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STRUCTURE AND PERFORMANCE OF WESTERN IRRIGATED AGRICULTURE WITH SPECIAL REFERENCE TO THE ACREAGE LIMITATION POLICY OF THE U.S. DEPARTMENT OF THE INTERIOR

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STRUCTURE AND PERFORMANCE OF WESTERN IRRIGATED AGRICULTURE

WITH SPECIAL REFERENCE TO THE ACREAGE LIMITATION POLICY OF THE U. S. DEPARTMENT OF INTERIOR

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PART I

FRAMEWORK OF ANALYSIS

INTRODUCTION

This report is divided into three parts. Part I introduces the subject matter, provides a brief background statement, and concludes with an enumeration of the many assumptions and procedures used in the analysis. Part II presents, as a case study, a detailed analysis of one of the 18 irrigation districts included in the study—the Westlands Water District. A detailed analysis of all 18 districts is presented in a separate Appendix.[4] Part III summarizes results from all 18 districts and draws policy implications with respect to acreage limitation policy in the irrigated West.

Irrigated agriculture in the 17 western states encompasses the most diverse and energy-, capital-, and labor-intensive agricultural production in the United States. The 1978 U. S. Census of Agriculture reported over 50 million acres of irrigated farmland. A vast majority of this land, 86 percent, is located in the 17 western states. Average gross crop value per harvested crop acre is over two and one-half times greater on U. S. irrigated than on nonirrigated farms.

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The Bureau of Reclamation (BOR), U. S. Department of Interior, is the largest single developer of irrigation water in the western states. BOR provides partial or full water service to about 10.5 million acres of land or about 24 percent of all irrigated lands in the 17 western states. Remaining lands are supplied from privately and cooperatively owned wells, irrigation districts (user cooperatives), private diversions from lakes and streams, and state-operated water projects.

Passage of the Reclamation Act of 1902 ushered in the most expensive land settlement program in the history of the United States. Prior land settlement acts—The Homestead Act of 1862, The Timber Culture Act of 1873, The Desert Land Act of 1877, The Timber and Stone Act of 1878, and the Carey Act of 1894—all had as a major objective the opening of the public domain for settlement purposes. But the Reclamation Act of 1902 was the first act with a commitment for large public investment in the development of irrigation works, a vital input in an arid region if stable settlement opportunities were to be realized on a large scale.

Water greatly enhances the productivity and thus the market value of arid lands. Since water developed under these projects was to be provided interest free to both public and private lands, a significant subsidy was apparent from the beginning. The Act contained several antimonopoly and antispeculation clauses; foremost was the clause limiting ownership of land receiving federal water to 160 acres per owner. No limit was ever placed on ownership of land not receiving federal project water, nor has a limit ever been placed on the leasing of land from qualified owners. Over the years, the magnitude of the subsidy has grown as interest rates have increased. The repayment period has been gradually lengthened to 40 and in some cases 50 years, and the water districts came to be charged according to their ability to pay rather than for the full costs.

From the very beginning, federal irrigation water development has generated heated arguments polarizing the electorate. Congressional debate over the 1902 Act took on a regional flavor with easterners opposing the income transfer inherent in western water development through taxation of the more populated East. Proponents of the 1902 Act flavored their rhetoric with phrases such as "settlement opportunities would be created for people who are without homes" and its purpose "to furnish homes for the homeless and farms for the farmless" (U. S. Department of Interior, Water and Power Resources Service, 1981). It was this appeal to the Act's social promise which finally won the day.

In 1980, when a series of bills was introduced in Congress to modify the original Act, the debate took on a different tone. No longer was the contention over whether or not to build water projects in the West since few feasible projects still remained on the drawing boards. Rather, the argument of federal project water users was for loosening the acreage limitation based on the allegation that larger farms are more efficient. Continued application of ownership limits could, therefore, raise the cost of food, cause large acreages to eventually be abandoned, and inevitably increase the use of pesticides causing increased pollution to the rivers and streams of the West. At the other end of the spectrum, supporters of retaining acreage limits at or near their existing level put forth arguments based on equity and fairness considerations usually citing statements made by the drafters and supporters of the original Act.

It is interesting that neither of the polarized groups in the more recent debates spent much time or effort in supporting measures which would, in essence, do away with the subsidy. The heart of the dispute seems not to revolve around how large the subsidy has become but rather around who should be the recipients. Should the subsidy and the opportunity to farm in a federal water project be distributed as widely as reasonably possible, as the small farm proponents advocate, or should the distribution of subsidies be based on the prior distribution of wealth (land) allowing economic forces alone to select the ultimate beneficiaries?

OBJECTIVES

Specific policy questions arising from the above issues center on (1) the trade-off between economic efficiency (fewer but larger farms) and equity (many small farms) and (2) elimination of the subsidy by recapture through higher water prices. To analyze these questions for each of the 18 irrigation districts across the western states (Figure 1-1), specific objectives were formulated to: (1) describe the distribution of landownership and farm operating units, (2) estimate the income-generating potential (net cash flow) for farms of differing sizes, (3) estimate the long-run average cost (LRAC) curve or economies of size for farms, (4) estimate the relative riskiness of agricultural production, (5) estimate the derived demand schedule for irrigation water and to estimate the maximum ability to pay for it, and (6) analyze and discuss these results within the framework of the potential economic impact of farm structure policy with special reference to the Department of Interior's Acreage Limitation Policy. Due to the large volume of data and analysis for each of the 18 districts, results for only one—the Westlands—are reported in detail in this report. Data and results for all 18 districts are presented in the Appendix.

PROCEDURES

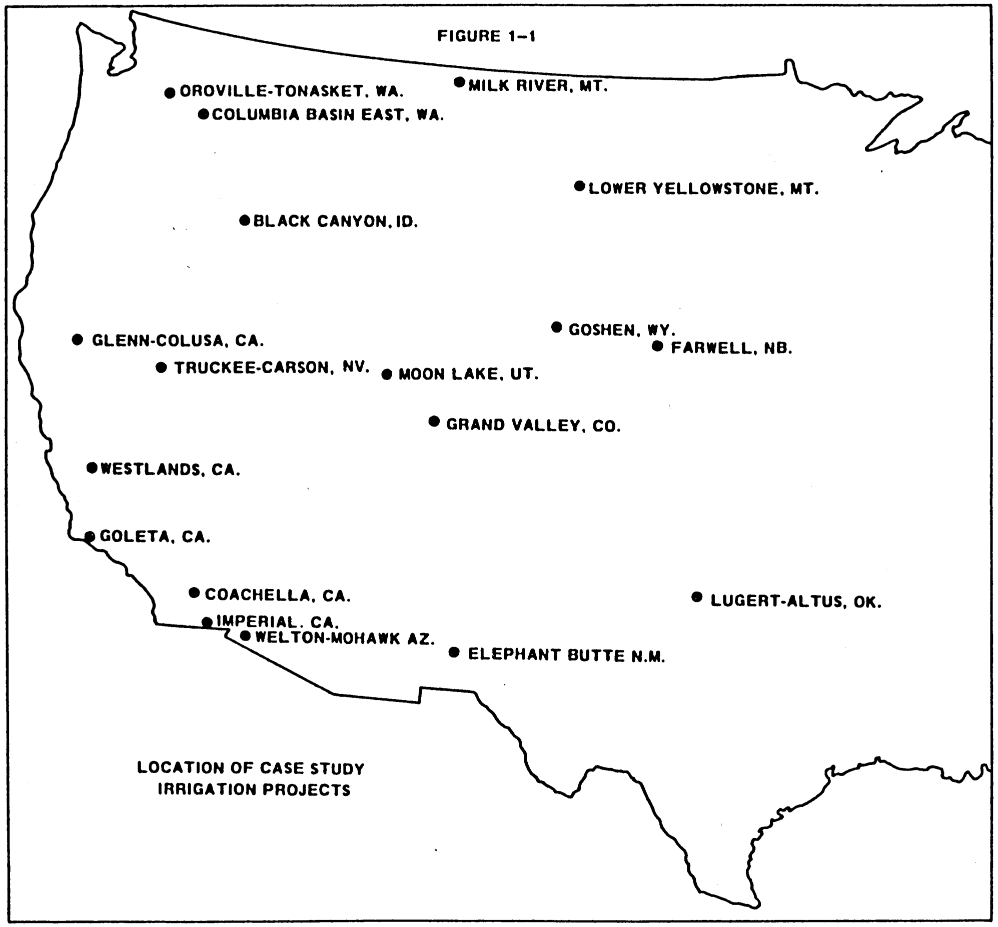
All of the 18 irrigation districts in this study have water service contracts with BOR; the data used were collected with the cooperation of BOR. The case-study districts were selected by the authors, jointly with BOR personnel, to represent the wide diversity of soils and agroclimatic areas in the 17 western states. Salient characteristics of the selected districts are presented in Table 1-1 and their approximate geographic location is shown in Figure 1-1.

A land tenure survey directed toward two target populations with the 18 districts was conducted. One population consisted of farm operators on irrigable farmland within the districts generating gross sales in farm products of $2,500 or more during 1978. The second population was the owners of the irrigable farmland in these districts. Farm operators are defined by business criteria; landowners are defined by legal criteria. These two target populations overlap but were treated independently in the survey.

Agricultural economic data were collected by research assistants using the following steps:

1. Collecting all available published and unpublished crop and farm budget information for each case-study district.
2. Developing a calendar of operations for each major crop grown in the district.
3. Collecting 1978 data on all input costs and machinery performance from available sources.

FIGURE 1-1



LOCATION OF CASE STUDY
IRRIGATION PROJECTS

Table 1-1

Characteristics of Irrigation Districts

District	State	1977 irrigated acres	Gross crop value per acre	Major crops		Growing season
		acres	dollars		percent	days
Black Canyon #2	ID	46,416	246	Forages Cereals	50 24	146
Coachella Valley	CA	78,500	2,169	Fruit Vegetables	48 21	310
Columbia Basin East District	WA	123,872	357	Forages Cereals Vegetables	38 30 10	140
Elephant Butte	NM	84,925	682	Cotton Forages Vegetables	37 19 19	194
Farwell	NB	50,051	184	Corn	87	149
Glenn-Colusa	CA	103,637	364	Rice Cereals	50 21	260
Goleta County	CA	6,390	5,788	Fruit	88	330
Goshen	WY	51,439	240	Forages Sugar beets	35 23	131
Grand Valley Gravity	CO	20,516	268	Forages Cereals	52 42	153
Imperial	CA	451,457	723	Alfalfa Cotton Vegetables	39 30 15	348
Lower Yellowstone	MT	29,035	214	Forages Sugar beets Cereals	34 32 27	130
Lugert-Altus	OK	44,832	241	Cotton Cereals	57 37	220
Milk River Malta	MT	42,432	62	Hay Pasture	42 19	106
Moon Lake	UT	51,983	34	Pasture Alfalfa	77 11	127
Oroville-Tonasket	WA	7,127	1,142	Fruit	94	173
Truckee-Carson	NV	57,530	159	Alfalfa Pasture	62 33	130
Welton-Mohawk	AZ	65,200	622	Alfalfa Cotton	30 27	348
Westlands	CA	477,404	527	Cotton Cereals Vegetables	40 22 10	272

Source: Crop reports of individual districts.

4. Preparing a preliminary crop budget for each crop.

5. Asking for review of these preliminary budgets by University, Bureau of Reclamation, and local Cooperative Extension personnel.

6. Forming a panel of four to five farmers representing a wide range of farm sizes to review the preliminary crop budgets and helping specify typical machinery complements and crop mixes for 160-, 320-, 640-, and 1,280-acre farms in each case-study district. The only exceptions were in tree crop districts where 40-, 80-, and 160-acre farms were analyzed.

7. Developing total farm budgets for each farm size.

8. Presenting typical farm budgets to the farmer panel for review and revision.

9. Submitting final budgets for standardization on the budget generator.

ASSUMPTIONS FOR FARM BUDGETS

Basic Specifications

Prices.—Water Resources Council (WRC) normalized prices were used as prices received by farmers in each state (U. S. Water Resources Council, 1978). They are the only consistent set of agricultural commodity prices available and were developed pursuant to the WRC Principles and Standards for Planning Water and Related Resources. For commodities not covered by WRC normalized prices, a three-year average of prices received by farmers was used; prices received were assumed constant for all farm sizes.

USDA Farm Programs.—Federal price-support programs were available in 1978. Provisions of these programs with respect to set-aside acreage for affected crops were included in the analysis if local program participation was typical in the particular district.

Yields.—District crop yields were based on the most recent three-year average of yields for irrigated crops in the district area as reported by the U. S. Economics, Statistics, and Cooperatives Service (ESCS) or BOR and were assumed constant for all farm sizes. Because crop yields used are statistical averages but the level of inputs—*e.g.,* fertilizer, irrigation water, pesticides—were specified by the farmer panel, which tended to have above-average management ability, the cost per unit of production may tend to be biased upward, but to an unmeasurable degree.

Input Costs.—Costs of production inputs (including fertilizer, irrigation water, labor, farm machinery, and land) were set at 1978 price levels. The quantities of these inputs were specified in the crop enterprise budgets and were reviewed by the farmer panels and local Cooperative Extension personnel.

Water Supply.—Typical cropping patterns were constrained by the total crop irrigation requirements and the expected normal water supply delivered to the farm headgate. Nonproject surface water and well water were included in the water supply calculations if they were available to the local farmer.

Interest Rate and Method of Depreciation.—Actual 1978 Production Credit Association and Federal Land Bank rates in each district were used to determine interest charges on operating capital, machinery, and land investments. For depreciable property, simple interest was charged on the amount of debt plus sinking fund depreciation was charged on the full original cost.

Amount of Debt.—Since the financial structure of the farm firm has a strong effect on financial feasibility (cash flow), two debt situations were considered. The first situation is for a "beginning farmer" where the farm has just been purchased with a minimum down payment. Minimum down payments required by local lenders (Federal Land Banks) ranged between 25 and 30 percent. The second situation is for a farm operator who has been in business for some time having purchased land at an earlier time at lower prices and interest rates. This "existing farmer" was assumed to have purchased land in 1958; machinery on average was five years old. Owner's equity was based on the *Balance Sheet of Farming Sector* (U. S. Economics, Statistics, and Cooperatives Service, 1978). Debt-asset ratios varied among states. Owner equity ranged from 74 to 94 percent as shown in Table 1-2.

Amortizing Debt on Land and Development Costs.—Instead of charging simple interest on land purchases and land development costs, the debt portions of these investments were amortized over the normal long—term real estate loan period for the area.

Land Values.—BOR regional offices provided 1978 appraised land values under two situations for use in the farm budgets:

1. Excess Land Value—the value of land in its most likely use without benefit of the federal water supply, based on the appraisal concepts contained in Interior's Proposed Rules and Regulations (U. S. Department of Interior, Office of the Secretary, 1979), plus the estimated on-farm land development costs at 1978 price levels for clearing, leveling, gravity irrigation systems, drainage, wells, and pumps representing typical 1978 levels of development.

2. The current market value of irrigated land with the federal project water supply.

Livestock Operations.—Although significant numbers of livestock are present in several of the case-study districts, livestock was excluded from consideration in all but two districts—Malta in Montana and Moon Lake in Utah. Crop production was considered the primary output of irrigated land and was valued at current normalized market prices. Costs for machinery used for both crop and livestock production were adjusted to reflect their use with crops only.

Dryland or Rangeland.—Nonirrigated land was included in the farm budgets when its use was considered typical by the farmer panel and local Cooperative Extension personnel.

Perennial Crops.—Orchard development and operating costs were determined by discounting these costs, over the life of the orchard, to their present value (worth). Gross crop revenues were handled in the same manner. Lump sum present value (worth) of these net incomes were then converted to annual equivalents (annuities) for comparison with annual crops in the enterprise budgets.

Table 1-2

Debt/Asset Ratio by State, 1978

State	Debt/asset ratio	Owner equity
	percent	
Arizona	14.6	85.4
California	25.7	74.3
Colorado	19.8	80.2
Idaho	21.3	78.7
Montana	16.9	83.1
Nebraska	18.1	81.9
Nevada	19.4	80.6
New Mexico	15.6	84.4
Oklahoma	17.5	82.5
Utah	12.6	87.4
Washington	17.8	82.2
Wyoming	16.8	83.2

Source: ESCS, Balance Sheet of the Farming Sector, Bulletin No. 411, June 1978.

Land Rental.—The proposed regulations limit leasing of project-served land by farm operators. For the study, all leases were converted to an annual cash rent to facilitate comparative analysis. Conditions of the lease, such as payment of real estate taxes and water costs, were taken into account if they were typical of the area. Most of the study districts showed that at 1978 prices and interest rates the annual cost of owning land exceeded annual cash rents. Such a disparity may exist primarily because of the time lag between current land prices and what this land will bring on the rental market and because land, like gold, is bid up by investors during period of inflation due to its nondepreciable nature. Income tax laws governing long-term capital gains tend to exacerbate this second problem. Consequently, a bias is created in favor of large farm operations because a higher proportion of their total land operated is cash rented.

Basis for Analysis of Cost Economies.—The theoretical basis for analysis of cost economies is illustrated in Figure 1-2, using the traditional average unit cost curves of the firm. The short-run average cost (SRAC) curves assume one or more resources to be fixed (a fixed "plant"), while other resources are variable; the LRAC curve assumes all resources are variable (including those designated as "fixed" in the short run). In this study the machinery complement specified by the farmer panel was designated as the resource assumed fixed in the short run. Thus, $SRAC_1$ illustrates the average cost per unit of output for different levels of output, assuming a fixed set of machinery, while land and other resources are variable. Curve $SRAC_2$ is a similar average cost curve based on a different fixed machinery combination composed of more and larger pieces of equipment. Curves $SRAC_3$ and $SRAC_4$ have similar interpretations for still larger fixed machinery combinations. This SRAC curve has a typical "U" shape: Average costs decline with an initial expansion of output as fixed costs are spread over more units; eventually, however, average costs per unit of output level off and then increase as other inputs must be added in increasing proportions to the fixed machinery combination in order to reach greater output levels.

From the standpoint of trends in farm size and survival of the firm, the LRAC curve is probably more relevant than are the short-run cost curves. The LRAC curve is an "envelope" formed as a tangency to the short-run cost curves. Thus, the LRAC theoretically represents the minimum cost for producing each quantity of output; in this sense the LRAC curve can be considered as a planning curve. In long-range planning, a farmer with sufficient funds could select any output point on the LRAC curve. Corresponding to this point is a particular machinery combination and associated levels of other inputs. Once this machinery complement has been selected, however, the LRAC is no longer relevant; the farmer is then restricted to the short-run cost curve corresponding to the machinery combination selected.

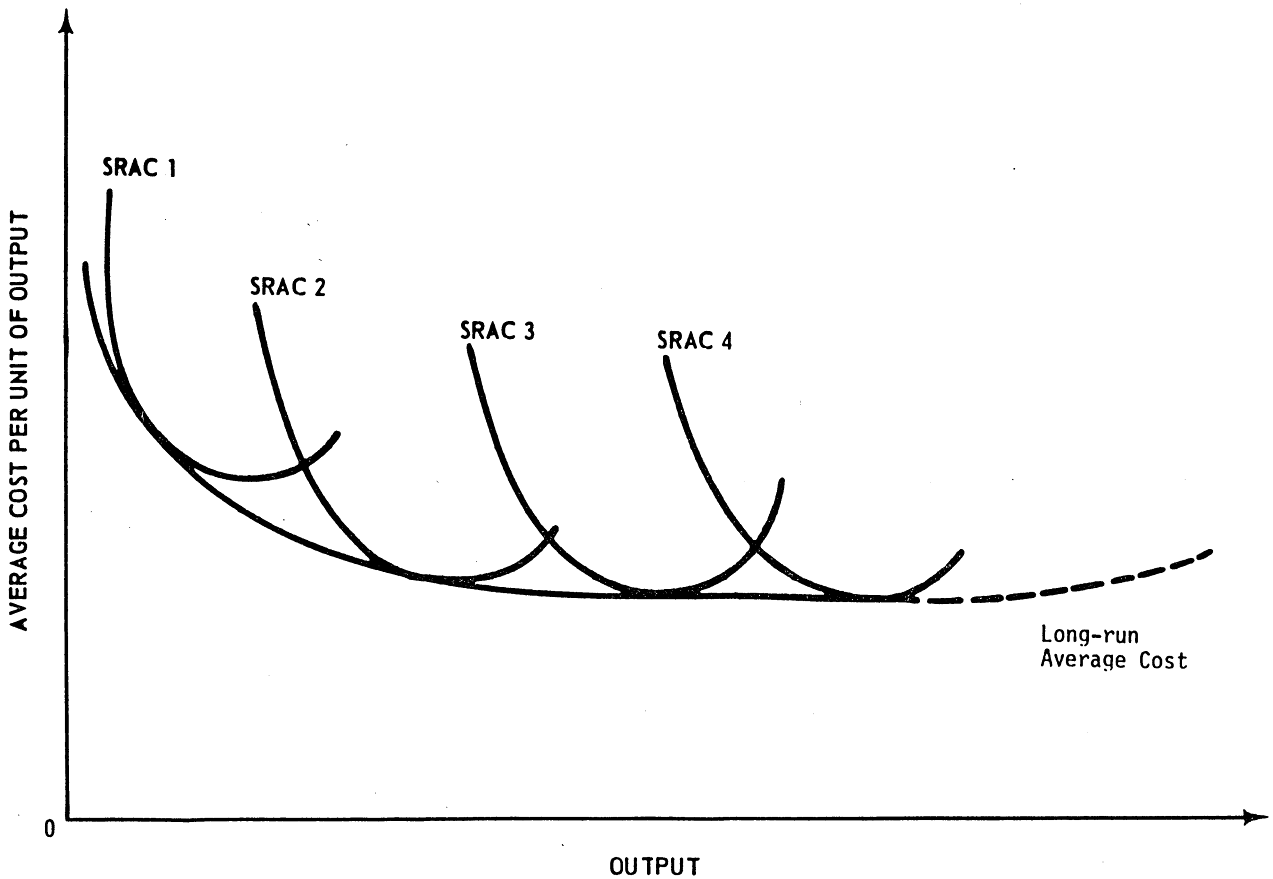
Measuring Output for Multiple-Product Farms

The multiple-product situation presents the problem of finding an appropriate measure of output, particularly when the product mix changes (is nonhomogeneous) as output expands. Without a measure of output, no meaningful average total cost surface exists, either conceptually or empirically.

In this study, product prices (P_i) are specified as weights on the i products Q_i, $i = 1, \ldots, n$, such that total revenue ($TR = \Sigma_{i=1}^{n} P_iQ_i$) becomes an index of output, and average total cost (ATC) is expressed as total cost (TC) per dollar of total revenue ($TC \div TR = ATC$). Given total revenue (TR) as a measure of output, comparisons can be

Figure 1-2

HYPOTHETICAL SHORT-RUN AND LONG-RUN
AVERAGE COST CURVES



made with ATC for any conceivable trace on the total cost surface. The break-even point is achieved when average total cost equals $1.00, or when the farmer receives $1.00 in revenue for each dollar of total cost.

Linear Programming Model

Linear programming was used to select the crop combinations and acreages which maximized the net income per dollar of operating capital subject to machinery capacity and certain agronomic and market constraints. With the machinery complement being the "fixed plant" for purposes of the SRAC, machinery capacity constraints were specified from the hours available during critical months to complete an operation. For example, a 12-foot, self-propelled combine is rated at 0.35 hours per acre. Assuming weather and crop conditions allow 20 working days at 8 hours per day, the machine's capacity is 160 hours ÷ 0.35 = 457 acres per year. An example of an agronomic constraint is the requirement that in some areas alfalfa be planted using wheat or barley as a nurse crop even though the latter was relatively unprofitable. Finally, constraints limiting acreage of high-valued (higher risk) crops to the current proportion of that crop in the district eliminated the possibility of overproduction which would depress market prices below those used in the study. Other than these acreage constraints on high-valued crops, land was not constrained. For a specific farm size and machinery complement, additional land was allowed to come under cultivation through cash leasing.

The economies-of-size analysis only covers technical economies, *i.e.,* spreading a fixed plant over more units of output. Pecuniary economies (market economies), usually associated with quantity discounts for large purchases of inputs or premium selling prices for commodities because of better access to market, are beyond the scope of this report.

Full-Cost Pricing

The basic crop and farm budgets used in the agricultural economic analysis were the starting point or baseline for this analysis. A panel of irrigation engineers, Extension workers, and farmers was convened in each area.[1] The panel was provided with published information on irrigation efficiencies, labor inputs, investment, and operating costs for a wide range of irrigation application and conservation practices. The panel was then asked to refine and adjust these data to represent local conditions for each crop included in the farm budget analysis.

The consensus of the panel was used to specify costs and water savings over and above the baseline situation in the original budgets. Crop enterprise budgets were developed for each crop for each irrigation practice. Conservation or application methods for an individual crop, which were dominated by another method, were eliminated from further consideration. That is, suppose two techniques or methods were being considered; if the second technique conserved a greater amount of water at a lower cost per acre-inch saved, then the first alternative was dropped from further consideration.

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[1]Virtually no data were available from controlled research experiments at the field level; therefore, data used in this section are based on the judgment of experts and users of these alternative conservation methods.

For example, in the Westlands Water District for sugar beets, four water conservation methods were analyzed: (A) Gated field pipe, the assumed application method on the representative farm, *i.e.,* the baseline. (B) Gated pipe plus the use of an Irrigation Management Service (IMS). IMS involves subscribing to a computerized advisory service which recommends the amount and timing of irrigation applications in order to match consumptive use of the crop and water-holding capacity of the soil with water applications. (C) Gated pipe plus IMS plus a return water recirculation system. (D) A wheel line sprinkler system in combination with IMS.

The incremental cost of water saved per acre and the quantity of water saved over the baseline situation were calculated. The results of this example are shown in Figure 1-3. Alternative (C) is clearly dominated by alternatives (B) and (D). That is, a greater amount of water can be saved at a lower cost per unit by methods (B) and (D). Therefore, method (C) was eliminated from further analysis.

To select a crop mix and irrigation water conservation method that is optimal for any given water price, the same basic linear programming models developed for the economies-of-size study were used except that for each crop additional activities were defined to represent the alternative conservation methods. Land (specified farm size in acres), machinery capacity, agronomic constraints, and marketing constraints on high-value, high-risk crops were maintained.

The price of water was varied in increasing increments of $5.00 per acre-foot from zero to a level where gross crop income minus variable expenses was reduced to zero. The results of this analysis provide the following information for each farm size:

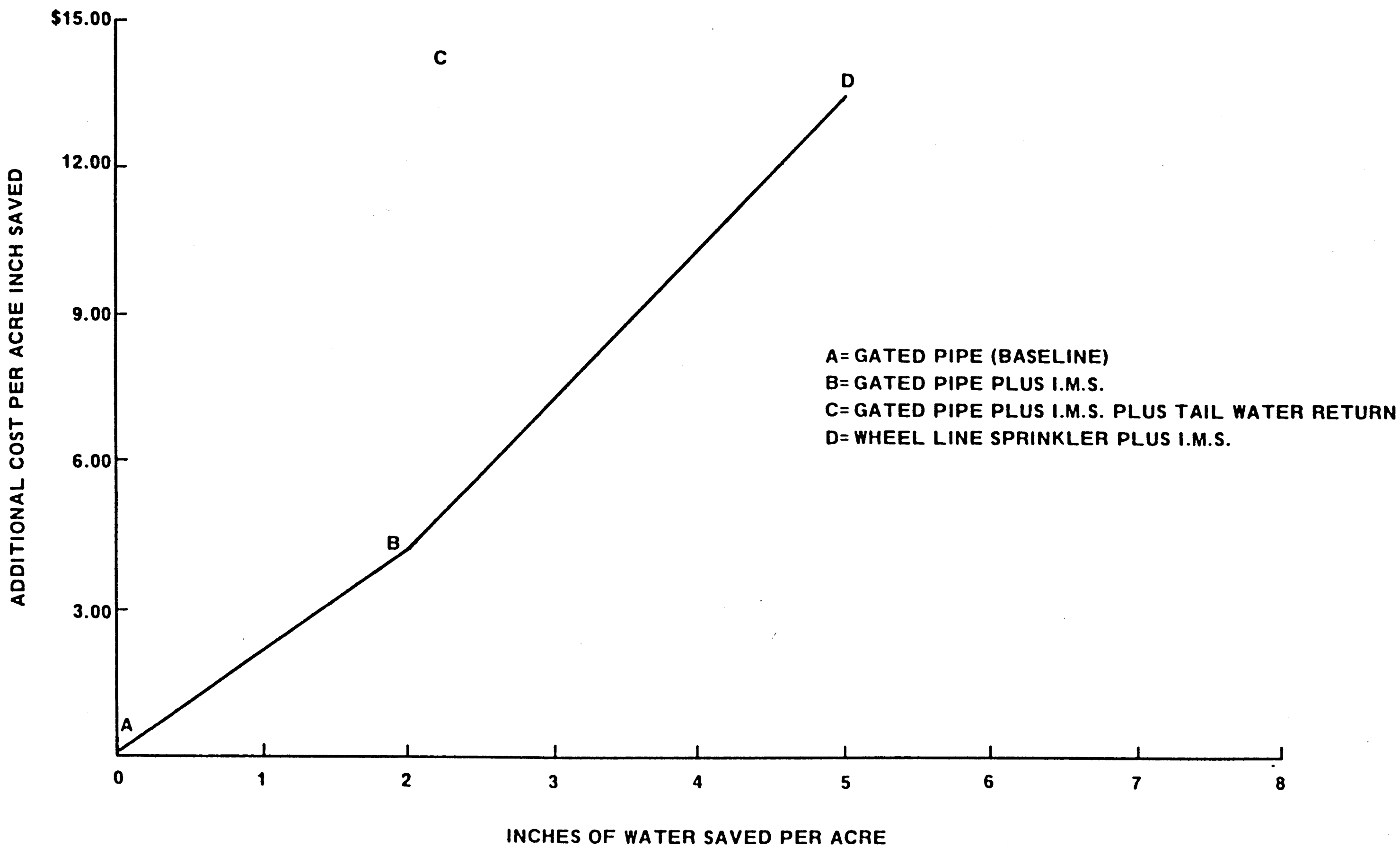
1. The optimum quantity of irrigation water for each water price.
2. The optimum combination of crops to be grown at each water price.
3. The optimum water conservation method for each possible water price.
4. The level of farm income at each possible water price and, therefore, the maximum ability to pay for irrigation water.

The maximum ability to pay for project water would be a water price which drives the land value to its excess land value, *i.e.,* the value of land without project water: *Gross farm income less production expenses (including water cost) equals gross margin; gross margin less fixed cost at excess land value equals zero.*

Land Tenure Survey

The land tenure survey was conducted independently of, but simultaneously with, the agricultural economic studies. BOR contracted directly with ESCS and field work began in March of 1979. Land segments were randomly selected, and both the landowners and farm operators of those lands were interviewed using a questionnaire designed for the survey. Responses were received from over 95 percent of the 11,000 farm operators/owners contacted in the 18 districts. Since this was not a complete enumeration, district totals were obtained by expanding from land area segments. This procedure created an occasional statistical anomaly in individual class interval estimates.

FIGURE 1-3
IRRIGATION WATER SAVINGS AND COST
BY CONSERVATION METHOD
WESTLANDS WATER DISTRICT–SUGAR BEETS



In the tabulation of the survey results, certain assumptions were made to avoid duplication from multiple ownerships. For example, land owned by a husband and wife was divided by two. The following divisions were made for each type ownership:

1. Individual: 1
2. Joint with spouse: 1/2
3. Family multiple ownership (partnerships, corporations):

$$\frac{1}{\text{number of family members}}$$

4. Nonfamily multiple ownerships with 10 or fewer members:

$$\frac{1}{\text{number of members}}$$

5. All other categories: 1.

This procedure will tend to underestimate the degree of concentration of ownership by placing a higher proportion of units in smaller size groups.

Data tapes were provided, courtesy of BOR, but farm size class intervals were changed to more nearly conform to U. S. Census of Agriculture economic class intervals to aid researchers interested in comparing results between the two sets of data.

In the following section, Part II, a single irrigation district is analyzed in detail. Westlands Water District, California, is used as an example of the type of analysis and results obtained for the other 17 districts. Westlands Water District was selected due to its wide diversity of crops, large land area, and because it has been the focus of the controversy surrounding acreage limitation policy.

PART II

WESTLANDS WATER DISTRICT: A CASE STUDY

The Westlands Water District of the Central Valley Project, containing 577,000 irrigable acres, is located primarily in Fresno County in the west-central portion of the San Joaquin Valley.

CLIMATE

The Westlands District is characterized by hot, dry summers and mild winters. The average annual precipitation is 6.7 inches which falls mostly in the period from November through March. The average frost-free growing season is 272 days.

SOILS

Soils in the district can be characterized as medium to heavy in texture with few agronomic limitations. The area along the eastern border of the district contains some salt-affected soils due to a high perched water table. Underground tile drains have been installed in this area. It is expected the drainage system will be expanded in the future.

BOR has classified the irrigable soils in the district as follows:[1]

Class	Acres
1	194,625
2	234,752
3	79,586
4	68,116
Total	577,079

WATER SUPPLY AND COST

BOR provides a supplemental water supply to the district. Although this water supply contract is still under negotiation, it is not expected that the surface water supply will exceed 1,278,000 acre-feet which with 250,000 acre-feet of groundwater will yield annually about 2.9 acre-feet per eligible irrigable acre (U. S. Department of Interior, Water and Power Resources Service, 1981). The 1978 farm headgate cost for project water was $15.80 per acre-foot; however, this cost is expected to rise in the future when the distribution system and drainage network repayments commence.

Prior to deliveries of project water, district lands were irrigated from private wells. In 1978 the local power company estimated that there were 700 irrigation pump accounts within the district. Pumping lifts range from 300 feet to over 700 feet and increase as one moves from north to south and from east to west within the district. The modal pump lift was estimated at 500 feet. The variable cost of pumping from the modal lift was estimated at $48.55 per acre-foot.[2]

Prior to the project, the district groundwater levels showed a long-term overdraft condition because annual pumping exceeded the groundwater basin's estimated annual safe yield of 300,000 acre-feet. Maintaining withdrawals in balance with this safe yield implies an annual groundwater supply of only about 0.4 acre-feet per acre.[3]

CROPS

The cropping pattern of the district is dominated by cotton (193,346 acres in 1977), cereals (104,138 acres), and vegetables (47,432 acres). In terms of value of production for

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[1]Unpublished data provided by BOR.

[2]*Ibid.*

[3]*Ibid.*

1977, cotton ranked first, contributing nearly $127 million, followed by vegetables which contributed over $73 million. A wide variety of other field crops, fruits, and seed crops makes up the balance of the acreage as shown in Table 2-1. In 1977, 69,548 acres of land were fallow due primarily to the drought-induced limitation of the water supply.

LAND TENURE

Westlands is a relatively new district and a large amount of acreage, subject to the Interior's Acreage Limitation, is under recordable contract. Once these agreements to sell excess land[1] have matured, landownership will be more widely dispersed than was that found in the 1978 survey. Based on the 1978 survey, the Gini coefficient[2] of landownership concentration was 0.52, second only to the Imperial Irrigation District.

Results of the 1978 ownership survey are presented in Tables 2-2 and 2-3. On one end of the ownership by size of holding scale, 59.3 percent of the owners own only 17.3 percent of the land while, at the other extreme, 0.4 percent own 23.5 percent of the land. Nonfamily corporations own 22.2 percent of the acreage or 112,549 acres. Multiple-family arrangements, including corporations and partnerships, are the most prominent with 1,913 owners owning 37 percent of the land.

Farm Operations

Compared to the average acreage per owner of 172 acres, the average farm size reported in the survey was 1,654 acres as shown in Table 2-4. Forty farms of 4,000 acres or larger averaged 7,733 acres per farm. Corporations were the leading form of business organization controlling 37.9 percent of the farms. The survey located 12 farms of less than 100 acres, all of which were joint husband-wife arrangements.

Crop mix varies widely by farm size as shown in Table 2-5. The farms in the smallest size category grew only alfalfa hay. Crop mix on the next larger farm size (100 acres to 179 acres) was more diversified with almost equal proportions of cereals, forages, and row crops. Larger farms, 500 acres and up, appear more diversified but with a fairly constant proportion of land in cotton and sugar beets (about 54 percent). While the proportion of land in cereals and grain also remains fairly stable as farm size increases on farms over 500 acres, only farms of this size and larger reported growing the more intensively cultivated vegetables, seed crops, fruits, and nuts. The largest farm size—4,000 acres and over—operated 62 percent of the land in the district, and these farms appear to be widely diversified.

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[1]"Excess land" is the amount of land owned beyond the amount specified in the BOR water contract, *e.g.,* 160 acres for an individual owner.

[2]The Gini coefficient ranges from 0 to 1.0. The higher the coefficient, the greater the degree of concentration. A value of zero would indicate that ownership is exactly evenly divided, *i.e.,* each owner has the same number of acres. A value near one would indicate that only one among all owners controlled nearly all the land.

Table 2-1

Crop Acreage, San Luis Unit, Westlands District,
Central Valley Project, California, 1977

Crop	Acres	Value of production
Cereals		
Barley	104,138	$ 19,274,902
Forage		
Alfalfa hay	16,855	5,498,980
Miscellaneous field crops		
Cotton lint, upland	193,346	113,817,446
Cotton seed, upland	(193,346)	13,147,520
Vegetables		
Lettuce	4,079	15,387,293
Cantaloupes, etc.	11,136	16,745,649
Tomatoes, canning	32,217	41,640,500
Seeds		
Alfalfa	11,841	7,193,448
Fruits		
Grapes, nontable	4,410	2,794,176
Nuts		
Almonds	6,023	2,113,092
Other & miscellaneous	23,811	13,791,144
Fallow	69,548	---
Total	477,404	$251,404,150

Source: Westlands Water District, Crop Report, 1977, Fresno, CA, 1978.

Table 2-2

Form of Ownership by Farm Size, Westlands, 1978

Farm size Acres	Individual	Joint with spouse	Family multiple	Trust	Nonfamily corp. 10 or less	Nonfamily corp. 11 or more	Fed., state or local gov't	Non-profit	Total	Cumulative percent
1-99										
No. of owners	154	42	1,279	46	213	5	0	0	1,739	59.3
Percent	8.8	2.4	73.5	2.6	12.2	0.2	0.0		100.0	
100-179										
No. of owners	330	24	494	33	54	7	0	0	942	91.4
Percent	35.0	2.5	52.4	3.5	5.7	0.7	0.0	0.0	100.0	
180-259										
No. of owners	13	6	33	0	0	0	0	0	52	93.2
Percent	25.0	11.5	63.4	0.0	0.0	0.0	0.0	0.0	100.0	
260-499										
No. of owners	8	6	43	15	0	0	0	3	75	95.8
Percent	10.6	8.0	57.3	20.0	0.0	0.0	0.0	4.0	100.0	
500-999										
No. of owners	9	2	41	18	0	7	0	0	77	98.4
Percent	11.6	2.5	53.2	23.3	0.0	9.0	0.0	0.0	100.0	
1,000-1,999										
No. of owners	2	2	23	1	0	6	0	0	34	99.6
Percent	5.8	5.8	67.6	2.9	0.0	17.6	0.0	0.0	100.0	
2,000-2,999										
No. of owners	4	0	0	0	0	3	0	0	7	99.8
Percent	57.1	0.0	0.0	0.0	0.0	42.8	0.0	0.0	100.0	
3,000 and greater										
No. of owners	1	0	0	1	0	2	2	0	6	100.0
Percent	16.6	0.0	0.0	16.6	0.0	33.3	33.3	0.0	100.0	
Total										
No. of owners	521	82	1,913	114	267	30	2	3	2,932	
Percent	17.7	2.7	65.2	3.8	9.1	1.0	0.0	0.1	100.0	

Source: Survey data.

Table 2-3
Acreage by Farm Size and Type of Ownership, Westlands, 1978

Farm size Acres	Individual	Joint with spouse	Family multiple	Trust	Nonfamily corp. 10 or less	Nonfamily corp. 11 or more	Fed., state or local gov't	Non-profit	Total	Cumulative percent
1-99										
Acres	6,536	19,869	45,949	2,287	11,528	109	0	0	86,278	17.3
Percent	7.5	23.0	53.2	2.6	13.3	0.1	0.0	0.0	100.0	
Average									49.6	
100-179										
Acres	49,283	21,198	66,536	5,234	6,964	729	0	0	149,944	47.3
Percent	32.8	14.1	44.3	3.4	4.6	0.4	0.0	0.0	100.0	
Average									159.1	
180-259										
Acres	2,841	5,658	6,827	0	0	0	0	0	15,326	50.4
Percent	18.5	36.9	44.5	0.0	0.0	0.0	0.0	0.0	100.0	
Average									294.7	
260-499										
Acres	2,611	10,087	13,445	5,223	0	0	0	1,306	32,672	56.9
Percent	7.9	30.8	41.1	15.9	0.0	0.0	0.0	3.9	100.0	
Average									435.6	
500-999										
Acres	8,705	3,330	24,656	12,165	0	3,482	0	0	52,338	67.4
Percent	16.6	6.3	47.1	23.2	0.0	6.6	0.0	0.0	100.0	
Average									679.7	
1,000-1,999										
Acres	2,305	2,688	29,818	781	0	9,859	0	0	45,451	76.5
Percent	5.0	5.9	65.6	1.7	0.0	21.6	0.0	0.0	100.0	
Average									1,336.7	
2,000-2,999										
Acres	11,316	0	0	0	0	6,964	0	0	18,280	80.2
Percent	61.9	0.0	0.0	0.0	0.0	38.0	0.0	0.0	100.0	
Average									2,611.4	
3,000 and greater										
Acres	5,289	0	0	8,203	0	72,914	17,823	0	104,229	100.0
Percent	5.0	0.0	0.0	7.8	0.0	69.9	17.0	0.0	100.0	
Average									17,371.5	
Total										
Acres	88,886	62,830	187,231	33,893	18,492	94,057	17,823	1,306	504,518	
Percent	17.6	12.4	37.1	6.7	3.6	18.6	3.5	0.2	100.0	
Average	170.6	766.2	97.8	297.3	69.2	3,135.2	8,911.5	435.3	172.0	

Source: Survey data.

Table 2-4

Type of Business Organization by Farm Size, Westlands, 1978

Farm size Acres	Incorporated		Joint operations		Individually	Other (gov't., estate, trust, etc.)	Total	Average farm size
	With more than 10 persons	With 10 or fewer persons	With partners/ spouse/family over 18	With spouse only				acres
1-99								
No. of farms	0	0	0	12	0	0	12	40
Percent	0.0	0.0	0.0	100.0	0.0	0.0	100.0	
100-179								
No. of farms	12	12	12	0	12	0	48	145
Percent	25.0	25.0	25.0	0.0	25.0	0.0	100.0	
180-259								
No. of farms	0	0	0	0	12	0	12	218
Percent	0.0	0.0	0.0	0.0	100.0	0.0	100.0	
260-499								
No. of farms	0	0	9	0	0	0	9	439
Percent	0.0	0.0	100.0	0.0	0.0	0.0	100.0	
500-999								
No. of farms	0	45	29	17	0	0	91	690
Percent	0.0	49.4	31.8	18.6	0.0	0.0	100.0	
1,000-1,999								
No. of farms	1	23	34	12	2	0	72	1,461
Percent	1.3	31.9	47.2	16.6	2.7	0.0	100.0	
2,000-2,999								
No. of farms	3	0	6	3	0	0	12	2,427
Percent	25.0	0.0	50.0	25.0	0.0	0.0	100.0	
3,000-3,999								
No. of farms	0	1	4	0	0	4	9	3,339
Percent	0.0	11.1	44.4	0.0	0.0	44.4	100.0	
4,000-or greater								
No. of farms	0	19	14	2	5	0	40	7,733
Percent	0.0	47.5	35.0	5.0	12.5	0.0	100.0	
Total								
No. of farms	16	100	108	46	31	4	305	1,654
Percent	5.2	32.7	35.4	15.0	10.1	1.3	100.0	

Source: Survey data.

Table 2-5

Irrigated Crop Patterns by Farm Size, Westlands, 1978

Farm size Acres	Cereals and grain	Forages	Field crops	Vegetables	Seeds	Fruits	Nuts	Total
1-99								
Total acres	0	463	0	0	0	0	0	463
Percent	0.0	100.0	0.0	0.0	0.0	0.0	0.0	100.0
100-179								
Total acres	1,969	2,246	2,527	0	0	0	0	6,742
Percent	29.2	33.3	37.4	0.0	0.0	0.0	0.0	100.0
180-259								
Total acres	0	0	2,524	0	0	0	0	2,524
Percent	0.0	0.0	100.0	0.0	0.0	0.0	0.0	100.0
260-499								
Total acres	134	0	2,144	0	0	0	0	2,278
Percent	5.8	0.0	94.1	0.0	0.0	0.0	0.0	100.0
500-999								
Total acres	11,537	0	23,505	5,935	740	463	811	42,991
Percent	26.8	0.0	54.6	13.8	1.7	1.0	1.8	100.0
1,000-1,999								
Total acres	12,640	2,000	39,764	15,590	3,383	1,918	0	75,295
Percent	16.7	2.6	52.8	20.7	4.4	2.5	0.0	100.0
2,000-2,999								
Total acres	1,158	657	10,635	4,034	686	0	0	17,170
Percent	6.7	3.8	61.9	23.4	3.9	0.0	0.0	100.0
3,000-3,999								
Total acres	8,286	0	14,938	6,360	166	0	0	29,750
Percent	27.8	0.0	50.2	21.3	0.5	0.0	0.0	100.0
4,000 or greater								
Total acres	71,747	8,679	159,955	38,036	13,316	375	1,613	293,722
Percent	24.4	2.9	54.4	12.9	4.5	0.1	0.5	100.0
Total								
Total acres	107,471	14,045	255,993	69,955	18,291	2,756	2,424	470,936
Percent	22.8	2.9	54.3	14.8	3.8	0.5	0.5	100.0

Source: Survey data.

Labor

The survey revealed a total of 5,305 full-time or regular employees in the Westlands Water District. Of this number, 77 percent were Hispanics and 21.5 percent were Caucasian (Table 2-6). Of the total full-time employees, 278 were reported as farm managers; 427 as foremen; and 4,600 as laborers (Table 2-7). Adding these hired employees to the 503 farm operators yields an estimate of the full-time labor input of 5,607 persons. Seasonal workers are, of course, in addition to this year-round labor force.

When the labor input is standardized on a labor per 1,000-acre basis, an estimate can be made of labor efficiency by farm size. These estimates are shown in the last column in Table 2-7. Labor input per 1,000 acres decreases rapidly for farms more than 180 acres and then becomes relatively stable, but with a range from 7.5 to 19.3. Part of this variation can be explained by changes in crop mix, custom services, off-farm employment, temporary help, and noncrop enterprises such as packing sheds. The lowest labor input was not on the largest farm size group.

TYPICAL FARM BUDGETS

Two sets of farm budgets, reflecting two water supply and cost situations, were developed. The first set—for 160-, 320-, 640-, and 1,280-acre farms—reflects the water-supply situation for farms using only project water. The second set assumed the same farm sizes but took into account the additional supply and cost of pumping groundwater.

Consistent with Interior's Proposed Rules and Regulations, these farm budgets assume a maximum landownership of 320 acres for husband and wife. All land over 320 acres was assumed to be leased at $110 per acre for land without an irrigation well and at $135 per acre for land relying on both project water and groundwater. Cash rental rates are low relative to ownership costs of land at current market land values, providing a cost advantage for large farms, which tend to have a higher proportion of leased land than do small farms.

Farm budgets were developed to reflect three sets of circumstances with respect to cash flow: (1) beginning farmers purchasing land at 1978 market values ($1,500 per acre) and interest rates (9 percent), (2) beginning farmers purchasing excess land at $550 per acre, and (3) existing farmers who purchased land at some earlier period of lower land prices and interest rates and who, partly as a result of inflation, have achieved a higher equity position.

In order to modify the capital accounts of these existing farms, the following information was used: (1) Since the estimated turnover rate for farms in the western United States is about 2.5 percent or once every 40 years, the average farm was assumed to have been purchased 20 years ago, in 1958, when Federal Land Bank interest rates averaged 5.5 percent. (2) Based on the *Balance Sheet of the Farm Sector* (U. S. Economics, Statistics, and Cooperatives Service, 1978), the estimated debt-asset ratio for California farms is 25.7.

Farm budgets for the three sets of cash-flow circumstances for the four farm sizes are found in Table 2-8 for project water and groundwater and in Table 2-9 for project water only.

Table 2-6

Racial/Ethnic Labor Force by Farm Size, Westlands, 1978

Farm size Acres	Total regular or full time employees	Caucasian	Hispanic	American Indian or Alaskan native	Black	Asian or Pacific islanders
1-99						
No. of employees	12	0	12	0	0	0
Average/farm	1.0	0.0	1.0	0.0	0.0	0.0
100-179						
No. of employees	104	58	46	0	0	0
Average/farm	2.2	1.2	0.9	0.0	0.0	0.0
180-259						
No. of employees	12	12	0	0	0	0
Average/farm	1.0	1.0	0.0	0.0	0.0	0.0
260-499						
No. of employees	68	22	46	0	0	0
Average/farm	7.5	2.4	5.1	0.0	0.0	0.0
500-999						
No. of employees	591	121	470	0	0	0
Average/farm	6.4	1.3	5.1	0.0	0.0	0.0
1,000-1,999						
No. of employees	770	275	484	0	11	0
Average/farm	10.9	3.8	6.8	0.0	0.1	0.0
2,000-2,999						
No. of employees	327	39	288	0	0	0
Average/farm	28.2	3.3	24.8	0.0	0.0	0.0
3,000-3,999						
No. of employees	217	31	185	0	0	1
Average/farm	24.2	3.4	20.6	0.0	0.0	0.1
4,000-or greater						
No. of employees	3,204	583	2,566	1	18	36
Average/farm	79.3	14.4	63.5	0.0	0.4	0.8
Total						
No. of employees	5,305	1,141	4,097	1	29	37
Percent	100.0	21.5	77.2	0.0	0.5	0.6

Source: Survey data.

Table 2-7

Labor Force Employment Categories by Farm Size, Westlands, 1978

Farm size Acres	Farm manager	Foreman	Laborers	Total employees	Total operators	Total employees and operators	Number of employees per 1,000 acres
1-99							
No. of workers	0	0	12	12	12	24	51.8
Average/farm	0.0	0.0	1.0	1.0	1.0	2.0	
100-179							
No. of workers	12	12	81	105	47	152	22.6
Average/farm	0.2	0.2	1.7	2.2	1.0	3.2	
180-259							
No. of workers	12	0	0	12	12	24	9.5
Average/farm	1.0	0.0	0.0	1.0	1.0	2.0	
260-499							
No. of workers	1	1	65	67	9	76	19.3
Average/farm	0.1	0.1	7.2	7.4	1.0	8.4	
500-999							
No. of workers	39	56	497	592	91	683	10.8
Average/farm	0.4	0.6	5.4	6.4	0.9	7.4	
1,000-1,999							
No. of workers	66	107	597	770	70	840	8.1
Average/farm	0.9	1.5	8.4	10.9	0.9	11.8	
2,000-2,999							
No. of workers	13	26	288	327	12	339	12.0
Average/farm	1.1	2.2	24.8	28.2	1.0	29.2	
3,000-3,999							
No. of workers	12	29	176	217	9	226	7.5
Average/farm	1.3	3.2	19.6	24.2	1.0	25.2	
4,000-or greater							
No. of workers	123	196	2,884	3,203	40	3,243	10.3
Average/farm	3.0	4.8	71.4	79.3	0.9	80.3	
Total							
No. of workers	278	427	4,600	5,305	302	5,607	

Source: Survey data.

Table 2-8

Westlands Water District, Project Water Plus Groundwater

Summary of Farm Budgets

A. Farm size	Crop	Acres	Investment	
160 acres irrigated	Cotton	132	Land	$240,000
	Tomatoes (leased)	20	Improvements	46,400
	Farmstead	8	Machinery	36,226
	Total	160	Total	$322,626

Financial summary

Beginning farmers

Land at current market value ($1,500/ac.)

gross sales	$86,620
expenses	86,116
return to operator labor, mgt., & equity	$ 504

Land at excess land value ($550/ac.)

gross sales	$86,620
expenses	75,253
return to operator labor, mgt., & equity	$11,367

Existing farmers

Land purchased previously

gross sales	$86,620
expenses	76,004
return to operator labor, mgt., & equity	$10,616

B. Farm size	Crop	Acres	Investment	
320 acres irrigated	Cotton	264	Land	$480,000
	Tomatoes (leased)	40	Improvements	92,800
	Farmstead	16	Machinery	80,271
	Total	320	Total	$653,071

Financial summary

Beginning farmers

Land at current market value ($1,500/ac.)

gross sales	$173,241
expenses	178,068
return to operator labor, mgt., & equity	$ -4,827

Land at excess land value ($550/ac.)

gross sales	$173,241
expenses	157,352
return to operator labor, mgt., & equity	$ 15,889

Existing farmers

Land purchased previously

gross sales	$173,241
expenses	157,653
return to operator labor, mgt., & equity	$ 15,588

Table continued

Table 2-8 continued

C. Farm size	Crop	Acres	Investment	
640 acres irrigated	Cotton	438		
	Sugar beets	90	Land	$480,000
	Tomatoes (leased)	80	Improvements	105,600
	Farmstead	32	Machinery	233,054
	Total	640	Total	$818,654

Financial summary

Beginning farmers

Land at current market value ($1,500/ac.)

gross sales	$443,909
expenses	435,283
return to operator labor, mgt., & equity	$ 8,626

Land at excess land value ($550/ac.)

gross sales	$443,909
expenses	414,567
return to operator labor, mgt., & equity	$ 29,342

Existing farmers

Land purchased previously

gross sales	$443,909
expenses	410,828
return to operator labor, mgt., & equity	$ 33,081

D. Farm size	Crop		Investment	
1,280 acres irrigated	Barley (irr.)	156		
	Cotton	700		
	Tomatoes	160	Land	$ 480,000
	Sugar beets	200	Improvements	131,200
	Farmstead	64	Machinery	700,000
	Total	1,280	Total	$1,311,652

Financial summary

Beginning farmers

Land at current market value ($1,500/ac.)

gross sales	$828,917
expenses	740,212
return to operator labor, mgt., & equity	$ 88,705

Land at excess land value ($550/ac.)

gross sales	$828,917
expenses	719,496
return to operator labor, mgt., & equity	$109,421

Existing farmers

Land purchased previously

gross sales	$828,917
expenses	703,152
return to operator labor, mgt., & equity	$125,765

Table 2-9

Westlands Water District, Project Water Only

Summary of Farm Budgets

A. Farm size	Crop	Acres	Investment	
160 acres irrigated	Cotton	132	Land	$240,000
	Tomatoes (leased)	20	Improvements	6,400
	Farmstead	8	Machinery	36,226
	Total	160	Total	$282,626

Financial summary

Beginning farmers

Land at current market value ($1,500/ac.)

gross sales	$86,620
expenses	82,557
return to operator labor, mgt., & equity	$ 4,063

Land at excess land value ($550/ac.)

gross sales	$86,620
expenses	72,198
return to operator labor, mgt., & equity	$14,422

Existing farmers

Land purchased previously

gross sales	$86,620
expenses	73,420
return to operator labor, mgt., & equity	$13,200

B. Farm size	Crop	Acres	Investment	
320 acres irrigated	Cotton	264	Land	$480,000
	Tomatoes (leased)	40	Improvements	12,800
	Farmstead	16	Machinery	80,271
	Total	320	Total	$573,071

Financial summary

Beginning farmers

Land at current market value ($1,500/ac.)

gross sales	$173,241
expenses	170,949
return to operator labor, mgt., & equity	$ 2,292

Land at excess land value ($550/ac.)

gross sales	$173,241
expenses	150,233
return to operator labor, mgt., & equity	$ 23,008

Existing farmers

Land purchased previously

gross sales	$173,241
expenses	152,487
return to operator labor, mgt., & equity	$ 20,754

Table continued

Table 2-9 continued

C. Farm size	Crop	Acres	Investment	
640 acres irrigated	Cotton	438		
	Sugar beets	90	Land	$480,000
	Tomatoes	80	Improvements	25,600
	Farmstead	32	Machinery	223,971
	Total	640	Total	$729,571

Financial summary

Beginning farmers

Land at current market value ($1,500/ac.)

gross sales	$443,909
expenses	428,164
return to operator labor, mgt., & equity	$ 15,745

Land at excess land value ($550/ac.)

gross sales	$443,909
expenses	407,403
return to operator labor, mgt., & equity	$ 36,506

Existing farmers

Land purchased previously

gross sales	$443,909
expenses	405,661
return to operator labor, mgt., & equity	$ 38,248

D. Farm size	Crop	Acres	Investment	
1,280 acres irrigated	Barley (irr.)	156		
	Cotton	700		
	Tomatoes	160	Land	$ 480,000
	Sugar beets	200	Improvements	51,200
	Farmstead	64	Machinery	724,077
	Total	1,280	Total	$1,255,277

Financial summary

Beginning farmers

Land at current market value ($1,500/ac.)

gross sales	$828,917
expenses	733,053
return to operator labor, mgt., & equity	$ 95,864

Land at excess land value ($550/ac.)

gross sales	$828,917
expenses	712,337
return to operator labor, mgt., & equity	$116,580

Existing farmers

Land purchased previously

gross sales	$828,917
expenses	697,945
return to operator labor, mgt., & equity	$130,972

Project Water Plus Pumping

Results of the typical farm budgets, in which both project and pumped water are used, indicate that, for beginning farmers purchasing under current market land values, the return to operator labor, management, and equity is positive for all farm sizes except the 320-acre farm and that, under excess land values, returns are positive for all farm sizes. With the $550 per acre excess land value at current interest rates, the beginning operator of a 320-acre parcel earns a return just about equal to the farm wage rate.

For existing farmers who have a much higher equity and a lower interest rate, the return to operator labor, management, and equity is positive for all farm sizes. Part of the difference in profitability by farm size can be explained by technical economies of size, but the results are made more complex by the fact that the cropping mix changes with farm size.

Project Water Only

The high cost of "drought insurance" provided by standby pumps can be seen by comparing budgets for beginning farmers with and without pumping (*i.e.,* by comparing Tables 2-8 and 2-9). Although total crop acreage is the same when only project water is used, net returns to unpaid labor, management, and equity are higher for all farm sizes using project water alone. Two apparent advantages of developing an irrigation well would be (1) a more certain water supply in case of drought and (2) a more uniform seasonal utilization of labor with larger crop acreage. Based on the results of the budget estimates, pumping appears to be a high cost to pay for these measurable benefits.

ECONOMIES OF SIZE

The machinery specified by the farmer panel complements were used as the "fixed plant" in order to develop SRAC curves. Figures 2-1 and 2-2 show SRAC curves which include operator labor at market farm wage rates for each farm size when the farm acreage is limited to the engineering capacity for each machinery complement.

Project Plus Irrigation Well

For the beginning farm operator at current land values ($1,500 per acre) using both project and pumped water (Figure 2-1), the minimum points on the SRAC curves, except for the 1,280-acre machine complement, are all above the break-even level of $1.00 cost per $1.00 of gross sales, *i.e.,* they show a loss. Under the excess land value assumption ($550 per acre), all four sizes do better than breaking even (Figure 2-2). Under both current market land values and excess land values, average total cost decreases as the investment in farm machinery and the amount of land farmed increase. The acreage scales in the lower portion of Figures 2-1 and 2-2 indicate the minimum points on the short-run curves.

The long-run planning curve, or LRAC curve, was estimated by fitting an envelope curve tangent to the SRAC curves for both the current market land value and the excess land value (Figure 2-3). The LRAC is relatively flat, especially when using excess land values. Most of the economies of size appear to be captured before output, measured in

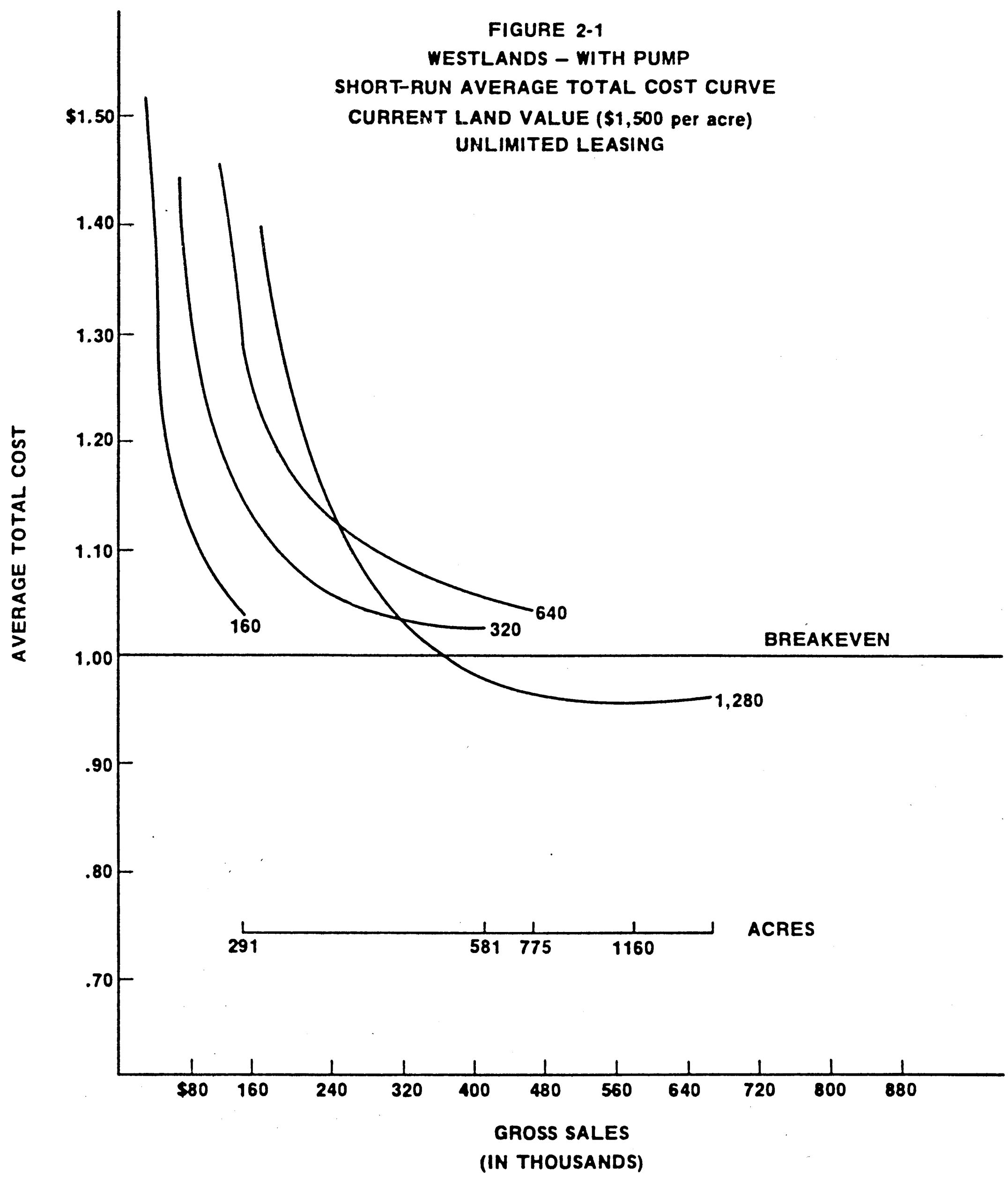


FIGURE 2-1
WESTLANDS – WITH PUMP
SHORT-RUN AVERAGE TOTAL COST CURVE
CURRENT LAND VALUE ($1,500 per acre)
UNLIMITED LEASING
AVERAGE TOTAL COST
$1.50
1.40
1.30
1.20
1.10
1.00
.90
.80
.70
160
320
640
1,280
BREAKEVEN
ACRES
291
581
775
1160
$80
160
240
320
400
480
560
640
720
800
880
GROSS SALES
(IN THOUSANDS)

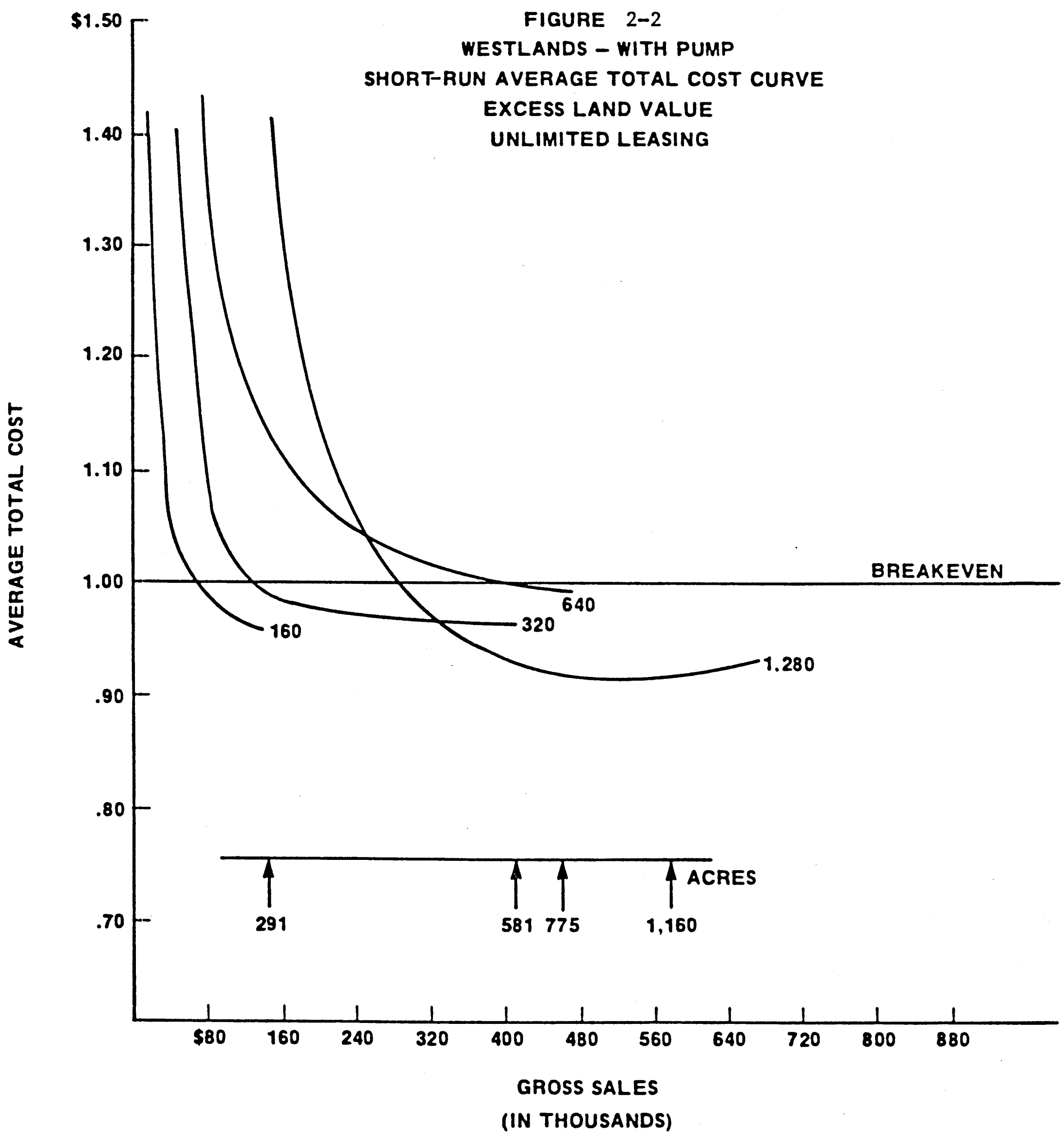


FIGURE 2-2
WESTLANDS – WITH PUMP
SHORT-RUN AVERAGE TOTAL COST CURVE
EXCESS LAND VALUE
UNLIMITED LEASING
AVERAGE TOTAL COST
$1.50
1.40
1.30
1.20
1.10
1.00
.90
.80
.70
BREAKEVEN
640
320
160
1,280
ACRES
291
581
775
1,160
$80
160
240
320
400
480
560
640
720
800
880
GROSS SALES
(IN THOUSANDS)

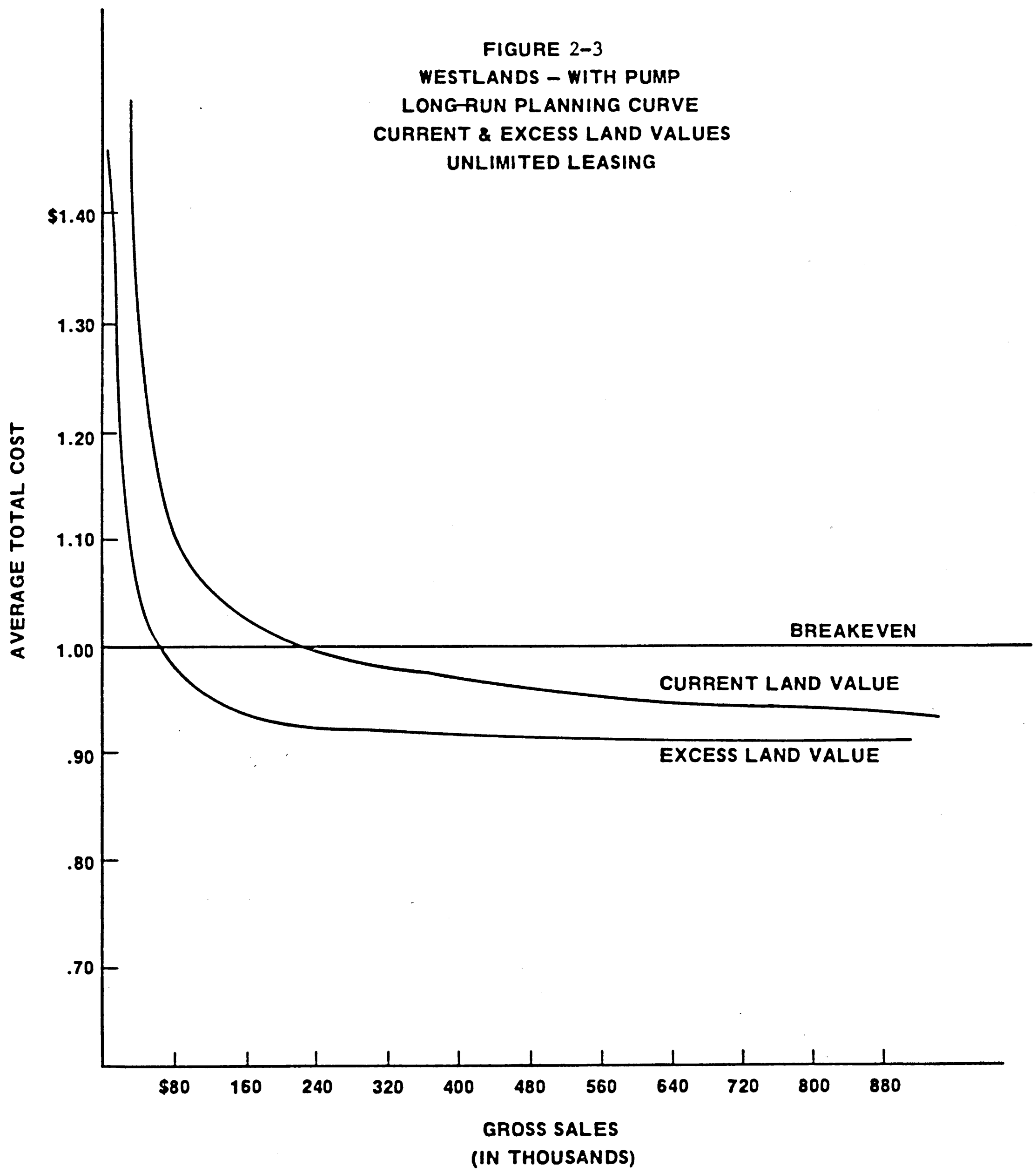


FIGURE 2-3
WESTLANDS – WITH PUMP
LONG-RUN PLANNING CURVE
CURRENT & EXCESS LAND VALUES
UNLIMITED LEASING
AVERAGE TOTAL COST
$1.40
1.30
1.20
1.10
1.00
.90
.80
.70
BREAKEVEN
CURRENT LAND VALUE
EXCESS LAND VALUE
$80
160
240
320
400
480
560
640
720
800
880
GROSS SALES
(IN THOUSANDS)

terms of gross sales, reaches the range of $200,000. Based on the assumptions of this analysis, sales in this range translate into the approximate output of a 450-acre farm.

Project Water Only

A similar analysis was conducted for farms where the project was the only source of water. The SRAC curves in Figures 2-4 and 2-5 are the result of optimizing the crop plan subject to machinery, agronomic, and land constraints on high-value crops and the water supply specified for each size farm for the two land value assumptions.

Comparing Figures 2-4 with 2-1 and Figures 2-5 with 2-2 reveals that costs per unit of output are significantly lower under the project-water-only assumption than under the project plus groundwater situation. For beginning farms of less than 1,280 acres, however, all minimum average total cost points are still above the break-even level for current market land values. Under the excess land value assumption, all sizes break even as before, but at lower costs, using project water alone.

The LRAC curves were also developed for this project-only water supply situation for both land-value assumptions (Figure 2-6). Most of economies of size are captured before output, measured in terms of gross sales, reaches $120,000 which translates into about 320 acres of land.

PRICE, YIELD, AND INCOME VARIABILITY

A time series of average prices and yields was developed for major crops grown in the district. The variability of price, yield, and gross income was estimated using Tintner's Variate Difference Method (Tintner, 1940). The standard deviation of these results is presented in Table 2-10.

Table 2-10

Standard Deviations of Yield, Price, and Gross Income by Crop
Westlands Water District

Crop	Yield	Price	Gross income per acre
		dollars	
Cotton lint	1.756 cwt.	5.796/cwt.	90.86
Lettuce	86.303 cwt.	3.519/cwt.	992.31
Tomatoes	2.361 ton	7.153/ton	369.87
Cantaloupes	46.280 cwt.	1.536/cwt.	668.22
Sugar beets	2.839 ton	9.864/ton	237.87
Alfalfa hay	1.055 ton	6.949/ton	136.85
Wheat	5.006 cwt.	0.597/cwt.	46.89
Barley	0.077 cwt.	0.597/cwt.	0.16

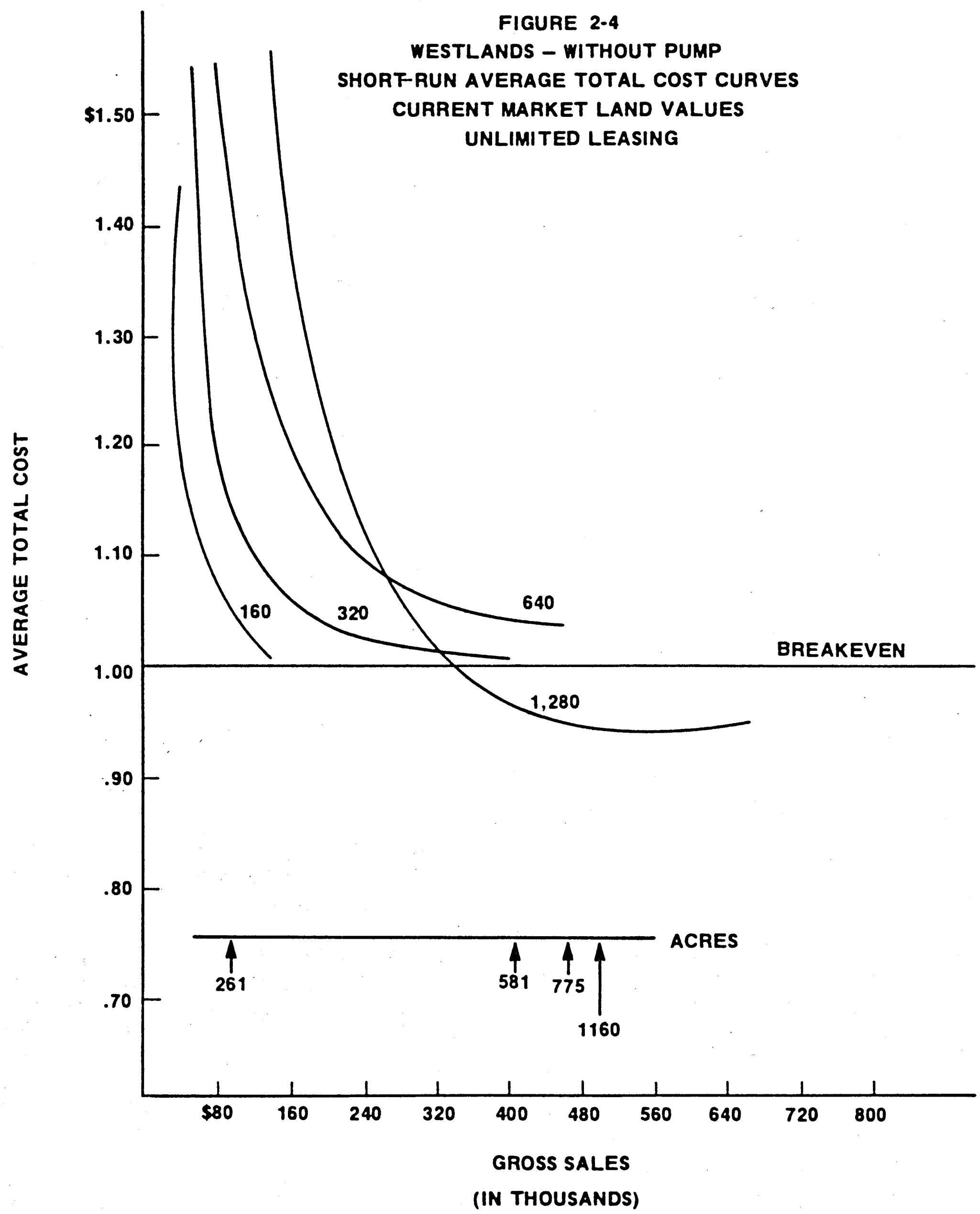


FIGURE 2-4
WESTLANDS – WITHOUT PUMP
SHORT-RUN AVERAGE TOTAL COST CURVES
CURRENT MARKET LAND VALUES
UNLIMITED LEASING
AVERAGE TOTAL COST
$1.50
1.40
1.30
1.20
1.10
1.00
.90
.80
.70
160
320
640
1,280
BREAKEVEN
ACRES
261
581
775
1160
$80
160
240
320
400
480
560
640
720
800
GROSS SALES
(IN THOUSANDS)

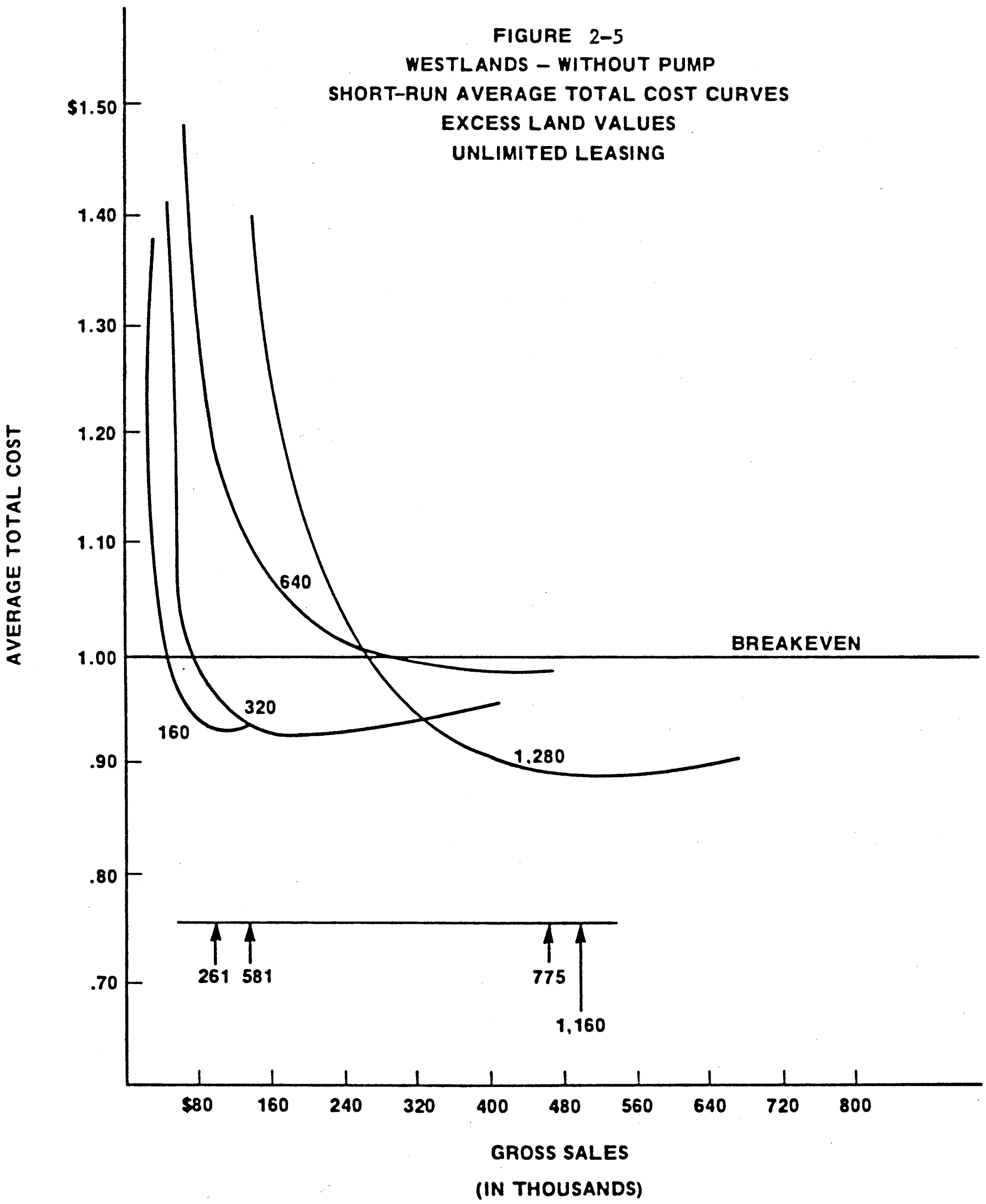


FIGURE 2-5
WESTLANDS – WITHOUT PUMP
SHORT-RUN AVERAGE TOTAL COST CURVES
EXCESS LAND VALUES
UNLIMITED LEASING
$1.50
1.40
1.30
1.20
1.10
1.00
.90
.80
.70
AVERAGE TOTAL COST
640
BREAKEVEN
320
160
1,280
261
581
775
1,160
$80
160
240
320
400
480
560
640
720
800
GROSS SALES
(IN THOUSANDS)

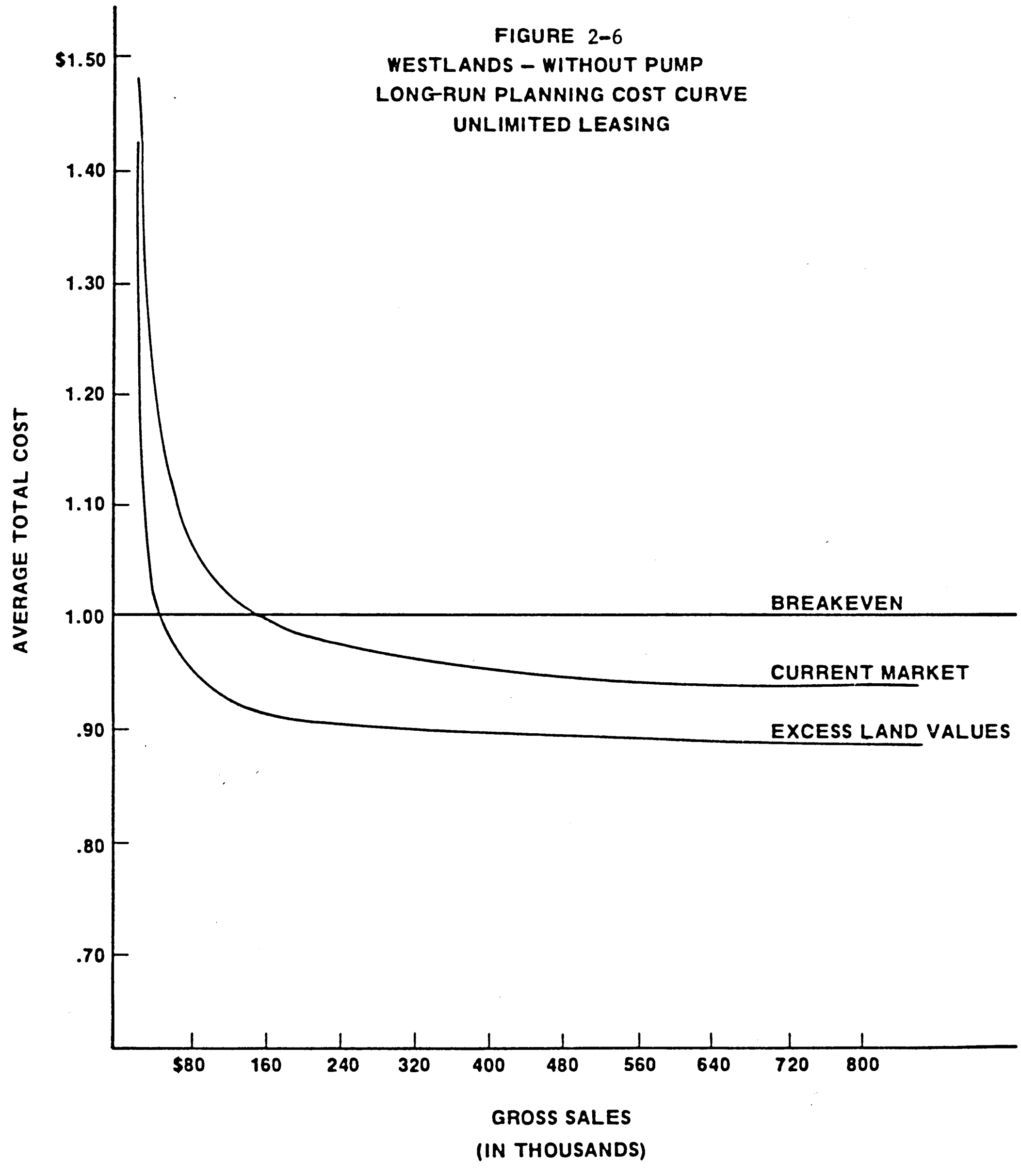


FIGURE 2-6
WESTLANDS – WITHOUT PUMP
LONG-RUN PLANNING COST CURVE
UNLIMITED LEASING
AVERAGE TOTAL COST
$1.50
1.40
1.30
1.20
1.10
1.00
.90
.80
.70
BREAKEVEN
CURRENT MARKET
EXCESS LAND VALUES
$80
160
240
320
400
480
560
640
720
800
GROSS SALES
(IN THOUSANDS)

Based on the proportion of land in each crop at the minimum point of the SRAC curves, the data in Table 2-10 were used to indicate the variability in overall gross sales. Total costs were then divided by plus and minus one standard deviation of gross sales and plotted about the LRAC curves in Figure 2-6. The results appear in Figures 2-7 and 2-8 where very wide bands around the LRAC curves are found within which costs and returns would be expected to fluctuate about two-thirds of the time.

DEMAND FOR IRRIGATION WATER

Derived demand for irrigation water in Westlands, with its diverse soils and crops, depends heavily on the profitability of the chosen crops, their consumptive use of water, the application efficiency of cost-effective irrigation methods, and the cost of water.

In Figure 2-9, a vertical dashed line is drawn to represent the historic water supply of 2.9 acre-feet per acre of eligible land. The asterisk located on that dashed line indicates the 1978 water price of $15.80 per acre-foot delivered to farm headgates. A downward-sloping stepped "curve" traces out the price-quantity relationships (demand curve) estimated from the linear programming model. This is an average demand curve obtained by weighting the demand for each farm size by the proportion of land in the district within that size farm. Results of this analysis indicate that the Westlands farm operators are (within the estimating error) utilizing the available water supply in an optimum manner, given the 1978 water-cost structure. If water costs rise to $25 per acre-foot or more, however, a significant (34 percent) decrease in water use could be expected due to a shift in the cropping pattern and more efficient water use. If water prices were increased to the BOR full-cost price of $67.50 per acre-foot, water use per acre would be drastically reduced to about 0.6 acre-foot per acre, and groundwater pumping would increase substantially.

Impacts of increased water costs on farm income are shown graphically in Figure 2-10. The solid dish-shaped curves trace out the net returns over variable costs including water costs for each farm size. Horizontal dashed lines represent the level of fixed costs at excess land values by farm size. A line drawn vertically from the intersection of the net returns curve and the fixed cost level to the base of the graph indicates the maximum ability to pay for irrigation water.

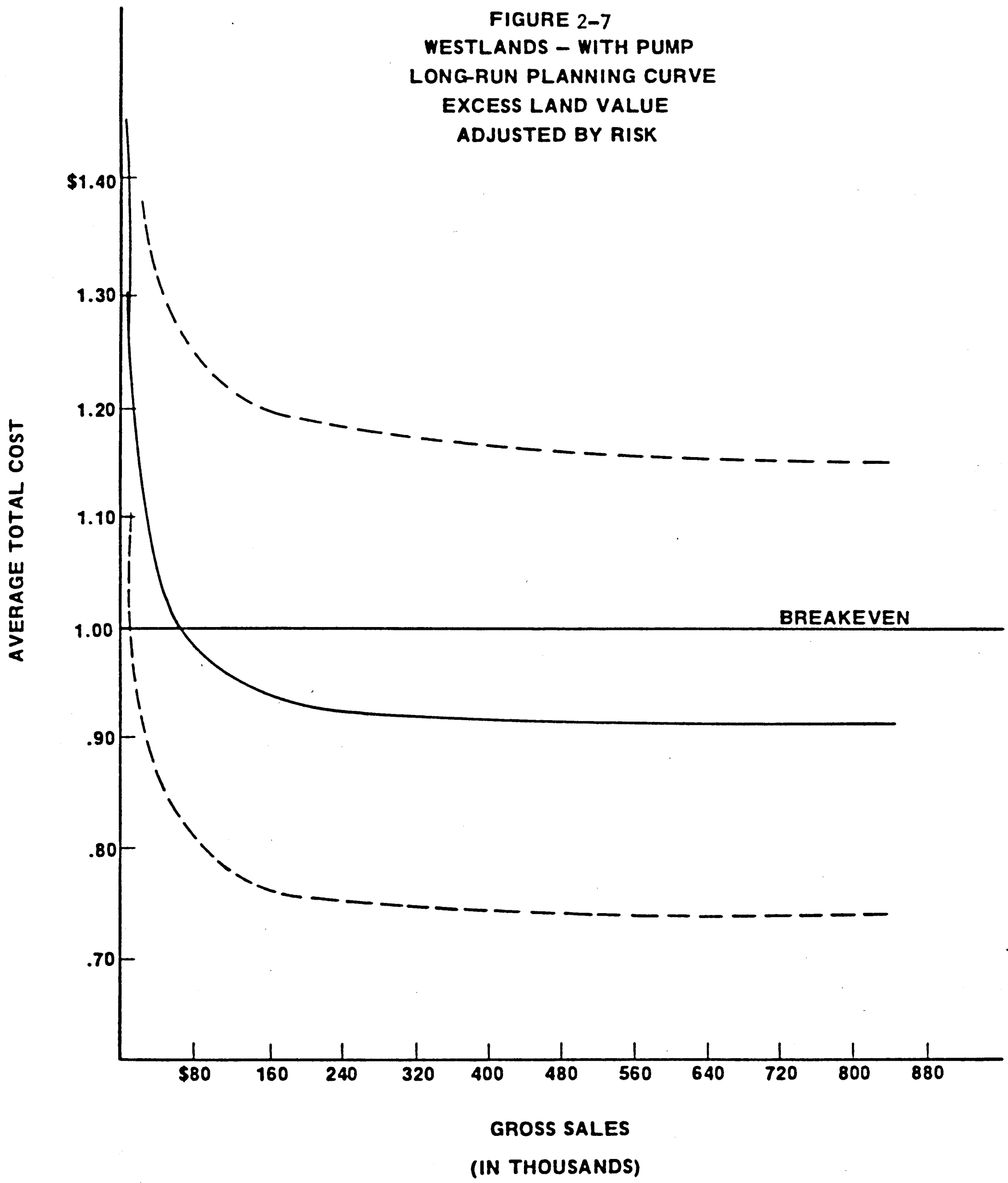
Reading from the graph for the 160-acre farm, the maximum ability to pay is estimated at $25 per acre-foot; the 320- and 640-acre farms are both estimated to be able to pay $27 per acre-foot. Due to economies of size, the ability to pay on the 1,280-acre farm size is considerably more—$36 per acre-foot. The results indicate that farm operators could pay water costs higher than 1978 levels but would be unable to pay the estimated BOR full-cost price of $67.50 per acre-foot.

PART III

SUMMARY AND POLICY IMPLICATIONS

Western irrigated agriculture, although sharing the common denominators of aridity and dependence on water, is highly varied in the structure and performance of its farms. Although the 18 case-study irrigation districts analyzed in this report were chosen to represent these varying aspects, some generalizations can be made. Table 3-1 summarizes selected structural and performance characteristics for the 18 districts.

FIGURE 2-7
WESTLANDS – WITH PUMP
LONG-RUN PLANNING CURVE
EXCESS LAND VALUE
ADJUSTED BY RISK



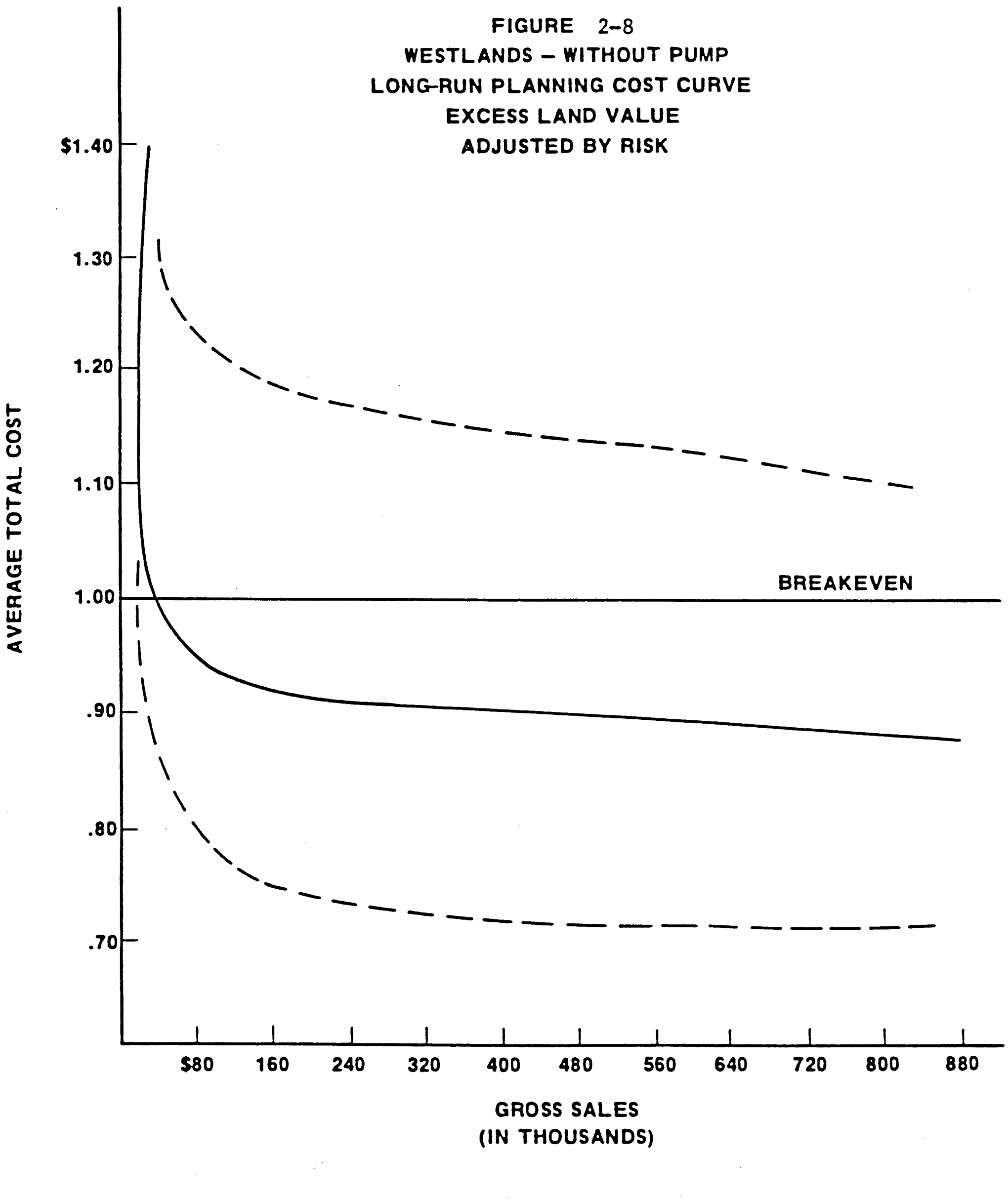


FIGURE 2-8
WESTLANDS – WITHOUT PUMP
LONG-RUN PLANNING COST CURVE
EXCESS LAND VALUE
ADJUSTED BY RISK
AVERAGE TOTAL COST
$1.40
1.30
1.20
1.10
1.00
.90
.80
.70
BREAKEVEN
$80
160
240
320
400
480
560
640
720
800
880
GROSS SALES
(IN THOUSANDS)

FIGURE 2-9
DEMAND FOR IRRIGATION WATER
WESTLANDS (WITH PUMP)

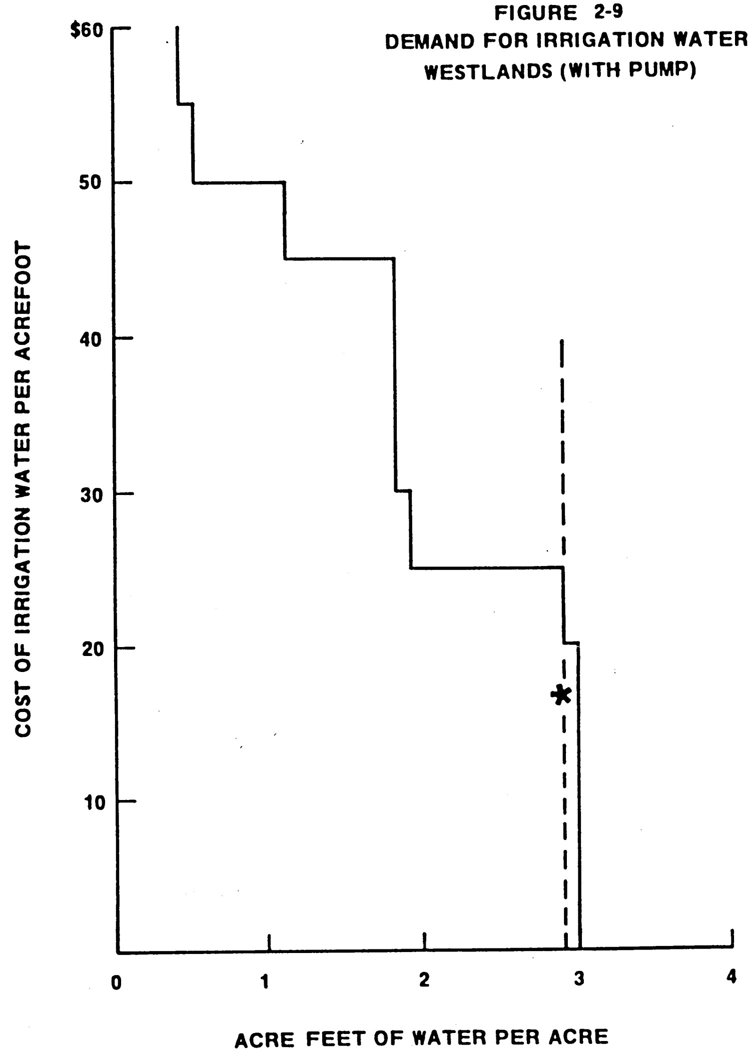


FIGURE 2-10
ABILITY TO PAY FOR IRRIGATION WATER
WESTLANDS (WITH PUMP)
(EXCESS LAND VALUE)

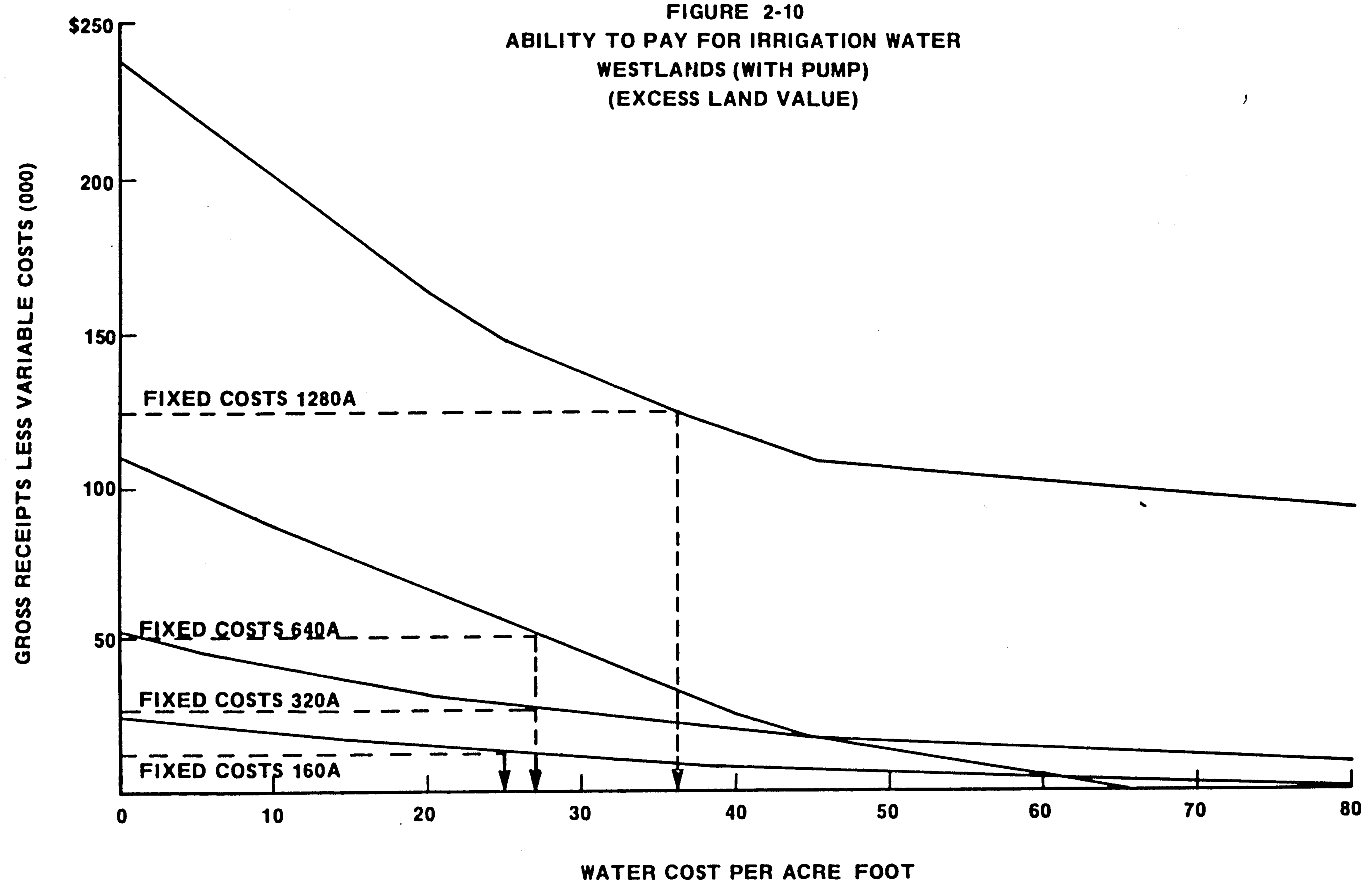


Table 3-1

Selected Structural and Performance Characteristics of 18 Case-Study Irrigation Districts

District	(1) 1978 gross sales	(2) 1978[a/] net cash flow	(3) Average ownership	(4) Gini coefficient owners	(5) Average farm size	(6) Gini coefficient operators	(7) Ratio operated/ owned land	(8) Land owned nonfamily incorporated	(9) 1978 land value	(10) 1978 cash rent	(11) Water cost	(12) Regular labor input: for mean size farm	(13) Regular labor input: minimum among all farm sizes
	dollars per acre		acres		acres			percent	dollars per acre		dollars per acre foot	per 1,000 acres	
Extensive forage crops													
Malta	65	112	107	0.35	276	0.48	2.8	1.3	600	38	7.79	6.6	2.7
Moon Lake	189	59	102	0.36	226	0.36	2.2	0.8	750	23	1.75	5.7	2.3*
Forage, cereal, field crops													
Truckee-Carson	205	128	120	0.35	322	0.52	2.7	9.9	1,800	70	2.19	7.0	2.0*
Grand Valley	239	49	59	0.06	146	0.38	2.5	3.0	1,900	62	1.18	9.5	3.7
Farwell	246	87	89	0.38	200	0.38	2.5	0.0	1,200	50	10.50	5.0	2.3
Goshen	256	113	84	0.16	229	0.32	2.7	0.0	1,250	100	4.22	5.5	4.3
Lugert-Altus	305	119	94	0.24	259	0.53	2.8	2.1	1,200	55	18.58	9.2	3.0
Black Canyon	310	59	60	0.05	171	0.33	2.8	0.6	1,600	65	1.41	11.0	5.8*
Lower Yellowstone	312	117	73	0.13	198	0.34	2.7	2.9	1,300	59	5.28	5.1	2.2
Glenn-Colusa	362	112	133	N.A.	367	N.A.	2.8	11.0	1,700	74	1.46	6.7	3.4*
Field crops, vegetables													
Columbia Basin East	422	123	149	0.06	543	0.45	3.6	1.4	1,500	90	4.19	5.3	4.0
Westlands	627	102	172	0.52	1,654	0.52	9.6	22.2	1,500	100	15.80	8.1	7.5*
Elephant Butte	773	216	82	0.41	332	0.52	4.0	1.2	1,800	125	6.45	11.9	11.9*
Imperial	837	89	268	0.55	1,328	0.57	4.9	8.7	1,800	101	4.75	5.9	5.3*
Welton-Mohawk	1,076	76	133	0.32	518	0.53	3.9	3.3	2,600	65	4.80	9.8	7.2*
Perennial crops													
Oroville-Tonasket	2,165	1,390	19	N.A.	41	N.A.	2.2	9.1	1,500	N.A.	11.47	76.0	30.3*
Coachella	2,252	365	96	0.38	336	0.65	3.5	34.7	2,000	N.A.	7.00	21.1	6.9*
Goleta	5,997	1,786	39	0.40	101	0.66	2.6	7.8	5,000	N.A.	59.24	23.2	8.9*

a/ Based on "existing farmer" budget for farm size closest to mean farm size.

b/ Not adjusted for off-farm work, seasonal labor, crop mix, custom services, or noncrop enterprises.

* Denotes that the lowest labor input figure was not observed on the largest farms in that district.

Due to the small sample size (18 districts), no statistical analysis was conducted on these data. However, ignoring the perennial-crop districts, there appears to be little correlation in these data between gross crop sales per acre (column 1) and net cash flow per acre (column 2). Among the 15 field crop districts, both the average size ownership unit (column 3) and the Gini coefficient of concentration (column 4) show more variability than the same data for farm operations (columns 5 and 6). Again, no strong correlation is apparent between type of farming or gross sales and average acres owned.

One surprising relationship revealed by these data was the consistency of the ratio of operated land to owned land (column 7) across type of farms. Except for Westlands, a central tendency around the ratio values of 2.7 or 2.8 is observable. The tendency for nonfamily corporations to invest in federal water projects (column 8) appears to be related more to geographic location in California and Nevada than to type of farm, intensity of cultivation, or land values, although none of the 11 states included in this study has strong laws controlling corporate ownership.

One of the stronger relationships observed was between gross sales per acre and the appraised value of land (column 9). Economic theory suggests a close relationship between market values for land (column 9) and annual cash rents (column 10), but these data do not support this contention. One explanation could be that the land rental market is not efficient due to the lack of information to both lessors and lessees and the strong influence of tradition and family relationships in leasing arrangements.

Since 1939, BOR has based water charges to the districts on the concept of ability to pay, *i.e.,* some relation between water charges and net income (column 2). Column 11 presents average water costs including district delivery charges for each district. Again, no consistent relationship is observable.

Summary statistics of regular or full-time labor input per 1,000 acres of land are presented in columns 12 and 13. Column 12 reports the regular (full-time) labor input for the mean farm size group in each district and, as such, is a reasonable indicator of type of farming, intensity of cultivation, and gross sales per acre. Column 13 reports the minimum labor input among all farm size groups within each district. In all but one district (Elephant Butte), the minimum is less than that reported for the average size farm. However, in 11 of the 18 districts, the lowest labor input figure was not observed on the largest farms giving some support to the constant or increasing LRAC curves found in this study.

FINANCIAL VIABILITY

Annual net cash flow to unpaid family labor, management, and equity was used as a measure of farm financial feasibility. Net cash flow is the cash available for family living expenses after cash production, expenses, principal, and interest payments on land and machinery loans have been deducted from gross crop sales: *Gross farm sales less production expenses equals farm income; farm income less loan payments (interest and principal) equals return to family labor, management, and equity.*

The bottom line—the cash flow—provides one measure of the economic viability of a farm.[1]

Returns to unpaid labor, management, and equity were estimated for four farm sizes—160 acres, 320 acres, 640 acres, and 1,280 acres—based on a typical crop mix for each district where field crops were dominant. Returns for three farm sizes—40 acres, 80 acres, and 160 acres—were estimated for 3 of the 18 districts in which perennial crops (fruit and nut trees and vines) dominate.

Net return estimates were made for three farm situations as before: (1) beginning farmer purchasing excess land under terms of commercial lending sources in 1978, (2) beginning farmer paying the current market price for land, and (3) existing farm operator having purchased land at an earlier time and at a lower price and interest rate. This latter group enjoys a much higher equity position because of land-value appreciation.

Summary results of case (1) and case (3) are presented in Table 3-2 for all 18 case-study districts. The net cash flow for beginning farmers purchasing excess land varies widely among districts. For instance, returns to unpaid labor, management, and equity on 160-acre field-crop farms range from a negative $8,200 in the Milk River Project in Montana to a positive $19,600 in the Elephant Butte District in New Mexico. As farm size increases, a higher proportion of the total farm labor is paid a cash wage; therefore, in many cases cash flows appear more favorable for the smaller farm sizes. This is especially true in districts where economies of size are not large, and the difference between excess land values and current market land prices is small.

In comparing new and existing farm operators, the latter, with their assumed high owner equity and lower mortgage interest rates, show a much more favorable cash flow. Returns to unpaid labor, management, and equity for existing farmers on the 160-acre farms are positive for all projects and range from $7,800 in the Grand Valley of Colorado to $34,900 in the Elephant Butte District in New Mexico. Under the assumptions used to describe the existing farm operator, annual cash flows tend to increase as farm size increases.

In the three districts dominated by perennial crops, cash flows are positive in all farm sizes for beginning and existing farm operators alike.

ECONOMIES OF FARM SIZE

Linear programming was used to develop SRAC and LRAC curves for each of the 18 districts as was done for the Westlands in Part II. This technique selects the profit-maximizing combination of crops subject to the supply of land in high value crops, water, machinery capacity, and agronomic limitations developed for the typical farm budgets analyzed in the previous section.

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[1]Nonmonetary factors are also important since viability also depends on what the family needs or wants. For this reason, a satisfactory cash flow may differ from one family to another and from one region to another.

Table 3-2

Returns to Unpaid Family Labor, Management, and Equity, 1978

District	State	160 acre farm		320 acre farm		640 acre farm		1,280 acre farm	
		Beginning a/	Existing	Beginning a/	Existing	Beginning a/	Existing	Beginning a/	Existing
		dollars							
Field crops									
Black Canyon	ID	-6,600	9,400	-1,200	28,000	-7,700	27,000	39,800	84,800
Columbia Basin East District	WA	12,800	26,400	25,700	53,200	31,300	78,600	78,500	150,300
Elephant Butte	NM	19,600	34,900	44,500	69,300	65,400	101,400	117,200	174,200
Farwell	NB	-2,600	14,000	-4,600	33,200	2,600	44,000	16,300	64,900
Glenn-Colusa	CA	8,700	22,900	10,100	36,000	17,500	48,500	-16,800	24,100
Goshen	WY	3,500	17,900	13,000	36,100	11,200	46,500	25,800	75,000
Grand Valley Gravity District	CO	600	7,800	-3,000	12,900	-5,600	17,000	12,500	40,100
Imperial (light soil)	CA	2,700	18,900	1,700	34,800	14,100	50,700	65,900	114,500
(heavy soil)		-2,700	3,800	-7,700	5,800	-11,300	4,200	1,400	22,300
Lower Yellowstone	MT	3,600	18,700	17,500	41,800	38,500	66,900	95,700	132,200
Lugert-Altus	OK	-7,100	17,700	-9,600	38,000	-18,000	63,200	-10,100	101,000
Milk River Malta District	MT	-8,200	12,600	-2,900	35,847	-12,700	51,300	-36,200	82,300
Moon Lake (high area)	UT	-800	6,500	2,000	15,100	9,700	26,400	14,900	38,300
(low area)		-100	9,200	4,500	19,000	12,900	31,300	23,500	48,500
Truckee-Carson	NV	11,600	12,900	37,100	41,000	63,200	69,600	99,300	109,100
Welton-Mohawk	AZ	9,900	26,600	27,400	53,500	18,200	48,600	17,600	53,300
Westlands (with pump)	CA	10,800	10,600	15,900	15,600	29,300	33,100	109,400	125,800
(without pump)		14,400	13,200	25,000	20,500	36,500	38,200	116,600	131,000

District	State	40 acre farm		80 acre farm		160 acre farm	
		Beginning	Existing	Beginning	Existing	Beginning	Existing
		dollars					
Perennial crops							
Coachella	CA	13,900	26,500	17,100	42,100	16,000	58,400
Coleta	CA	42,700	73,800	81,300	142,900	155,000	277,300
Oroville-Tonasket	WA	36,700	55,600	63,600	99,100	107,800	178,400

a/ Beginning farm operator is assumed to have purchased up to 320 acres of excess land.

The results of the linear programming analysis are presented in Figures 3-1, 3-2, 3-3, and 3-4. All 18 LRAC curves exhibit a rapidly declining average cost per unit of output up to the point where gross farm sales exceed $100,000; in all but one district (Lugert-Altus), the LRAC drops below the break-even level of $1.00 of total cost per $1.00 of gross sales.

Use of gross sales as a measure of farm output means that prices for different commodities were used as weights to reach a dollar common denominator for the various crops, allowing comparisons to be made among districts. In reality, however, commodity prices fluctuate so that the LRAC curves would be expected to shift up and down over time. The critical characteristic of these curves is their general shape, not their position on the graph. The relative "flatness" of most curves, after crop sales reach the $150,000 to $200,000 range, is their most important attribute for acreage limitation policy. A limited number exhibit a slightly increasing average cost at larger outputs due to the cost of managerial and supervisory labor increasing faster than technical economies of size. A small number of LRAC exhibit a slightly decreasing average cost over the entire range of output.

ACREAGE TO ACHIEVE SPECIFIED EFFICIENCY

A major question raised by a proposed enforcement of any acreage limitation policy is: How much economic efficiency would be lost, if any, by reducing the size of existing farms through the enforcement of ownership or farm-operating size limitations? Table 3-3 presents the approximate acreage and gross crop sales required to achieve 95 percent and 98 percent[1] of the minimum average total cost in each district, derived from the economies-of-size analysis.

Table 3-3 data indicate that, except for the tree-fruit districts which require much smaller acreages, 95 percent of the maximum economic efficiency can be achieved by a farm size in the 300- to 450-acre range with gross crop sales in the $75,000-$150,000 range.

A somewhat larger acreage is required to achieve 98 percent of potential economic efficiency. For all but two of the case-study districts, this level of efficiency is achieved at or below 900 acres, with most of the districts in the 320- to 640-acre range and gross crop sales in the $150,000-$300,000 range.

MINIMUM ACREAGE TO ACHIEVE SPECIFIED INCOMES

The amount of money available to the farm family after production expenses and debt service is one measure of farm viability. Table 3-4 presents the minimum crop acreage required to achieve three levels of cash flow ($10,000, $15,000, and $20,000), based on the linear programming analysis under the excess land-value, beginning farmer scenario.

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[1]Determined by dividing minimum average total cost by 0.98 and 0.95, respectively, and interpolating along the LRAC.

FIGURE 3-1
LONG-RUN AVERAGE COST CURVES, EXCESS LAND VALUE,
LOWER COLORADO AND UPPER MISSOURI REGIONS, 1978

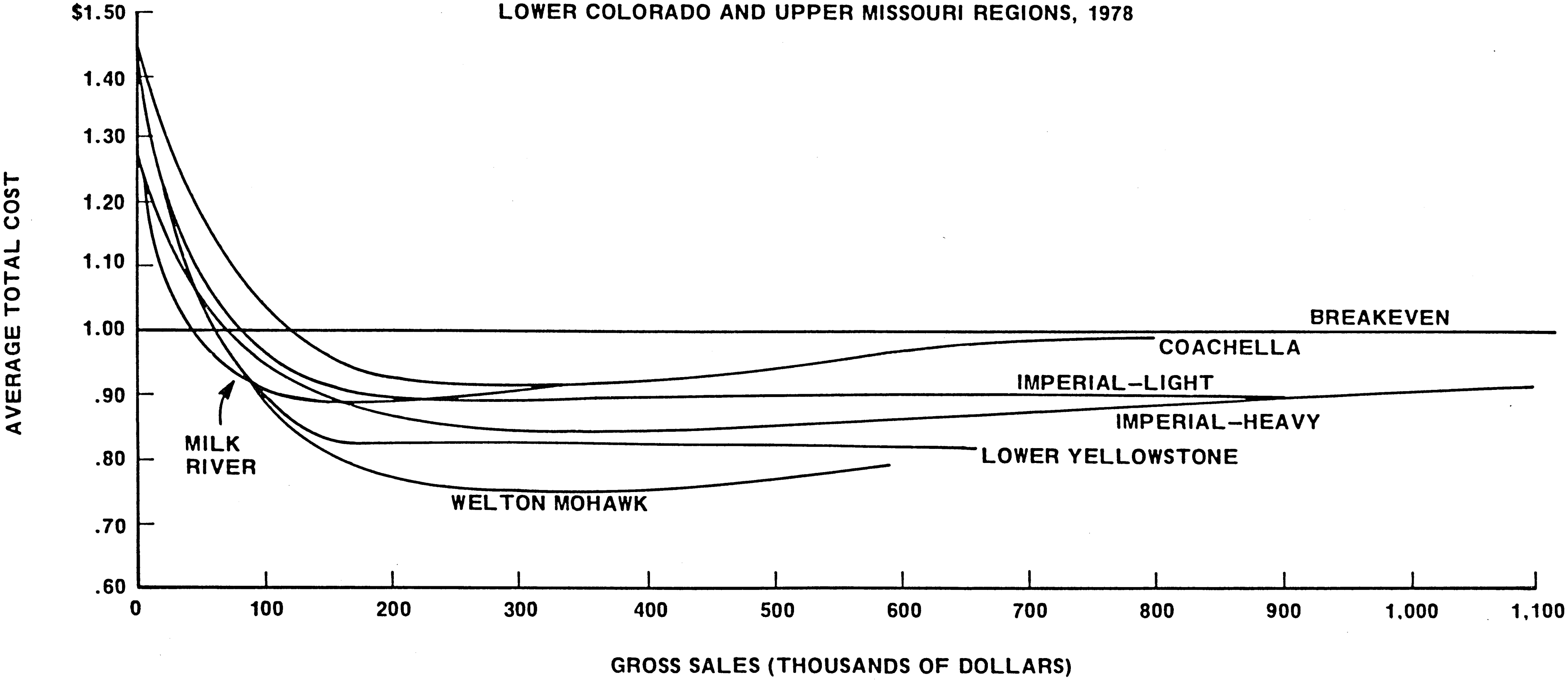

FIGURE 3-2

LONG-RUN AVERAGE COST CURVE, EXCESS LAND VALUES

MIDPACIFIC REGION, 1978

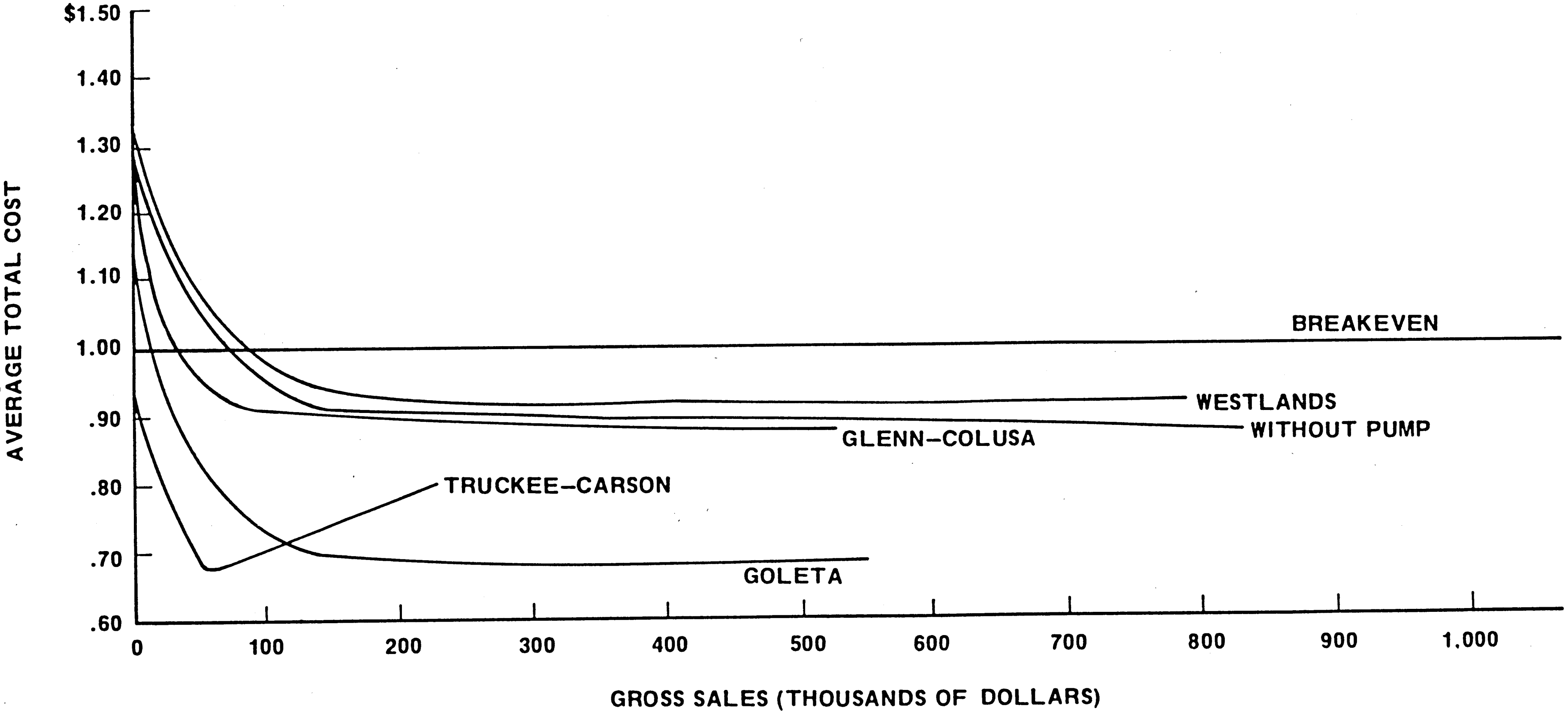

FIGURE 3-3
LONG-RUN AVERAGE COST CURVE, EXCESS LAND VALUES UPPER COLORADO AND PACIFIC NORTHWEST REGIONS, 1977

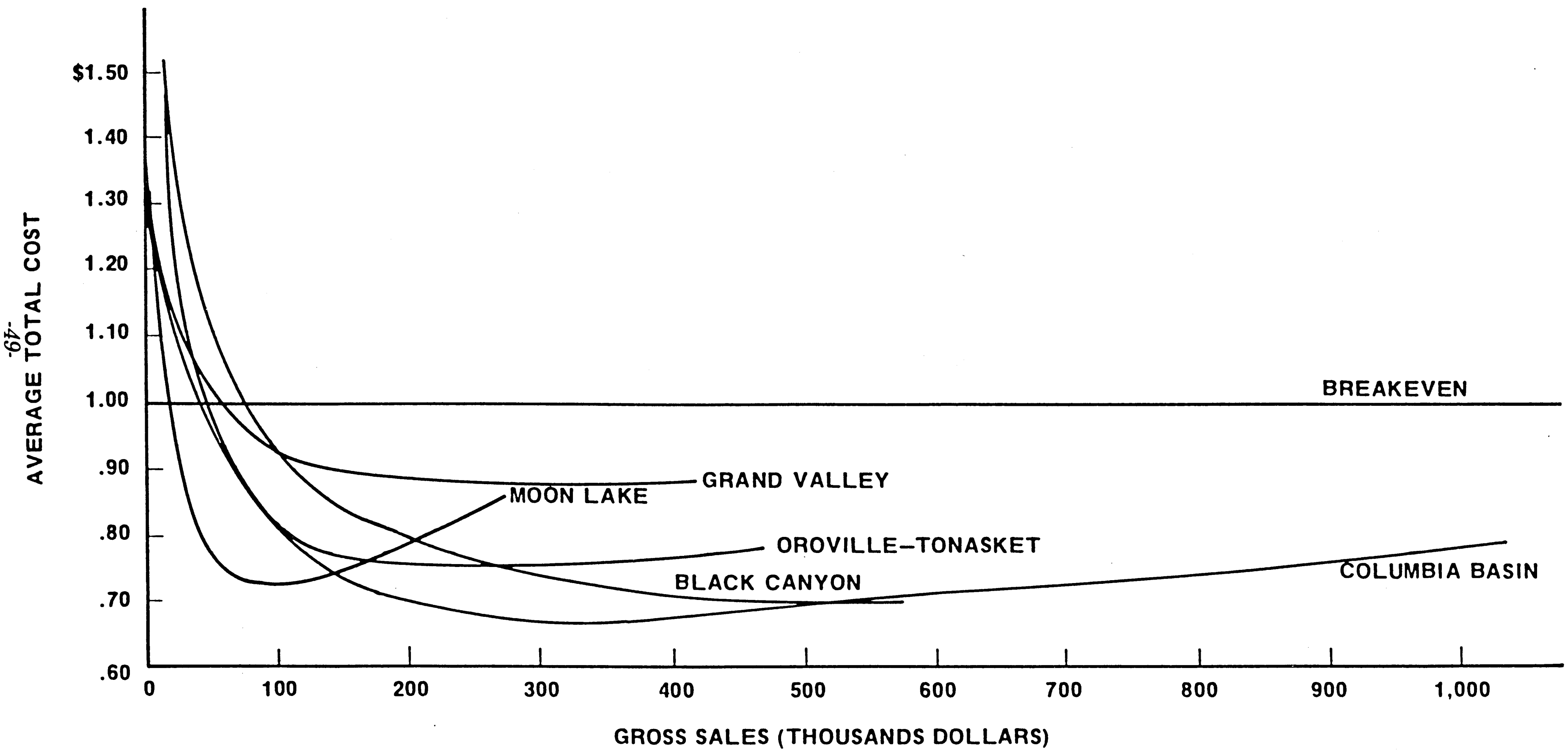

FIGURE 3-4
LONG-RUN AVERAGE COST CURVES, EXCESS LAND VALUE
LOWER MISSOURI AND SOUTHWEST REGION, 1978

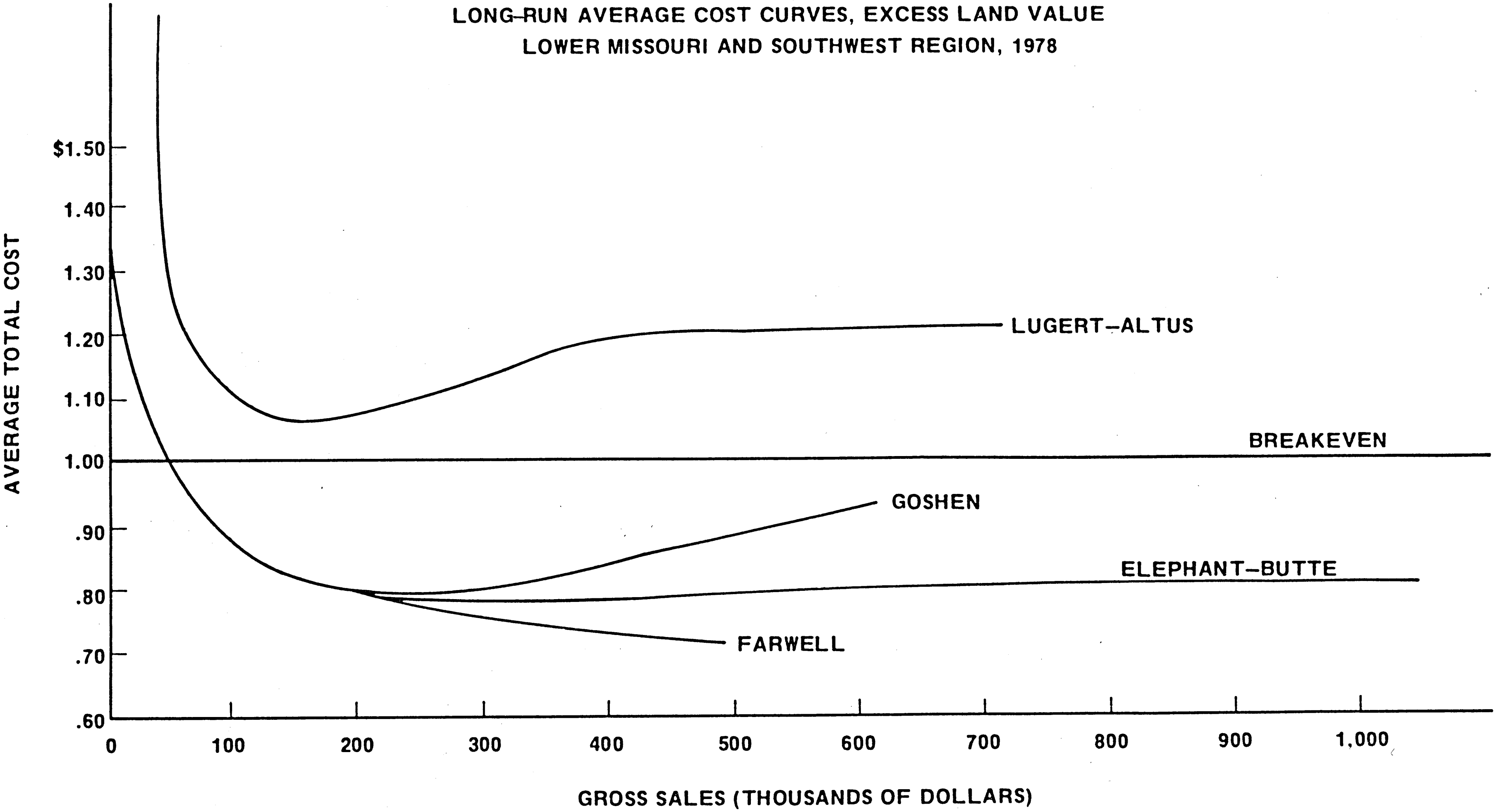

Table 3-3

Approximate Irrigated Crop Acreage and Gross Sales to Achieve 95 and 98 Percent of Minimum Long-Run Average Costs, Beginning Farmer, Excess Land Value, 1978

District	95 percent		98 percent	
	Acres	Sales	Acres	Sales
Black Canyon	740	$250,000	900	$315,000
Coachella	30	150,000	40	200,000
Columbia Basin East District	380	210,000	520	290,000
Elephant Butte	410	284,000	440	305,000
Farwell	680	300,000	1,000	380,000
Glenn-Colusa	580	320,000	620	345,000
Goleta	22	71,000	40	130,000
Goshen	420	155,000	550	205,000
Grand Valley	320	83,500	900	153,000
Imperial - light soil	300	90,000	375	150,000
heavy soil	890	400,000	1,350	490,000
Lower Yellowstone	645	110,000	735	155,000
Lugert-Altus	170	85,000	200	95,000
Milk River	350	110,000	570	150,000
Moon Lake (low)	450	55,000	475	64,000
Oroville-Tonasket	75	220,000	78	230,000
Truckee-Carson	220	50,000	275	60,000
Welton-Mohawk	300	180,000	320	230,000
Westlands - with pump	420	360,000	510	440,000
without pump	152	100,000	500	400,000

Table 3-4

Minimum Crop Acreage Required to Achieve $10,000, $15,000, and $20,000 Annual Return to Unpaid Family Labor, Management, and Equity; Optimized Crop Mix Under Excess Land Value, Beginning Farmer, 1978

District	$10,000	$15,000	$20,000
		acres	
Black Canyon	280	400	620
Coachella	38	77	150
Columbia Basin East District	100	125	135
Elephant Butte	40	60	80
Farwell	210	265	310
Glenn-Colusa	120	140	150
Goleta	23	25	30
Goshen	180	200	230
Grand Valley	160	200	300
Imperial - light soil	190	240	260
heavy soil	250	280	310
Lower Yellowstone	215	270	335
Lugert-Altus	a/	a/	a/
Milk River	290	430	525
Moon Lake	255	330	400
Oroville-Tonasket	23	26	29
Truckee-Carson	140	160	275
Welton-Mohawk	160	175	210
Westlands - with pump	160	180	210
without pump	150	170	180

a/ Not possible to achieve this return under assumed prices and yields.

Under the assumptions of this study, only one district—Lugert-Altus—requires more than 960 acres to achieve a cash flow of $20,000. Most of the remaining districts require crop acreages in the range of 150 acres to 320 acres to achieve a return to unpaid labor, management, and equity of $20,000 annually. Nonmonetary considerations and off-farm income are also important determinants of family-farm viability. In 1978 the national average total income per farm-operator family was $22,400; of this amount, $11,500 was earned off the farm (U. S. Department of Agriculture, 1981). The national average net farm income to be compared with that shown in Table 3-4 was $10,900 (U. S. Department of Agriculture, 1981).

RISK AND UNCERTAINTY

A graphic presentation of the inherent risk in farming was developed and shown for each of the case-study districts. Summary graphics are not possible within the space permitted; therefore, for interdistrict comparisons the total variance and coefficient of variation for a farm in each district are presented in Table 3-5.[1]

In general, as measured by the coefficient of variation, the fruit-growing districts show the highest degree of risk. Goleta (specializing in avocados) and Oroville-Tonasket (specializing in apples) both face risk from frost damage. Among the field crop districts, Elephant Butte also grows a specialty crop, peppers; Lugert-Altus must face the risks associated with dryland grain production in conjunction with its irrigated crops; and Glenn-Colusa is predominately a rice-growing area where wet weather at planting time in May and again at harvesttime in October can significantly affect yields.

POLICY QUESTIONS AND IMPLICATIONS

Full-Cost Pricing of Project Water

Most of the controversy over federal acreage limitation policy centers around who is to receive the large subsidies associated with federal water projects as pointed out by Seckler and Young (1978). A logical question is: What would happen if all or part of the subsidy were eliminated by recapture through higher water charges to landowners and operators?

According to the U. S. Department of Interior, Water and Power Resources Service (1981), their definition of full cost of irrigation water includes all construction costs allocated to irrigation plus all operation and maintenance cost deficits, with interest charged on both; their definition of irrigation subsidy is the unpaid full costs net of the present worth of future payments (Table 3-6, column 4).

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[1]The coefficient of variation—the standard deviation divided by the mean—allows a unitless comparison of variation among districts with very different means; variance was determined based on crop mix at minimum SRAC for a 1,280-acre farm in field-crop districts and a 160-acre farm in perennial-crop districts.

Table 3-5

Relative Risk of Gross Income Per Acre by District[a/]

District	State	Variance	Coefficient of variation
			percent
Field crops			
Black Canyon	ID	134.1	4.3
Columbia Basin East District	WA	488.3	4.7
Elephant Butte	NM	13,560.1	19.6
Farwell	NB	194.5	6.1
Glenn-Colusa	CA	4,175.3	15.8
Grand Valley	CO	28.4	2.5
Imperial - light soil	CA	3,960.8	8.6
- heavy soil		2,840.3	9.5
Lower Yellowstone	MT	573.0	7.8
Lugert-Altus	OK	432.4	15.3
Milk River	MT	103.6	14.9
Moon Lake - high area	UT	13.0	3.4
- low area		43.6	4.4
Truckee-Carson	NV	170.4	5.8
Welton-Mohawk	AZ	1,199.0	6.5
Westlands - with pump	CA	5,481.7	12.9
- without pump		4,314.2	12.3
Perennial crops			
Coachella	CA	50,963.1	5.8
Goleta	CA	378,052.8	20.8
Oroville-Tonasket	WA	279,904.4	36.0

a/ Crop mix at minimum SRAC for a 1,280 acre field crop farm and a 160 acre farm in perennial crop districts.

Table 3-6

Increase in Land Values Due to Project Water and Estimated Subsidy Per Acre

Project	Excess land value per acre[a]	Current market land price per acre	Increase per acre in land value[b]	Estimated subsidy per acre[c]
	dollars			
Oroville-Tonasket, WA	1,500	1,550	50	417
Black Canyon #2, ID	1,200	1,600	400	762
East Columbia Basin, WA	850	1,500	650	1,619
Goleta, CA	15,500[d]	17,500[d]	2,000	1,378[e]
Truckee-Carson, NB	410	1,800	1,390	931
Glenn-Colusa, CA	1,200	1,700	500	101
Westlands, CA	550	1,500	950	1,422[f]
Coachella, CA	1,450	2,000	550	1,000
Welton-Mohawk, AZ	1,245	2,600	1,355	1,786
Imperial, CA	1,700	1,800	100	149
Moon Lake, UT	350	750	400	58
Grand Valley, CO	600	1,900	1,300	1,623
Elephant Butte, NM	775	1,800	1,025	363
Lugert-Altus, OK	765	1,200	435	675
Malta, MT	325	600	275	812
Lower Yellowstone #1, MT	750	1,300	550	507
Farwell, NB	1,100	1,200	100	1,446
Goshen, WY	605	1,250	645	416

a/ Includes value of land and irrigation improvements except irrigation pumps.
b/ Measured as the difference between current market land price and excess land values.
c/ Retroactive to year of initial construction.
d/ Includes value of mature avocado grove.
e/ Average for entire Cachuma Project.
f/ Average for San Luis Unit.

Farm owners or operators may not capture the full amount of the calculated subsidy. If the *ex post* benefit-cost ratio of a project is less than 1.0, either due to errors in estimating benefits or to cost overruns, the full amount of the income transfer may not be received by landowners or operators.

The agricultural value of land is the discounted present value of the expected stream of future net income. Thus, any increase in irrigation water costs would be expected to have a depressing effect on land prices. If the preproject (excess land) value is the market value today without the benefits of the project, then the difference between excess land value and current market price should represent the land market estimate of the present value of the water subsidy. Further, if the project benefit-cost ratio is just 1.0, land-value enhancement should just equal the Interior's calculated unpaid full cost. Recapture of the project subsidy through increased water prices should, therefore, force the market price for land down to its excess land value. Table 3-6 displays information on both land-value enhancement and the Interior's calculated subsidy for all 18 case-study districts.

Thus, there are two measures of the irrigation subsidy: (1) the calculated one based on the costs and interest rates used by the Department of Interior (Table 3-6, column 4) and (2) the land buyer's estimate, as reflected in the bid price for project land, compared to the appraised value of the same land without the project (column 3). Note that only 6 of the 18 districts show enhanced land values greater than the calculated subsidy. In other words, in 12 of the districts the amount of the subsidy actually captured by landowners through value enhancement was less than society's investment in that land as indicated by the calculated subsidy. Two hypotheses can be made: (1) As indicated earlier, the *ex post* benefit-cost ratio may have been less than 1.0 and (2) there may be oligopsony power in the land rental market which allowed a few large lessees to capture a portion of the project subsidy.

Were full-cost water pricing to be imposed, farm operators would be expected to make two types of adjustments to mitigate the impact: (1) shift to more water-conserving technologies to improve on-farm irrigation efficiencies and (2) adjust the crop mix to crops with a higher return per unit of water.

Using the basic linear programming model from the economies-of-size estimations, additional activities were specified to represent several possible irrigation technologies for each crop. Results of this analysis for 18 irrigation districts provided (1) optimum quantity of irrigation water at each water price in $5.00 per acre-foot increments, (2) optimum combination of crops and the optimum irrigation technology for each of these crops for each water-price increment, and (3) resulting level of farm income at each water price.

A major benefit of full-cost pricing beside the recapture of the water subsidy would be conservation of existing water supplies. Table 3-7 presents summary data on water use per acre based on historic (1972-1976) deliveries, 1978 average cost per acre-foot, and estimated full-cost water rates for all 18 districts. For the 10 irrigation districts with significant changes in water use under full-cost pricing, Table 3-8 presents the estimated quantity of water per acre and district totals that might be conserved if all water were charged at its full cost—that is, if a pure economic efficiency criterion were applied to federal water policy and water use was determined by the point where average cost equaled the value of the marginal production. The largest districts—Imperial, Westlands, and Welton-Mohawk—could be expected to conserve the most water under full-cost pricing; and the total for all 10 districts is almost 1,000,000 acre-feet per year or about 12 percent of the total supply which could be put to alternative uses including instream and municipal and industrial uses.

Table 3-7

Water Supply Per Acre Delivered to Farm Headgate and Estimated Subsidized and Full-Cost Rates

District	Average supply 1972-1976	Current charges converted to acre-foot rate (subsidized)	Estimated full-cost rate
	acre-feet per acre	dollars	
Black Canyon	5.20	1.41	15.77
Coachella	6.31	7.00	26.27
Columbia Basin East	4.19	4.19	41.16
Elephant Butte	2.14	6.45	24.43
Farwell	1.20	10.50	135.50
Glenn-Colusa	.71 a/ (5.88) b/	1.46	17.85
Goleta	1.84	59.24	263.12
Goshen	2.10	4.22	22.96
Grand Valley	5.40	1.18	31.10
Imperial	5.82	4.75	11.00
Lower Yellowstone	1.80	5.28	34.62
Lugert-Altus	0.52	18.58	143.19
Milk River	0.80	7.79	119.13
Moon Lake	1.13	1.75	7.04
Oroville-Tonasket	4.40	11.47	21.33
Truckee-Carson	3.38	2.19	33.46
Welton-Mohawk	6.96	4.80	29.58
Westlands	2.54	15.80	67.56

a/ Federal water delivery per acre.
b/ Total water delivery per acre.

Table 3-8

On-Farm Water Use Per Acre Under Current Pricing
and Under Full-Cost Pricing

District	Current water use	Estimated water use at full cost	Difference	Potential total conservation on-farm for district
	(1)	(2)	(1-2)	
	acre feet per acre			acre-feet
Black Canyon	5.2	2.3	2.7	125,000
Columbia Basin East District	4.2	3.8	0.4	51,600
Goshen	2.1	1.4	0.7	36,000
Grand Valley	5.4	1.6	3.8	79,000
Imperial	5.9	5.4	0.5	225,700
Milk River, Malta	0.8	0.4	0.4	13,200
Oroville-Tonasket	4.4	3.5	0.9	6,400
Truckee-Carson	3.4	2.6	0.8	46,000
Welton-Mohawk	6.9	3.8	3.1	204,600
Westlands	2.6	0.5	2.1	203,900

Ability to pay for water by farms within an irrigation district (Table 3-9) was directly related to the economies-of-size relations found for that district; that is, in most cases the ability to pay increased with farm size. Since ability-to-pay calculations were based on the difference between the worth of land at its excess land value and its current market value, those districts with large subsidies per acre also tended to have the highest ability to pay.

Results indicate that in only 7 of the 18 districts were any farms able to repay the full-cost price; in general, these were the largest farm sizes studied. This indicates that an alternative water price structure incorporating a two-tiered price scheme, as suggested by Seckler and Young (1978), may be desirable: Smaller farms would pay a subsidized water rate, and farms above a socially desirable size would pay an unsubsidized rate in exchange for removal of limitations on farm size.

Implications for Acreage Limitation Policy

Three basic policy questions are raised by the proposed acreage limitation rules and regulations:

1. What is the loss in efficiency, *i.e.,* increased cost per unit of output, if any, if existing excess lands are sold to beginning farmers to create new smaller farms or to existing small farmers for size expansion.

2. How widely should the benefits and subsidies of federal water projects be distributed? Any distribution policy must be subject to the limitation that the annual cash flow from operating the farm be positive and at a level high enough to make the farm a viable operation.

3. Can removal of irrigation subsidies through recapture using full-cost pricing eliminate the need for administrative limitation of farm size and landownership, or would the impact on farm net incomes be so great—especially for those owners who have recently purchased land at current market prices—as to make the policy politically untenable?

Efficiency

Two points are important in discussing the policy implications of the LRAC curves presented in Figures 3-1 through 3-4. First, under 1978 income and cost conditions, including excess land values, almost all of the 18 case-study districts show some portion of the LRAC falling below the break-even level, *i.e.,* they show a positive net income. Second, average costs decrease rapidly as output increases until gross farm sales reach the level of about $100,000. In general, after most of the economies of size are achieved, the LRAC curve becomes flat or constant. In economic literature, an industry with this characteristic would be classified as a constant cost industry.

The policy implication of a constant cost industry is that, once most of the economies of size have been captured, there is little or no benefit to society from having farms of a larger size; that is, there is no gain in efficiency which might translate into lower food prices from having farms of a size larger than those exhibiting the minimum average total cost. Stated another way, there is no efficiency loss to society from creating smaller farms out of large

Table 3-9

Probable Willingness to Pay for Irrigation Water by Farm Size Under a Charge Per Acre Foot Water Rate that Recaptures the Increased Land Value[a/]

District	Farm size			
	160 acres	320 acres	640 acres	1,280 acres
	dollars per acre-foot			
Black Canyon	1	13	24	70*
Columbia Basin	17	18	20	11
Elephant Butte	50*	51*	67*	69*
Farwell	5	5	34	67
Glenn-Colusa	2	2	6	9
Grand Valley	1	2	4	7
Imperial (light)	8	8	10	13*
Lower Yellowstone	16	25	35*	47*
Lugert-Altus	b/	b/	b/	b/
Milk River (Malta)	8	11	80	24
Moon Lake (low)	3	5	7	8*
Truckee-Carson	49*	65*	72*	68*
Welton-Mohawk	6	29	31	24
Westlands (with pump)	25	27	27	36
Tree crops	40 acres	80 acres	160 acres	
	dollars per acre foot			
Coachella	9	7	8	
Goleta	12	28	35	
Oroville-Tonasket	90*	90*	90*	

a/ Assuming a farm operator of 640 and 1,280 acre farms would be willing to pay a water price that would reduce the income on his owned land (320 acres) to its value without the federal water supply.

b/ Unable to cover any water cost at assumed prices and yields.

*/ Indicates that the ability to pay exceeds the full-cost price.

farms if the average total cost for both farm sizes is the same. For the individual farm owner in a constant cost industry producing a normal profit, there is still an incentive to expand beyond the minimum of LRAC because farm income increases proportionately with volume thereafter.

If the LRAC curve is increasing (an increasing cost industry), diseconomies of size are present. Under this condition there is an efficiency gain to society from creating smaller farms (at the minimum of LRAC) out of larger farms. For the individual farm operator in an increasing cost industry, there is still an incentive to expand farm size because total net income is still increasing as long as long-run marginal cost is below the break-even level. The incentive to expand, however, is less under this situation than under a constant or decreasing cost industry. As can be seen in Table 3-3, acreage to achieve 95 percent and 98 percent of minimum average total cost is heavily dependent on the slope or lack of slope in the LRAC. A wide spread between the acreage for 95 percent and 98 percent of minimum average total cost reflects a flat or constant cost situation. An extreme case is the Westlands Water District which exhibits a very gradual decreasing cost situation over the entire range of the curve. On the other hand, a district such as Moon Lake in Utah with a relative steep slope exhibits a narrow spread between the acreage of the 95 percent and 98 percent levels. Note, also, in Table 3-3 that only 2 of the 18 districts exceeded the BOR proposed acreage limitation of 960 acres at the 98 percent achievement level under excess land values.

Equity

The equity or fairness question stems from the magnitude and distribution of the federal subsidy to water users. The original Reclamation Act of 1902 had as one of its goals the widest practical distribution of benefits from federal water projects. Taking this goal to its extreme, however, would create a large number of very small farms unable to generate sufficient cash flow to service debt, pay farm expenses, and contribute something toward family living expenses. Thus, the equity goal is restricted by the question of farm viability.

Table 3-4 presents the district acreage required to generate $10,000, $15,000, and $20,000 annual return to unpaid labor, management, and equity (cash flow), based on an optimized crop mix and excess land values. Out of the 18 case-study districts, only one was not able to generate an annual cash flow of at least $20,000 within the upper acreage limit of 960 acres in the Interior's Proposed Rules and Regulations.

Full-Cost Pricing

Water in federal irrigation projects is highly subsidized; however, all of this subsidy is not captured by landowners and farm operators. A policy of subsidy recapture through full-cost pricing could produce significant economic effects.

For districts where the construction subsidy per acre exceeds the project benefits captured through increased land values, full subsidy recovery through full-cost pricing could force the agricultural value of project land below its value in alternative uses causing absolute capital losses to landowners. That is, if full-cost water prices were set in these districts at a level high enough to recapture the subsidy, land values would probably fall to a level below the excess land value; and landowners would be worse off than if the project had never been built.

Districts where project benefits captured by landowners and operators exceed the subsidy would probably observe a decline in current market land values (on nonexcess land), but land market prices would probably still exceed the excess land values.

To the extent that increased water charges induce farm operators to invest in more water-conserving practices and technologies, water use per acre would be reduced. The water thus conserved could be redirected toward a wide range of uses including irrigation of additional land within the district or in other districts; instream uses for recreation, fish, and wildlife; or storage for year-end carry-over and peak power generation. Increased water conservation also may help mitigate local drainage problems.

A large increase in water costs would cause significant shifts in the district cropping pattern. Acreage of forage crops, such as alfalfa hay, native hay, and irrigated pasture, would probably decline. This, in turn, would probably trigger changes in the local livestock economy due to increased market prices for forage and roughages. Up to a point, irrigated food and feed grains would replace these forages in the crop mix. In areas with sufficient rainfall, dryland crops would replace irrigated crops.

In conclusion, both equity and efficiency goals are clouded by the problem of some apparently inefficient projects in the cost-benefit sense. That is, *ex post facto*, some of the projects on a pure economic efficiency criterion should not have been built or portions of the project should not have been included within the service area. These projects, however, have been built; accordingly, people have invested in irrigation systems and made their cropping plans based on the availability of federal product water, albeit, at a subsidized price.

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