union County. In 1970 there were 7,650 (39.5 percent of the total population) workable persons

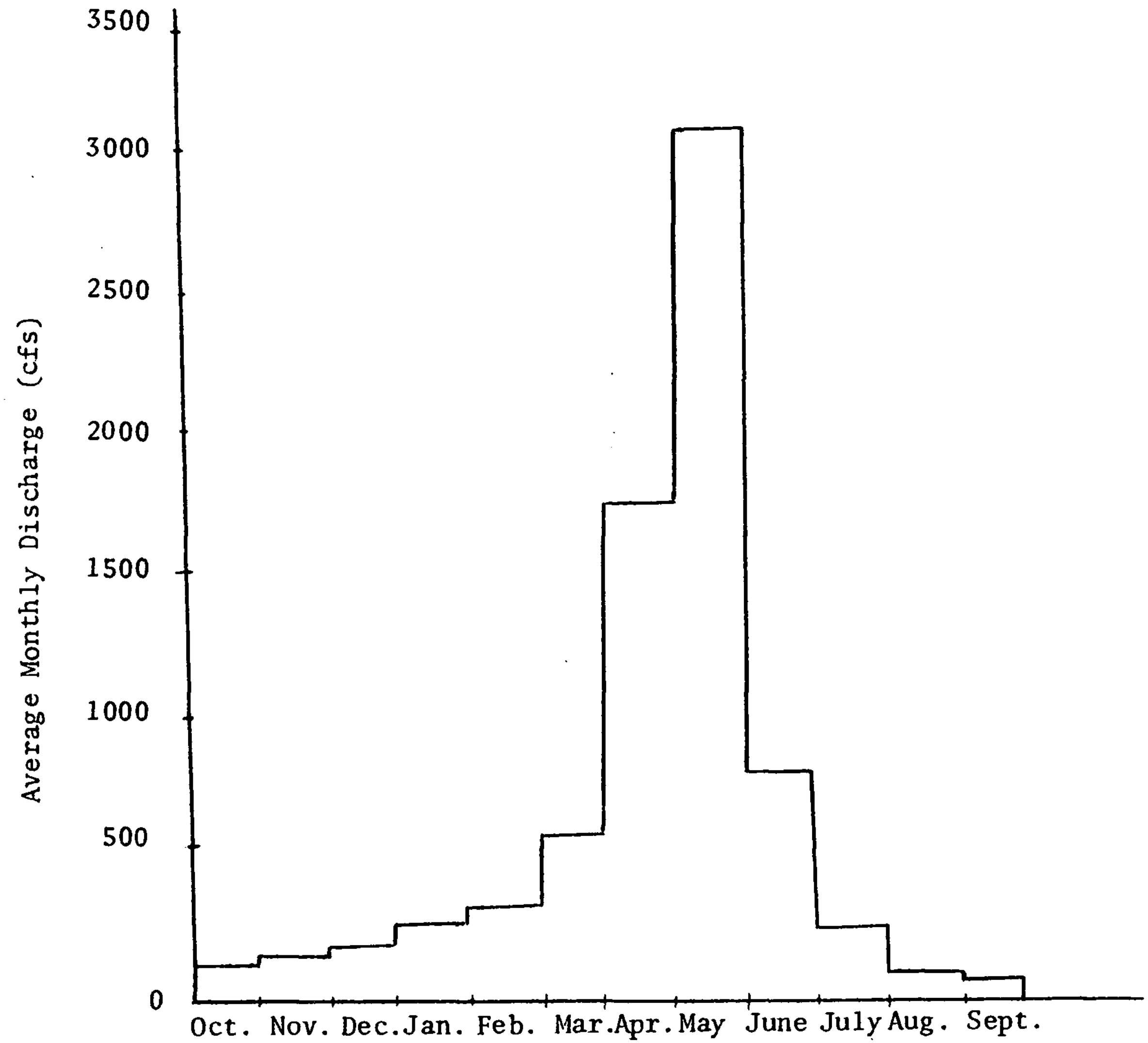

Figure 3. Average Runoff Distribution (1963-1978) of the Wolf Creek - Ex Post Evaluation Project. [Source: Data obtained from North Powder Water Control District.]

16 years of age or older versus 9,780 (41 percent) in 1979.1/ On the other hand, the unemployment rate shows some stability over time (at an eight percent average annual rate) except in 1974 through 1976 when the rate exceeded ten percent (13 percent in 1975). While the civilian labor force has increased over time, the portion of the labor force employed by the agricultural sector has continually declined. In fact, 980 people (ten percent of the civilian labor force) were employed in agriculture in 1979 versus 1,130 (14 percent of the labor force) in 1970. The major employing sectors in the county in 1979 were government (21 percent), wholesale and retail trade (17 percent), services (17 percent), and manufacturing (16 percent) [Oregon State Department of Human Resources, 1980].

The agricultural sector in Union County sold more than 25 million dollars worth of crops ($17,500,000), and livestock, and livestock products ($8,460,000) in 1979 versus 11.8 million dollars worth of crops ($6,473,000) and livestock ($5,288,000) in 1970 [Oregon State University Extension Economic Information Office, 1980]. Part of these increases in farm income in the county can be attributed to the project which has been in operation only during the last five years.

According to the Bureau of Economic Analysis [U.S. Department of Commerce, 1980], personal income in the county has increased steadily since 1970 and totalled $156.5 million in 1978.2/ Per capita income also has increased, and averaged $6,700 in 1978.3/

1/ Because the project was completed in 1975, the years 1970 and 1979 were selected as appropriate points of reference before and after the project's construction phase.

2/ The most recent available Bureau of Economic Analysis Data is for 1978.

3/ For the State of Oregon, the personal and per capita income averages were 19,736 and 8,076 dollars, respectively, in 1978.

A network of all-weather transportation facilities provides access to the Wolf Creek watershed, a necessary condition if potential increases in agricultural production in the watershed were to have materialized and have had a positive impact on economic growth in the county. Interstate Highway 80 traverses the county and the watershed north and south. A mainline of the Union Pacific railroad provides facilities for handling livestock and crops at North Powder and Telocaset. Airport facilities exist at La Grande and Baker for private, fire fighting, commercial spraying, and crop dusting planes.

The existence of these various facilities, coupled with the good soil fertility characteristic of the Wolf Creek watershed, enhanced its development potential explaining why members of the North Powder Water Control District pressed for the establishment of the Wolf Creek irrigation project.

Characteristics of the Project

The structural measures actually installed to meet the increased irrigation water supply, flood prevention, and water-based recreation objectives of the project consist of (1) the Wolf Creek Reservoir, and (2) water delivery systems made up of gravity pressurized pipelines and open ditches (Figure 4). The Wolf Creek Reservoir, a multipurpose structure for irrigation, flood prevention, and water-based recreation, is located about 7.2 miles upstream from the mouth of Wolf Creek and six miles west of the town of North Powder. It has a capacity of 11,100 acre-feet, is 6,400 feet long, 2,400 feet wide, 108 feet deep, and covers 220 acres. Of the 11,100 acre-feet capacity, 10,350 acre-feet are available for irrigation water storage. The remaining 750 acre-feet capacity constitute a permanent pool with 350 acre-feet of storage for 100 year

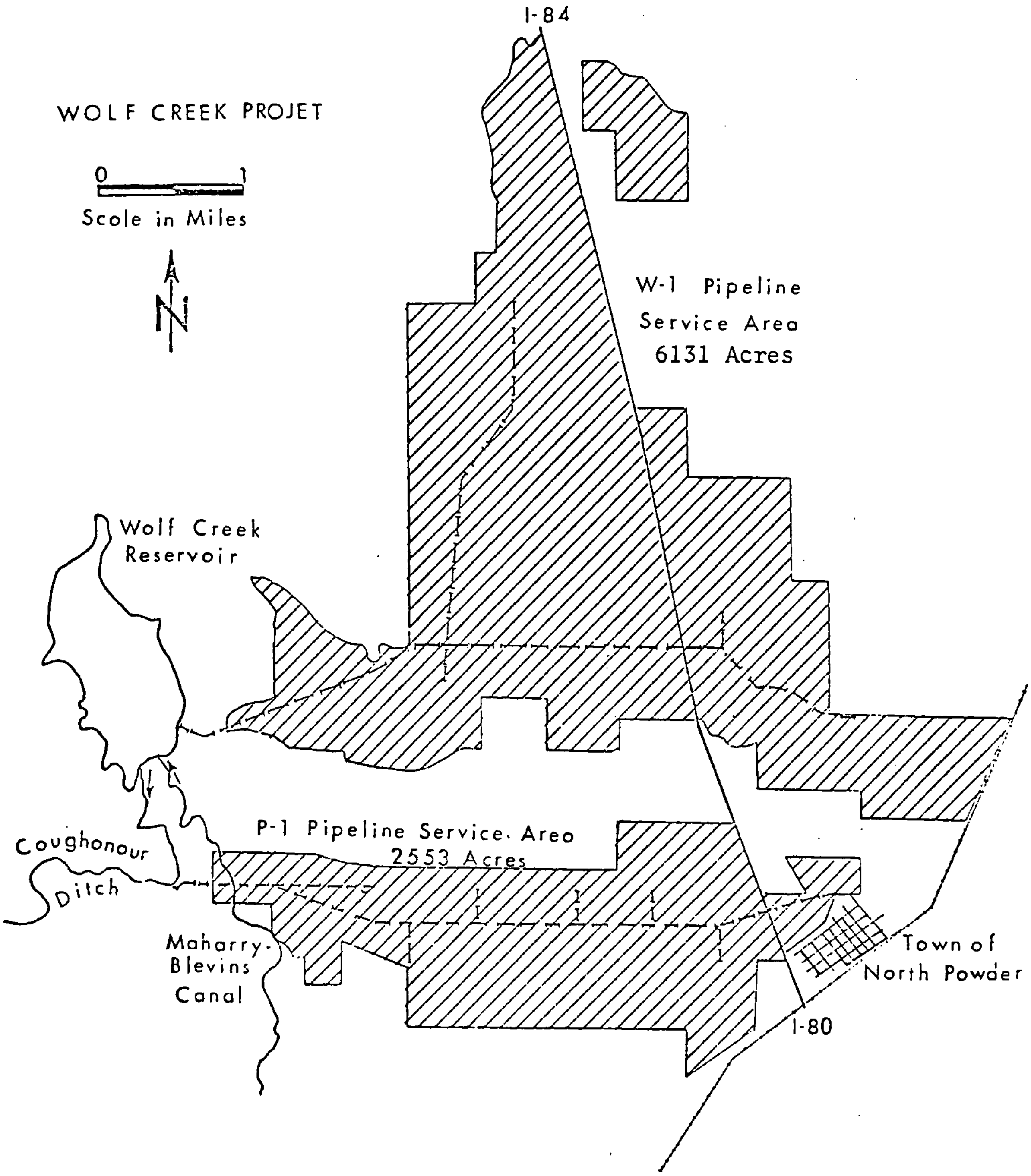

Figure 4. Wolf Creek Project Service Area - Ex Post Evaluation Project. [Source: Kraynick, et. al., 1980.]

sediment accumulation, and 400 acre-feet for a recreation pool with a surface area of 50 acres.

The gravity pressurized pipelines are used to distribute water in areas where the soil has steep slopes, and where canal erosion and water losses are major problems. There are two main pipelines (W-1 and P-2) which delivery water to the farmers under a maximum pressure of 55 pounds per square inch (psi) under static head conditions, and 35 psi operating pressure. The two pipelines service 8,684 acres, 6,131 by the W-1 pipeline and 2,553 acres by the P-2 pipeline.[4/]

While only a few of the growers were using sprinkler systems at the time of the project's initiation, many of them quickly became aware of its advantages, and as a consequence the demand for the gravity pressurized delivery system grew. Even though only two of the three planned gravity pressure pipelines were actually installed, the total acreage served by these two pipelines is far larger than planned (see Table 3).

Table 3. Planned Versus Realized Gravity Pressurized Pipeline Service Area: Wolf Creek Project.

Pipelines	Planned Irrigated Acreage[a/]	Acreage Actually Irrigated[b/]
P-1	890 acres	not installed
P-2	1,620 acres	2,533 acres
W-1	921 acres	6,131 acres

a/ These figures are drawn from the Wolf Creek Project Work Plan Table 3-B.

b/ These figures are obtained from the North Powder Water Control District.

4/ The data have been obtained from the North Powder Water Control District files.

There also have been changes in the planned use of irrigation channels. Instead of using the Carnes Canal as originally planned, the water diverted from Anthony Creek to Wolf Creek Reservoir is carried through the Coughanour Canal which also directly feeds one of the P-2 pipeline branches, west of the Maharry-Blevins Ditch. The main branch also is fed by the Maharry-Blevins instead of the Lone Pipe Ditch as planned.

Also important is the increase in the total acreage irrigated in contrast to what was deemed possible. The planned capacity of the Wolf Creek Reservoir was thought to be insufficient to guarantee project water for full-season irrigation every year for the entire acreage that could be serviced through the distribution system. It then was estimated that only 8,035 acres could receive supplemental water on a regular basis, because based on the expected cropping pattern, a full-season irrigation water supply of 2.57 acre-feet per acre would be necessary. Further, because of loss of water due to transportation and other factors, 3.33 acre-feet of average farm delivery actually would be required [Soil Conservation Service, 1966]. Contrary to these projections, 13,407 acres are currently being irrigated.[5/]

Two reasons can account for this increase in total acreage irrigated. The cropping pattern is one of these reasons. It was estimated that under project conditions, 85 percent of the cropland would be in perennial hay and pasture, five percent in annual hay, and only ten percent in small grains. The expected crops are actually being grown, but the allocation of land among them is different. On a typical 500 acre farm, 40 percent of the farm is in small grains (wheat and barley) and 60 percent is

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5/ This information is derived from data in the North Powder Water Control District files.

perennial hay (alfalfa) and pasture. Since the small grains required half as much water as the hay or pasture they replaced, more water is freed to irrigate additional acreage.

The second source of the water savings in the project area is the more generalized use of the pipeline distribution system by the district and the sprinkler irrigation system by the project area farmers. The pipelines eliminate the loss of water due to evaporation and seepage in the open ditches. Due to its relatively greater application efficiency, the sprinkler system helps reduce water application requirements relative to water requirements under flood irrigation.

Benefit Estimation and Results

The evaluation of the Wolf Creek Project irrigation benefits was based on primary data collected in the North Powder area for the 1978 production season, other secondary data (factor and product prices) obtained from the Extension Economic Information Office at Oregon State University, and on an input-output model describing the structure of the local economy. The procedures used in gathering these data and estimating benefits are elaborated below.

Investigation Procedures

Both direct interviews and mail surveys were used in this study to collect the necessary primary data. Series of informal interviews and discussions with county extension agents, Soil Conservation Service engineers in La Grande, and individual farmers in the North Powder area resulted in general information about the project area before and after the project was installed, and also about how the project has performed since its completion in 1975.

In the quest for specific data on agricultural practices in the watershed, a formal meeting was arranged by county extension agents with three representative farmers, selected on the basis of their knowledge about agriculture in the watershed. The purpose of that meeting was to estimate the characteristics of a "typical farm" enterprise, with and without irrigation water supplied from the Wolf Creek Reservoir, in the watershed. According to these farmers, agricultural practices in the project area with and without the project could be characterized by a 500 acre farm with five major crops as presented in Table 4.

Based on the typical farm assumptions, a crop budget was computed and submitted for comments to farmers and other professionals in Union County as well as in the Department of Agricultural and Resource Economics at Oregon State University. Most of the comments received concerned inaccuracies in the typical farm assumptions. As a result of these comments, a decision was made to undertake a survey of all the growers of the project area for more information about yields and especially land use changes resulting from the project. A set of questionnaires was sent to all 31 growers in the project area; 20 of them responded. Two respondents indicated that they were not receiving any project water. One returned questionnaire provided insufficient data to be useful in the analysis. The results of the remaining 17 returned questionnaires[6/] (58.6 percent response rate) although generally consistent with the original typical farm assumption caused some modifications to be made. These modifications relative to the original typical farm estimates are highlighted below; and the adjusted typical farm is described in Table 5.

[6/] A sample of the questionnaire is shown in the Appendix.

Table 4. Typical Farm of 500 Acres With and Without the Wolf Creek Project, by Enterprise.

Crops	With Project: Acres in Production	Type of Irrigation	Yield/Acre	Without Project: Acres in Production	Type of Production	Yield/Acre
Alfalfa	125	Sprinkler	5.0 t	125	Flood	3.0 t
Barley	100	Sprinkler	1.5 t	100	Dryland	0.5 t
Pasture	50	Sprinkler	7.5 AUM	50	Flood	5.5 AUM
Spring wheat	225	Sprinkler	50.0 bu	NA		
Winter wheat		Sprinkler	70.0 bu	225	Dryland	25.0 bu

Table 5. Adjusted Typical Farm of 500 Acres With and Without the Wolf Creek Project, by Enterprise.

	With Project			Without Project		
Crops	Acres in Production	Type of Production	Yield/Acre	Acres in Production	Type of Production	Yield/Acre
Alfalfa	175	Sprinkler	5.0 t	125	Flood	3.0 t
Barley	100	Sprinkler	2.0 t	50	Flood	1.5 t
Meadow Hay	N/A			75	Flood	1.5 t
Pasture	125	Flood	7.5 AUM	150	Flood	5.5 AUM
Wheat	100	Sprinkler	70.0 bu	100	Flood	60.0 bu

- Contrary to the original assumptions, acreage devoted to alfalfa and barley production increased with the project relative to without project levels.

- There also was more acreage in pasture production with and without the project than was originally assumed for the typical farm.

- The acres in wheat production with and without and project were less substantial than originally estimated, with practically no spring wheat production.

- The barley and wheat yields increased less significantly with the project than originally estimated, although the actual barley yield was higher with the project than was assumed for the typical farm.

- Other (generally meadow) hay was grown before the project but virtually disappeared after the project. No hay was assumed for the typical farm.

- All the crops included in the typical farm were flood irrigated before the project. Of course, there was some dryland wheat and pasture in the watershed but the returned questionnaires indicated that most of the land benefiting from project water had some form of irrigation before the project.

The typical farm crop budget was adjusted to incorporate the new information. Crop budgets computed include, in addition to the cash expenses made by the farmers to purchase production inputs (seed, fertilizer, pesticide, etc.), the costs of owning, operating, and maintaining farm equipment. Derivation of the latter costs is shown in the Appendix.

Factor and Product Prices

Data used in computing crop budgets represent 1978 production conditions. Therefore, all the production inputs and outputs were initially valued at their 1978 prices. Input prices were either obtained from farmers and represent the actual prices paid for these inputs or were derived from the Oregon State University Extension Service Special Report 521 [Holst, 1978] and represent the average price for the State of Oregon. These prices are shown in Table 6.

Since the farms in the project area are primarily operated by the owner and his family, it was assumed that hired labor is used only for irrigation activities and was paid at $4.00 per hour including social security, workman's compensation, and other fringe benefits. A $5.00 per hour charge was attributed to the owner-operator's labor.

Project outputs were valued by using the prices received by farmers in Union County. For the purpose of this study, county price data appeared to be superior to any other price data available because they represent the prices actually received by local growers for their crops during the production year. These prices are compiled every year by the Extension Economic Information Office at Oregon State University, through direct survey of the producers in each county. County prices received by farmers are net of market costs. In order to minimize the effects of annual price fluctuations, an average of the last five year prices (1974-1978) was used in computing benefits. Average prices of the com-

Table 6. Input Prices Used in the Ex Post Evaluation of the Wolf Creek Project.

Factors	Unit	Cost ($/unit)
Alfalfa seed	pound	2.08
Barley seed	pound	.08
Wheat seed (winter)	pound	.09
Grass seed (spring)	pound	.28
Nitrogen	pound	.20
Phosphorus	pound	.34
Sulfur	pound	.12
Zinc	pound	.60
Boron	pound	1.30
Bromate (custom)	acre	9.50
Fertilizer spreader rental	acre	.75
Bale wire	ton	1.40
Fence maintenance	acre	3.00
Hauling (custom)	acre	2.00
Combine (custom)	acre	12.00
Labor (incl. payroll taxes)		
hired	hour	4.00
owner-operator	hour	5.00
Alfalfa harvest (labor		
cut-bale-stack	ton	20.00
cut-handstack (loaf)	ton	15.00
cut-loose	ton	10.00
Clipping (custom)	acre	3.50

modities produced in the project area are presented in Table 7.

Production Costs and Revenues

Production and associated costs represent the expenditures farmers have to incur in order to make their products available for sale. These expenditures include all the cash and non-cash costs such as amortization or depreciation of machinery and equipment. The charge for water, the farmer's management, and interest on land are not included among the production costs. Instead they comprise the residual net return. The latter is the difference between the proceeds from sales (gross revenue) and the costs of production.

Although the costs and revenue were originally expressed in 1978 values for the reasons mentioned earlier, the estimated primary and secondary benefits were expressed in 1979 prices (the year of reference used in the study), by inflating the production costs and revenues by the farm price and consumer price indices.[7/] More specifically, production costs were inflated by the prices paid by farmers' index, gross revenues by the prices received by farmers' index, and secondary benefits by the consumer price index. While statistics on prices received by farmers and consumer price indices were available for the State of Oregon, the only accessible statistics on the prices paid by farmers' index were those for the U.S. as a whole. Therefore, the national index of prices paid by farmers was used to proxy the conditions in Oregon. Tables 8 and 9 show the production costs and revenues with and without the project. The details of the calculations are presented in the Appendix.

7/ c.f. ante, p. 44.

Table 7. Average Prices Received by Farmers in Union County for Selected Commodities Used in the *Ex Post* Evaluation of the Wolf Creek Project.[a]

Commodity	Unit	Price ($)
Alfalfa	Ton	58.98
Barley	Ton	93.17
Other hay	Ton	45.00
Cull bulls	Pound	.338
Cull cows	Pound	.26
Heifer calves	Pound	.34
Steer calves	Pound	.40
Wheat	Bushel	3.25
Irrigated Pasture (lease price)[b]	AUM	9.00

[a] A complete table of the five-year series is presented in the Appendix.

[b] Data were obtained from Ralph D. Hart, Union County, Oregon, extension livestock agent.

Table 8. Estimated Annual Costs and Revenues Per Acre Based on 1978 Prices: "With Project", Wolf Creek Project.

	Barley ($)	Wheat ($)	Alfalfa ($)	Pasture ($)
CULTURAL OPERATIONS				
Amortized establishment			8.91	5.08
Mold board plow	7.53	7.53		
Disc	5.56	5.56		
Fertilizer	18.20	18.20	30.10	15.70
Harrow	2.87	2.87		
Drill	16.27	10.07		
Spray	9.50	9.50		9.50
Irrigate	12.41	12.41	18.17	13.41
Clip				3.50
HARVEST OPERATION				
Bale and haul			87.50	
Combine and haul	14.00	14.00		
OTHER CHARGES				
Truck	7.86	9.43	5.24	
Pickup	7.78	7.62	6.21	4.66
Fence				3.00
Tax on land	7.00	7.00	7.00	7.00
Operating capital interest @ 9%	2.35	4.36	4.21	1.82
General overhead @ 3%				
TOTAL COST PER ACRE (excluding management, water, and land)	114.67	111.81	172.36	65.58
1979 Value[a]	(130.90)	(127.64)	(196.76)	(74.86)
GROSS REVENUE PER ACRE	186.34	227.50	294.90	67.50
1979 Value[a]	(201.10)	(245.52)	(318.26)	(72.85)
NET REVENUE PER ACRE	70.20	117.88	121.50	-2.01
WEIGHTED NET REVENUE PER TYPICAL FARM[b]	7,020.00	11,788.00	21,262.50	-251.25
TOTAL NET REVENUE PER TYPICAL FARM				$39,819.25
AVERAGE NET REVENUE PER ACRE = $\frac{\$39,819.25}{500}$				$ 79.64

a/ The values in parentheses and the net revenues are expressed in 1979 prices.

b/ For the desciption of a "typical farm" see Table 5.

Table 9. Estimated Costs and Revenues Per Acre Based on 1978 Prices: "Without Project", Wolf Creek Project.

	Barley ($)	Wheat ($)	Alfalfa ($)	Meadow Hay ($)	Pasture ($)
CULTURAL OPERATIONS					
Amortized establishment			10.21		7.08
Mold board plow	7.53	7.53		7.53	
Disc	5.56	5.56		5.56	
Fertilizer	11.20	11.20	30.10	10.00	15.70
Harrow	2.87	2.87		3.16	
Drill	9.37	8.67			
Spray	9.50	9.50			9.50
Irrigate	5.37	5.37	8.85	8.85	8.85
Clip					3.50
HARVEST OPERATION					
Cut-stack hand haul				22.50	
Bale and haul			52.50		
Combine and haul	14.00	14.00			
OTHER CHARGES					
Truck	7.86	9.43	5.24	2.62	
Pickup	7.78	7.55	6.21		4.66
Fence					3.00
Tax on land	7.00	7.00	7.00	7.00	7.00
Operating capital interest @ 9%	1.84	3.66	3.00	2.76	1.75
General overhead @ 3%	2.70	2.80	3.69	2.10	1.83
TOTAL COST PER ACRE (excluding management water, and land)	92.58	95.25	126.80	72.08	62.87
1979 Value[a/]	(109.68)	(108.73)	(144.74)	(83.28)	(71.76)
GROSS REVENUE PER ACRE	139.75	195.00	176.94	67.50	49.50
1979 Value[a/]	(150.82)	(210.44)	(190.95)	(72.85)	(53.42)
NET REVENUE PER ACRE	45.14	101.71	46.21	-10.43	-18.34
WEIGHTED NET REVENUE PER TYPICAL FARM[b/]	2,257.00	10,171.00	5,776.25	-782.25	-2,751.00
TOTAL NET REVENUE PER TYPICAL FARM					$14,471.00
AVERAGE NET REVENUE PER ACRE = $\frac{\$14,471}{500}$ =					$ 29.34

a/ The values in parentheses and the net revenues are expressed in 1979 prices.

b/ For the description of a "typical farm" see Table 5.

Benefits of the Wolf Creek Project

Primary Benefits

Primary benefits are the difference between the average net return per acre with and without the project. For example, it was estimated in the previous tables that the net return per acre with the project is \$79.64 versus \$29.34 without the project. The difference between the two -- \$50.30 or (\$79.64 - 29.34) -- represents the primary benefit per acre irrigated. Total primary benefits are the product of the per acre benefit and the number of acres serviced by project water. Some 13,407 acres receive either full or supplemental water from Wolf Creek Reservoir.[8/] Thus, total annual primary benefits were estimated to be \$674,372 (\$50.30 per acre times 13,407 acres).

The supplemental water requirement varies widely from season to season and from one grower to another during the same season. Before the project was built, growers held water rights that allowed them to fully or partially irrigate their land. Because these rights still exist under the project, the need for water varies from one grower to the next depending on the extent and nature of his right. While these differential needs for irrigation water were easily recognized, their actual measurement turned out to be a tedious task. In order to determine an annual average water requirement in the area, it was assumed that with water rights before the project, there was sufficient water available to produce according to the "without project" typical farm scheme on the 13,407 acres. This is not an unreasonable assumption since, according to the returned

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8/ The estimate of number of acres irrigated was provided by North Powder Water Control District officials.

questionnaires, about 60 percent of the acres currently irrigated were under irrigation before the project.

Secondary Benefits

The secondary benefits or impact on the local economy were evaluated in terms of the total change in local household income as a result of the project. Assuming that the project did not induce any structural change in the county economy, the Union County "1974 Input-Output Model", was used to derive the secondary benefits of the project [Obermiller, 1977].

Use of the input-output model requires the determination of the level or change in total sales or exports by the agricultural sector attributable to the project. According to area farmers, the small grains produced are sold in Portland (wheat) or in Idaho and Washington (barley). Alfalfa hay is partially used to feed local livestock (one-half) and partially exported as baled hay. The pasture is grazed by livestock in cow-calf operations. Farmers export the calves to Idaho and Washington feedlots.

The increase in total sales by the typical farm, shown in Table 10, was derived by multiplying the increased outputs produced with the project (the difference between the output with and without the project) by output prices. The increase in the livestock herd was derived using the additional AUMs produced with the project and assuming that a 1,000 pound cow-calf unit consumes 12 AUM/year and that one bull needs 15 AUM per year. Also assumed was a 90 percent calf crop, 10 percent replacement rate, two percent death loss, one bull for 20 cows, and a four-year life for the

Table 10. Increased Total Sales Per Typical Farm, By Enterprise, Wolf Creek Project.

Products	Quantities Produced: With Project	Without Project	Changes	Prices	Changes in Gross Revenues
Barley	200.0 t	75.0 t	125 t	93.17/t	$11,646.25
Wheat	7,000.0 bu	6,000.0 bu	1,000 bu	3.25/bu	3,250.00
Alfalfa hay (baled)	437.5 t	187.5 t	250 t	58.98/t	14,745.00
TOTAL AUMS	2,250.0 AUM	1,725.0 AUM	525.0 AUM		
Pasture	937.5 AUM	825.0 AUM	112.5 AUM		
Alfalfa hay[a/]	1,312.5 AUM	562.5 AUM	750.5 AUM		
Meadow hay		337.5 AUM	-337.5 AUM		
Livestock[b/]					
Steer calves (450 lb.)			18	.40/lb	3,240.00
Heifer calves (425 lbs)			14	.34/lb	2,023.00
Cull cows (1,000 lbs)			3	.26/lb	780.00
Cull bulls (1,300 lbs)			½	.338/lb	219.70
TOTAL[c/]					$35,903.95 ($40,807.90)
AVERAGE GROSS REVENUE PER ACRE	$\frac{40,807.90}{500} = \$81.62$				

a/ One ton of hay is equivalent to 3 AUM.

b/ Based on 90 percent calf-crop, 10 percent replacement rate, 2 percent death loss of cows, 1 bull for every 20 cows and 4-year life stand for the bulls.

c/ The value in parentheses and the average gross revenue per acre are expressed in 1979 prices.

bulls.[9/]

From additional total sales per typical farm was derived an average gross revenue per acre ($81.62) which, when multiplied by the total acres irrigated (13,407), yielded the total annual sales or exports of the agricultural sector in the Wolf Creek project ($1,094,279.30) as shown in Table 11. The 1974 values presented in the second column of Table 11 are the 1979 adjusted values, an adjustment necessary when using an input-output model that was derived at an earlier time. To obtain the 1974 values, the total sales and the budget primary benefits are deflated by the indices of prices received by farmers, respectively, for all farm products and for all crops. Water charges are deflated by the index of prices paid by farmers.

Table 11. Values Used in Deriving the Secondary Benefits Attributable to Irrigation, Wolf Creek Project.

	Index Number (1967 = 100)	
	Actual Values (1979 $)	Deflated Values (1974 $)
Increased total sales	$1,094,279.30	$901,703.81
Budget primary benefits	674,372.10	677,465.55
Water charges (assessment)	195,313.76	131,875.85
Budget primary benefits (excluding water assessment)	479,058.34	545,589.70

The product of the total sales in 1974 prices ($901,703.81) and the household technical coefficient from the direct coefficient matrix of the

[9/] These assumptions are based on data developed by Robert Sterling and Gene Nelson in cooperation with ranchers in Baker County, February 1973.

input-output model gives the value of the "input-output primary benefits": \$901,703.81 x .14322 = \$129,141.95.[10/] The product of the total sales and the household coefficient from the direct and indirect coefficient matrix gives the total impact of the project on county household incomes: \$901,703.81 x .4879 = \$439,941.29. The difference between that total impact and the I-O primary benefits represents the benefits that accrue to households other than the farmers' (indirect benefits): \$439,941.29 - \$129,141.95 - \$310,799.34. The difference between the budget primary benefits (excluding water assessment) and the I-O primary benefits represents an excess primary benefit that acfrues to the farmers but is not measured by the I-O model: \$545,489.70 - \$129,141.95 = \$416,447.75.[11/] Assuming the farmers spend this "excess income" like any other household in the county, their expenditures can create secondary benefits equal to the product of the final demand and the household coefficient from the inverse matrix: \$416,447.75 x .34468 = \$143,541.21.[12/]

Finally there also are secondary benefits that arise from the district expenditures of the water assessment for operation and maintenance expenses within the county. These benefits equal \$2,076.55 (see Appendix for details). Therefore, the total secondary benefits generated by the project (in 1974 prices) are equal to \$310,799.34 + \$143,258.03 + \$2,076.55 = \$456,133.92. Inflated back to 1979 prices using the consumer

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10/ Technically, the input-output primary benefit is the product of the relevant direct coefficient and the gross output--not the final demand. However, here the final demand can be used to approximate the gross outputs.

11/ A detailed discussion of how the excess income arises appears in the methodology section, c.f. <u>ante</u>, pp. 37.

12/ The coefficients used above are reported by Obermiller, 1977, pp. 61-62.

price index,[13/] the secondary benefits become $\frac{\$456,133.92 \times 225.4}{142.8}$ = $719,976.08.

Other Benefits

The structural measures adopted for the Wolf Creek Project were expected to give rise to erosion control and energy saving benefits. In an era of general concern with environmental issues, as well as the costs and availability of energy, there is no doubt that an irrigation system with resource (energy, environment) saving measures will assume special importance not only to farmers but also to the general public. However, no attempt had been made in this study to quantify the actual energy saving and erosion control benefits because the resources available for the study did not permit such quantifications.

In order to evaluate the benefits from the energy saved by the use of the gravity pressurized pipeline system in the Wolf Creek Project, the actual system must be compared to a least-cost and feasible alternative measure that may require energy to provide the same service to the farmers. The description of such a system would not be an easy task. Engineering studies would be needed to determine what other system can be put in place in the project area. However, as a first approximation it is likely that another system of water delivery from the Wolf Creek Reservoir to its places of use would consist of open canals and ditches. The construction costs as well as the operation and maintenance for such a system likely would differ from the comparable costs for the current

13/ The Consumer Price Index instead of the Farm Price Index is used to inflate the secondary benefits because the latter accrue to households other than the farmers. 225.4 and 142.8 represent, respectively, the 1979 and 1974 Consumer Price Index values.

system. There would be greater losses of water due to seepage and evaporation than obtained with the current system.

Farmers would have several options about the manner in which they would apply the water. Some would pump from open ditches to pressurize a sprinkler system, others would use flood irrigation. There is also the possibility that some currently irrigated land would remain dry due to (1) lack of water, or (2) the economic infeasibility of irrigation when a combination of pump and sprinkler represents the only technically possible alternative.[14/]

In short, the outcome of an alternative to the pressurized distribution system is very difficult to predict. It would depend on the design features of the alternative system, how farmers would be affected by the costs of that system, and how they would appraise the benefits and costs under their own individual circumstances of the various irrigation schemes available to them. A prediction of the outcome would require detailed engineering and economic studies which were not feasible within the limits of the present inquiry. Instead, the principal focus has been the performance of agricultural production in the watershed with the project as compared to without project conditions.

A second reason and probably the most decisive for not pursuing the evaluation of the energy saving benefits is that, for the purpose of ex post evaluation, the benefits of resources saved (energy in this case) will be reflected in the estimates of primary and secondary benefits in the form of cost savings computed in the crop budgets. Furthermore, to the extent that the pressurized distribution system allows for the irrigation

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14/ Lack of water could be due to increased seepage and evaporation in the distribution system and/or to higher per acre water requirements on some lands irrigated by flooding.

of a larger number of acres than would be possible under an alternative system, this also is reflected in the estimates of both primary and secondary benefits.

With regard to erosion control benefits stemming from irrigation development at Wolf Creek, to the extent that the existing system only eliminates or reduces production costs which farmers had to incur previously because of soil erosion, these already would have been considered in the primary benefit evaluation for the same reason as the energy saving case discussed previously. However, if the project has prevented a long-term deterioration in agricultural land productivity, such effects may not be reflected in the proposed measurement of primary and secondary benefits. Their quantification would require not only a prediction of the changes in land productivity which would take place over time, but also an evaluation of the cost of alternative erosion control measures to prevent them. Once again, the resources of this study did not allow such an evaluation.

Summary

The nature of the irrigation development of Wolf Creek lends itself to the conservation of energy and water. The project also is likely to contribute to the achievement of soil conservation objectives. The economic impacts which were evaluated amounted in 1979 dollars to \$674,372 per year accuring to farmers as primary beneficiaries, and to \$719,976 in household income received by others in the local economy.

In the next chapter, these observed results are compared to the *ex ante* estimates of benefits and to the actual costs of developing the Wolf Creek Project. A general conclusion and some thoughts about the possible limitations of the thesis also are presented.

CHAPTER V

SUMMARY AND CONCLUSIONS

The Wolf Creek Project has been in operation for only five years, and yet its estimated benefits have largely exceeded every expectation. The original estimate of project benefits was made in 1966. According to this *ex ante* projection, the project was expected to generate an annual income of $210,090 (in 1966 dollars) to the households in Union County. Eighty-five percent of the annual income (about $179,760) would be in the form of irrigation benefits and the remaining 15 percent would be recreation and flood control benefits. From the *ex post* evaluation, however, the estimated annual income that accrues to Union County households, suppliers of the primary factors of production, amounted to $665,726 (in 1966 dollars) of which $659,765 (99 percent) were irrigation benefits.

The project has not only contributed to the achievement of conservation objectives (soil, water, and energy) but also can be argued to have provided psychological benefits to the irrigators. Although these benefits may be incorporated in the monetary gains experienced by the area farmers and in the form of subsequent secondary benefits in the local economy, they are nonetheless worth mentioning. These benefits are related to the stabilization of income experienced by area farmers as a result of the constant availability of water. The farmers are more likely to make long-term plans, to borrow against their future earnings. In the eyes of lenders, these farmers are a "better risk" than they were without the project.

On the cost side, the Wolf Creek Project has proven to be equally efficient. Contrary to the initial cost estimates presented in the Work

Plan, the project cost $1,200,000 (in 1966 dollars) was less than planned. The *ex post* benefit-cost ratio is consequently more significant than as estimated *ex ante*. Even at a ten percent discount rate which reflects the economic conditions of 1979 more nearly than those of 1966, and moreover which is three times larger than the 3.125 percent rate used when the project was planned in 1966, the *ex post* benefit-cost ratio is about 2.77 versus the *ex ante* estimate of 1.5. At a four percent discount rate which is comparable to the actual 1966 conditions, the *ex post* benefit-cost ratio jumps to 6.79 leaving no doubt as to the relative cost efficient of the project.

A principal explanation of the increased attractiveness of the project lies in the amendments introduced in the project design during the construction phase. The general use of a gravity pressurized pipeline distribution system at the district level, and the sprinkler irrigation system at the farm level, have led to: (1) a reduction in construction and operation and maintenance costs; (2) increased efficiency in water distribution and use; (3) increased productivity per acre irrigated; and (4) increases in total benefits. The trends are likely to continue in the future because it can be assumed that, since the project is still recent, the irrigators have not yet acquired all the skills it takes to make the best use of the new technology. Additional efficiencies may be realized as experience with sprinkler irrigation is acquired, and as local farmers find the best crop rotation that will maximize their income. In short, net benefits can be expected to increase further as managerial skills improve.

Even though the above results suggest rather conclusively that the Wolf Creek Project can be considered a good investment, there remains one important question that needs to be resolved before any remaining doubt about the efficiency of the project can be discarded. This is related to the possibility of overstatement of the benefits resulting from misuse of the evaluation procedures.

The methodology used in this study has been carefully elaborated to avoid such a drawback. It is also fairly consistent with the Water Resource Council (WRC) new Principles and Standards (December 1979) which "address the common errors of attributing to water the return to other scarce resources such as risk capital, specialized labor or management, or institutional constraints" [Duffield, J.W., 1980].

To reduce these errors, the Principles and Standards require that irrigation benefits from shifts in land use be limited to increased returns on low net income crops of which "outputs are seldom restricted by factors other than the availability of land and water" [Duffield, J.W., 1980]. There are ten crops recognized in this category and they are: cotton, wheat, barley, corn, milo, oats, pasture, rice, soybeans, and hay. If the underlying WRC argument is true, then the benefits estimated in this study for the Wolf Creek Project area, where only low net income crops (alfalfa hay, pasture, wheat, barley) are grown, cannot be an overstatement of the return to project water since land does not appear to be a limiting resource in the project area.

Relative to secondary benefits, some might question the size of the estimated impacts. Compared with the _ex ante_ estimates which were simply taken as a given percentage of the production costs and revenues, the _ex post_ estimates seem in fact very large. However, they are consistent with the input-output analysis used to derive them. The input-output model is more reliable than the "magic proportion" method used in the *ex ante* evaluation. Of course, the input-output model also has its limitations that are embodied in the underlying assumptions (linearity and constant technology) that do not allow factor-factor or product-product substitution to take place as economic conditions change. This means that in using an input-output model established in a prior time period to estimate secondary impacts, the prevailing interactions in the economy may be misrepresented. Even with these limitations, input-output models have definite advantages over the use of arbitrary proportions to estimate the secondary impacts of projects.

The prime objective pursued in this study was to evaluate the overall impacts that the project has had on the local economy. By strictly pursuing this objective, some important issues may have been overlooked, while others may have seemed to receive too much attention. It is true that the study did not address issues related to cost-sharing and the distribution of benefits among the project users. How have the user groups or beneficiaries actually shared in the burden of the project costs? Nor have questions involving efficiency in water application at the farm level and water pricing at the district level been explored. Does the water pricing system reflect the irrigator's willingness to pay for water? Does it lead to efficiency and conservation in water application? What should be the optimum level of water use?

Questions dealing with optimality in the project area crop mix have been sidestepped. Are the existing crop rotations maximizing the farmers' income? What is the optimum crop combination on a 500 acre typical farm unconstrained with respect to existing crops and acreages? Given the actual allocation of land to various crops, what is the marginal revenue of each crop and what are the returns, by crop, to the factors of production?

All these unexplored issues and others have normative connotations, and answers to them could help farmers make better management decisions. Does the failure to address them make any less meaningful the conclusions of this thesis? Probably not, because the results presented here do not constitute an end in themselves. Instead, the problem defined, procedures followed, and results attained are a stepping stone to more comprehensive evaluations of the performance of existing projects in order to learn more about resource development forces and to improve future resource planning process.

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APPENDIX

APPENDIX

Machinery and Equipment Cost Calculations

The machinery and equipment costs used in the crop budgets include ownership and operating costs for tractors and other items of farm equipment used in the production process. The ownership cost is the sum of interest on investment, depreciation, taxes, and insurance paid on the equipment. These costs generally are fixed and do not depend on the rate of use of the equipment. Depreciation, although regularly interpreted as a fixed cost, is influenced by use. In fact, depreciation is defined as the loss in value due to wear which is a function of use, obsolescence, and age (see Table A-1). It can be estimated by the formula:

$$\text{Depreciation} = \frac{\text{Purchase value X (100 - RFV)}}{\text{Age of Machinery}}$$

where RFV stands for "remaining farm value", or salvage value, and is expressed as a percentage of the new cost of the equipment as of the end of the equipment's useful life. The RFV values used in this report are derived from the "Farm Business Management Reports" published by Washington State University [1978, p. 4]. The sum of interest on the investment, insurance, and taxes (ITT) is calculated as the product of the "average investment value" and the sum of insurance at 0.7 percent, property tax at 1.1 percent, and interest on investment at 9.0 percent (summing to 10.8 percent). The total charge is given by the formula:

$$\text{ITT} = \frac{\text{Purchase value (PV) + (PV x RFV)}}{2} \text{ x .108,}$$

and it is assumed that all equipment was purchased in 1978. The purchase prices are derived from the Farm Business Management Reports and a linear

Table A-1. Machinery and Equipment Ownership Cost Calculations.

Item & Unit	Wheel Tractor (100 hp)	Mold Board Plow 4 - 16'	Offset Disk 16'	Harrow Spiketooth 8 - 5'	Drill 2 - 12'	4-Wheel Drive Pickup	2-Ton Truck
	Type of Equipment						
Purchase price ($)	26,069.50	4,087.00	6,933.30	4,500.00	8,500.00	6,700.00	14,000.00
Salvage value ($)	6,517.40	392.30	665.60	432.00	816.00	1,929.60	3,164.00
Average investment ($)	16,293.45	2,239.70	3,799.40	2,466.00	4,658.00	4,314.80	8,582.00
Year to trade	12	15	15	15	15	6	8
Hours of use	434	167	94	62.5	37.5	250	150
Depreciation ($)	1,629.30	246.30	417.80	271.20	512.20	795.00	667.20
Interest + tax + insurance ($)	1,759.70	241.80	410.30	266.33	503.10	466.00	926.80
Annual cost ($)	3,389.00	488.20	828.20	537.53	1,015.30	1,261.00	1,604.00
Hourly cost ($)	7.8	2.92	8.81	8.60	27.07	5.04	10.69
Repair and maintenance ($)	1.64	1.91	2.81	2.26	5.88	2.02	5.61
Fuel and lub ($)	3.56	0	0	0	0	3.50	4.91

relationship between price and the size of equipment is assumed when necessary.

The variable operating costs consist of the costs of equipment repair and maintenance, fuel, and lubrication. Repair and maintenance costs are very difficult to predict because of their dependence on working conditions and the type of work performed. Despite this variability, there are estimates available based on extensive surveys of machinery records kept by farmers and published in the 1977 Agricultural Engineers Yearbook (pp. 326, 333).[1/] These estimates are used to derive the repair costs in the present calculations.

The fuel and lubrication costs depend on the machine fuel consumption which in turn depends on the size of the engine. In addition, the type of fuel and the rate of machine use are largely determinant of the cost. The lubrication cost is usually estimated at 15 percent of the fuel cost. According to the Farm Business Management Reports [1978, p. 7], tractor fuel and lubrication costs (FL) often are estimated by the following formula:

$$FL = \frac{\text{hp x load factor x price per gallon}}{k} \text{ x } 1.15 \text{ x hours of use,}$$

where horsepower (hp) is for power take-off, and k equals 8.4 for gasoline engines and 11.2 for diesel engines. For 100 horsepower and above the load factor is assumed to be 75 percent. The gasoline price might also be variable among and even within regions. In this study, however, \$.46 per gallon is used to diesel fuel and \$.61 per gallon for gasoline.

1/ The Yearbook is published by the American Society of Agricultural Engineers.

Irrigation Equipment and Installation Costs

Irrigation equipment consists of the side roll sprinkler and main line on sprinkler irrigated farms, and irrigation channels on flood irrigated farms.

The typical farm in the project area uses quarter mile long side roll systems which can irrigate 240 acres. According to farmers' estimates, each such system costs \$5,000 - \$6,000 and there are five per typical farm. The capital investment equals \$27,500 per farm.

It is assumed that the system will have 20 years of life, that the salvage value will be zero at the end of the use life, that the buried main line represents one-third of the purchase value, and that it is not insured. The ownership and operating costs (Table A-2) are culculated on a per acre basis:

Depreciation: $\frac{27,500}{20} = \$1,375$

Interest: $\frac{27,500}{2} \times .09 = \$1,237.50$

Taxes: $\frac{27,500}{2} \times .011 = \$151.25$

Insurance: $\frac{27,500}{2} \times \frac{2}{3} \times .007 = \$64.17$

Total Ownership Cost = \$2,827.92

Ownership Cost Per Acre: $\frac{2,827.92}{500} = \$5.65$

The farmers estimate that each system costs \$100 per year in repair and maintenance. There is practically no energy consumption involved in the production process. Even though energy is required to move the system across the field, farmers state that the gasoline required for doing so is very small. Therefore, energy costs are not included in the operating costs, and the latter amount to $\frac{\$100 \times 5}{500} = \$1.00/\text{ac}$.

Table A-2. Ownership and Operating Costs.

Type of Equipment	Size	Hours of Use	Years to Trade	Ownership Cost[a] ($/hr)	Operating Cost[b] ($/hr)
Wheel tractor	100 hp	434	12	7.80	5.20
Mold board plow	4-16'	167	15	2.92	1.91
Offset disk	16'	94	15	8.81	2.81
Harrow spiketooth	40'	62.5	15	8.60	2.26
Drill disk	2-12'	37.5	15	27.07	5.88
Truck	2 t	150	8	10.69	10.52
Pickup--4 wheel drive	3/4 t	250	6	5.04	5.52
Side-roll system[c]	1/4 t		20	5.65	1.00
Flood irrigation channels[c]				1.77	.12

a/ Includes depreciation, interest on average investment at nine percent, taxes at 1.1 percent, and insurance at .7 percent.

b/ Includes fuel, oil, repairs, and maintenance.

c/ Ownership and operating costs are expressed in dollars per acre.

In flood irrigation production, land preparation and the construction of the distribution systems are generally the principal sources of expenses. The distribution system can be a simple earth ditch, wood, concrete, or even a pipeline. In the project area, the first type is most common. Besides the construction of corrugators need for on-farm distribution with contour irrigation, the area growers do not perform any major land preparation. They estimate that it takes about four hours at \$15 per hour for two persons and machines (tractor and plow) to prepare 40 acres, or \$1.50 per acre. The corrugators are constructed each year before the growing season, and therefore no maintenance cost is attached.

The main ditch is, on the other hand, constructed once and maintained forever. It is assumed for amortization purposes that the ditch has 50 years of use life. It takes eight hours at \$15 per hour for two people and machines to dig a ditch to service 40 acres, or \$3.00 per acre. By multiplying the per acre construction cost by .0912 (an amortization factor: based on an assumed payment period of 50 years at nine percent), the main ditch annual construction cost of \$0.27 per acre is obtained. Cleaning and maintenance costs also are derived from growers' estimates. Eight hours at \$25 per hour is spent every three or four years to clean and maintain the ditch servicing 500 acres in usable condition. The annual maintenance cost is then $\frac{\$25 \times 8}{3.5 \times 500} = \$0.12$ per acre.

Operating Capital Interest

Interest on operating capital also is included in production costs. The operating capital or outstanding cash expenses are determined by summing over all the cash expenses relative to hired labor, cultural and harvest operations, and tax on land, over the establishment and/or the production period. The following establishment and/or growing period assumptions, obtained from farmers in the project area, are used in calculating the interest on operating capital.

> Four months of outstanding cash expenses for barley and alfalfa in production years.
>
> Five months of outstanding cash expenses for pasture in production years.
>
> Seven months of outstanding cash expenses for pasture and alfalfa in the establishment year.
>
> Eight months of outstanding cash expenses for fall grain in production years.

It also is assumed that the alfalfa and pasture are harvested and grazed during the establishment year.

Crop Budgets

Tables A-3 to A-15

Table A-3. Wolf Creek Watershed, Irrigated Alfalfa Establishment, With Project, Estimated Cost Per Acres.

Assumptions: 175 Acre enterprise; 5 year life of stand; Hired labor $4.00/hr.; Operator labor $5.00/hr.; 100 Hp wheel tractor; Yield 2 tons/acre

Operation	Labor		Machinery & Equipment		Other		Total Cost
	Hours	Value	Operating Cost[a/]	Ownership Cost[b/]	Item	Cost	
		($)	($)	($)		($)	($)
CULTURAL OPERATIONS							
Mold board plow	.33	1.65	2.34	3.54			7.53
Disk (1.5X)	.188	.94	1.50	3.12			5.56
Fertilizer	.30	1.50			mtl.+appl.	29.10	30.60
Harrow (3X)	.15	.75	1.20	2.46			4.41
Drill	.074	.37	.82	2.58	seed	20.50	24.27
Irrigation (6X)	2.88	11.52	1.00	5.65			18.17
HARVEST OPERATIONS							
Bale stack & stack haul ($17.5/t)					custom	35.00	35.00
OTHER CHARGES							
Truck	.192	.96	2.01	2.05			5.02
Pickup	.300	1.50	1.65	1.51			4.66
Tax on land						7.00	7.00
Opt. cap. int. @ 9%						5.96	5.96
Overhead[c/]						4.44	4.44
TOTAL COST PER ACRE (excluding management, water & land)		19.19	10.52	20.91		102.00	152.62
Gross income 2t of hay @ $63.09/ton							126.18
Net cost for establishment							26.44
Amortized establishment cost (5 years @ 9%)							6.79

a/ Includes fuel, oil, repairs.

b/ Includes depreciation, interest on average investment at nine percent, taxes, and insurance.

c/ Estimated at three percent of all costs except land interest and management.

Table A-4. Wolf Creek Watershed, Irrigated Alfalfa Production, With Project, Estimated Cost Per Acre.

Assumptions: 175 acre enterprise; 5 year life of stand; Yield 5 tons/acre; Operator labor \$5.00/hr.; Hired labor \$4.00/hr.

Operation	Labor		Machinery & Equipment		Other		Total Cost
	Hours	Value	Operating Cost[a/]	Ownership Cost[b/]	Item	Cost	
		(\$)	(\$)	(\$)		(\$)	(\$)
CULTURAL OPERATIONS							
Fertilizer	.20	1.00			mat.+appl.	29.10	30.10
Irrigation (4X)	2.88	11.52	1.00	5.65			18.17
HARVEST OPERATIONS[c/]							
Bale stack & stack haul (\$17.5/t)					custom	87.50	87.50
OTHER CHARGES							
Truck	.20	1.00	2.10	2.14			5.24
Pickup	.40	2.00	2.20	2.01			6.21
Tax on land						7.00	7.00
Opt. Cap. int. @ 9%						4.21	4.21
Overhead[d/]						5.02	5.02
Amortized establishment						8.91	8.91
TOTAL COST PER ACRE (excluding management, water & land)		15.52	5.30	9.80		141.74	172.36

a/ Includes fuel, oil, repairs.

b/ Includes depreciation, interest on average investment at nine percent, taxes, and insurance.

c/ One-half of the product is balsed at \$20/ton while the other half is stacked by hand at \$15/ton.

d/ Estimated at three percent of all costs except land interest and management.

Table A-5. Wolf Creek Watershed, Irrigated Barley, With Project, Estimated Cost Per Acre.

Assumptions: 100 acre enterprise; Hired labor @ $4.00/hr.; Operator labor @ $5.00/hr.; Yield 2.0 tons/acre; 100 Hp wheel tractor

Operation	Labor		Machinery & Equipment		Other		Total Cost
	Hours	Value	Operating Cost[a]	Ownership Cost[b]	Item	Cost	
		($)	($)	($)		($)	($)
CULTURAL OPERATIONS							
Mold board plow	.33	1.65	2.34	3.54			7.53
Disk	.188	.94	1.50	3.12			5.56
Fertilizer	.20	1.00			mtl.+appl.	17.20	18.20
Harrow (2X)	.100	.50	.74	1.62			2.87
Drill	.074	.37	.82	2.58	seed	12.50	16.27
Spray					mtl.+custom appl.	9.50	9.50
Irrigation (4X)	1.44	5.76	1.00	5.65			12.41
HARVEST OPERATIONS							
Combine					custom	12.00	12.00
Haul					custom	2.00	2.00
OTHER CHARGES							
Truck	.30	1.50	3.16	3.20			7.86
Pickup	.50	2.50	2.76	2.52			7.78
Tax on land						7.00	7.00
Opt. cap. int. @ 9%						2.35	2.35
Overhead[c]						3.34	3.34
TOTAL COST PER ACRE (excluding management, water & land)		14.22	12.33	22.23		65.89	114.67

a/ Includes fuel, oil, repairs.

b/ Includes depreciation, interest on average investment at nine percent, taxes, and insurance.

c/ Estimated at three percent of all costs except land interest and management.

Table A-6. Wolf Creek Watershed, Flood Irrigated Pasture Establishment, With Project, Estimated Cost Per Acre.

Assumptions:	125 acre enterprise	Operator labor $5.00/hr.
	10 year life of stand	Hired labor $4.00/hr.
	yield 5.5 AUM/acre	100 Hp wheel tractor

Operation	Labor		Machinery & Equipment		Other		Total Cost
	Hours	Value	Operating Cost[a/]	Ownership Cost[b/]	Item	Cost	
		($)	($)	($)		($)	($)
CULTURAL OPERATIONS							
Mold board plow	.33	1.65	2.34	3.54			7.53
Disk (1.5X)	.188	.94	1.50	3.12			5.56
Fertilizer	.10	.50			mtl.+appl.	15.20	15.70
Harrow (3X)	.15	.75	1.20	2.46			4.41
Drill	.074	.37	.82	2.58	seed	6.80	10.57
Spray					mtl.+custom appl.	9.50	9.50
Irrigation (6X)	2.88	11.52	.12	1.77			13.41
OTHER CHARGES							
Fence						3.00	3.00
Tax on land						7.00	7.00
Opt. cap. int. @ 9%						3.09	3.09
Overhead[c/]						2.39	2.39
TOTAL COST PER ACRE (excluding management, water & land)		15.73	5.98	13.47		46.98	82.16
Gross income 5.5 AUM @ $9/AUM							49.50
Net establishment cost							32.66
Amortized establishment cost (10 years @ 9%)							5.08

a/ Includes fuel, oil, repairs.

b/ Includes depreciation, interest on average investment at nine percent, taxes, and insurance.

c/ Estimated at three percent of all costs except land interest and management.

Table A-7. Wolf Creek Watershed, Flood Irrigated Pasture Production, With Project, Estimated Cost Per Acre.

Assumptions: 125 acre enterprise; 10 year life stand; Yield 7.5 AUM/acre; Operator labor $5.00/hr.; Hired labor $4.00/hr.; 100 Hp wheel tractor

Operation	Labor: Hours	Labor: Value	Machinery & Equipment: Operating Cost[a/]	Machinery & Equipment: Ownership Cost[b/]	Other: Item	Other: Cost	Total Cost
		($)	($)	($)		($)	($)
CULTURAL OPERATIONS							
Fertilizer	.10	.50			mtl.+appl.	15.20	15.70
Irrigation (6X)	2.28	11.52	.12	1.77			13.41
Spray					mtl.+custom appl.	9.50	9.50
Clip					custom	3.50	3.50
OTHER CHARGES							
Fence						3.00	3.00
Pickup	.30	1.50	1.65	1.51			4.66
Tax on land						7.00	7.00
Opt. cap. int. @ 9%						1.82	1.82
Amortized establishment						5.08	5.08
Overhead[c/]						1.91	1.91
TOTAL COST PER ACRE (excluding management, water & land)		13.52	1.77	3.28		47.01	65.58

a/ Includes fuel, oil, repairs.

b/ Includes depreciation, interest on average investment at nine percent, taxes, and insurance.

c/ Estimated at three percent of all costs except land interest and management.

Table A-8. Wolf Creek Watershed, Irrigated Winter Wheat, With Project, Estimated Cost Per Acre.

Assumptions: 100 acre enterprise; Hired labor @ $4.00/hr.; Operator labor @ $5.00/hr.; Yield 70 bu./acre; 100 Hp wheel tractor

Operation	Labor		Machinery & Equipment		Other		Total Cost
	Hours	Value	Operating Cost[a/]	Ownership Cost[b/]	Item	Cost	
		($)	($)	($)		($)	($)
CULTURAL OPERATIONS							
Mold board plow	.33	1.65	2.34	3.54			7.53
Disk (1.5X)	.188	.94	1.50	3.12			5.56
Fertilizer	.20	1.00			mtl.+appl.	17.20	18.20
Harrow (2X)	.100	.50	.75	1.62			2.87
Drill	.074	.37	.82	2.56	seed	6.30	10.07
Spray					mtl.+custom appl.	9.50	9.50
Irrigation	1.44	5.76	1.00	5.65			12.41
HARVEST OPERATIONS							
Combine					custom	12.00	12.00
Haul					custom	2.00	2.00
OTHER CHARGES							
Truck	.36	1.80	3.78	3.85			9.43
Pickup	.49	2.45	2.70	2.47			7.62
Tax on land						7.00	7.00
Opt. cap. int. @ 9%						4.36	4.36
Overhead[c/]						3.26	3.26
TOTAL COST PER ACRE (excluding management, water & land)		14.47	12.99	22.83		61.62	111.81

a/ Includes fuel, oil, repairs.

b/ Includes depreciation, interest on average investment at nine percent, taxes, and insurance.

c/ Estimated at three percent of all costs except land, interest and management.

Table A-9. Wolf Creek Watershed, Flood Irrigated Alfalfa Establishment, Without Project, Estimated Cost Per Acre.

Assumptions: 125 acre enterprise; 5 year life of stand; Hired labor $4.00/hr.; Operator labor $5.00/hr.; 100 Hp wheel tractor; Yield 1.5 tons/acre

Operation	Labor		Machinery & Equipment		Other		Total Cost
	Hours	Value	Operating Cost[a/]	Ownership Cost[b/]	Item	Cost	
		($)	($)	($)		($)	($)
CULTURAL OPERATIONS							
Mold board plow	.33	1.65	2.34	3.54			7.53
Disk (1.5X)	.188	.94	1.50	3.12			5.56
Fertilizer	.3	1.50			mtl.+appl.	29.10	30.60
Harrow (3X)	.15	.75	1.12	1.29			3.16
Drill	.074	.37	.82	2.58	seed	20.50	24.27
Irrigation	.87	3.48	.12	1.77			5.37
HARVEST OPERATIONS							
Cut, bale, haul @ $17.5/t					custom	26.25	26.25
OTHER CHARGES							
Truck	.192	.96	2.02	2.05			5.03
Pickup	.30	1.50	1.65	1.51			4.66
Tax on land						7.00	7.00
Opt. cap. int. @ 9%						5.03	5.03
Overhead[c/]						3.73	3.73
TOTAL COST PER ACRE (excluding management, water & land)		11.15	9.57	15.86		91.61	128.19
Gross income: 1.5t of hay @ $58.98							88.47
Net cost for establishment							39.72
Amortized establishment cost (5 years @ 9%)							10.21

a/ Includes fuel, oil, repairs.

b/ Includes depreciation, interest on average investment at nine percent, taxes, and insurance.

c/ Estimated at three percent of all costs except land interest and management.

Table A-10. Wolf Creek Watershed, Flood Irrigated Alfalfa Production, Without Product, Estimated Cost Per Acre.

Assumptions: 125 acre enterprise; 5 year life of stand; Hired labor $4.00/hr.; Operator labor $5.00/hr.; 100 Hp wheel tractor; Yield 3 tons/acre

Operation	Labor		Machinery & Equipment		Other		Total Cost
	Hours	Value	Operating Cost[a]	Ownership Cost[b]	Item	Cost	
		($)	($)	($)		($)	($)
CULTURAL OPERATIONS							
Fertilizer	.20	1.00			mtl.+appl.	29.10	30.10
Irrigation (2X)	1.74	6.96	.12	1.77			8.85
HARVEST OPERATIONS							
Cut, bale, haul @ $17.5/t					custom	52.50	52.50
OTHER CHARGES							
Truck	.20	1.00	2.10	2.14			5.24
Pickup	.40	2.00	2.20	2.01			6.21
Tax on land						7.00	7.00
Opt. cap. int. @ 9%						3.00	3.00
Overhead[c]						3.69	3.69
Amortized establishment cost						10.21	10.21
TOTAL COST PER ACRE (excluding management, water & land)		10.96	4.42	5.92		105.50	126.80

a/ Includes fuel, oil, repairs.

b/ Includes depreciation, interest on average investment at nine percent, taxes, and insurance.

c/ Estimated at three percent of all costs except land interest and management.

Table A-11. Wolf Creek Watershed, Flood Irrigated Barley, Without Project, Estimated Cost Per Acre.

Assumptions: 50 acre enterprise — Yield 1.5 tons/acre
Hired labor $4.00/hr. — 100 Hp wheel tractor
Operator labor $5.00/hr.

Operation	Labor Hours	Labor Value	Machinery & Equipment Operating Cost[a/]	Machinery & Equipment Ownership Cost[b/]	Other Item	Other Cost	Total Cost
		($)	($)	($)		($)	($)
CULTURAL OPERATION							
Mold board plow	.33	1.65	2.34	3.54			7.53
Disk (1.5X)	.188	.94	1.50	3.12			5.56
Fertilizer	.20	1.00			mtl.+appl.	10.20	11.20
Harrow (2X)	.100	.50	.75	1.62			2.87
Drill	.074	.37	.82	2.58	seed	5.60	9.37
Spray					mtl.+appl.	9.50	9.50
Irrigation (2X)	.87	3.48	.12	1.77			5.37
HARVEST OPERATION							
Combine						12.00	12.00
Haul						2.00	2.00
OTHER CHARGES							
Truck	.30	1.50	3.16	3.20			7.86
Pickup	.50	2.50	2.76	2.52			7.78
Tax on land						7.00	7.00
Opt. cap. int. @ 9%						1.84	1.84
Overhead[c/]						2.70	2.70
TOTAL COST PER ACRE (excluding management, water & land)		11.94	11.45	18.35		50.84	92.58

a/ Includes fuel, oil, repairs.

b/ Includes depreciation, interest on average investment at nine percent, taxes, and insurance.

c/ Estimated at three percent of all costs except land interest and management.

Table A-12. Wolf Creek Watershed, Flood Irrigated Meadow Hay Production, Without Project, Estimated Cost Per Acre.[a/]

Assumptions: 75 acre enterprise; Yield 1.5 tons/acre; Hired labor $4.00/acre; Operator labor $5.00/hr.; 100 Hp wheel tractor

Operation	Labor		Machinery & Equipment		Other		Total Cost
	Hours	Value	Operating Cost	Ownership Cost	Item	Cost	
		($)	($)	($)		($)	($)
CULTURAL OPERATIONS							
Plowing	.33	1.65	2.34	3.54			7.53
Disk (1.5X)	.188	.94	1.50	3.12			5.56
Harrow	.15	.75	1.12	1.29			3.16
Fertilizer					custom	10.00	10.00
Irrigation (2X)	1.74	6.96	.12	1.77			8.85
HARVEST OPERATIONS							
Cutting, stack hand, haul ($15/t)					custom	22.50	22.50
OTHER CHARGES							
Truck	.10	.50	1.05	1.07			2.62
Tax on land						7.00	7.00
Opt. cap. int. @ 9%						2.76	2.76
Overhead[b/]						2.10	2.10
TOTAL COST PER ACRE		10.80	6.13	10.79		44.36	72.08

a/ Derived from the Enterprise Data Sheet established by Baker County Agent, Gus Markgraf and Farm Management Technologist, Stanley D. Miles in cooperation with Baker County rangers in February, 1971.

b/ Estimated at three percent of all costs except land interest and management.

Table A-13. Wolf Creek Watershed, Flood Irrigated Pasture Establishment, Without Project, Estimated Cost Per Acre.

Assumptions: 150 acre enterprise; 10 year life of stand; Yield 3.5 AUM/acre; Operator labor $5.00/hr.; Hired labor $4.00/hr.; 100 Hp wheel tractor

Operation	Labor		Machinery & Equipment		Other		Total Cost
	Hours	Value	Operating Cost[a]	Ownership Cost[b]	Item	Cost	
		($)	($)	($)		($)	($)
CULTURAL OPERATIONS							
Mold board plow	.33	1.65	2.34	3.54			7.53
Disk (1.5X)	.188	.94	1.50	3.12			5.56
Fertilizer	.10	.50			mtl.+appl.	15.20	15.70
Harrow (3X)	.15	.75	1.12	1.29			3.16
Drill	.074	.37	.82	2.58	seed	6.80	10.57
Spray					mtl.+custom appl.	9.50	9.50
Irrigation (2X)	1.74	6.96	.12	1.77			8.85
OTHER CHARGES							
Fence						3.00	3.00
Tax on land						7.00	7.00
Opt. cap. int. @ 9%						2.86	2.86
Overhead[c]						2.27	2.27
TOTAL COST PER ACRE (excluding management, water & land)		11.17	5.90	12.30		46.63	76.00
Gross income 3.5 AUM @ $9/AUM							31.50
Net establishment cost							45.50
Amortized establishment cost (10 years @ 9%)							7.08

a/ Includes fuel, oil, repairs.

b/ Includes depreciation, interest on the average investment at nine percent, taxes, and insurance.

c/ Estimated at three percent of all costs except land interest and management.

Table A-14. Wolf Creek Watershed, Flood Irrigated Pasture Production, Without Project, Estimated Cost Per Acre.

Assumptions: 150 acre enterprise; 10 year life of stand; Yield 5.5 AUM/acre; Operator labor $5.00/hr.; Hired labor $4.00/hr.; 100 Hp wheel tractor

Operation	Labor		Machinery & Equipment		Other		Total Cost
	Hours	Value	Operating Cost[a/]	Ownership Cost[b/]	Item	Cost	
		($)	($)	($)		($)	($)
CULTURAL OPERATIONS							
Fertilizer	.10	.50			mtl.+appl.	15.20	15.70
Spray					mtl.+custom appl.	9.50	9.50
Irrigation	1.74	6.96	.12	1.77			8.85
Clip					custom	3.50	3.50
OTHER CHARGES							
Fence						3.00	3.00
Pickup	.30	1.50	1.65	1.51			4.66
Tax on land						7.00	7.00
Opt. cap. int. @ 9%						1.75	1.75
Amortized establishment						7.08	7.08
Overhead[c/]						1.83	1.83
TOTAL COST PER ACRE (excluding management, water & land)		8.96	1.77	3.28		48.86	62.87

a/ Includes fuel, oil, repair.

b/ Includes depreciation, interest on average investment at nine percent, taxes, and insurance.

c/ Estimated at three percent of all costs except land interest and management.

Table A-15. Wolf Creek Watershed, Flood Irrigated Wheat, Without Project, Estimated Cost Per Acre.

Assumptions: 100 acre enterprise; Hired labor $4.00/hr.; Operator labor $5.00/hr.; Yield 60 bu./acre; 100 Hp wheel tractor

Operation	Labor		Machinery & Equipment		Other		Total Cost
	Hours	Value	Operating Cost[a/]	Ownership Cost[b/]	Item	Cost	
		($)	($)	($)		($)	($)
CULTURAL OPERATIONS							
Mold board plow	.33	1.65	2.34	3.54			7.53
Disk (1.5X)	.188	.94	1.50	3.12			5.56
Fertilizer	.20	1.00			mtl.+appl.	10.20	11.20
Harrow (2X)	.100	.50	.75	1.62			2.87
Drill	.074	.37	.82	2.58	seed	4.90	8.67
Spray					mtl.+custom appl.	9.50	9.50
Irrigation (2X)	.87	3.48	.12	1.77			5.37
HARVEST OPERATIONS							
Combine						12.00	12.00
Haul						2.00	2.00
OTHER CHARGES							
Truck	.36	1.80	3.78	3.85			9.43
Pickup	.49	2.49	2.70	2.47			7.66
Tax on land						7.00	7.00
Opt. cap. int. @ 9%						3.66	3.66
Overhead[c/]						2.80	2.80
TOTAL COST PER ACRE (excluding management, water & land)		12.23	12.01	18.95		52.06	95.25

a/ Includes fuel, oil, repairs.

b/ Includes depreciation, interest on average investment at nine percent, taxes, and insurance.

c/ Estimated at three percent of all costs except land interest and management.

Powder Valley Water Control District Data

Tables A-16 to A-18

Table A-16. Income Received by the Powder Valley Water Control District from Water Assessment, Wolf Creek Project.

Assessment	Wolf Creek Reservoir	Pipelines		Maharry-Blevins Ditch
		(W-1) + on-Farm	P-2	
Annual Construction Costs	$53,553.72	$54,753.50	$35,367.00	$2,576.27
Operation & Maintenance				
1977	20,000.35	2,499.76		2,500.44
1978	22,549.55	3,978.98	2,949.04	912.65
1979	11.066.62	6,369.19		
Average annual O&M	17,872.17	4,282.64	983.01	1,706.54
Total Assessment Costs[a]	71,425.89	59,036.14	36,350.01	4,282.81

Annual Total Revenue From Water Assessment to the District = $171,094.85

[a] Annual construction costs plus average annual O&M.

SOURCE: Operation and Maintenance Assessment Order -- Powder Valley Water Control District.

Table A-17. Powder Valley Water Control District Operation and Maintenance Expenditure Budgets, Wolf Creek Project.

	Year	
	1975-1976	1977-1978
Insurance	$ 124.00	$ 551.00
Payroll tax & W/H		984.90
Utilities	767.78	902.32
Operating supplies & costs		2,759.25
Insurance, liabilities	4,737.75	
Liab., errors & omission		6,931.25
Safe deposit box	6.00	
Repair & maintenance		4,127.57
Legal fees (attorney)	183.25	828.95
Accounting		2,484.32
Bookkeeping & travel	250.00	
Manager time & travel		5,442.09
Water assessment	103.56	
Property taxes		11.73
Oregon State		479.94
Miscellaneous		11.15
Engineering & survey		345.00
TOTAL	$6,172.34	$25,859.47

Source: Summary of transaction of the Power Valley Water Control District.

Table A-18. Operation and Maintenance Expenditures by the Powder Valley Water Control District, Wolf Creek Project, & induced Benefits.

Sources of Expenditures[a/]	1975-1976	1977-1978	Average Annual Expenditures		Secondary Benefits from Average Annual Expenditures[c/]
	$	$	(1978 $)	(1974 $)[b/]	(1974 $)
General Construction (sector 3)	---	4,127.57	2,063.78	1,590.11	1,590.11 x .13049 = 207.50
Transportation Communication and Utilities (sector 8)	1,121.34	6,344.41	3,732.87	2,877.21	2,877.21 x .12815 = 368.71
Legal, Engineering and Accounting (sector 11)	183.25	3,658.27	1,920.76	1,480.48	1,480.48 x .39132 = 579.34
Wholesale-Retail Trade (sector 13)	---	2,759.25	1,376.62	1,061.10	1,061.10 x .09288 = 98.55
Finance, Insurance and Real Estate (sector 14)	4,867.75	7,493.40	6,180.57	4,763.83	4,763.83 x .15765 = 751.02
Local, State and Federal Agencies (sector 16)	---	1,476.57	738.28	569.05	569.05 x .12553 = 71.43
TOTAL	6,172.34	25,859.47	16,015.88	12.341.73	2,076.55

a/ The operation and maintenance expenditures made by the district are derived from the district's annual budgets (see Table A-17) and grouped into sectors as defined in the 1974 Union County, Oregon, Input-Output Model (Obermiller, F.W., 1977, p. 57)

b/ The expenditures in 1974 prices are given by the following formula:

$$\text{Exp}(1974) = \frac{\text{Exp}(1978\ \$) \times 1974 \text{ price paid by farmers index } (168.8)}{1978 \text{ price paid by farmers index } (219)}$$

c/ The secondary benefit is the product of the final demand and the household indirect coefficient. This latter is the difference between the household direct and indirect coefficient and the household technical coefficient from the relevant sector.

Commodity Prices

Table A-19

Table A-19. Commodity Prices (Prices Received by Farmers) in Union County, Oregon.

Commodity & Unit	Year 1974	1975	1976	1977	1978	Average Price
Alfalfa ($/t)	61.3	62.8	63.5	60.3	47	58.98
Other hay ($/t)	42.2	48.2	45.3	46.2	39.1	45.00
Barley ($/t)	122.5	108.34	91.67	75.42	67.92	93.17
Wheat ($/bu)	4.15	3.77	2.44	2.65	3.22	3.25
Steer calves ($/lb)	.34	.30	.36	.40	.68	.40
Heifer calves ($/lb)	.30	.26	.30	.36	.58	.34
Cull cows ($/lb)	.24	.20	.25	.24	.37	.26
Cull bull ($/lb)	.35	.26	.33	.30	.45	.338
Irrigated pasture ($/AUM)						9.00

Source: Extension Economic Information Office, Department of Agricultural and Resource Economics, Oregon State University, Corvallis.

Land Use Survey Form

Wolf Creek Project

Questionnaire Number ____________

WOLF CREEK PROJECT LAND USE SURVEY

Dept. of Agricultural & Resource Economics
Oregon State University
Corvallis, OR 97331

June 1979

1. First of all we would like to ask you a few questions about your operation during 1978. In total, how many acres did you operate during 1978? ________ acres

2. How many acres did you irrigate using Wolf Creek Project water in 1978? ____________ acres

3. Did you grow BARLEY in 1978?* (check appropriate answer)

   ☐ Yes (continue) ☐ No (skip to question 4)

   a. How many acres of BARLEY did you grow in 1978 under sprinkler irrigation, flood irrigation, or dryland conditons?

      ________ acres sprinkler irrigated
      ________ acres flood irrigated
      ________ acres dryland conditions

   b. What was your BARLEY yield in 1978 under sprinkler irrigation, flood irrigation, or dryland conditions?

      _____ tons per acre sprinkler irrigated
      _____ tons per acre flood irrigated
      _____ tons per acre dryland conditions

4. Did you grow WINTER WHEAT in 1978? (check appropriate answer)

   ☐ Yes (continue) ☐ No (skip to question 5)

   a. How many acres of WINTER WHEAT did you grow in 1978 under sprinkler irrigation, flood irrigation, or dryland conditions?

      _____ acres sprinkler irrigated
      _____ acres flood irrigated
      _____ acres dryland conditions

   b. What was your WINTER WHEAT yield in 1978 under sprinkler irrigation, flood irrigation, or dryland conditons?

      _____ bushels per acre sprinkler irrigated
      _____ bushels per acre flood irrigated
      _____ bushels per acre dryland conditions

5. Did you grow SPRING WHEAT in 1978? (check appropriate answer)

   ☐ Yes (continue) ☐ No (skip to question 6)

   a. How many acres of SPRING WHEAT did you grow in 1978 under sprinkler irrigation, flood irrigation, or dryland conditions?

      _____ acres sprinkler irrigation
      _____ acres flood irrigation
      _____ acres dryland conditions

   b. What was your SPRING WHEAT yield in 1978 under sprinkler irrigation, flood irrigation, or dryland conditions?

      _____ bushels per acre sprinkler irrigated
      _____ bushels per acre flood irrigated
      _____ bushels per acre dryland condition

6. Did you grow ALFALFA in 1978? (check appropriate answer)

   ☐ Yes (continue) ☐ No (skip to question 7)

   a. How many acres of ALFALFA did you grow in 1978 under sprinkler irrigation, flood irrigation, or dryland conditions?

      _____ acres sprinkler irrigated
      _____ acres flood irrigated
      _____ acres dryland conditions

   b. What was your ALFALFA yield in 1978 under sprinkler irrigation, flood irrigation, or dryland conditions?

      _____ tons per acre sprinkler irrigated
      _____ tons per acre flood irrigated
      _____ tons per acre dryland conditions

7. Were CATTLE a part of your operation in 1978? (check appropriate answer)

   ☐ Yes (continue) ☐ No (skip to question 8)

   a. How many COWS did you have? _______ head

   b. How many CALVES did you have? _______ head

   c. How many YEARLINGS did you have? _____ head

   d. How many OTHER ANIMALS did you have? (please specify)

      ________ head of __________
      ________ head of __________
      ________ head of __________

8. Were any of your acres in PASTURE in 1978? (check appropriate answer)

   ☐ Yes (continue) ☐ No (skip to question 11)

   a. How many acres of PASTURE did you have under sprinkler irrigation, flood irrigation, or dryland conditions?

      _____ acres sprinkler irrigated
      _____ acres flood irrigated
      _____ acres dryland conditions

9. Was your PASTURE grazed in 1978 by: (check appropriate answer)

   ☐ Your CATTLE (continue)

   ☐ Someone else's CATTLE (skip to question 10)

   a. How many acres of PASTURE were grazed by your cattle? __________ acres

* This and the following questions apply only to your operation in the Wolf Creek Project Area.

b. How many COWS, CALVES, YEARLINGS, and OTHER ANIMALS grazed your pasture?

_____ head of COWS
_____ head of CALVES
_____ head of YEARLINGS
_____ head of others (please specify)

_____ head of _____
_____ head of _____
_____ head of _____

c. How many Months was the PASTURE grazed in 1978? ____________ months

10. Did you rent or lease out part or all of your pasture in 1978? (check appropriate answer)

☐ Yes (continue) ☐ No (skip to question 11)

a. How many acres of pasture did you rent or lease out? ________ acres

b. How many COWS, CALVES, YEARLINGS, and OTHER ANIMALS grazed the pasture you rented or leased out?

_____ head of COWS
_____ head of CALVES
_____ head of YEARLINGS
_____ head of OTHER (please specify) ____________

c. How many Months was the PASTURE you rented out grazed in 1978? __________ months

11. Did you grow any other crops in 1978?

☐ Yes (continue) ☐ No (skip to question 12)

What other crops did you grow in 1978? (Please list them - specify if possible acres and yield for each crop)

Crops	Acres	Yield

Now let us ask you some similar questions about your operation prior to the construction of the Wolf Creek Project, in a TYPICAL YEAR, say in 1974.

12. Were you operating your farm in the Wolf Creek Area before the construction of the Project?

☐ Yes (continue) ☐ No (you have completed this survey. Please mail it to us and accept our thanks for your help.)

13. How many ACRES were you farming in the Wolf Creek Project Area before the project was built?
_________ acres

14. Did you grow BARLEY before the Project on any of your acres in the Project Area? (check appropriate answer)

☐ Yes (continue) ☐ No (skip to question 15)

a. How many acres of BARLEY did you grow before the Project under sprinkler irrigation, flood irrigation, or dryland conditions?

_____ acres sprinkler irrigated
_____ acres flood irrigated
_____ acres dryland conditions

b. What was your BARLEY yield before the Project under sprinkler irrigation, flood irrigation, or dryland conditions?

_____ tons per acre sprinkler irrigated
_____ tons per acre flood irrigated
_____ tons per acre dryland conditions

15. Did you grow WINTER WHEAT before the Project on any of your acres in the Project area? (check appropriate answer)

☐ Yes (Continue) ☐ No (skip to question 16)

a. How many acres of WINTER WHEAT did you grow before the project under sprinkler irrigation, flood irrigation, or dryland conditions?

_____ acres sprinkler irrigated
_____ acres flood irrigated
_____ acres dryland conditions

b. What was your WINTER WHEAT yield before the Project under sprinkler irrigation, flood irrigation, or dryland conditions?

_____ bushels per acre sprinkler irrigated
_____ bushels per acre flood irrigated
_____ bushels per acre dryland conditions

16. Did you grow SPRING WHEAT before the Project on any of your acres in the Project area? (check appropriate answer)

☐ Yes (continue) ☐ No (skip to question 17)

a. How many acres of SPRING WHEAT did you grow before the Project under sprinkler irrigation, flood irrigation, or dryland conditions?

_____ acres sprinkler irrigated
_____ acres flood irrigated
_____ acres dryland conditions

b. What was your SPRING WHEAT yield before the Project under sprinkler irrigation, flood irrigation, or dryland conditions?

_____ bushels per acre sprinkler irrigated
_____ bushels per acre flood irrigated
_____ bushels per acre dryland conditions

17. Did you grow ALFALFA before the Project on any of these acres? (check appropriate answer)

☐ Yes (continue) ☐ No (skip to question 18)

a. How many acres of ALFALFA did you grow before the Project under sprinkler irrigation, flood irrigation, or dryland conditions?

_____ acres sprinkler irrigated
_____ acres flood irrigated
_____ acres dryland conditions

b. What was your ALFALFA yield before the Project under sprinkler irrigation, flood irrigation, or dryland conditions?

_____ tons per acre sprinkler irrigated
_____ tons per acre flood irrigated
_____ tons per acre dryland conditions

18. Were CATTLE a part of your operations before the Project? (check appropriate answer)

☐ Yes (continue) ☐ No (skip to question 19)

a. How many COWS did you have? _________ head

b. How many CALVES did you have? _______ head

c. How many YEARLINGS did you have? _______ head

d. How many OTHER ANIMALS did you have?
_________ head (please specify) __________
____
____
____

19. Did you maintain PASTURE before the Project on any of your acres in the Project Area? (check appropriate answer)

☐ Yes (continue) ☐ No (skip to question 22)

a. How many acres of PASTURE did you have before the Project under sprinkler irrigation, flood irrigation, or dryland conditions?

_____ acres sprinkler irrigated
_____ acres flood irrigated
_____ acres dryland conditions

20. Was your PASTURE grazed by your cattle before the Project? (check appropriate answer)

☐ Yes (continue) ☐ No (skip to question 21)

a. How many acres of PASTURE were grazed by your cattle? __________ acres

b. How many COWS, CALVES, YEARLINGS, and OTHER ANIMALS grazed the pasture?

_____ head of COWS
_____ head of CALVES
_____ head of YEARLINGS
_____ head of OTHERS (please specify) __________________
____
____

21. Did you rent or lease out part or all of your pastures before the Project? (check appropriate answer)

☐ Yes (continue) ☐ No (skip to question 22)

a. How many acres of pasture did you rent or lease out? ___________ acres

b. How many COWS, CALVES, YEARLINGS, and OTHER ANIMALS grazed the pasture you rented out?

_______ head of COWS
_______ head of CALVES
_______ head of YEARLINGS
_______ head of OTHERS (please specify) ______________
____
____

22. Did you grow any other CROPS in the Project Area before the Project was constructed?

☐ Yes (continue) ☐ No (You have completed this survey - Please mail it back to us and accept our thanks for your help.)

What other Crops did you grow in the Project Area before the Project (please list them, and specify if possible acres and yield for each crop).

Crops	Acres	Yield

Please us the addressed ~~standard~~ stamped envelope to return this questionnaire to us. Thank you very much for your help.