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AN ECONOMIC ANALYSIS OF WATER AVAILABILITY IN CALIFORNIA CENTRAL VALLEY AGRICULTURE

Phase II Draft Report

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Phase II Draft Report

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1.0 INTRODUCTION

1.1 Background

The Sacramento/San Joaquin River Delta system plays a critical role in the California economy. The Delta and its tributaries provide a significant share of the water resources required to meet municipal, industrial, agricultural, recreational and environmental needs. Each of these sectors contributes to the economic well-being of the entire state. The agricultural sector is both one of the top contributors to the state's economy and the largest consumptive user of its water resources. As the State Water Resources Control Board (SWRCB) engages in a process to balance competing uses of scarce water supplies, understanding the economic and financial consequences of reduced water availability for California agriculture, its related industries and local economies is critical.

The Bay-Delta Hearings (D. 1485) Economic Work Group identified the need for an independent assessment of the likely impacts of improved water quality and flow standards in the Delta on agriculture. This study is designed to provide information to the SWRCB as it enters the "water rights phase" of the Bay-Delta Hearings. The focus of the analysis is an assessment of the short and long-run economic and financial impacts of water supply reductions on California's agricultural sector and related industries. Representatives of government, water agencies, agriculture and environmental organizations participated in the design of the study to assure common understanding and agreement on the research base used for analyzing the impacts of alternative water supply scenarios.

1.2 Study Goals and Objectives

Research for this study was conducted in a phased, interactive manner to assure that the diverse participating parties were fully informed during the process. The study team and its Technical Advisory Committee (TAC) proposed a study approach that would capture the complex legal, institutional and physical environments in which water agencies and producers operate and the implications these complexities present for assessing adjustments and impacts.

A case study approach was selected to capture and reflect these complexities. The lack of a consistent, state-level data base covering the relationships between water availability, the agricultural sector and the state's economy provides additional impetus for a case study approach. Through this approach the legal, institutional and physical system constraints facing decision makers as they respond to reduced water supplies can be examined at a disaggregated level. This level of analysis is necessary for an accurate identification of the financial and economic impacts affecting districts and producers.

The documented responses of water suppliers (water districts, irrigation districts, water storage districts and other organizations) and agricultural producers to drought-induced water scarcities, both present and historical, provide an indication of the nature and likely direction and magnitude of the economic and financial impacts of future supply reductions. An analysis of short-run responses to water reductions can help to identify both positive and negative impacts that are largely temporary. In the long-run, however, continued shortages will necessitate adjustments with longer term implications for water suppliers, production agriculture, related agricultural industries and the state's economy more broadly. This study provides a research base for such an assessment.

Specific objectives for the study include:

- Determine the research base needed to assess the likely short-run and long-run impacts of a range of alternative supply levels on agriculture, related industries and local economies, and the resource base;
- Through a study of selected water supply districts, and based upon available data:
    - —identify the magnitude of water supply reductions for selected water suppliers and related short-run responses and long-run adjustments;
    - —identify the existing legal, institutional and physical system constraints and opportunities which guide observed adjustments to water shortages;

—identify the resulting range and distribution of observed and potential economic impacts relevant to water suppliers and agricultural producers faced with shortages ; and

—identify indicators of change in local economy and resource quality conditions resulting from adjustments to water shortages at the district and farm-levels;

- Evaluate the direction and magnitude of key district, producer, local economy and resource quality impacts, based on the case studies. The economic impact analysis will be guided by a "partial" net social welfare framework that considers both the private and social costs and benefits of adjustments to reduced surface water suppliers. Quantitative and/or qualitative analytical techniques will be used to estimate impacts, depending upon data availability.

- Analyze the potential "mitigating" effects on the case studies of changing or "relaxing" certain prevailing physical and institutional constraints on adjustments (e.g. changes in physical system capacity and legal and institutional rules and regulations);

- Explore the extent to which the case study results can be generalized at higher levels of aggregation - both regionally and statewide.

Phase II of the study, presented in this report, focuses on assessing the short-run responses of water suppliers and agricultural producers to recent water shortages and identifying potential long-run adjustments. Adjustment opportunities and constraints have been analyzed. The likely economic impacts of these adjustments have also been identified. A research plan for Phases III and IV has been developed (see Chapter 7) which specifies additional data needs and an analytical framework for assessing the direction and magnitude of the key economic impacts identified in Phase II. Methods for extending the case study results regionally and statewide will be determined during Phase III for completion in Phase IV.

1.3 Study Approach

The research has been divided into several phases with specific tasks identified for each, following the original proposal.

1.3.1 Phase I Description

In Phase I the methodology and scope of the project were developed. The case study approach was adopted for the initial investigation as that most likely to ensure an understanding of the complex legal, institutional, physical, economic and financial relationships that exist between the California water industry, the agricultural sector and the rest of the state economy.

Criteria were developed to guide the selection of the study areas. Water supply districts were selected as the unit of analysis to control for differences in water sources, costs and reliability, and to capture a variety of institutional arrangements, including decision making and governance structures likely to affect intra- and inter-district water allocations and costs.

Seven water supply districts and a sample of agricultural producers who are "self-suppliers" of irrigation water were selected for the case studies. These cases cover the major agricultural counties in California's Central Valley. In aggregate, these districts receive approximately 35 percent of Central Valley Project (CVP) entitlements and 32 percent of State Water Project (SWP) entitlements in the San Joaquin Valley and cover about 20 percent of California's irrigated acreage. The case studies reflect the significant heterogeneity that exists in California agriculture with respect to water supply sources, hydrology and soil type, production opportunities, farm structure and size, irrigation technology, and other important characteristics.

Phase I research also identified the information needed to assess the adjustments resulting from reductions in water availability. The scope of data collected in this phase was sufficiently broad to accommodate an array of analytical methodologies that might be used in later phases of the study.

Finally, Phase I research delineated an initial conceptual framework to identify the complex relationships between water source, water suppliers, agricultural producers and local economies. This framework was designed to serve as a guide for evaluating the full range of financial, economic and environmental impacts likely to result from reductions in water availability. The framework also describes the prevailing physical system, and the institutional and legal constraints that affect the adjustment paths of water suppliers and agricultural producers.

All Phase I steps were reviewed by the Technical Advisory Committee of the Bay-Delta Economic Work Group. The results are reported in the working document: *Phase I Report: Economic Impacts of Water Availability on California Agriculture*, July 1991, and are summarized in Chapter 2 of this Phase II Report.

1.3.2 Phase II Description

The major objective of Phase II was to assemble a research data base for use in the economic analysis of identified impacts in later phases of the study. In Phase II, field interviews were conducted in the case study districts and information identified in Phase I was collected. Gaps in currently available information and knowledge were identified. To this end, data on normal and critical year CVP/SWP entitlements and deliveries and other sources of supply including groundwater and water transfers were obtained for the 17 year period, 1975–1991. Methods of allocating supplies under normal conditions were assessed and changes in those allocation methods to meet critical year requirements were identified. The specifications of the physical delivery system were obtained with particular attention paid to levels of water delivery efficiency, current and planned system improvements and existing system constraints that may limit districts' abilities to meet changes in the nature and timing of users' demands for water. In addition, the mechanisms districts employed for adjusting to reduced water supplies while meeting on-going district financial obligations were explored.

Data to assess producer impacts were also collected. District crop surveys were tabulated for the years 1975–1990, and preliminarily for 1991. Water allocations to producers in both normal and critical year periods were obtained and retail pricing policies assembled. District estimates of grower groundwater extractions were obtained where available. Information on the number of landowners and farm entities, and corresponding size of holdings, was obtained from districts. In some cases, particularly with respect to identifying changes in levels and types of input demands, district data were augmented with published county and/or state level data.

Phase II did not include resources to conduct survey interviews with producers, but rather, was designed to identify available producer-level data. Nevertheless, interviews were conducted with growers in each of the districts to supplement aggregate district data and identify variable conditions which must be considered in interpreting district level data.

1.3.3 Objectives for Phases III and IV

The case study approach used in Phases I and II of the study will be continued in Phase III, building on the research base developed thus far for analysis of selected district, producer, local economy and resource quality impacts. These impacts will be modelled using surface and groundwater supply assumptions provided to the study team by the Technical Advisory Committee (TAC). These assumptions will be expressed as "probabilities" of delivering different levels of supply to CVP and SWP contractors, and will approximate the reduction levels expected from changes in water quality standards in the Bay-Delta. Specific objectives for Phases III and IV include:

- Measuring—both qualitatively and quantitatively—the direct and indirect economic impacts to case study districts, producers, local economies and the agricultural resource base of surface water supply reductions under TAC-provided water supply scenarios, within existing constraints;
- Analyzing how these measured impacts might be reduced or mitigated by relaxing certain constraints, including changes in physical systems, regulations and institutional arrangements;
- Extending the results of the case study analyses to draw out anticipated impacts of water supply reductions both regionally and statewide.

1.4 Assumptions Regarding the State of the System

As discussed above, Phase II of the study examines actual responses to water shortages experienced by the selected case study districts during drought conditions as a mechanism for identifying the scope and range of likely economic and financial impacts under more permanent water supply reductions. As such, certain assumptions are in place regarding water supply levels including quality, storage, conveyance and timing of delivery constraints, allocation mechanisms and prices, and the financial status of government projects, water districts and producers.

It is important to make these assumptions explicit both as a basis for judging the adequacy of the research base assembled and for future analysis of impacts. Given that some important aspects of water supply, delivery and allocation are "fixed" over a period of time by the high capital costs of constructing new facilities and the legal and contractual arrangements which guide allocation of existing supplies, a number of these assumptions will also hold in any sensitivity analysis of alternative supply models over a fairly long time period. Explicit treatment of these constraints will also highlight areas for potential policy changes.

The assumptions made to facilitate the research in this report break down into four categories: available water supplies, system and conveyance facilities, legal and institutional, and economic and financial. In Phases III and IV of this study, these assumptions may be relaxed to accommodate analysis of different proposals for mitigating the impacts of water supply reductions.

1.4.1 Available Water Supplies

This study is unique in that it uses the dry conditions experienced in California during the late 1980s and early 1990s to determine how water supply entities, agricultural producers and local communities have adjusted to reduced supply levels. District water supply availability includes total water received from all sources, not just surface water received under contracts or agreements with the state and federal projects. Included are surface water deliveries and augmentations from water transfers and groundwater sources. These supplies are a function of physical, legal, and economic parameters on the state and local water conveyance systems.

Estimates of total supply reductions in the state and federal projects from normal year deliveries are only preliminary at this time. Estimates indicate that total CVP deliveries were 20 and 37 percent below the 1985 level of 6.5 MAF in 1990 and 1991, respectively (Carter, USBR). This amounts to approximately 1.3 and 2.4 MAF reductions in total deliveries. Deliveries to agriculture for these same years are estimated at 22 and 38 percent below 1985 levels, that is, a reduction of 1.3 and 2.2 MAF in 1990 and 1991, respectively.

For the SWP, water deliveries totalled 2.3 MAF in 1985, but increased to 2.85 MAF in 1989 as both demand and entitlements increased. In 1990, total SWP deliveries increased by an estimated 11 percent as compared with the 1985 level, and decreased by 11 percent as compared with 1989. In 1991, SWP deliveries were reduced by 50 and 60 percent as compared with 1985 and 1989 levels, respectively (estimates by DWR staff). For agriculture, the SWP reductions in 1990 amounted to 54 percent as compared with 1985 and 48 percent as compared with 1989; the reductions were 100 percent in 1991 for both base cases. SWP allocation cuts are subject to contractual rules for apportioning dry year reductions between municipal and agricultural users.

Thus, given available information at this time on CVP and SWP project deliveries, the 1990 and 1991 drought conditions translated to a reduction in total surface water supplies of 1.63 and 3.90 MAF, respectively. Although no firm estimates or even ranges of estimates have been provided thus far on the likely impact of changes in Bay-Delta water quality standards on water availability to agriculture, informal conversations with experts on Delta ecology indicate that the upper bound on water flow reductions from the Delta would be included in these drought-induced supply cuts.

The water supply reductions experienced during the last two years vary widely by district. Some districts faced 100 percent reductions in firm water contracted supplies while others experienced no reduction in firm entitlement at all. Districts' abilities to augment project cuts with alternative water supplies also varied widely. These differences are related to water sources, the availability of groundwater supplies, the nature of the right or contract underlying access to surface supplies and the district's ability both in physical and financial terms to import additional water. By examining a wide range of delivery reductions, this study should provide insight on representative impacts that might be anticipated under several different water quality policies and allocation schemes.

For the next phase of the study, working with the TAC and experts in the state and federal system, alternative water supply scenarios to meet specified assumptions regarding water quality and flow requirements will be developed.

1.4.2 System and Conveyance Facilities

For Phase II of the study, existing water storage and conveyance facilities were taken as given and fixed. At present there are several proposals for augmenting these facilities to increase the reliability and quantity of developed water supplies in the state. Some of the more prominent facilities under discussion include: a cross-Delta canal, Los Banos Grande Reservoir, Auburn Dam, the Kern Water Bank and the North and South Delta Improvement Projects. Severe budget constraints within the federal and state governments coupled with environmental concerns and the expected high marginal costs of water developed from these facilities make it unlikely, however, that these projects will come on-line in the near future.

1.4.3 Legal and Institutional Assumptions

The study recognizes that current laws and institutions affect both the positive and negative impacts of water reductions on California agriculture, and the ability of agriculture to mitigate any negative impacts. Numerous institutions affect the allocation of water to and among growers, including local districts, state agencies and the federal Bureau of Reclamation. Federal and state laws restrict the discretionary authority of these institutions, as well as directly regulate the manner in which water is developed, allocated, transferred and used. Federal commodity and set-aside programs constrain the ability of farmers to switch crops or modify their contractual obligations in response to changing water supplies.

Phase II of the study examines water supply shortages, and the responses to those shortages, given current institutions and laws. This phase does not attempt to determine what the shortages and responses might be with different institutions and laws. Modifications of current laws and institutional authority, however, may well be able to reduce or mitigate those shortages and resulting responses and impacts, as will be shown in Phases III and IV. To obtain a better understanding of how institutions and laws can affect water supply and available mitigating measures, the study looks at the major types of districts that supply water to Central Valley farmers (irrigation districts, water districts and water storage districts). The study, in Phase II, and later in Phases III and IV, also examines the potential of legal and institutional changes to mitigate the impacts that might result from changes in water rights, including changes in federal commodity programs and the rules and regulations of the USBR and DWR that affect water deliveries.

1.4.4 Economic and Financial Assumptions

Economic analysis relies on a number of fundamental assumptions with respect to the way in which markets and prices function to allocate resources. Since it is clear that the complex institutional and legal environment in which water is developed, distributed and allocated shape both markets and allocative mechanisms, careful attention to how the water industry and the production sector depart from normal assumptions regarding efficient or "free" markets will be made throughout the study. In this Phase of the study, care has been taken to assure that the research base developed is sufficiently broad to accommodate to a wide variety of economic modeling approaches and analytical methods.

1.5 Limitations of Study Approach

The large reduction in available water supplies experienced in 1990 and 1991 provides information on actual responses and adjustments experienced by farmers and their communities. By analyzing these responses and adjustments at the case study level, as well as changes in local economy and resource quality conditions, the magnitude and distribution of ensuing economic and financial impacts can be assessed.

There are limitations, however, to this approach. Water suppliers and agricultural producers may have responded to drought conditions with "emergency" measures that may not reflect their most efficient long-term strategy for managing reduced water availability. The study of drought conditions also confines analysis to a particular scheme for allocating water supply reductions. The five-year 1986-1991 period of short supplies, although not approaching the critical year scarcity experienced in 1990 and 1991, has likely led to longer term adjustment decisions. Additionally, as with all case study approaches, there is a trade-off between the complex and detailed treatment of a thorough but limited data set, on the one hand, and the degree to which such results can be extrapolated and generalized, on the other. The implications of these limitations will be addressed in Phase III.

1.6 Organization of the Report

The report is divided into seven chapters. Chapter 1, presented above, discusses briefly the case study methodology, study assumptions with respect to water supply availability, the existing physical storage and conveyance system, the legal environment related to water use and the economic framework employed in the analysis. Study limitations are also highlighted in this chapter.

Chapter 2 summarizes the results of Phase I of the study. It states the criteria that were employed in selecting the particular cases, including geographic representation, water source diversity and physical system characteristics. This chapter also details the cropping systems, production structure, irrigation technology and different crop water requirements for each case to demonstrate that the diversity of California agriculture in the study area is adequately represented.

Chapter 3 provides a framework for the case study research which outlines the complex linkages between water supply agencies, both wholesale and retail, agricultural producers and local economies. Chapter 3 also discusses the data sources employed in this phase of the analysis, including data shortcomings and priority needs for the next research phase.

Chapter 4 presents the case study analyses from the Phase II field research. This chapter, which builds upon the linkages discussed in Chapter 3, describes the observed district responses and adjustments to water shortages over the past several years. Various initial constraints on the districts are highlighted and resulting impacts are identified.

Chapter 5 provides parallel information on key grower responses and adjustments to reductions in district-provided water supplies, based solely on district information and other primary data sources. This chapter includes aggregate estimates of well development, changes in energy use and shifts in cropping patterns both within case districts and with respect to the rest of the state. Key information needs for Phase III are also discussed.

Chapter 6 presents a summary of Phase II research findings, focusing on the responses and adjustments of the case study districts and producers to water supply reductions.

Chapter 7 presents an "inventory" of impacts associated with the district and producer responses and adjustments to water shortages discussed in Chapters 4 and 5 and summarized in Chapter 6. Impacts have been broadly defined to include the full range of direct and indirect (both private and social), short-run and long-run changes that resulted or can be expected to result from reductions in water supplies to Central Valley agriculture. An "inventory" of constraints affecting district and producer decisions is also provided. The chapter concludes with a proposed plan of study for Phases III and IV.

2.0 PROFILE OF CASE STUDIES

2.1 Case Studies

In Phase I of the study, case studies were developed for eight Central Valley water suppliers, including seven water supply districts and a sample of self-supplying producers. Study areas were selected to represent the Central Valley's heterogeneous agricultural sector. The selection criteria for the study areas are described in Table 2.1. Table 2.2 lists the selected cases and their location. Figure 2.1 displays the study area.

2.1.1 Case Study Selection Criteria

Case study areas were selected on the basis of seven characteristics:

- geographic location;
- irrigation water source(s);
- water supplier structure (including district size, delivery system and legal framework);
- cropping system (including principal crops, water intensity and irrigation technology);
- farm size and structure (including farm size, ownership and operator type);
- role of agriculture in the local economy; and
- resource quality and water management/conservation issues.

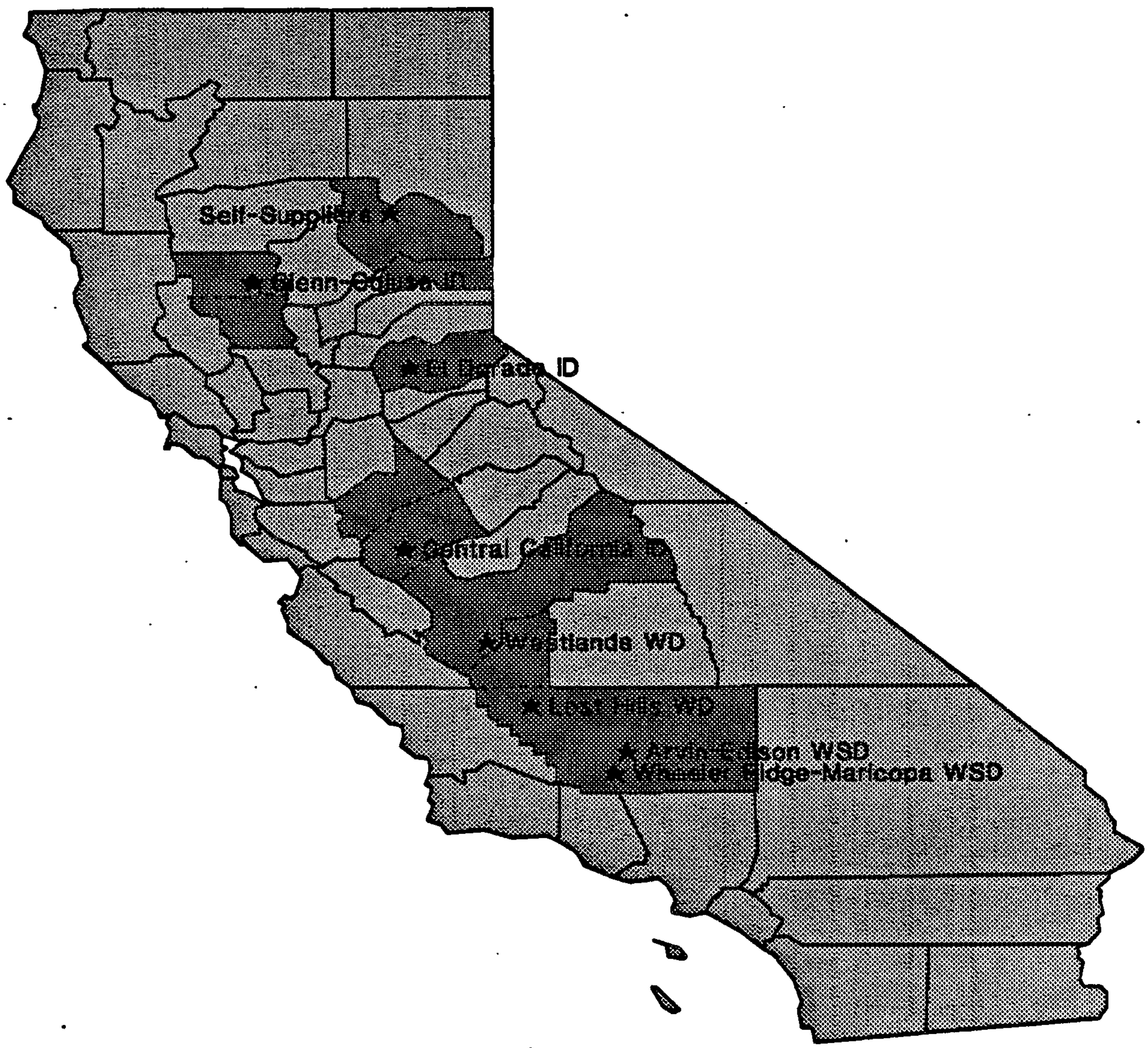
These criteria were chosen for two principal reasons. First, as mentioned above, they ensure that the selected districts and service areas reflect, to the degree possible, the wide hydrological, production, and institutional heterogeneity that exists in California's Central Valley agriculture. Second, by examining study areas with varying characteristics, a

Table 2.1: Proposed Criteria for Selecting Case Studies

Proposed Criteria for Selection	Arvin-Edison WSD	Central Calif. ID	El Dorado ID	Glenn-Colusa ID	Lost Hills WD	West-lands WD	Wheeler Ridge WSD
Water Sources							
Surface Water							
CVP							
SWP							
approptv. rgts							
Groundwater							
Storage							
Banking							
Exchanges							
District Structure							
Legal Authority							
Services Provided							
irrigation							
municipal							
industrial							
Conveyance System							
Pricing Policies							
Cropping Systems							
Permanent Crops							
Annual Crops							
Water Intensity							
Irrigation Tech.							
furrow/border							
sprinkler							
drip/micro-jets							
Diversity							
Calif. Dominance							
Farm Structure							
Ownership Patterns							
Size Distribution							
Organizational Type							
Production Costs							
Labor							
Capital							
Other Inputs							
Other Issues							
Conservation Prgms							
Wildlife Habitat							
Drainage							
Groundwater Quality							

Table 2.2: Location of Case Study Districts	
District	Location by County
Arvin-Edison Water Storage District	Kern
Central California Irrigation District	Stanislaus, Merced and Fresno
El Dorado Irrigation District	El Dorado
Glenn-Colusa Irrigation District	Glenn and Colusa
Lost Hills Water District	Kern
Self-Supplying Producers	Sierra and Plumas
Westlands Water District	Fresno and Kings
Wheeler-Ridge Maricopa Water Storage District	Kern

Figure 2.1: Study Area, Selected Cases



broader range of district and producer opportunities and constraints for responding to changes in water supply conditions and associated impacts can be identified.

2.2 Case Study Characteristics

This section provides details of the study area characteristics. Of the eight cases, seven are organized districts with brief profiles provided below. The eighth case consists of a sample of producers who supply their own irrigation water secured through riparian and/or appropriative water rights. These self-supplying producers were selected with the assistance of the TAC and are not included in the following tables (except for Tables 2.3 and 2.9). Appendix C presents information on the surveyed self-supplying producers.

Arvin-Edison Water Storage District (AE) was formed in 1942. It is located in the southern end of the San Joaquin Valley about twenty miles south of Bakersfield. Central Valley Project (CVP) irrigation water is supplied to the District through the Friant-Kern Canal. The District also receives Delta water through the Cross Valley Canal. Arvin-Edison's land area is 132,000 acres, of which 92,818 were planted to crops in 1989. The crops with the most acreage include grapes, potatoes and cotton.

Central California Irrigation District (CCID) was formed in 1951. It is located in the central San Joaquin Valley between the cities of Mendota and Crows Landing. CCID is an exchange contractor with the USBR. CVP irrigation water is supplied to the District through the Delta-Mendota Canal. The District's land area is 144,000 acres. With double cropping, 149,047 acres of cropland were planted in 1989. Leading crops include cotton, alfalfa, beans and grain.

El Dorado Irrigation District (EID) was formed in 1925. It is located in the foothills of the Sierra Nevada northeast of Sacramento with its central office in the town of Placerville. The District receives water from the CVP's Sly Park Reservoir facility and Folsom Lake, as well as through a contract with PG & E for American River water. The District's land area is 139,000 acres, of which 7,086 were planted in 1989. The principal crops are fruit trees, irrigated pasture and hay.

Glenn-Colusa Irrigation District (GCID) was formed in 1920. It is located in the Sacramento Valley between Hamilton City and Williams. The District receives irrigation water from the CVP and through appropriative rights to the Sacramento River. GCID's land area is 175,000 acres, of which 111,704 were planted to crops in 1989. Rice is the dominant crop.

Lost Hills Water District (LHWD) was formed in 1963. It is located on the far west side of the San Joaquin Valley northwest of Bakersfield. The District depends entirely on entitlement water from the State Water Project retailed through the Kern County Water Agency. It's land area is 72,000 acres, of which 44,136 acres were planted in 1989. Leading crops include pistachios, almonds, cotton, grapes and barley.

Westlands Water District (WWD) was formed in 1952 and is the largest agricultural water supplier in California. It is located on the west side of the San Joaquin Valley between Fresno and the California Coastal Range. The District receives irrigation water from the CVP through the Delta-Mendota and San Luis Canals. Westlands' land area is 605,000 acres, of which 567,817 acres were planted in 1989. A wide variety of crops are grown in the District, with cotton and processing tomatoes leading in acreage planted.

Wheeler Ridge-Maricopa Water Storage District (WRM) was formed in 1959. It is located on the west side of the San Joaquin Valley about 25 miles southwest of Bakersfield. The District receives irrigation water from the State Water Project through the Kern County Water Agency. Its land area is 147,000 acres, of which 88,937 were planted in 1989. Cotton, vegetables and grapes are the principal crops.

2.2.1 Irrigation Water Sources

District management of reduced water deliveries and increased water supply variability is influenced by the number and types of water sources relied upon by the district. Table 2.3 shows the primary water sources for the seven case studies. Four of the districts are U.S. Bureau of Reclamation (USBR) CVP contractors; one is a USBR exchange contractor; and two are Kern County Water Agency (KCWA) subcontractors for SWP water. Three of these districts also receive surface water from other sources. Four of the seven organized districts use groundwater supplies from district-owned and operated wells, and/or privately owned wells leased to the district. No information on groundwater pumped by producers for on-farm use is included here.

Table 2.3: Primary Water Sources, Case Study Districts

District	USBR Contractor	USBR Exchange Contractor	KCWA Sub-Contractor	Other Water Rights (a)	District Provided Groundwater (b)
Arvin-Edison WSD	X				X
Central Calif. ID		X			X
El Dorado ID	X			X	
Glenn-Colusa ID	X			X	
Lost Hills WD			X		
Self-Supplying Prod.				X	
Westlands WD	X				X
Wheeler Ridge WSD			X		X

Footnotes: (a) Includes only those water rights that contribute significantly to the District's total water supply. (b) Includes districts with "integration" programs that allow producers to pump groundwater into district conveyance systems for distribution and/or credits for future water deliveries.

Sources: Telephone interviews with district staff, district reports and documents from the District Securities Division, California State Department of the Treasurer.

Table 2.4 shows case study CVP and KCWA contractor water entitlements under normal year conditions and in "dry" and/or "critical" water supply years (1990 and 1991). The five districts with CVP entitlements account for an estimated 30 percent of total CVP contract entitlements. Reductions in firm water entitlements for these districts ranged from 0 to 50 percent in 1990 and from 0 to 75 percent in 1991. The two districts receiving SWP water through the KCWA account for approximately 30 percent of total annual SWP entitlements to the San Joaquin Valley, and 10 percent of annual SWP entitlements to all of California. SWP deliveries to agricultural contractors were cut by 50 percent in 1990 and 100 percent in 1991.

All of the case study districts have the capability to augment normal deliveries or partially offset reductions in project water supplies with rights to local water sources and/or by pumping groundwater, except for Lost Hills WD. Lost Hills WD relies solely on SWP water.

Table 2.5 provides information on district held water rights obtained from the State Water Resources Control Board. Of the seven districts, four claim appropriative rights to local water supplies for irrigation. The date of application for an appropriative water right, once approved, establishes the priority of that right based on the "first in line, first in right" doctrine.

Three case study districts (CCID, EID and GCID) claim pre-1914 appropriative water rights and have "Statements of Diversion and Use" on file with the SWRCB. These "Statements" do not guarantee water rights and can only be verified or revoked in a court of law. Lost Hills WD applied for appropriative rights to the Kern River in 1988, however, any decision requires resolution of on-going disputes with existing appropriators. The case study districts not included in Table 2.5 (AE, WWD and WRM) do not hold appropriative water rights.

2.2.2 Institutional Structure of Water Suppliers

The institutional structure of water suppliers affects their opportunities and constraints for adjusting to water supply reductions. In all, there are 35 different types of general water districts in California and literally scores of other districts created by special acts. Virtually all of the "retailing" agencies in the Central Valley, however, were formed under the general acts authorizing irrigation districts, water districts or water storage districts. All of

Table 2.4: Surface Water Entitlements, Case Study Districts			
District	Firm Entitlement (Acre-Feet)	Percent of Entitlement Available	
		1990	1991
Central Valley Project			
Arvin-Edison WSD	40,000 (a)	68	100
Central Calif. ID	532,400	85 (b)	80
El Dorado ID	30,600 (c)	88	81 (d)
Glenn-Colusa ID	105,000 (e)	100	75
Westlands WD	1,150,000	50	25
State Water Project (f)			
Lost Hills WD	140,400 (g)	50	0
Wheeler Ridge WSD	252,900 (h)	50	0

Footnotes: (a) This does not include the 152,700 acre-feet per year of "class II" (non-firm) water to which the District is entitled. As will be discussed later, Arvin-Edison WSD signed a water exchange agreement with several water supplying entities along the Cross Valley Canal. Thus the class I and II entitlement is not representative of the District's available water supplies in any given year. (b) In February 1990, USBR declared the water situation as "critical," thus reducing supplies available to the District. In June, however, full supplies were restored. The District Manager estimates that the amount of water that was available to the District ended up to be approximately 85 percent of normal. (c) El Dorado ID's entitlement includes 23,000 acre-feet per year from the Sly Park Project and 7,600 acre-feet per year from Lake Folsom. This does not include District supplies from the PG&E Forebay or the Crawford Ditch. (d) Includes a 75 percent reduction in water supplies from Lake Folsom. (e) This figure does not include the 720,000 acre-feet per year of "base supply" specified in the District's contract with USBR. (f) Lost Hills WD and Wheeler Ridge-Maricopa WSD are subcontractors of the Kern County Water Agency (KCWA) and receive an apportionment of KCWA's State Water Project contract entitlement. (g) The entitlement for Lost Hills WD increased steadily between 1975 and 1990 from 76,100 acre-feet per year to 140,400 acre-feet per year. The entitlement will not increase any further under the terms of the current contract with KCWA. (h) This figure does not include the "surplus" water entitlement that in 1990 was 38,146 acre-feet per year. The "firm" entitlement for Wheeler Ridge-Maricopa WSD increased steadily between 1975 and 1990 from 58,400 acre-feet per year to 252,924 acre-feet per year. The entitlement will not increase any further under the terms of the current contract with KCWA.

Sources: Arvin-Edison WSD: "Study of Second Priority Water Availability -- Friant Kern Declaration of Class I and II" (June, 1991); "Annual Report 1988 Water Year;" "History of Project Operations" (1988); and personal communications with Cliff Trotter and Steve Collup. Central California ID: Financial Statements and Annual Reports (various years); "Water Distribution" (1980); and personal communications with Mike Porter. El Dorado ID: Personal communication with Rob Alcott and Dorine Kelley. Glenn-Colusa ID: "Report on Water Measurement Program" (1981 and 1990) and personal communications with Bob Clark and Lou Hosky. Westlands WD: "Facts and Figures, 1989" and personal communication with Steve Ottemoeller and Shelley Vuicich.

Table 2.5: Appropriative Water Rights, Case Study Districts

District (a)	Sources of Irrigation Water	Priority Date for Water Rights
Central Calif. ID	San Joaquin R.	1870
El Dorado ID	Cosumnes R., American R. & Misc. Creeks	1852
Glenn-Colusa ID	Sacramento R. & Misc. Creeks	1883
Lost Hills WD	Kern R.	1988 (b)

Footnotes: (a) The SWRCB records did not show any appropriative rights for the other three case study districts. (b) Year that LHWD submitted an application for water rights.

Sources: State Water Resources Control Board, Division of Water Rights, Data Base Reports, 1990.

the case study districts are covered by these three district types. The Kern County Water Agency that provides water to two of the case study districts through a subcontracting arrangement was formed pursuant to special legislation. The self-supplying producers surveyed for the study are not affiliated with a water agency.

Irrigation, water and water storage districts all have the general power to import, control, distribute and store water for use within their borders. This includes authority to construct and maintain conveyance and distribution facilities. It would also appear that the districts have authority to store water underground.

To pay for their operations, districts can generate revenue in three ways. First, districts can charge for the water they deliver to their customers. Both irrigation and water districts have considerable discretion in how they charge for water (e.g. by acre, connection or metered use).[1] Rules for water charges imposed by water storage districts are only slightly more restrictive, stipulating that "tolls and charges shall be proportional, as nearly as practicable, to the services rendered."[2] Second, districts can assess property within their borders. Irrigation and water districts must generally assess property on an *ad volorum* basis whereby the amount of the tax is specified as a percentage of land value.[3] Water storage districts, by contrast, must generally assess in proportion to the benefits conferred by their services.[4] Third, all districts can issue both general obligation and revenue bonds and interest-bearing warrants to generate additional funds.

Within the confines of the authorizing statutes, district policies are determined by the board of directors and implemented by the district manager and other personnel. How a district responds to reduced water supplies may well depend on the way in which the board of directors is constituted and how members of the board are elected. Indeed, the most striking differences between irrigation districts, water districts and water storage districts are related to board structure and voting rules. In irrigation districts, the board consists of three or five property owners. Members are elected by popular vote of the registered voters living in the district. In water districts, boards generally consist of five directors who must be property holders within the district; only property holders can vote and votes are

1 Cal. Water Code §§ 22283, 35470 and 35474.

2 Cal. Water Code § 43006.

3 Cal. Water Code §§ 23242, 23667, 25801 and 36555. Assessed value is exclusive of improvements made to the land.

4 Cal. Water Code §§ 46176 and 46902.

allocated by dollar of assessed land value. The board of directors of water storage districts consists of five, seven, nine or eleven members depending on the number of divisions in the district. Like water districts, only property holders can vote and their votes are allocated by dollar of assessed value.

2.2.3 Physical Structure of Water Suppliers

Table 2.6 shows the primary water delivery systems in each of the case study districts. As can be seen in the table, "mixed" systems exist for most of the cases, each with some proportion of canals (lined and unlined) and pipeline. The systems also vary widely regarding the types of turnouts and flow meters used to measure water consumption.

Arvin-Edison WSD and Wheeler Ridge-Maricopa WSD both utilize lined canal and pipeline delivery systems. Arvin-Edison WSD has 45 miles of lined canals with 170 miles of pressurized pipeline. Wheeler Ridge has seven miles of lined canals and more than 300 miles of pipeline that deliver water directly to the fields. El Dorado ID transports water through 65 miles of lined and unlined ditches and 800-1,000 miles of pipeline directly to individual fields. Some fields receive water through community ditches. Glenn-Colusa ID delivers water from its 65 mile unlined Main Canal plus 420 miles of laterals. Central California ID has 263 miles of unlined canals. Lost Hills WD delivers irrigation water through underground pipeline and from lined and unlined canals. Westlands WD transports water through a 13 mile lined canal and 1,034 miles of underground pipeline to individual farms.

2.2.4 Production, Irrigation Technology and Water Costs

This section describes selected farm-level characteristics of the case studies and examines how reflective these cases are of California's Central Valley. The selected characteristics include: cropping patterns, water requirements, production, irrigation technology, water rates, and farm size and operation.

2.2.4.1 Cropping Patterns

Table 2.7 shows the distribution of case studies by irrigable agricultural acreage. District size spans from less than 30,000 irrigable acres in El Dorado ID to nearly 600,000 irrigable acres in Westlands WD, with more than half of the districts falling in the 100,000-199,000 acre range. Total planted acreage for the seven districts sums to roughly 1.1 million acres in a non-critical water year, or about 17 percent of total planted acreage in the Central Valley (*1987 Census of Agriculture*, U.S. Dept. of Commerce).

Table 2.8 shows the principal categories of crops grown in each water supplier service area. The table indicates that among the seven districts there is considerable crop diversity both within and between districts. The crops with the largest acreage in the study area are cotton, alfalfa, grapes and almonds. These crops also represent the state's leading crops by harvested acreage (*California Statistical Review 1988*. CDFA, 1989). Table 2.9 confirms that a wide variety of field and feed crops, orchards/vineyards, vegetables and specialty crops are represented in the study area, covering most of the important commodities grown in California.

2.2.4.2 Water Requirements

Water use depends not only on crop water needs, but on local precipitation, irrigation system efficiency and leaching and frost control requirements. Evapo-transpiration rates (ET) are a function of site-specific soil quality, climate conditions and biological water requirements. The DWR provides ET estimates based on field experimentation at sites throughout California. Table 2.10 presents USBR and DWR estimates of annual evapo-transpiration rates for six major California crops. The USBR estimates are specific to CVP districts, whereas the DWR estimates apply more broadly to the Sacramento and San Joaquin Valleys.

ET estimates vary considerably across crops, but appear to be fairly constant per crop across regions, with the possible exception of almonds. The lowest to highest water requirement crops in terms of average ET rates are: grapes, tomatoes, cotton, almonds, alfalfa and rice.

Table 2.6: Primary Types of Delivery Systems, Case Study Districts

District	Type of Delivery System		
	Unlined Canals/Ditches	Lined Canals/Ditches	Pipeline
Arvin-Edison WSD		X	X
Central Calif. ID	X		
El Dorado ID	X	X	X
Glenn-Colusa ID	X		
Lost Hills WD	X	X	X
Westlands WD		X	X
Wheeler Ridge WSD		X	X

Sources: Telephone interviews with district staff, reports and data from districts and documents from the District Securities Division, California State Department of the Treasurer.

Table 2.7: Distribution of Irrigable Acreage, Case Study Districts

	Irrigable Agricultural Acreage	
<100,000	100,000 to 199,000	>200,000
El Dorado ID Lost Hills WD	Arvin-Edison WSD Central California ID Glenn-Colusa ID Wheeler Ridge-Maricopa WSD	Westlands WD

Table 2.8: Principal Crop Types, Case Study Districts (a)				
District	Crop Type (b)			
	Field Crops	Vegetables	Fruits and Nuts	Pasture
Arvin-Edison WSD	X	X	X	
Central Calif. ID	X	X	X	
El Dorado ID			X	X
Glenn-Colusa ID	X	X		X
Lost Hills WD	X		X	
Westlands WD	X	X		
Wheeler Ridge WSD	X	X	X	

Footnotes: (a) Only crop types devoted to a significant portion of District acreage are noted.
(b) This table follows California Department of Agriculture crop category designations.

Sources: Telephone interviews with district staff, reports and data from districts and documents from the District Securities Division, California State Department of the Treasurer.

Table 2.9: Leading Commodities, Case Study Districts, 1989.	
District	Leading Crops (by planted acreage)
Arvin-Edison WSD	Grapes, potatoes, cotton, vegetables and orchard crops
Central Calif. ID	Cotton, alfalfa, beans, grain and sugar beets
El Dorado ID	Pasture, pears, apples, hay and grapes
Glenn-Colusa ID	Rice, clover, tomatoes, alfalfa and orchard crops
Lost Hills WD	Cotton, barley, pistachios, almonds and grapes
Self-Supplying Prods.	Livestock, pasture and hay
Westlands WD	Cotton, tomatoes, wheat, canteloupe and barley
Wheeler Ridge WSD	Cotton, vegetables, grapes, fruit and nut trees and citrus

Source: District Crop Surveys.

Table 2.10: Annual Evapo-Transpiration Rates for Selected Crops, by District and Regions

Location	Alfalfa ET (a)	Almonds ET	Cotton ET	Grapes ET	Tomatoes ET	Rice ET
Arvin-Edison WSD	3.5	3.2	2.6		2.3	
Central Calif. ID		2.2	2.6			3.8
El Dorado ID (b)	3.5			2.3		
Glenn-Colusa ID	3.5	2.4			2.3	3.5
Westlands WD	3.5	3.2	2.6	2.3	2.3	
Sacramento Valley	3.5	2.4		2.2	2.3	3.5
San Joaquin Valley	3.5	2.2	2.6	2.3	2.3	3.8
	Figures in Acre-Feet Per Acre					

Footnotes: (a) ET is an abbreviation for "evapotranspiration" which describes the amount of water that evaporates from the soil surface or is transpired during vegetative growth. (b) ET rates for fruit trees, the most common crop in El Dorado Irrigation District, are not included in this table.

Sources: Information for the districts came from: USBR, "Farm Delivery Requirements: 1984-1986)" (1987). Information for the Sacramento and San Joaquin Valleys came from: DWR, "Vegetative Water Use in California, 1974" (Bulletin No. 113-3) (April 1975).

2.2.4.3 Crop Yields

Table 2.11 summarizes crop yield data from the most recent County Agricultural Commissioners Crop and Livestock Reports for all counties represented among the case study districts (1990). Only those crops that are grown in more than one case district, and are among the top five in terms of acreage within each, have been included in the table. An exception is rice, which is a top crop only in Glenn-Colusa ID.

Regional yield variations are usually a function of differences in soil quality, climate, pest conditions and local crop varieties. Management and technology differences may also be region-specific. Yields are given for 1989 and 1990 to show that production varies significantly from year to year as well.

The table shows fairly wide regional yield variation in tomatoes (processing), raisin and wine grapes and almonds, and somewhat less yield variation in rice, cotton and alfalfa hay. For instance, 1989 almond yields were 0.73, 0.37 and 0.66 tons per acre in Fresno, Glenn and Kings Counties, respectively, whereas 1990 almond yields were considerably higher at 0.93, 0.67 and 0.76 tons per acre for the same counties.

2.2.4.4 Irrigation Technology and Water Management

Table 2.12 shows the primary irrigation technologies used by growers in each case study district. The choice of irrigation technology is a function of cropping patterns, cultural practices, water availability, the delivery system and relative input and output prices. Available data indicate that flood/furrow and sprinkler technologies are used extensively in the majority of districts. Drip irrigation is used in five districts.

The current drought has focused greater attention on water management programs. Specific programs in the case study districts include Central California ID's Conservation Loan Program that supports laser leveling, lining ditches, and installation of pipeline and water return systems at the farm level, and El Dorado ID's Irrigation Management Service that provides computerized soil and irrigation information on a weekly basis to over 300 field sites.

Glenn-Colusa ID has adopted a Water Conservation Incentive Plan, which gives an 8 percent reduction on water rates to participants that demonstrate compliance with two

Table 2.11: Crop Yields for 1989 and 1990, Selected Counties

County	Almonds		Alfalfa Hay		Cotton Lint (a)		Raisin Grapes(b)		Wine Grapes		Tomatoes		Rice	
	'89	'90	'89	'90	'89	'90	'89	'90	'89	'90	'89	'90	'89	'90
Colusa	0.5	0.6	6.3	6.2							31.5	30.5	3.9	3.7
El Dorado									4.2	3.7				
Fresno	0.7	0.9	8.9	9.0	0.7	0.7	10.1	9.5	8.4	10.3	35.0	35.5	2.7	3.2
Glenn	0.4	0.7	6.5	6.5									3.9	3.8
Kern	0.9	0.9	8.5	8.0	0.6	0.6			8.4	8.7	32.7	32.7	3.8	3.2
Kings	0.7	0.8	9.0	8.0	0.6	0.6			8.0	8.7	25.6	20.0		
Stanislaus	0.6	0.9	7.5	7.2			9.5	10.0	9.3	8.0	31.4	27.0	3.1	3.7
	Figures are Tons Per Acre													

Footnote: (a) Acala variety. (b) Table grapes not included.

Sources: County Crop and Livestock Reports, County Departments of Agriculture (1990).

Table 2.12: Primary Irrigation Technologies, Case Study Districts

District	Irrigation Technology			
	Flood/Furrow	Border	Sprinkler	Micro/Drip
Arvin-Edison WSD	X	X	X	X
Central Calif. ID	X	X	X	
El Dorado ID			X	X
Glenn-Colusa ID	X	X	X	
Lost Hills WD		X	X	X
Westlands WD	X	X	X	X
Wheeler Ridge WSD	X	X	X	X

Sources: Telephone interviews with district staff, reports and data from districts and documents from the District Securities Division, California State Department of the Treasurer.

recommended measures. The District also recaptures 200,000 AFY of drain water that is used for irrigation. Lost Hills WD has adopted programs to encourage adoption of drip and other low volume irrigation technologies. Westlands WD has had an extensive water management program since 1972 including incentives to adopt more efficient irrigation practices and technologies, water use monitoring and drainage water capture and reuse.

2.2.4.5 Retail Water Rates

Table 2.13 provides some information about the components that make up retail water charges for the case study districts. This pricing information is only illustrative given the diversity and complexity of district water pricing policies and grower water rates. Current water rates vary substantially throughout the Central Valley reflecting differences in source of water, priority in water rights, delivery system efficiency, pumping or lift charges and the financial and pricing structure of the supplier.

In general, SWP contractors (KCWA subcontractors) face higher water costs than CVP contractors. The three districts with the lowest water costs (Central California ID, El Dorado ID and Glenn-Colusa ID) hold pre-1914 appropriative water rights.

2.2.4.6 Farm Size, Ownership and Operator Types

Farm size, ownership and operator type may affect producers' abilities to respond to changing water supply conditions. Average farm size, farm size distribution and ownership/operator patterns very widely throughout the Central Valley and among the case study districts. In general, districts are comprised of more landowners than farm operations, indicating a common practice of leasing land to tenants and farm management companies. Discussion at this point is limited to aggregate data.

Table 2.14 shows farm operator types by region. Ownership patterns based on 1987 Census of Agriculture data indicate they are fairly consistent between the Sacramento and San Joaquin Valleys, with just slightly fewer full owners and slightly more part owners in the Sacramento Valley. Disaggregated data available for the San Joaquin Valley show differences in ownership patterns between the east and west sides of the Valley, with

Table 2.13: Water Rate Components, Case Study Districts	
District	**Components of District Water Rates (a)**
Arvin-Edison WSD	USBR water contract payments, district O&M, pumping lifts and property assessments
Central Calif. ID	District O&M and groundwater pumping costs
El Dorado ID	USBR water contract payments, district O&M, billing charges and property assessments
Glenn-Colusa ID	USBR water contract payments, district O&M, pumping lifts, standby charges and property assessments
Lost Hills WD	SWP Delta water charge, SWP transportation charge, KCWA charges, district O&M, standby charges, pumping costs and property assessments
Westlands WD	USBR water contract payments, district O&M, drainage fees and property assessments
Wheeler Ridge-Maricopa WSD	SWP Delta water charge, SWP transportation charge, KCWA charges, district O&M, debt service, pumping costs and special use charges

Footnotes: (a) These are the categories of costs that producers pay to receive water from the district. Not all growers pay all charges (e.g. pumping lifts, groundwater pumping fees, etc.), nor are all charges assessed for a given unit of water (e.g. property assessments).

Sources: Telephone interviews with district staff, district financial reports, district water rate schedules, and documents from the District Securities Division, California State Department of the Treasurer.

Table 2.14: Farmer Operator Types By Region						
Area	Full Owners		Part Owners		Tenants	
	Farms	Acres	Farms	Acres	Farms	Acres
Sacramento Valley						
Number	7,324	1,157,459	2,046	2,371,352	1,607	838,171
Percent	66	27	19	54	15	19
San Joaquin Valley						
Number	22,386	3,396,756	4,938	5,228,750	3,426	1,849,419
Percent	73	32	16	50	11	18
Source: U.S. Department of Commerce, Census of Agriculture, 1987.						

slightly more farms categorized as tenant farms on the west side. These patterns can be expected to vary by district as well.

2.2.5 Local Economy Characteristics

The seven case study districts are located in eight counties in California. Local economy effects extend beyond district boundaries, however, and may not even be contiguous with county lines. Changes in factor and product markets at the district level may have regional and statewide repercussions given employment, processing and other agriculturally related patterns. Local economy characteristics and linkages specific to the selected case studies have been explored in this phase as they emerged from Phase II field surveys. Local economy impacts will be investigated in Phases III and IV.

Available county level data on agriculture-related local economy indicators are scarce, inconsistent and unreliable. For example, available data on employment for both agricultural and agriculturally-related industries, shown in Tables 2.15 and 2.16, demonstrate the wide variation in employment estimates. This variation is a function of how the agriculture sector is defined (i.e. choice and level of disaggregation of Standard Industrial Classification code data, definition of agricultural labor, and assumptions about multiplier effects).

The production and factor share data collected and developed in Phase II for the case studies (from districts, farms and local and state government offices) will provide the basis for the analysis of local and regional economic impacts in Phases III and IV.

2.2.6 Resource Quality Issues

A range of resource quality issues are being addressed in the case study districts. Table 2.17 provides preliminary information about some of these issues. Two important issues facing many of the districts are irrigation drainage and water quality problems. A third issue, groundwater overdraft, is both an inter-temporal water supply and farm production problem as well as a regional resource quality issue. Prolonged groundwater overdraft can have important environmental consequences such as land subsidence and deteriorating water quality as well as aquifer depletion and collapse.

Table 2.15: Agricultural Employment in the Central Valley		
Location	**Number Employed (a)**	**Percent of Area Employment**
Sacramento Valley	21,416	4
Butte County	1,336	3
Colusa County	665	24
Glenn County	777	17
Sacramento County	9,014	3
Solano County	2,714	4
Sutter County	1,621	13
Tehama County	435	5
Yolo County	3,520	9
Yuba County	1,334	17
San Joaquin Valley	55,674	9
Madera County	1,683	13
Merced County	4,623	15
Fresno County	13,407	8
Kings County	1,696	12
San Joaquin County	9,130	8
Kern County	5,107	4
Stanislaus County	13,701	15
Tulare County	6,327	11

Footnote: (a) The definition of agricultural employment used in this table is from the U.S. Department of Commerce.

Source: U.S. Department of Commerce, County Business Patterns, 1988.

Table 2.16: Agriculture-Related Employment in the San Joaquin Valley

Location	Number of Establishments	Number of Employees	Annual Payroll (thousands)
California			
Total	662,744	9,368,825	$192,416,000
Agriculture-Related (a)	96,761	1,620,807	$35,597,000
Percent Ag.-Related	15	17	19
San Joaquin Valley			
Total	50,911	551,951	$9,387,000
Agriculture-Related (a)	14,963	268,138	$5,088,000
Percent Ag.-Related	29	49	54

Footnote: (a) Agriculture-related employment is defined broadly to include backward-linked industries such as pesticide manufacturing and forward-linked industries such as refrigerated warehousing and storage.

Source: S. Archibald, "Economic Profile of Agriculture in the Westside of the San Joaquin Valley" (Federal-State San Joaquin Valley Drainage Program, June 1990).

Table 2.17: Resource Quality Issues, Case Study Districts	
District	**Issue**
Arvin-Edison WSD	Potential groundwater overdraft and accompanying water quality problems.
Central Calif. ID	Some drainage water contains selenium. Some groundwater has high TDS levels.
El Dorado ID	Groundwater contamination in some residential wells.
Glenn-Colusa ID	The District conveys water to three U.S. Fish and Wildlife Service Refuges. Producers use irrigation water for duck ponds.
Lost Hills WD	Problems with disposal of drainwater.
Westlands WD	Drainage disposal problems, particularly in areas with high levels of selenium.
Wheeler Ridge WSD	Poor quality groundwater in the western portion of the District from elevated TDS levels.

Source: Telephone interviews with district staff, reports and data from districts and documents from the District Securities Division, California State Department of the Treasurer.

3.0 FRAMEWORK FOR PHASE II FIELD RESEARCH

3.1 Linkages Between Water Suppliers, Agricultural Producers and Local Economies

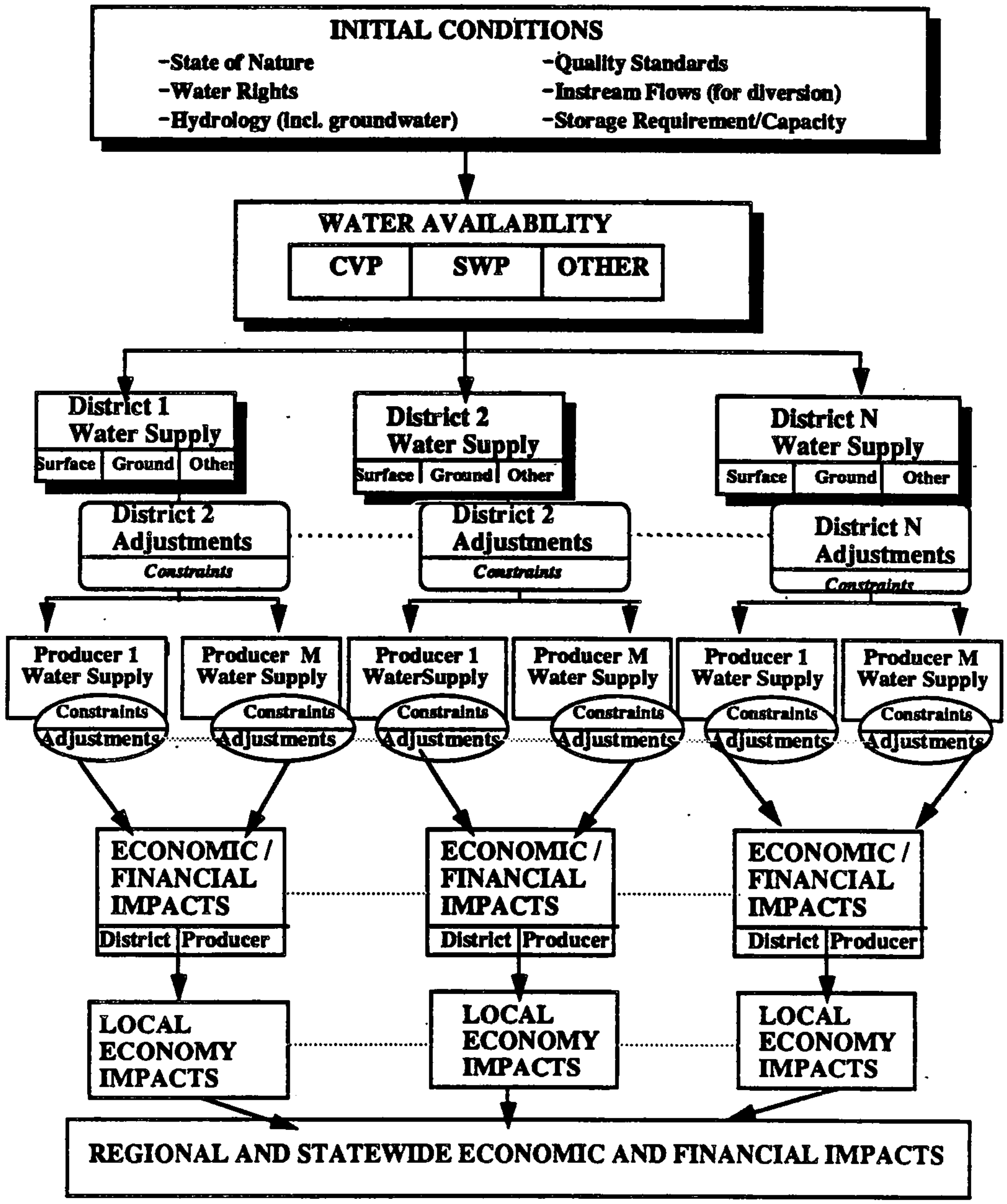
The complex relationships and feedback loops inherent in California water supply, allocation and management between water suppliers—both wholesale and retail—agricultural producers and local economies need to be considered in developing the research base for impact analysis. A general framework outlining the linkages that are likely to be affected by water scarcity and variability is presented in Figure 3.1. These linkages relate aggregate water supply—the system's initial conditions–to distribution and use at the district and farm levels.

District water supply and adjustments to scarcity set the conditions under which producers must operate with respect to the supply, timing and cost of irrigation water. Producers' responses and adjustments to changed water conditions in turn affect local economies through ensuing economic and financial impacts. Chapters 4 and 5 further disaggregate these general relationships for the case study water suppliers and agricultural producers, respectively. The data needs which emerge from this framework are discussed at the end of this chapter.

3.2 Initial Supply Conditions

The impacts of changes in water quality standards and any reductions in agricultural supplies allocated for other uses depend fundamentally on initial water supply conditions, as represented at the top of Figure 3.1. Annual California water availability is a function of snowpack and runoff combined with storage capacities and groundwater levels. The distribution of annual water supplies is determined by a complex system of water rights and contracts.

FIGURE 3.1: ECONOMICS OF WATER AVAILABILITY: AN OVERVIEW



3.2.1 Water Supplies in California

A general picture of water supplies in the state provides some perspective on the recently experienced shortages. Over the long run, the annual average precipitation in the state provides approximately 71 million acre feet (MAF) of streamflow, which is augmented by approximately 1.4 MAF of water flow from Oregon and another 4.8 MAF from the Colorado River. Together, these sources provide California with 77.2 MAF of streamflow in an average year (DWR, Bull. 160-87). California also has extensive groundwater reserves; aquifers in the state hold approximately 850 MAF of groundwater (DWR, Bull. 160-87).

Total "developed" supplies—water that is captured, stored and distributed to meet irrigation, residential, hydroelectric and industrial needs—are approximately half of the average annual streamflow. In 1985, "applied water," or the total amount of water that is diverted from rivers and pumped from underground for delivery to farm headgates or to intakes in urban water systems, was estimated by the Department of Water Resources as 40.5 MAF (DWR, Bull. 160-87). Of that, 16.6 MAF or 41 percent was groundwater (DWR, Bull. 160-87). Net water use, which is computed by deducting evapotranspiration and unrecoverable distribution losses from applied water, totalled 34.2 MAF in that same year (DWR, Bull, 160-87). To avoid double counting, these estimates exclude agricultural return flows and other supplies of water that are reused.

The agricultural sector is the largest consumer of the state's developed water resources. In 1985, net use of developed water supplies by agriculture totalled 27.0 MAF or 79 percent of the total (DWR, Bull. 160-87). In that same year, urban water use was 5.6 MAF or 16 percent of developed supplies. The remaining 1.6 MAF was consumed by industry and other water users.

The "undeveloped" streamflows provide essential water for riparian ecosystems and other "instream" uses such as navigation and recreation. Some undeveloped streamflow percolates into the subsurface and contributes to groundwater storage. The remainder evaporates or flows into the Pacific Ocean.

Average water supply figures, however, can be misleading. The year-to-year variability in water supply is quite large. Between 1975 and 1991, only a few years (1978, 1980, 1986, 1989) have experienced runoff levels somewhat close to the long-term average. Total streamflow in 1977 totalled 15 MAF; less than 5 MAF originated from Northern California as represented by the Sacramento River Index (see Figure 3.2.) In contrast, heavy rains led to a record-setting runoff level of approximately 135 MAF in 1983, over 35 MAF from Northern California rivers. In the years 1987-1991, water supplies were substantially below average. DWR classified 1989 as a "dry" year; the other years were classified as "critically dry" (DWR, 1991). DWR has estimated that runoff in 1991 will be 45 percent of normal and reservoir storage will be 65 percent of normal (DWR, Bull. 120-91-4).

3.2.2 Institutions and Water Rights in California

As mentioned in Chapter 1, the impacts of water reductions on water suppliers, producers and local communities depend on a myriad of laws and institutions. To develop a realistic assessment of the economic and financial impacts of reduced supplies, therefore, the analysis must take into account the various legal and institutional factors affecting water availability in California agriculture.

The current allocation and use of water in California is dictated or constrained by its institutions and by federal and state laws. Both surface water and groundwater are initially allocated under state law. Owners of lands that are riparian to surface waterways are generally entitled to a reasonable amount of the water for beneficial use on their riparian lands. Such "riparian rights" generally cannot be transferred separate from the land to which they attach.

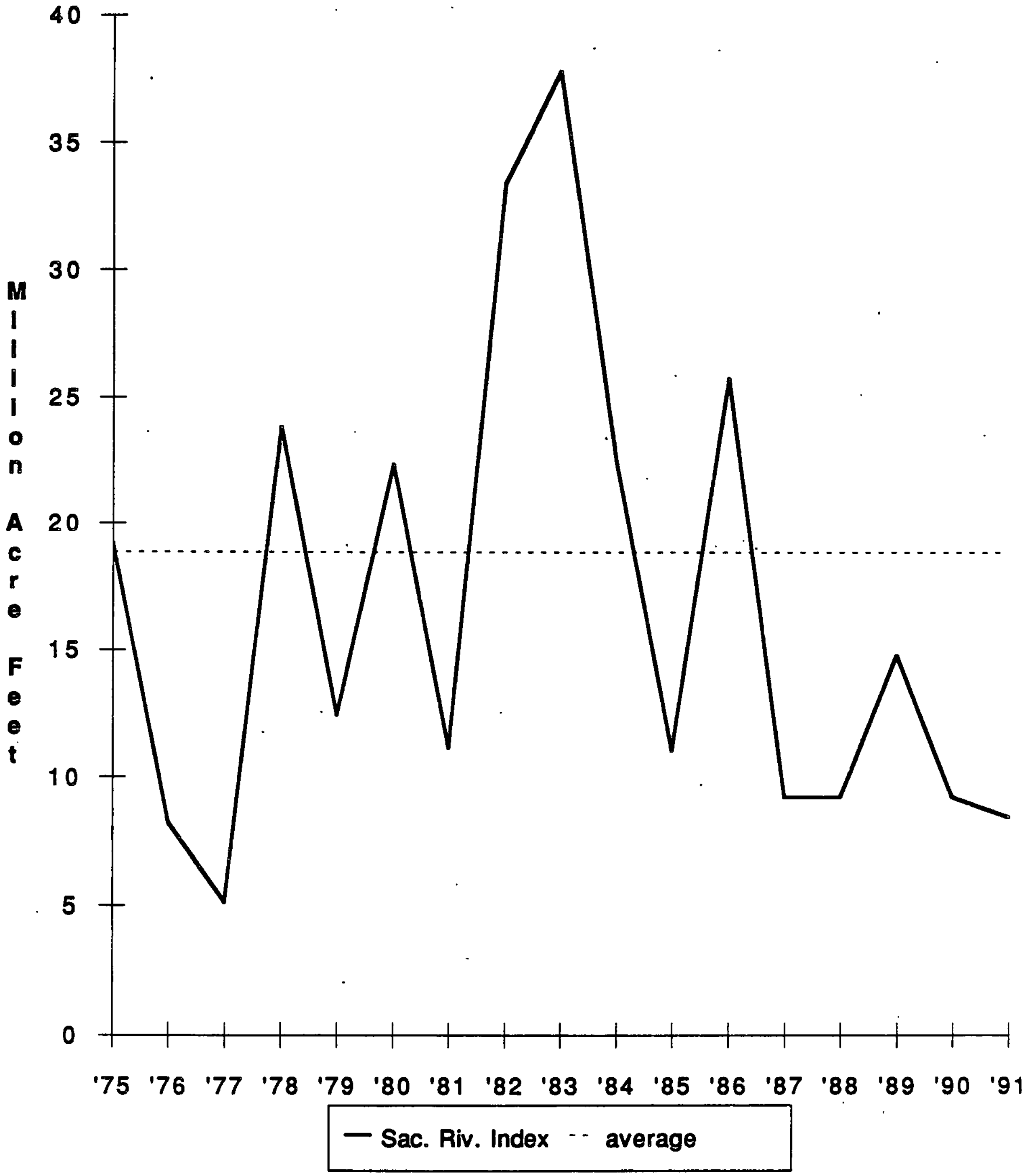
Remaining surface waters are allocated on a "first in time, first in right" basis under state appropriation laws.[1] Appropriative rights are often divided into pre-1914 and post-1914 rights because, under the Water Commission Act of 1913, anyone seeking to obtain an appropriation right since 1914 has had to apply for and obtain a permit from a state administrative agency, currently the SWRCB. As discussed in Chapter 4, appropriative rights can be transferred subject to the approval of the SWRCB in cases where the transfer will involve a change in the point of diversion or the place or type of use.

In theory, groundwater is initially allocated to owners of land overlying the groundwater basin, each of whom is entitled to a "fair and just" proportion of the "safe yield" of the basin in order to meet any "reasonable and beneficial" need for water on the overlying land.

[1] Older appropriative rights, where water was diverted from points on the public domain, may be superior to some or all riparian rights. See generally J. Sax, R. Abrams, & B. Thompson, Legal Control of Water Resources 340 (2d ed. 1991).

Figure 3.2: Sacramento River Index

Source: DWR Bulletins



If the entire safe yield of a basin is not used for overlying land, the surplus water can then be appropriated for use on other land on a "first in time, first in right" basis. Theoretically, groundwater mining is not permitted. The state, however, does not regulate groundwater usage as closely as it does surface water. As a result, there is no permit system for groundwater and groundwater use in many basins exceeds the safe yield.

Groundwater users can seek an adjudication of groundwater rights in state court, but because adjudications are both costly and time-consuming, few basins have been adjudicated. Where withdrawals have exceeded safe yield for many years, moreover, the California Supreme Court has generally declined to follow the allocation rules outlined above. In its most recent decision, the Court has indicated that it will typically resolve long-time overdrafts through some form of "equitable apportionment" of the safe yield. In short, it is quite unclear how a California court would apportion the water from an overdrafted basin, adding risk to the potential drawbacks that a farming area will consider in deciding whether to pursue groundwater adjudication.

Only a minority of farmers in California have direct rights to surface water. Most farmers receive their water from a local district (generally an irrigation, water or water storage district) or from a mutual water company. As discussed in Chapter 4, local districts have considerable discretion over the acquisition, allocation and pricing of water. The nature and limits of the discretion, however, vary among districts depending on the laws under which a district was formed, any special legislation unique to a district and a district's local rules and regulations.

Local districts, in turn, often receive some or all of their water from a larger state or federal agency. All of the districts studied receive at least part of their water from either the State Water Project (SWP) operated by the Department of Water Resources, or the Central Valley Project (CVP) operated by the federal Bureau of Reclamation. The SWP and CVP receive their water through state appropriation permits and distribute water to local districts by contract. The contract under which a district receives water often limits the district's discretion over the allocation and use of the water. In most cases, for example, CVP contractors must comply with the acreage limitations and other requirements of federal reclamation law.

The major exceptions are "exchange contractors" such as Central California ID. CCID receives CVP water from the Delta-Mendota Canal in exchange for pre-1914 appropriation rights that it held previously on the San Joaquin River. As a result, CCID does not have to pay for its CVP water and is not subject to federal acreage limitations.

Both Lost Hills WD and Wheeler Ridge-Maricopa WSD receive most of their water from the Kern County Water Agency (KCWA), which receives its water by contract from the SWP and then subcontracts the water to its 16 member agencies. Water allocation to farmers in these districts is thus controlled to some degree by four levels of government agencies—the SWRCB (which has authority over the SWP's appropriation), the DWR (which oversees the SWP), the KCWA and the local district.

3.2.3 Water Deliveries from Developed Surface Water Sources: the Central Valley and State Water Projects

Central to any understanding of the impacts of water allocation on California agriculture are the State Water Project and Central Valley Project which provide the majority of surface water to Central Valley farmers. The CVP delivers an average of more than 6,000,000 AF of water to approximately 3,400,000 acres of cropland (see Figure 3.3.). Shasta Dam and other USBR reservoirs in the Sacramento River watershed supply water to local agricultural producers and producers in the San Joaquin Valley through the Sacramento-San Joaquin Delta. Some producers in the San Joaquin Valley receive water from the San Joaquin River through the USBR's Friant-Kern Canal. In recent years, more than 90 percent of CVP water has been delivered to agriculture (USBR). The rest is delivered to municipalities and industry as well as wildlife refuges.

The SWP delivered 2.9 MAF of entitlement water to its contractors in 1989, the last year of full deliveries (see Figure 3.4). About half of the SWP water is captured behind Oroville Dam. The remainder is pumped directly from the southern Delta when surplus freshwater flows are available. SWP water is stored in the San Luis Reservoir, along with CVP supplies, and conveyed by the California Aqueduct to agricultural users in the southern San Joaquin Valley and to urban contractors south of the Tehachapi Mountains.

Local surface water supply projects (as distinguished from state or federal projects) deliver nearly as much water as the CVP and SWP combined (DWR, Bull. 160-87). These projects have been constructed to serve agricultural, urban and industrial interests.

Figure 3.3: Central Valley Project Water Deliveries
Source: USBR; deliveries for 1991 are estimates

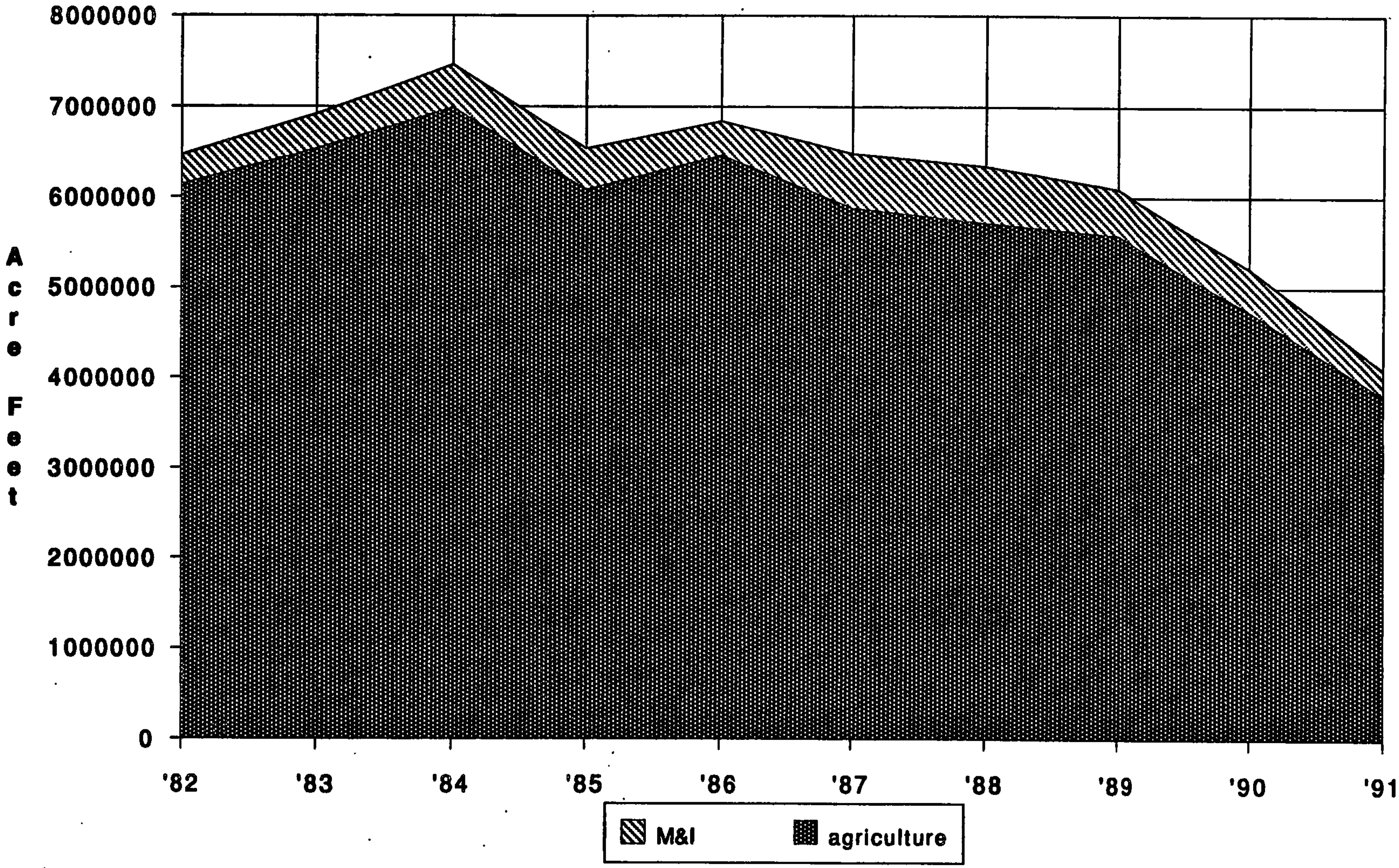
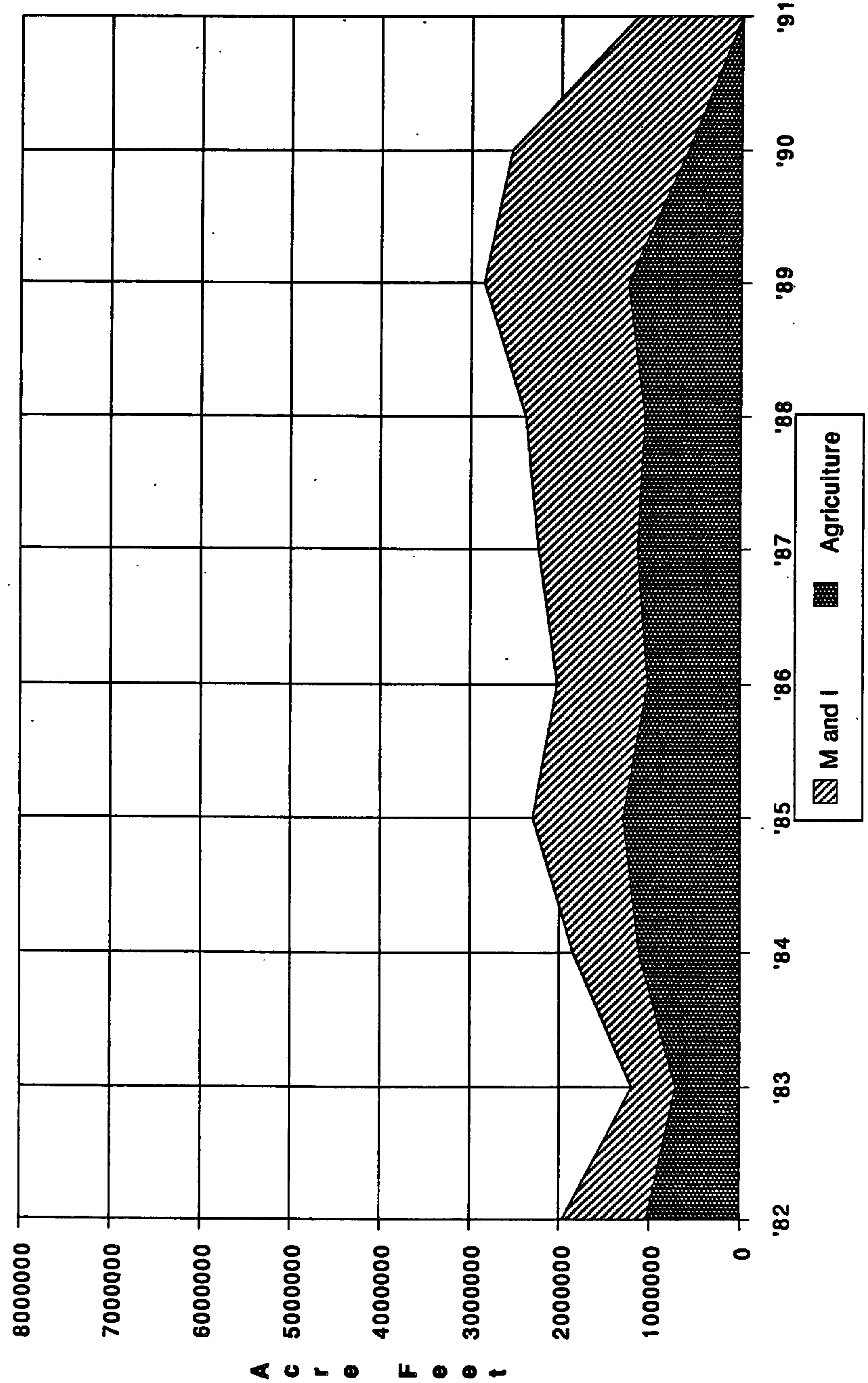


Figure 3.4: State Water Project Deliveries

Source: DWR Bulletins; '90 and '91 are estimates



As discussed in Chapter 1, estimates of total supply reductions in the state and federal projects from normal year "demands" or deliveries are only preliminary at this time. Estimates indicate that 1990 and 1991 total CVP deliveries were 20 and 37 percent below the 1985 level of 6.5 MAF (USBR), equal to reductions of 1.3 and 2.4 MAF, respectively. Estimated deliveries to agriculture for these same years were 22 and 38 percent below the 1985 level of 6.0 MAF. This is a reduction of 1.3 and 2.3 MAF in 1990 and 1991, respectively.

For the SWP, 1985 deliveries totaled 2.0 MAF, but increased to 2.85 MAF in 1989 as both demands and entitlements increased. SWP total deliveries were reduced from their 1989 level by an estimated 11 percent in 1990 and 60 percent in 1991 (estimates by DWR staff). Supplies to the agricultural sector were reduced even further—by 48 percent in 1990 (by 54 percent compared with 1985) and in 1991 farmers received no SWP water[2]. Total acre feet reductions in SWP deliveries over 1989 levels were approximately 0.3 and 1.7 MAF for 1990 and 1991, respectively.

3.3 District Impacts

3.3.1 District Water Supplies

In determining the impacts of cutbacks in surface water supplies over time, as a result either of drought or administrative mandate, the first question is how the reduced supplies will be allocated among suppliers. This is a complex issue, requiring one to work through the consequences of changes in water availability on each of the water allocation systems discussed earlier.

First, how will the water reduction be apportioned among the various holders of state appropriative and riparian rights? In theory, reductions should be apportioned according to the riparian and appropriation rules outlined above. Riparian rights holders would generally receive the greatest protection (except, as noted above, in the case of some very early appropriators). Most junior appropriators, by contrast, would generally be forced to cut back on their withdrawals first; then appropriators of ever increasing seniority would

22 Article 18 of the SWP contracts outlines procedures for allocating reduced supplies between agricultural and municipal and industrial users. During a short year, agriculture takes the first water cuts, which cannot exceed 50 percent in any one year. Over a seven year period, agriculture cannot take more than a cumulative 100 percent cut. When these limits are reached, agriculture and M & I take cuts equally (as in 1992).

generally reduce their withdrawals until withdrawals equaled the available supply. The Racanelli Court's decision in United States v. State Water Resources Control Board,[3] however, indicates that the SWRCB has at least some authority to alter the historic appropriation principle of "first in time, first in right," as a result of its reserved jurisdiction over appropriation permits (and perhaps its power to enforce the State's "reasonable use" requirement).

In addition to the above issues, any study on the impact of water reductions on California agriculture must also consider the affects of such reductions on water quality and the reliability and timing of water supplies.

It is difficult to determine how any water supply reductions resulting from changes in Bay-Delta water quality standards may affect the water supplies of a particular district. Nor has the study been given any firm estimate or even range of estimates of how the water quality standards that the SWRCB has currently proposed would affect total supply to agriculture. Based on information from various members of state and federal agencies, however, it appears as if the upper bounds of any reductions resulting from the Bay-Delta Hearings would not significantly exceed the drought-induced reductions studied in this report.

3.3.2 District Objectives and Authorities

Every water district is different. These differences—including unique institutional, physical and economic characteristics—present a set of constraints and opportunities that largely determine an individual district's responses and adjustments to changing water supply conditions. Water source, water supplier structure and environmental issues (such as water quality and drainage) are particularly important for understanding district-level responses and adjustments.

The primary economic function of the water supplier is to meet the water demands of its user group subject to certain hydrological, institutional, physical, financial and environmental constraints. The nature of these constraints largely determines the flexibility of individual districts to manage water supply variability.

3 227 Cal. Rptr. at 187-89.

Changes in water supply conditions (quality, quantity, reliability and timing) may prompt districts to respond in the short-run with modifications in various management policies. For the purpose of this analysis, the short-run is defined in economic terms to include those adjustments possible within existing institutional, physical and capital constraints. Long-run adjustments typically involve capital investments in water project development or improvements in delivery and storage systems, but may also include long-term water transfer and exchange agreements and permanent changes in district pricing and other policies. This economic definition differs from the "chronological" definition that classifies short-run and long-run adjustments in terms of a particular time span.

In the short-run, water suppliers can respond to reduced and/or more variable supplies by adopting policies to modify demand (consumption) and supply, within existing constraints. Given the user-orientation of water agencies, districts can be expected to adopt policies that minimize negative producer impacts and facilitate their adjustment to reduced water availability. Suppliers may directly reduce producer water allocations by decreasing total or per acre allotments, or indirectly encourage reduced water use through district programs that provide technical services and/or create economic incentives for improved on-farm water management.

In order to meet relatively fixed revenue requirements, some districts may increase per unit water rates and charges to offset reduced water sales, higher district water costs and/or repayment obligations for undelivered contract water. In the short-run, opportunities to augment reduced supplies include increases in groundwater pumping, for those with the capability, and temporary out-of-district water purchases.

In the long-run, districts may choose to make capital investments to permanently improve water availability, efficiency and reliability. Such investments could include improvements in delivery systems and/or pumping and storage facilities as well as development of new water supply projects. Districts may also attempt to augment existing supplies through long-term water transfer or exchange agreements, often involving the creation of new institutional arrangements.

The ability of the water supplier to manage year-to-year and seasonal variabilities in supply tends to increase with the number, quantity and types of water sources. In general, a greater number of water sources can be expected to provide suppliers with greater flexibility to respond to changes in water supply conditions.

3.3.3 Constraints on District Responses

State and federal laws, the institutional structure of a district, and the district's physical infrastructure can all affect the ways in which a district can respond to water shortages. As detailed in Chapter 4, state and federal laws both provide the basic discretion that districts need to respond to shortages and often limit that discretion. For example, legal statutes limit the degree to which districts can transfer water both in and out of the district, engage in conjunctive water storage, reallocate water among users, modify pricing systems and impose conservation measures.

The responses of a particular district will also depend on its local rules and regulations and flexibility for changing current policies. Thus, even the makeup of a district's board and the manner in which board members are elected can affect a district responses to water shortages. The size, structure and election of district boards varies among districts. For example, boards can vary from three to eleven members, sometimes but not always elected by geographic division. In water and water storage districts, only property holders can vote and their votes are weighted by the assessed value of their land. Board members of irrigation districts are elected by popular vote of all the district's registered voters, although members must own property in the district.

Resource quality issues may constrain supplier responses to changes in water availability and reliability. Two important issues are the management and disposal of drainage water and the protection of wildlife. Drainage management and wildlife habitat will be affected by water quality standards and allocations authorized by the SWRCB and other state and federal agencies. This phase of the study will consider resource quality issues that act as direct constraints and/or opportunities for case study water supplier responses and adjustments to changes in water quality and supply.

Key physical and organizational constraints include district size, level of integration and delivery system characteristics. For example, the size of the district service area may limit or facilitate opportunities for water saving through water banking and other intra-district supply management programs. District size is also important for management of water supply externalities, particularly drainage problems. Smaller districts may have fewer adjustment options available to them than larger districts.

The level of water supplier integration, that is, the degree to which it captures, stores and retails its own water supply affects water cost components, revenue requirements and the ability to supply during periods of scarcity. A vertically integrated water supplier (one with the ability to capture, store and retail its own water supply) may maintain more control over supply than a federal or state contractor, but may incur greater costs from diseconomies of scale in water capture, storage, and transportation.

The nature of the physical delivery system—the types of canals, pipelines, turnouts and meters—affects water supply efficiency, particularly the system's flexibility for responding to supply disruptions. Evidence suggests that lining canals, converting canals and ditches to pipeline and improving delivery system maintenance will generally increase water use efficiency at the district level for a given level of capital investment (Chakravorty and Roumasset, 1991 and district documents). Canal lining and ditch conversion costs may not be justified, however, if the "lost" water can be recaptured within the district or if environmental mitigation is required (e.g. the "losses" support a wetland).

3.4 Producer Impacts

3.4.1 Supply Levels

The level and cost of water to agricultural producers are set in large part by water supplier policies and decisions. In most of the districts in California, farmers participate in these decisions as board members, often operating to mitigate fluctuations in prices and quantities over time that result from natural variability in water supplies. Farmers may have options, at least in the short-run, to augment surface water allocations with groundwater and/or the purchase of additional supplies from both within and outside the district.

3.4.2 Farm-level Adjustments

Farm-level production decisions are greatly influenced by water supply conditions. Changes in these conditions can result in modifications to existing pricing, allocation and water management policies. Given available water supplies and relative output and factor prices, producers select cropping patterns, production inputs and technologies to achieve their objectives.

Short-run production decisions are constrained by existing irrigation technologies, machine complements and managerial abilities. Market conditions and contracts, predominance of perennial versus annual crops and affiliation with commodity programs may also constrain these short-run responses. Within these constraints, producers can respond to water supply reductions by fallowing land, reducing double cropping, changing crops and modifying water application rates. Where feasible, producers may augment water supplies with increased on-farm groundwater pumping and intra-district water transfers. However, the groundwater option is often not sustainable over the long-run. In addition, improvements in irrigation efficiency are often possible through increased monitoring of water use and changes in timing of application, which may require increased use of labor and management.

Producers' long-run adjustments to continued water supply reductions (or greater variability) are a function of their capital resources and the relative profitability of their farms. Such adjustments could include permanent reductions in planted acreage, changes in crop mix or adoption of more efficient irrigation technology. Some producers may elect to leave farming, depending upon site-specific water supplies and expected returns from land sales for agricultural and non-agricultural uses. Producers adjacent to growing urban communities are likely to face pressures to convert their land to residential use (e.g. producers in El Dorado ID).

Farm-level adoption of more efficient irrigation systems can increase irrigation effectiveness and reduce drainage effluent and associated externalities (Caswell et al., 1990). Increased adoption of these technologies depends on favorable economic conditions that can be influenced by policy, such as: 1) economic incentives, particularly higher water rates and/or technology subsidies; 2) high elasticities of marginal productivity with respect to water (i.e. crop output is elastic (responsive) with respect to small changes in water application); and 3) sufficiently high crop returns to justify the incremental investment and variable costs associated with adoption of water-saving technologies.

Producer modifications of cropping patterns and water use practices can affect farm product supply, prices and product quality. The level of production and product price are interrelated, particularly in cases where California dominates regional, national and international product markets. Depending on supply and demand elasticities, reductions in output may result in significant price increases. The impact of changing water supply conditions on the supply of high quality farm products can either be positive or negative.

Yield effects that result from reduced per acre water application depend on the level of irrigation efficiency, land quality (soil permeability), potential substitutability between water and other inputs and the water needs of the particular crop (Whittlesey, N. 1990). In some situations, product quality may deteriorate due to plant stress associated with declining water quality and availability. In other situations, if market conditions are favorable, producers may try to offset revenue losses with increased production of higher quality, higher value crops on reduced acreage. In aggregate, water-induced changes in cropping patterns can affect California's market share in certain commodities and the state's national and international agricultural competitiveness.

3.4.3 Constraints on Producer Responses

Farm size, ownership and operator characteristics may affect producer responses to changes in water supply conditions. The relationship between farm size and financial well-being, for instance, will often produce different sets of responses to water shortages for small and large producers. The farm's financial position—debt to equity ratios, liquid cash reserves and access to credit—will bear on the willingness and ability of the producer to assume financial risks associated with reduced water availability. Faced with rising water prices, lower profit margins may induce small producers to adopt more labor/management intensive on-farm conservation measures. Larger producers, with greater financial resources, may adopt more capital intensive conservation technology.

Who owns and operates the farm will also influence management decisions regarding land use, farming practices and capital improvements associated with increases in water rates and reductions in allocations. For instance, contractual agreements with landowners may limit farm managers' or tenants' abilities to respond to water scarcity, particularly with respect to capital investments in technological change. Long-run crop mix adjustments are also constrained by land suitability and by local infrastructure (e.g. mills, dryers).

The producer's ability to substitute other factors of production for water are limited, depending upon biological, agroclimatic and economic conditions. The input substitutability of labor and capital for water may enhance or constrain producers' opportunities to respond to water shortages. In the short-run, evidence suggests that reductions in water application rates with fixed irrigation technology would lead to reduced yields. In the longer-run, adoption of water-saving irrigation technology may result in yield improvements depending upon site-specific conditions. Empirical evidence suggests that farms with low water holding capacity land are positively correlated with adoption of more precise water application technologies (Caswell, Lichtenberg and Zilberman, 1990). Some important constraints on adoption of new irrigation technology include financial resources, mechanization and frost control requirements, delivery systems and crop profitability.

3.5 Local Economy Impacts

Short and long-run adjustments by producers and water suppliers may affect local economies. The magnitude and direction of these impacts, positive or negative, depend upon producers' abilities to manage water supply reductions and on the importance of input supply and agriculture related industries to the local economy. Minimal local economy impacts are likely in areas where producers can adjust to changes in water supply with few modifications in established cropping patterns and output. However, in areas where there are substantial changes in crop mix, or large reductions in acreage and/or output, local economy impacts may be very substantial, particularly in the short-run or over a specific season. In the long-run the net losses of such impacts will tend to decline with increased mobility and substitution possibilities.

Farm adjustments to reduced water supplies would most directly affect "backward linked" input supply industries (e.g. farm-level demand for labor, agrochemicals, machinery, capital, irrigation technology and technical services). Adjustments that result in changes in the supply of farm products (product availability, quantity, quality and prices) can be expected to affect "forward linked" agriculture related industries, such as food processing and packing, storage, transportation and marketing. These effects may be passed on to consumers of agricultural products (final demand linkages) through changes in retail products and prices.

On-going water reductions and greater unreliability in water availability can also be expected to affect California's comparative advantage in producing certain commodities. Currently, California dominates U.S. production for many commodities (e.g. almonds—100%, grapes—93%, processing tomatoes—85%) and produces a significant share for others (e.g. cotton lint—23%, rice—22%, sugar beets—21%) (CDFA, 1985). Adjustments to reduced water supplies may include changes in the location of production of some crops both within California and to other states or countries, altering these relative shares.

Location changes and/or reduced production of certain commodities may also affect the value of California agricultural exports. In 1985, the value of California exports compared to total value of production was over 30 percent for several commodities (e.g. cotton lint—65%, almonds—68%, rice —49%, safflower—48% and prunes—37%) (CDFA, 1985).

Suppliers and producers with access to sufficient water supplies (from water rights, groundwater or improved water management) may gain financial benefits as a result of increased water and land values and new opportunities for water marketing. Conversely, regions with very restricted water availability would experience decreased land values and large increases in water prices. The financial resources generated from land sales and water transfers could partially offset the negative production impacts associated with reduced water supplies. However, the benefits to the local economy from such transactions depend upon reinvestment of sale proceeds into locally productive enterprises.

Local economy impacts on agricultural and non-agricultural employment, land values, the tax base (sales and income) and future economic growth can be aggregated to estimate these impacts at the regional and state levels. In the short-run, these estimates will primarily reflect impacts on agriculture and related industries. In the long-run, alternative non-agricultural uses for land and water may become viable local economy options for some areas. However, transfers of natural resources, employment and income to non-agricultural activities would lead to changes in the level and composition of economic activity statewide that should be evaluated *ex-ante* by state planners.

3.6 Data Needs, Status of Data Collection and Sources

Data that would be required for assessing impacts were determined generally in Phase I of the study based on the identified linkages between suppliers, producers and local economies depicted in Figure 3.1. In Phase II, a key objective was to identify and collect available primary information before any original data collection was begun in later phases of the study. Tables 3.1 and 3.2 provide a review of the identified data needs, the status of data collection at the end of Phase II, along with some indication of how comprehensive and consistent these data were between districts. As indicated from these tables, a great deal of the data identified as necessary in Phase I were collected and verified by the districts. Phase III research efforts will be partially directed toward completing data collection, particularly at the farm-level where district specific data are somewhat limited. Appendix B provides a list of field visits and interviewees.

Table 3.1: District Data Needs and Collection Status

Information and Data Needs	Collection Status	Explanation	Sources
A. General District Characteristics			
1. Location	yes		District interviews and documents
2. Service area			
a. Agriculture (gross and irrigable acreage)	yes		
b. Municipal and industrial uses	yes		
3. Social and economic characteristics	partial	Phase III*	
B. Water Supply			
1. Surface water entitlements and deliveries by rights and contracts	yes	1975-91	District interviews and documents, USBR, DWR, SWRCB, KCWA, SWP
2. Groundwater supplies			
a. District owned/operated wells	yes	1975-91	
b. Private wells leased by district	yes	1975-91	
3. Water sales, transfers, exchanges and	yes		
purchases	yes	1975-91	
4. Return flows	yes	1975-91 GCID	
C. Hydrological Parameters			
1. Watershed characteristics (e.g. size, mean flow, etc.)	yes		District interviews and documents, DWR, USBR, Soil Conservation Service, SWP Regional Offices, Federal-State San Joaquin Valley Drainage Program
2. Soil Profile	no	Phase III*	
3. Drainage	partial	Phase III*	
4. Groundwater availability	partial	Phase III*	
5. Surface and groundwater quality	partial	Phase III*	
D. Institutional Characteristics			
1. Water rights	yes		District interviews and documents, CA. Water Code, USBR, DWR, KCWA, SWP, SWRCB
2. District rules and regulations	yes		
3. USBR contracts	yes		
4. SWP/KCWA contracts	partial	Phase III	
5. Legal authorization	yes		
E. Physical System			
1. Water Delivery Systems			
a. Canals/pipelines (location, capacity, materials, etc.)	yes		District interviews and documents, Federal-State San Joaquin Valley Drainage Program, USBR, DWR, KCWA
b. Number of turnouts	yes		
c. Number and type of water meters	partial		
2. Drainage systems	yes		
3. Storage facilities	yes		

Table 3.1 (continued)			
Information and Data Needs	**Collection Status**	**Explanation**	**Sources**
F. Financial Structure			
1. Revenues			
a. Water sales	yes	1988-90	District financial
b. Fixed producer charges	yes	1988-90	statements
c. Other revenue	yes	1988-90	
2. Expenses			
a. General and administration	yes	1988-90	
b. Sources of supply	yes	1988-90	
c. Pumping and power	yes	1988-90	
d. Transmission and distribution	yes	1988-90	
e. Other expenses	yes	1988-90	
G. Resource Quality Issues			
1. Drainage water management and disposal	yes	interviews	District interviews and
2. Groundwater overdraft and associated resource quality problems (e.g. changes in water quality, subsidence, lost storage capacity, etc.)	yes		documents, Federal-State San Joaquin Valley Drainage Program, Cal. Fish and Game, U.S. Fish and Wildlife
3. Fish and wildlife habitat	partial		Service, DWR, SWRCB
H. Water Conservation Activities			
1. Physical system improvements	partial	WWD and EID	District interviews and
2. Producer information and technical assistance	yes		documents
3. Economic incentives to producers			
a. Price policy (e.g. tiered prices)	yes	CCID only	
b. Water allocation limits	yes		
c. Subsidies (e.g. low interest loans)	yes	CCID only	
		*if needed	

Table 3.2: Producer Data Needs and Collection Status

Information and Data Needs	Collection Status	Explanation	Sources
A. Agroclimatic Conditions			
1. Climate	partial	Phase III*	District interviews and
2. Soil type	partial	Phase III*	documents, CDFA, DWR,
3. Topography	partial	Phase III*	Soil Conservation Service
B. Producer Water Sources			
1. District	yes		District interviews and
2. On-farm			documents, SWRCB, DWR,
a. Number of wells	partial	drillers logs	PG&E, survey of self-
b. Quantity of groundwater pumped	partial	WWD, WRM	supplying irrigators
c. Surface water rights	partial		
d. Storage	no	Phase III*	
C. Hydrological Parameters			
1. Depth of water table	partial	interviews	District interviews and
2. Groundwater quality	partial	interviews	documents, USGS studies,
3. Drainage	partial	interviews	DWR, private hydrologists
D. Cropping Systems			
1. Acreage by crop	yes	1975-91	District crop surveys, ASCS
2. Cropping patterns			data, CDFA data.
a. Fallow	yes		
b. Double cropping	partial	Phase III	
c. Common rotations	no	Phase III*	
3. Commodity program participation	no	Phase III	
E. Production Structure			
1. Factors and costs of production			
a. Labor	partial	1987, County	District interviews and
b. Capital	partial	1987, County	documents, CDFA Census of
c. Energy	partial	1987, County	Agriculture, U.C. Cooperative
d. Fertilizer and chemical use	partial	1987, County	Extension, U.C. Davis Budget
e. Water requirements	partial	1987, County	Generator, 1987 Cost of
f. Seeds and other inputs	partial	1987, County	Production Survey, Federal-
2. Irrigation technology			State San Joaquin Valley
a. Irrigation systems (flood,			Drainage Program
sprinkler, furrow, drip, etc.)	partial	district data	
b. Irrigation management practices	partial	interviews	
c. Energy systems for irrigation	partial	1987, County	
d. Information and technical assistance	yes		
3. Resource conservation practices			
a. Water management	partial		
b. Soil management	no	Phase III*	
c. Drainage management	partial		

Table 3.2 (continued)			
Information and Data Needs	**Collection Status**	**Explanation**	**Sources**
F. Farm Structure 1. Size distribution 2. Organization type (partnership, corporation, etc.) 3. Operator characteristics	 yes partial partial	 1987, County 1987, County	District interviews and documents, California Ag. Census, County Assessors Office, U.C. Cooperative Extension
G. Financial Health Indicators 1. Bank lending policies 2. Land values 3. Farm revenues 4. Farm expenditures 5. Bankruptcies	 yes partial partial partial partial	 interviews county info. county info. local banks	District interviews and documents, Local banks, Local real estate boards and agents, Marketing boards, CDFA, County Ag. Comm., ASCS, NASS
		*if needed	

4.0 DISTRICT RESPONSES AND ADJUSTMENTS TO CHANGES IN WATER AVAILABILITY

4.1 Introduction

Figure 4.1 illustrates the potential options available to water suppliers facing changes in water availability, subject to certain hydrological, institutional, physical and environmental constraints. The case study districts cover a wide range of water supply scenarios in California agriculture. Each district's access to water through historical rights and contract entitlements, and unique set of constraints and opportunities for conserving existing supplies and/or acquiring new supplies, will determine its ability to successfully manage water shortages and increased water supply variability in the future.

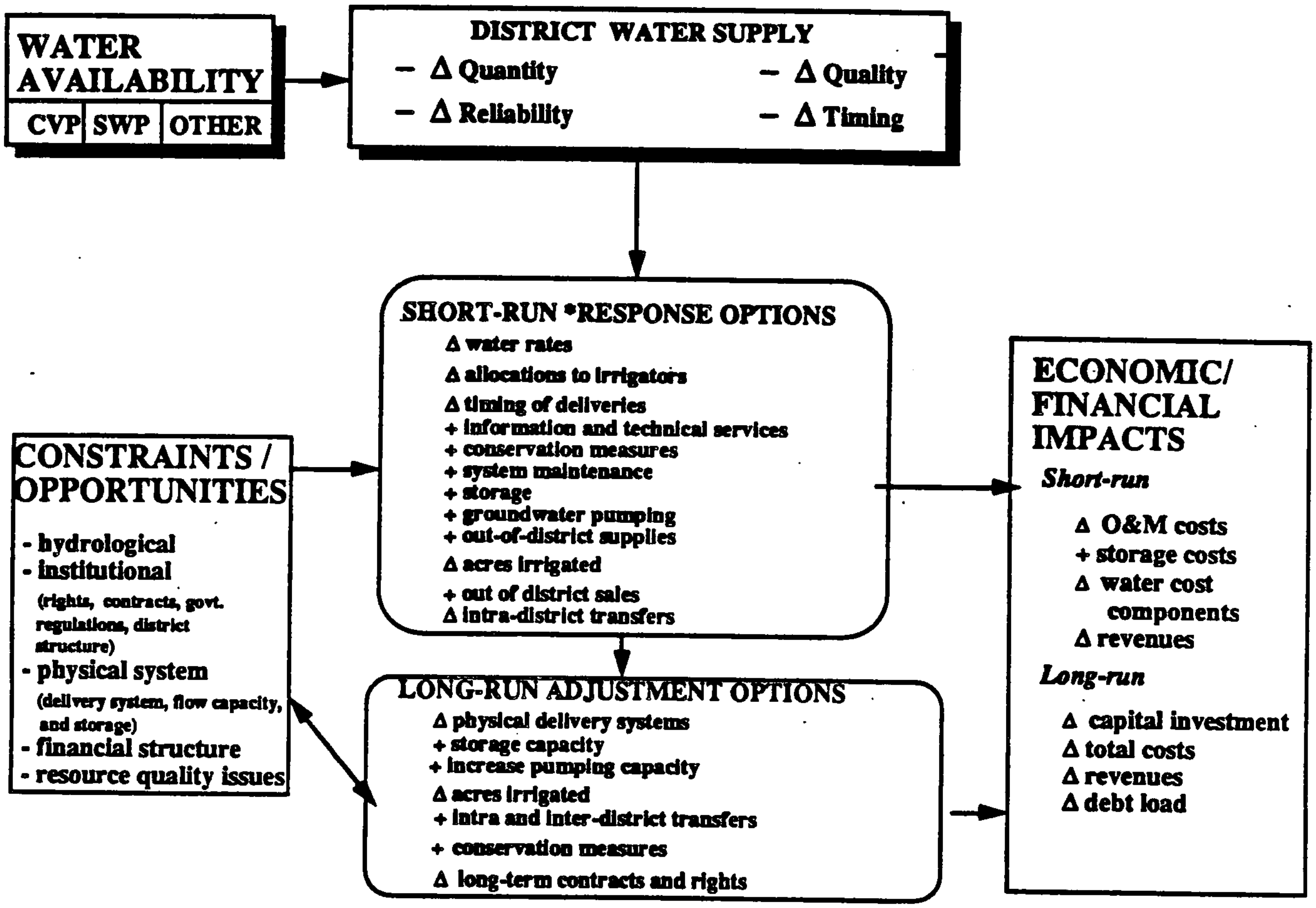
4.1.1 District Adjustment Mechanisms: Short-Run Responses and Long-Run Adjustments

In the short-term, water districts employ two basic strategies for managing water supply reductions: 1) enhance water supplies through alternative sources, and 2) utilize techniques to reduce water demand and redistribute scarce supplies. Alternative sources of supply can be obtained from increased groundwater pumping, either directly from district wells or indirectly through district encouragement of on-farm groundwater pumping and integration, and from out-of-district water transfers, including State Water Bank purchases.

Districts utilize a variety of techniques to reallocate supplies among water users and to reduce aggregate water demand, including: 1) "critical" year allocation programs; 2) timing restrictions on deliveries; 3) management of intra-district surface water and groundwater transfers; and 4) carry-over provisions and credits.

To bring reduced water supply in line with demand, districts may institute temporary (or long-run) economic disincentives for high intensity water use, such as tiered pricing. This mechanism may also raise revenue for districts hurt financially by reduced water sales.

FIGURE 4.1: DISTRICT ADJUSTMENTS, CONSTRAINTS AND IMPACTS



* The short-run is defined as those adjustments possible within existing institutional, physical and capital constraints.

Water users can be encouraged to adopt more efficient water management techniques through district-provided information, technical assistance and economic rewards for demonstrated water savings.

Although some short-term responses are effective at reducing water demand (e.g. better management practices), changes in water availability on a more permanent basis generally require more long-lasting actions. Changes may have to be made in existing institutional and/or physical conditions, requiring significant investments of capital. Such investments include: 1) improvements in the physical delivery system; 2) increased groundwater pumping capacity; 3) increased surface water recharge capacity; and 4) improved water storage facilities. Districts can also adopt policies that encourage long-run water conservation at both the district and grower levels, such as replacement of inaccurate water meters, canal and ditch lining and low interest loan programs to fund on-farm irrigation efficiency improvements.

Some water suppliers may have the option to improve long-run inter-temporal water supply reliability through water exchange agreements with other suppliers, both agricultural and urban. Depending upon water availability, others may seek to expand total supply through new diversion and/or storage rights. If granted, new water rights are often tied to water supply projects involving considerable outlays of capital. Water suppliers lacking local water sources may pursue new or greater volume long-term contracts with the CVP or SWP, although this option has become less viable in recent years.

4.1.2 Opportunities and Constraints

The short and long-term responses available to each district are dependent on its unique characteristics. Each district, for example, faces a different "cost curve" to implement water saving strategies. The heterogeneity in prevailing opportunities and constraints among Central Valley water suppliers explains, in large part, the wide variation in these strategies. For example, district access to abundant, good quality groundwater storage presents an opportunity for conjunctive management of surface and groundwater, while limited access presents a constraint.

Legal and institutional rules can make some adjustments more attractive than others, and in some cases may even block potential adjustments. For example, the fact that groundwater pumping is largely unregulated is one reason why districts turn to this option as a primary response to shortages in surface supplies. By contrast, various legal and institutional restrictions on water transfers have sometimes deterred districts from using transfers as a method of adjusting to water shortages. Particular districts may also lack the statutory authority to pursue other adjustment mechanisms.

The physical delivery system of each water supplier, and of the major government water projects, also present opportunities and constraints for managing water shortages. The physical components of the conveyance system (canals, pipelines, pumps, turnouts, meters)—and their location, capacity and effectiveness—affect water delivery efficiency and the potential for reduction and/or recovery of system water losses. Intra-seasonal pumping capacity, flow restrictions at the Delta, storage and flood control requirements and conveyance system bottlenecks place constraints on water transfers and the timely delivery of water to meet irrigator needs.

Financial and institutional factors determine the extent to which a water supplier can invest in physical system improvements and new facilities to increase water supply reliability. Districts with limited reserves and large fixed costs or high debt service are less able to invest in major improvements such as canal lining, installation of underground pipeline and automated pumping and metering systems. Development of new water diversion and storage projects is usually contingent upon securing additional water rights from the SWRCB, a lengthy, costly and uncertain process.

Environmental concerns are playing an increasingly important role in circumscribing the adjustment mechanisms open to water suppliers faced with reduced water supplies. The resource issues most closely linked with water supply, use and disposal are: 1) surface water and groundwater quality; 2) drainage management and disposal; and 3) protection of wetlands and fish and wildlife habitat. Statewide regulation of water quality standards and protection of habitat are guided by the water quality standards, flow levels and allocations authorized by the SWRCB, and by the laws and regulations governing environmental protection at the state and federal levels.

The environmental review requirements for obtaining approval for new water supply projects are rigorous and the views of environmental groups are gaining more attention and credibility. This has tended to create an antagonistic relationship between water suppliers and developers interested in expanding supply, on the one hand, and environmental organizations interested in limiting new sources of developed water, on the other. This antagonism can act as a major constraint for certain kinds of adjustments to water shortages, but it can also present an opportunity for looking toward long-term solutions that are more sensitive to environmental impacts. In essence, environmental concerns oblige water suppliers to consider and justify or mitigate the long-run net social costs of their decisions, in addition to any short-run private costs and benefits.

4.1.3 Identifying Impacts

The adjustment mechanisms adopted by water suppliers facing changes in water availability have certain impacts that are important to identify and evaluate. These impacts may be readily apparent in the short-run or "potential" and too uncertain to assess with any confidence. In this report, both the apparent and potential impacts of the more significant water supplier and producer adjustments are identified, with some specific examples cited. However, the quantification of these impacts is left to Phase III when further data required for this type of analysis will be collected.

4.2 District Water Supplies

Annual water supplies in California fluctuate with snowpack and runoff, storage capacity and inventories and groundwater levels as discussed in Chapter 3. The distribution of annual supplies among competing users is determined by government enforced water quality and environmental standards, on the one hand, and long-standing water rights and supply contract obligations, on the other hand. These "state of nature" conditions and institutional factors determine not only the quantity of water available for use by agriculture, but also the quality, timing and reliability of this supply. Each district's historical access to water, and unique set of opportunities and constraints for conserving existing supplies and/or acquiring new supplies, will determine its ability to successfully manage water shortages and increased water supply variability in the future.

4.2.1 District Project Water Entitlements and Deliveries

All seven of the case study districts receive a portion or all of their water through either the federal Central Valley Project (CVP) or the California State Water Project (SWP). Four of the suppliers are CVP service contractors: Arvin-Edison WSD (AE), El Dorado ID (EID), Glenn-Colusa ID (GCID), and Westlands WD (WWD). One supplier, Central California ID (CCID), is a CVP exchange contractor, having exchanged its original water rights on the San Joaquin River in 1939 for access to a firm supply of CVP water delivered through the Delta-Mendota Canal. Two of the suppliers are Kern County Water Agency (KCWA) subcontractors for SWP water: Lost Hills WD (LHWD) and Wheeler Ridge-Maricopa WSD (WRM).

Table 4.1 shows the Class I (firm) and Class II (non-firm) water entitlements and deliveries for each of the five CVP contractors, on average, and in drought years 1977, 1990 and 1991 as well as in 1989. The average figures reflect entitlements and deliveries from 1975 through 1989, excluding 1977. Figure 4.2 depicts the delivery figures graphically, demonstrating the relative variability of water supply among districts over time. Table 4.2 and Figure 4.3 show the same information for the two KCWA subcontractors.

Each district's contract with the USBR for CVP water specifies water entitlements in normal and critical years. Critical year entitlement cuts vary according to type of contract, priority level and source of water, among other factors. CCID, an exchange contractor, was subject to a cut of 25 percent in critical years 1977 and 1991, and a 15 percent cut in 1990.

Glenn-Colusa ID receives the bulk of its water from its "base supply" from the Sacramento River and Stony Creek, and a small portion from a service contract for CVP water (Table 4.1, footnote h). Both the service contract and the base supply are subject to cuts when the inflow to the Shasta Reservoir falls below 3.2 million AF. GCID's total CVP entitlement cut was 25 percent in 1977 and 1991. The projected 25 percent cut in 1990 was restored to full entitlement after the late May rains brought Shasta above the threshold level. Nevertheless, planting decisions based on short supply projections reduced irrigation demand such that a portion of the CVP deliveries was freed for transfer (25,000 AF) and the remainder went unused (22,300 AF). This incident points out that late water entitlement announcements, or late changes in deliveries on entitlements, can impose serious difficulties for water and agricultural planning.

Arvin-Edison WSD's CVP contract differs from the other CVP districts in two aspects: 1) it receives its entitlement water from the Friant-Kern (FK) Unit of the CVP; and 2) its CVP Class I or firm entitlement, 40,000 AF, represents only a small portion of its total entitlement, 351,675 AF, when Class II supplies are included. Average annual CVP deliveries to the district of 191,000 AF, reflect this highly variable Class II water

Table 4.1: Entitlements and Deliveries of Contract Water, Case Study CVP Contractors

District	Entitlement (a)			Actual Deliveries of Contract Water
	Class I	Class II	Total	
Arvin-Edison WSD (b)				
Average (c)	38,300	152,700	191,000	191,000 (d)
1977	10,000	0	10,000	10,000
1989	39,200	0	39,200	39,200
1990	27,200	0	27,200	27,200
1991	40,000	0	40,000	40,000
Central California ID				
Average	532,400	0	532,400	516,600
1977	423,900	0	423,900	379,000
1989	532,400	0	532,400	544,000
1990 (e)	452,500	0	452,500	508,500
1991	423,900	0	423,900	391,500 (f)
El Dorado ID (g)				
Average	30,600	0	30,600	22,300
1977	28,700	0	28,700	6,500
1989	30,600	0	30,600	17,300
1990	26,800	0	26,800	15,900
1991	24,900	0	24,900	10,300
Glenn-Colusa ID (h)				
Average	105,000	0	105,000	93,200
1977	78,800	0	78,800	69,800
1989	105,000	0	105,000	99,300
1990 (i)	105,000	0	105,000	105,000
1991	78,800	0	78,800	77,600
Westlands WD				
Average	1,150,000	0	1,150,000	1,188,600
1977	287,500	0	287,500	298,300
1989	1,150,000	0	1,150,000	1,100,200
1990	575,000	0	575,000	799,100 (j)
1991	287,500	0	287,500	360,000 (k)
Total				
Average	1,856,300	152,700	2,009,000	2,011,700
1977	828,900	0	828,900	763,600
1989	1,857,200	0	1,857,200	1,800,000
1990	1,186,500	0	1,186,500	1,455,700
1991	855,100	0	855,100	879,400
	Values in Acre-Feet (rounded to nearest 100)			

Table 4.1 (continued)

Footnotes: (a) Entitlement is defined as the maximum amount of water the district may receive in a given year under the terms of its USBR contract. Class I water represents "firm" deliveries" while Class II water is distributed on an "if and when available" basis. (b) These entitlement and delivery figures do not adequately represent Arvin-Edison's surface water supplies. Under a 1975 Exchange Agreement with Cross Valley Canal (CVC) water suppliers, the District gave up the first 174,300 AF of Friant-Kern water for 128,300 of surface water supplied from the Delta. In 1988, an amended agreement was signed that provides Arvin-Edison with 108,300 AF of Delta water from the CVC suppliers in exchange for 150,596 AF of the first 174,300 AF of Friant-Kern water. (c) Average is defined as the average of 1975 through 1989, excluding 1977. (d) This amount of water is available to the District from the Friant-Kern Canal, though its exchange agreement requires that a portion be traded to the CVC exchangors. (e) In February 1990, USBR declared water supplies to be "critical," thus reducing supplies available to the District. In June, however, full supplies were restored. CCID's manager estimates that the cutback and later restoration of supplies had the effect of reducing the overall entitlement by approximately 15 percent, though actual delieveries fell short of average levels by less than two percent. (f) CCID's USBR contract includes three other water supplying entities that together receive a 25 percent reduction in supplies in critical years. CCID, however, receives a 20 percent cut while the reduction for other entities is higher. (g) The discrepancy between the entitlement and deliveries is linked to the District's management of the Sly Park Reservoir as a two year supply. In addition, District water treatment and delivery facilities are inadequate to make use of all entitlement water in a given year. (h) Only the service contract amount is shown here. The annual "base supply" (720,000 AF/Y) is excluded. (i) In February 1990, the USBR made a critical year determination. Full supplies were restored in June after heavy rain in the spring. The district was only able to use 57,700 AF. Of the remainder, 25,000 AF was sold to the Sacramento River Water Contractors Association and 22,300 AF went unused. (j) Deliveries include 68,486 AF of 1989 deliveries rescheduled for 1990 after assessing a 15 percent storage loss. (k) Deliveries include 19,492 AF of 1990 deliveries rescheduled from 1990 after assessing a 5 percent storage loss.

Sources: Arvin-Edison WSD: "Study of Second Priority Water Availability -- Friant Kern Declaration of Class I and II," (June, 1991); "Annual Report 1988 Water Year;" "History of Project Operations," (1988) and personal communications with Cliff Trotter and Steve Collup. Central California ID: Financial Statement and Annual Reports (various years); Water Distribution," (1980) and personal communications with Mike Porter. El Dorado ID: Personal communication with Rob Alcott and Dorine Kelley. Glenn-Colusa ID: "Report on Water Measurement Program" (1981 and 1990) and personal communications with Bob Clark and Lou Hosky. Westlands WD: "Facts and Figures, 1989" and personal communications with Steve Ottemoeller and Shelley Vuicich.

Figure 4.2: Central Valley Project Deliveries, Case Study Districts

Source: CVP Entitlements and Deliveries Table

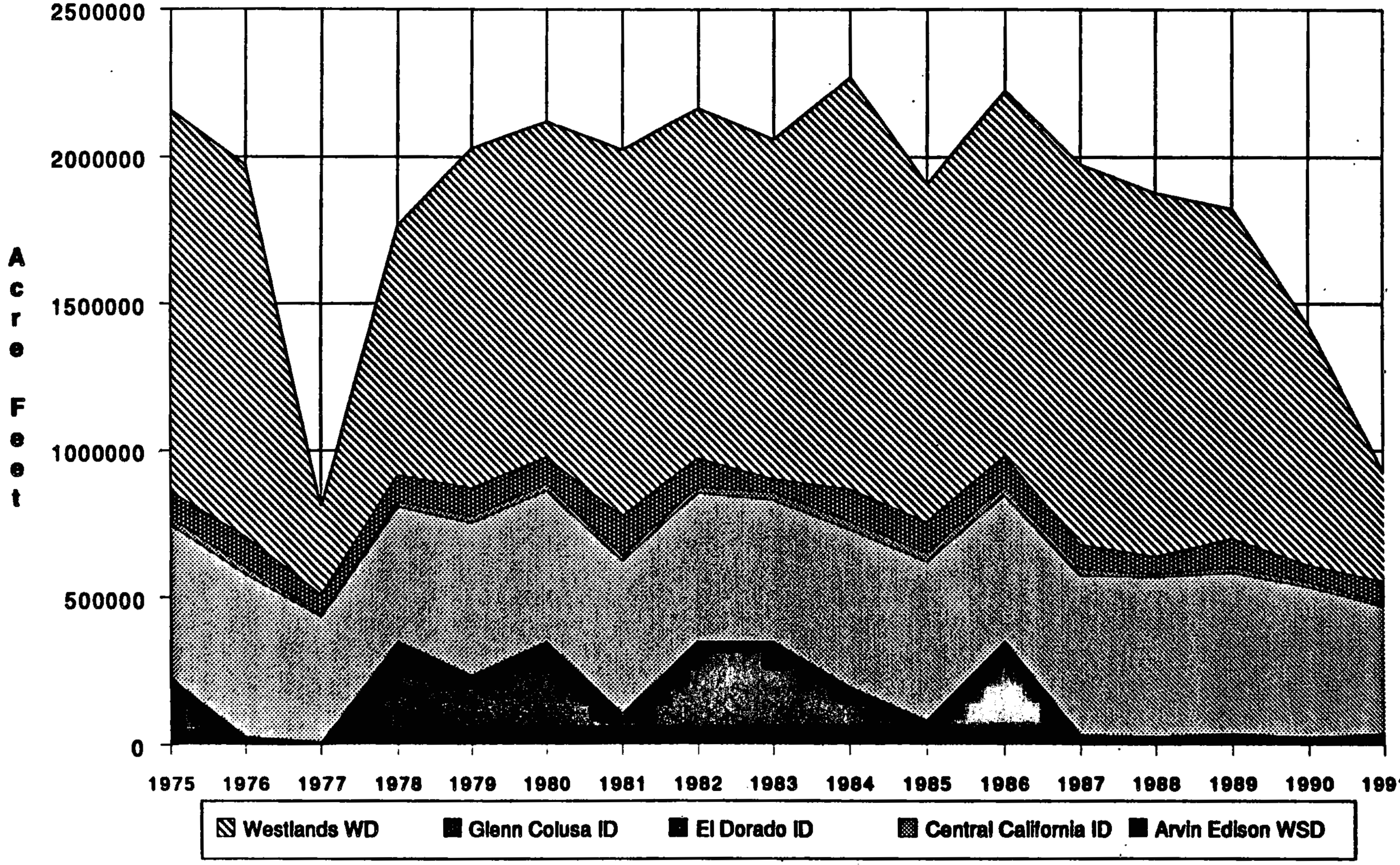


Table 4.2: Entitlements and Deliveries of Contract Water, Case Study SWP Contractors (a)

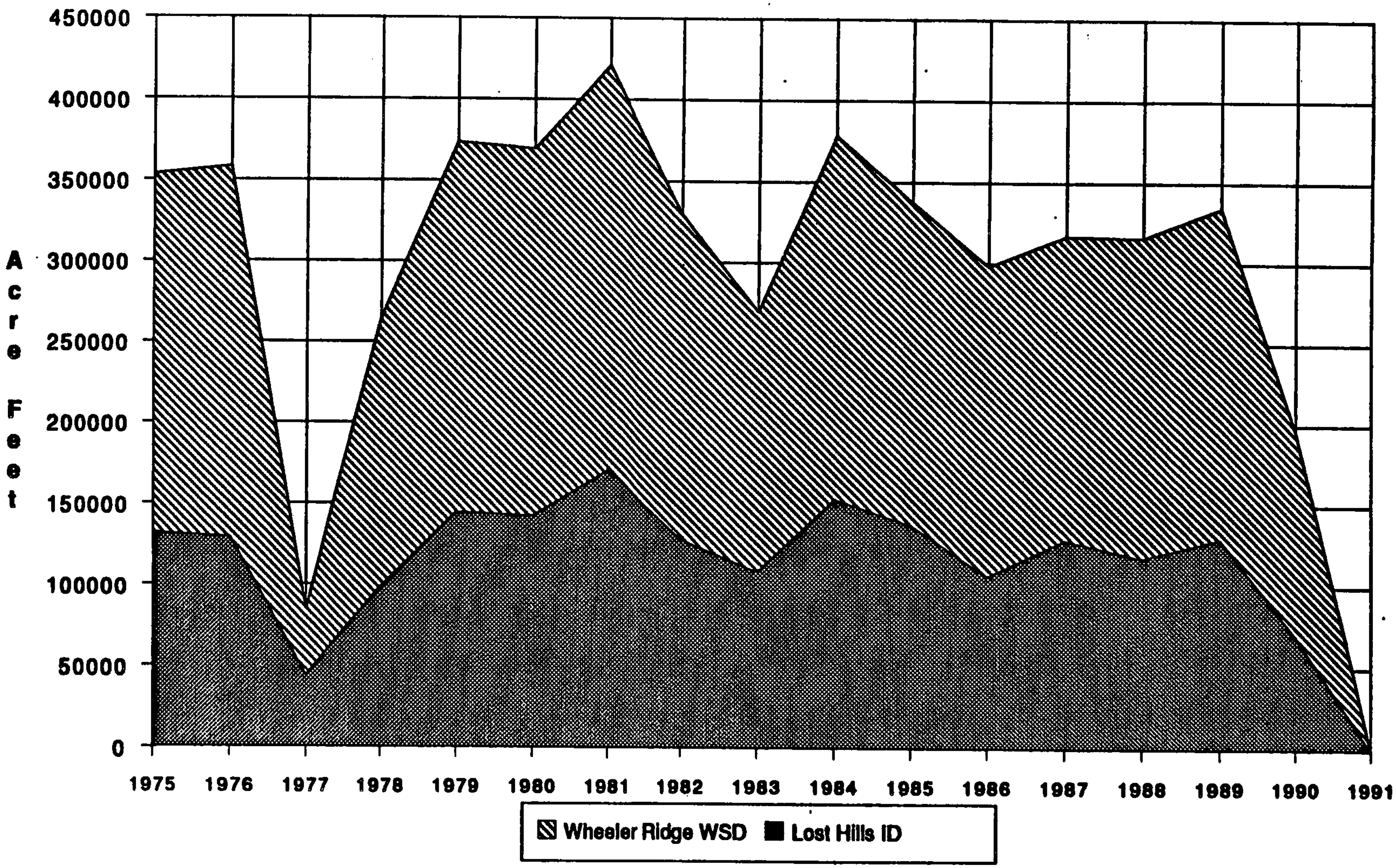
District	Entitlement (b) Firm	Entitlement (b) Surplus	Entitlement (b) Total	Actual Deliveries of Contract Water
Lost Hills WD				
Average (c)	115,400	0	115,400	130,300
1977	44,200	0	44,200	44,200
1989	139,800	0	139,800	129,400
1990	70,200	0	70,200	70,200
1991	0	0	0	0
Wheeler Ridge WSD				
Average (d)	156,200	91,000	247,200	206,600
1977	41,000	0	41,000	41,000
1989	242,800	0	242,800	205,000
1990	126,500	0	126,500	126,500
1991	0	0	0	0
Total				
Average	271,600	91,000	362,600	336,900
1977	85,200	0	85,200	85,200
1989	382,600	0	382,600	334,400
1990	196,700	0	196,700	196,700
1991	0	0	0	0
	Values in Acre-Feet (rounded to nearest 100)			

Footnotes: (a) Lost Hills WD and Wheeler Ridge-Maricopa WSD are subcontractors of the Kern County Water Agency (KCWA) and receive an apportionment of KCWA's State Water Project (SWP) contract entitlement. They do not receive water directly from the SWP. (b) Entitlement is defined as the maximum amount of water the district may receive in a given year under the terms of its contract. (c) Average is based on data from 1975 through 1989, excluding 1977. Lost Hills WD's entitlement slowly increased in those years, reaching a maximum of 140,400 AF in 1990. During the intervening years, the District purchased additional SWP surplus water which resulted in deliveries exceeding entitlements. (d) The average is based on data from 1975 through 1989, excluding 1977. Wheeler Ridge-Maricopa WSD's entitlement slowly increased in those years to reach a maximum of 252,924 AF/Y in 1990. The District's entitlement for surplus water increased to a maximum of 110,300 AF/Y in 1979 and then decreased to its present level of 38,146 AF.

Sources: Lost Hills Water District: "Annual Water Use Summary" (1979-1991); "Kern County Water Agency Unit Water Rate Computations" (1990) and personal communications with Phil Nixon and Joe Steele. Wheeler Ridge-Maricopa WSD: "Ten Years of Water Management -- 1971 through 1980" (1981); "Water Deliveries: 1981 through 1991" (1991); Kern County Water Agency Unit Water Rate Computations" (1990); and personal communications with Arnold Rummelsburg and William Taube.

Figure 4.3: State Water Project Deliveries, Case Study Districts

Source: SWP Entitlements and Deliveries



availability, which has ranged from zero in critical years to over 300,000 AF in wet years. Arvin-Edison has a contractual agreement to exchange with other CVP contractors a portion of its highly variable F-K supplies for a lower but more stable level of Delta water delivered through the Cross Valley Canal. Arvin-Edison WSD experienced a 29 percent cut in its CVP firm water entitlement in 1990 and no cut in 1991.

El Dorado ID has three USBR contracts to pump water from Lake Folsom for a total entitlement of 7,600 AF per year, and a separate contract to consume up to 23,000 AF of water per year from the Sly Park Unit of the CVP. EID manages the Sly Park facility to ensure adequate inter-temporal water storage for the district. The facility is not subject to CVP entitlement cuts during dry years. Entitlements from Lake Folsom were cut by 25 percent (1,900 AF), 50 percent (3,800 AF) and 75 percent (5,700 AF) in 1977, 1990 and 1991, respectively. Deliveries to El Dorado ID typically fall short of entitlements, in both normal and dry years, because of physical capacity and treatment facility constraints.

Westlands WD (WWD) is the largest contractor among the case studies, and the largest agricultural water district in the Central Valley. Its full entitlement is 1.15 million AF of Class I water moved through the Delta-Mendota Canal and delivered to the District through the San Luis Canal. Of the total, 900,000 AF are allotted to Priority Area I, the original Westlands Water District, and 250,000 AF to Priority Area II, the former Westplains Water Storage District. During water short years, Westlands' CVP entitlement reductions are based on the District's full contract entitlement (as a fraction of total CVP entitlements) multiplied by the total water supply available to all contractors on the San Luis Unit. WWD's entitlement was cut by 50 percent in 1990 and by 75 percent in 1977 and 1991. Actual deliveries to WWD have exceeded entitlements when "interim" water (before 1987) or emergency ("hardship") water (1977, 1991) were available for purchase, or when additional supplies became available after unexpected spring rains (1990).

There appears to be less variability in the distribution of entitlement cuts among SWP contractors (and KCWA subcontractors) than among CVP contractors. Article 18 of the SWP contract specifies a complex formula for sharing the burden of reduced water supplies among agricultural and urban users. Article 12d of the SWP contract states that firm water entitlements not delivered during a shortage period can be requested in the following year(s), and that such requests will have priority over surplus water entitlements.

The two case study districts that rely on KCWA apportionments of SWP water, Lost Hills WD and Wheeler Ridge-Maricopa WSD, were subject to the same entitlement cuts: 50

percent in 1977 and 1990, and 100 percent in 1991 (Table 4.2). Both districts had "ramped" entitlements built into their contracts, such that the original entitlement increased annually until full entitlement was reached in 1990 (140,400 AF firm for Lost Hills WD, 252,924 AF firm plus 38,146 AF surplus for Wheeler Ridge WSD). Entitlement cuts in 1977, 1990 and 1991 were in proportion to the firm entitlements corresponding to those years.

Total Class 1 and Class 2 (surplus) entitlements and deliveries to the case study districts, on average, and for 1977, 1990 and 1991, are given at the end of Tables 4.1 and 4.2.

As described above, there is a great deal of variability in the level of project cuts experienced by the case study districts during the three critical years. However, averaging over these differences, the total cuts in Class 1 entitlements for the five CVP contractors amounted to approximately 55 percent in 1977, 40 percent in 1990 and 54 percent in 1991. The corresponding average cuts for the two KCWA subcontractors were 69 percent, 28 percent and 100 percent (based on "ramped" averages, 1975-1989, excluding 1977). All Class 2/surplus water entitlements and deliveries were suspended during these years. Total water delivered to the five CVP contractors sums to about 2.0 million AF, on average. Deliveries fell short of the average by 62 percent in 1977, 28 percent in 1990 and 56 percent in 1991. The corresponding shortages for the two KCWA subcontractors were 75 percent, 42 percent and 100 percent.

Figures 4.2 and 4.3 show the cumulative project (CVP/SWP) deliveries to the case study districts for 1975 through 1991. The figures clearly show the dramatic decline in deliveries in 1977, and, with respect to CVP deliveries, the more gradual decline beginning in 1986 and accelerating after 1989. The fairly sharp decline in SWP deliveries in 1983 is explained by the Payment-In-Kind (PIK) option available to producers participating in federal commodity programs which resulted in large reductions in planted acreage and corresponding water use. Figure 4.2 also shows the largest share of deliveries going to Westlands WD, with CCID second.

4.2.2 Total District Water Supply Availability

In addition to project water supplies, all seven case study districts receive water from other sources, either on a regular basis or in critical years on an emergency basis. Table 4.3 shows the quantity of total available water from each source for the five CVP contractors, over a fourteen year average, and for the critical years 1977, 1990 and 1991. The sources of water included are: CVP deliveries, other long-term supplies (exchanges, appropriative rights, private contracts), transfers and district provided groundwater. On-farm groundwater extractions are not included. The last column gives the total quantities available for use for the same years and districts. Table 4.4 provides the same information for the two KCWA subcontractors.

4.2.2.1 Rights to Other Sources

Of the case study districts, two obtain non-project water through pre-1914 appropriative rights to local water sources: El Dorado ID (American River–post-1914, Consumnes River, Misc. Creeks) and Glenn-Colusa ID (Sacramento River, Stony Creek). El Dorado ID also has a permanent contract entitlement from PG&E (PG&E Forebay) acquired in exchange for the right to develop a portion of the American River for hydroelectric power. Central California ID held pre-1914 appropriative rights to the San Joaquin River, but exchanged these rights in 1939 for CVP water delivered through the Delta-Mendota Canal. Lost Hills WD filed an application with the SWRCB in 1988 for appropriative rights to the Kern River, which remains under dispute.

Arvin-Edison's contract provisions with the USBR for Class I and Class II water result in very high variability in surface water supply, varying from over 300,000 AF in wet years to less than 40,000 AF in dry years. In 1974, the District entered into agreements with eight small CVP contractors located on the east side of the San Joaquin Valley to exchange a maximum of 174,300 AF of Class I and Class 2 Friant-Kern water for 117,300 AF of firm Delta water through the Cross Valley Canal (CVC). Arvin-Edison sought this agreement for the purpose of stabilizing its average annual surface supply and increasing supply during dry years. In exchange for these benefits, Arvin-Edison forfeited higher quality Friant-Kern water for CVC water. An amended exchange agreement effective in 1989 provides for 108,300 AF of CVC water in exchange for 150,596 AF of the first 174,300 AF of Friant-Kern water. Figure 4.4 shows the variability in Friant-Kern water delivered to Arvin-Edison WSD and exchanged, versus the relatively more stable supply of water sent by the Exchangors to Arvin-Edison through the Cross Valley Canal.

Table 4.3: Total Water Supply Availability, Case Study CVP Contractors

District	CVP Contract Deliveries	Other Long-Term Supplies (a)	District and Private Transfers (b)	District Provided Groundwater	Total Water Availability (c)
Arvin-Edison WSD					
Average (d)(e)	38,300	73,400	2,000	-25,800	87,900
1977 (f)	10,000	31,100	400	82,000	123,500
1989 (f)	39,200	117,300	1,000	36,300	193,800
1990 (f)	27,200	55,600	4,100	99,200	186,100
1991 (f)	40,000	24,400	5,500	76,800	146,700
Central Calif. ID					
Average	516,600	0	10,000	25,800	552,400
1977	379,000	0	0	55,800	434,800
1989	544,000	0	0	23,600	567,600
1990	508,500	0	-10,000	48,100	546,600
1991	391,500	0	0	65,100	456,600
El Dorado ID (g)					
Average	22,300	10,200	0	0	32,500
1977	6,500	12,700	0	0	19,200
1989	17,300	12,000	0	0	29,300
1990	15,900	14,800	0	0	30,700
1991	10,300	11,000	0	0	21,300
Glenn-Colusa ID					
Average	93,200	679,800 (h)	2,400	0	775,400
1977	69,800	488,000	0	0	557,800
1989	99,300	666,400	0	0	765,700
1990	105,000	627,600	-25,000	0	707,600
1991	77,600	529,600	0	0	607,200
Westlands WD (i)					
Average	1,188,600	0	16,100	1,200	1,205,900
1977	298,300	0	9,900	10,500	318,700
1989	1,100,200	0	69,900	8,300	1,178,400
1990	799,100	0	25,300	27,300	851,700
1991	360,000	0	61,000	87,000	508,000
Total					
Average	1,859,000	763,400	30,500	1,200	2,654,100
1977	763,600	531,800	10,300	148,300	1,454,000
1989	1,800,000	795,700	70,900	68,200	2,734,800
1990	1,455,700	698,000	-5,600	174,600	2,322,700
1991	879,400	565,000	66,500	228,900	1,739,800
	Values in Acre-Feet (rounded to nearest 100)				

Table 4.3 (continued)

Footnotes: (a) Includes non-USBR exchange agreements, non-CVP water supply contracts, appropriative rights, etc. (b) Includes both public and private transfers. Transfers away from the district are indicated by negative amounts. (c) "Total Water Availability" does not include groundwater extracted by producers. (d) Average is based on data from 1975 through 1989, excluding 1977. (e) Arvin-Edison WSD's average deliveries through the Friant Kern Canal are shown under "CVP contract deliveries" while deliveries from the CVC canal are shown under "other long-term supplies." The 2,000 AF in average transfers is a rough estimate. District percolation exceeded "district provided groundwater" on average. (f) Unlike the "average" data above which is based on the physical source of the surface water supplies, data for 1977, 1989, 1990 and 1991 are based on the contractual source of the surface supplies. It shows that in years when Class II water is not available, the District exchanges nearly all of its CVP contract water for water supplied by the CVC water suppliers. (g) The water supply data for El Dorado ID is for municipal and agricultural use. The District's "other long-term supply" is obtained through a contract with Pacific Gas and Electric and through appropriative rights from the Crawford Ditch. (h) Glenn-Colusa ID's "other long-term supply" is "base supply" provided for in its USBR contract. (i) "District provided groundwater" includes water supplied by producers participating in the District's "Groundwater Integration Program" which allows producers to pump groundwater into the District's distribution system or the California Aqueduct for water "credits."

Sources: Arvin-Edison WSD: "Project Operations Summary" (3/1/91); "Study of Second Priority Water Availability -- Friant Kern Declaration of Class I and II" (6/11/91); "Annual Report 1988 Water Year;" "History of Project Operations" (1988) and personal communications with Cliff Trotter and Steve Collup. Central California ID: "Financial Statement and Annual Report (1990); "Water Distribution" (1988); and personal communications with Mike Porter. El Dorado ID: Personal communication with Rob Alcott and Dorine Kelley. Glenn-Colusa ID: "Report on Water Measurement Program" (1981 and 1990) and personal communications with Bob Clark and Lou Hosky. Westlands WD: "Facts and Figures" (1989); "Drainage Operating Plan" (December 1990); and personal communications with Steve Ottemoeller and Shelley Vuicich.

Table 4.4: Total Water Supply Availability, Case Study SWP Contractors (a)

District	SWP Contract Deliveries	Other Long-Term Supplies (b)	District and Private Transfers	District Provided Groundwater	Total Water Availability (c)
Lost Hills WD					
Average (d)	130,300	0	0	0	130,300
1977	44,200	0	43,500	0	87,700
1989	139,800	0	0	0	139,800
1990	70,200	0	37,900	0	108,100
1991	0	0	38,800 (e)	0	38,800
Wheeler Ridge WSD					
Average	206,600	0	0	0	206,600
1977	41,000	0	39,400	0	80,400
1989	205,000	0	0	0	205,000
1990	126,500	0	60,400	0	186,900
1991	0	0	41,400 (f)	26,500 (g)	67,900
Total					
Average	336,900	0	0	0	336,900
1977	85,200	0	82,900	0	168,100
1989	344,800	0	0	0	344,800
1990	196,700	0	98,300	0	295,000
1991	0	0	80,200	26,500	106,700
	Values in Acre-Feet (rounded to nearest 100)				

Footnotes: (a) Lost Hills WD and Wheeler Ridge-Maricopa WSD are subcontractors to the Kern County Water Agency (KCWA) and receive an apportionment of the KCWA's State Water Project (SWP) contract entitlement. (b) Other long-term supplies includes exchange agreements, non-SWP water supply contracts, appropriative rights, etc. (c) "Total Water Availability" does not include groundwater that is extracted by producers. (d) Average is based on data from 1975 through 1989, excluding 1977. (e) Includes 10,200 acre-feet of water that was transferred to producers through private transfers. (f) Includes 33,300 acre-feet from the KCWA Emergency Groundwater Pool and 8,100 acre-feet from other transfers. (g) Wheeler Ridge-Maricopa WSD gave water "credits" to growers who pumped groundwater into District conveyance facilities for delivery to producers in the Surface Water Service Area.

Sources: Lost Hills WD: "Annual Water Use Summary: 1979-1991" (8/21/91) and personal communications with Phil Nixon and Joe Steele. Wheeler Ridge-Maricopa WSD: "Ten Years of Water Management: 1971-1980" (1981); "Water Deliveries: 1981-1991" (1991) and personal communications with Arnold Rummelsburg and William Taube.

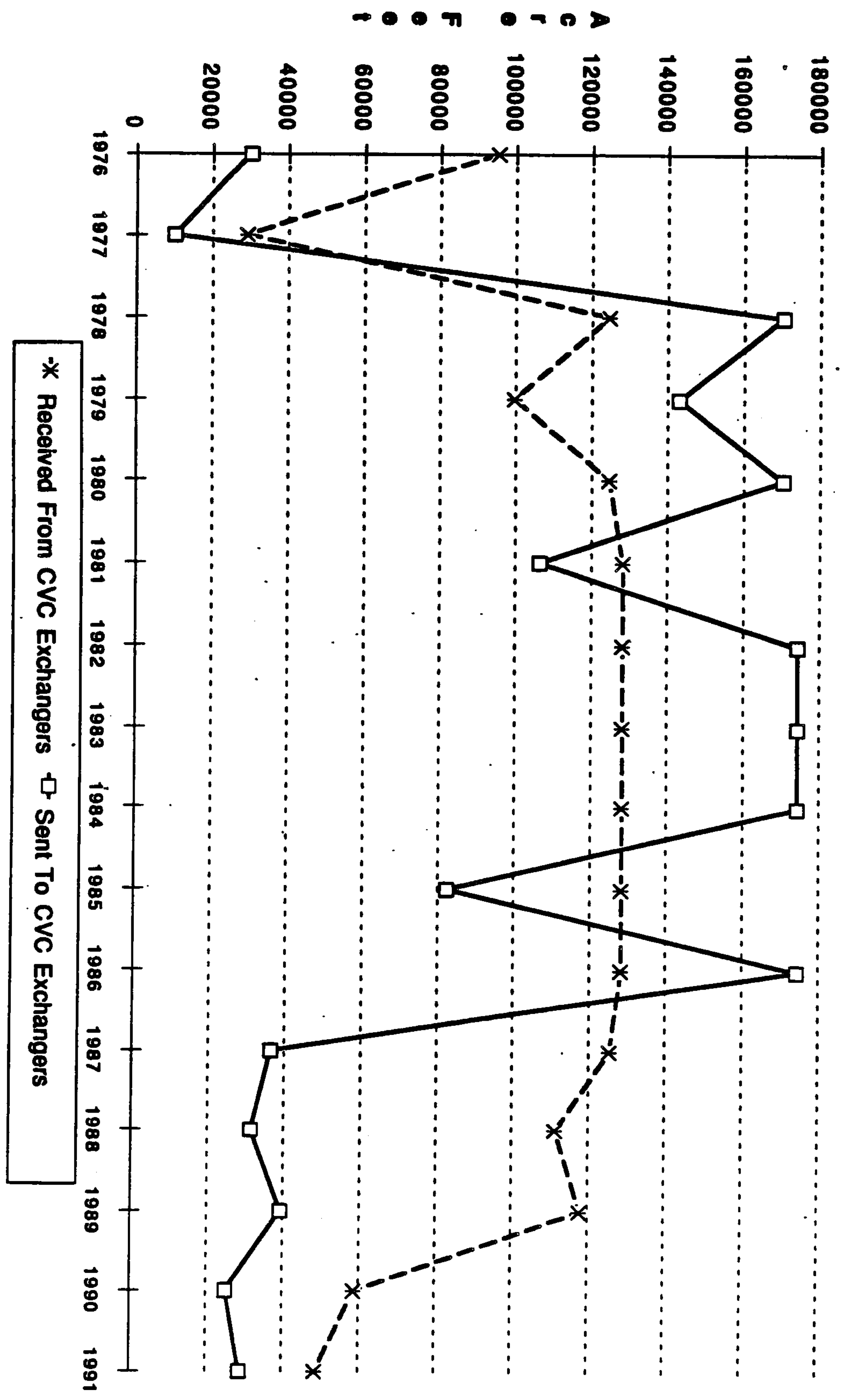


Figure 4.4: Arvin-Edison WSD/Cross Valley Canal Exchange Agreement

Source: Communications with Steve Collup, Arvin-Edison

4.2.2.2 Water Transfers

In average water supply years, none of the districts engage in external water transfers to a significant degree. However, during critical years, Lost Hills WD, Westlands WD and Wheeler Ridge WSD have all depended on transfers to supplement large surface water entitlement cuts, especially in 1991. Transfers include purchases of "banked" water from the State of California and the Kern County Water Agency, as well as purchases from water agencies, farms and ranches throughout the state. Two of the case study districts, CCID and GCID, have sold excess water outside the district from time to time. The transfer activity is detailed in Tables 4.5 and 4.6. Transfer data for WWD, LHWD and WRM include both transfers by districts and transfers by individuals conveyed through district facilities.

4.2.2.3 District Groundwater

Two of the case studies supply groundwater to producers from district-owned and operated wells and/or privately owned wells leased to the district: Arvin-Edison WSD and Central California ID. The percentage figures presented in Table 4.3 indicate that district groundwater extractions increased markedly in the dry years 1977, 1990 and 1991 as compared with average levels, particularly in Arvin-Edison WSD. In 1990, Westlands WD implemented the "Groundwater Integration Program" to allow growers to pump groundwater that meets drinking water quality standards into the District's distribution system and the San Luis Canal for future water "credits". This supply is included under "District Provided Groundwater." In 1991, Wheeler Ridge-Maricopa WSD allowed 26,500 AF of grower groundwater to be delivered through the District's conveyance system to the "surface water service area," in exchange for surface water credits. This water is also included under "District Provided Groundwater" in Table 4.4. On-farm groundwater pumping as an option for growers coping with reduced district allocations is reviewed in Chapter 5.

4.2.2.4 Total District Supplies

The last column in Tables 4.3 and 4.4 gives total water availability per district for the combined water sources (average, 1977, 1989, 1990, 1991). The information provides

Table 4.5: Water Transfer Activity, Case Study CVP Contractors

District	District and Private Transfers	Total Water Availability	Percent of Total Supply by Transfers
Arvin-Edison WSD			
Average	2,000	147,900	1
1977	400	113,500	0
1989	1,000	154,600	1
1990	4,100	158,900	3
1991	5,500	113,500	5
Central Calif. ID			
Average	10,000	552,400	2
1977	0	434,800	0
1989	0	567,600	0
1990	-10,000	546,600	-2
1991	0	456,600	0
El Dorado ID			
Average	0	32,500	0
1977	0	19,200	0
1989	0	29,300	0
1990	0	30,700	0
1991	0	21,300	0
Glenn-Colusa ID			
Average	2,400	775,400	0
1977	0	557,800	0
1989	0	765,700	0
1990	-25,000	707,600	-4
1991	0	607,200	0
Westlands WD			
Average	16,100	1,205,900	1
1977	9,900	318,700	3
1989	69,900	1,178,400	6
1990	25,300	851,700	3
1991	61,000	508,000	12
Total			
Average	30,500	2,714,100	1
1977	10,300	1,444,000	1
1989	70,900	2,695,600	3
1990	-5,600	2,295,500	0
1991	66,500	1,706,600	4
	Values in Acre-Feet (rounded to nearest 100)		

Sources: See Table 4.3

Table 4.6: Water Transfer Activity, Case Study SWP Contractors

District	District and Private Transfers	Total Water Availability	Percent of Total Supply by Transfers
Lost Hills WD			
Average	0	130,300	0
1977	43,500	87,700	50
1989	0	139,800	0
1990	37,900	108,100	35
1991	38,800	38,800	100
Wheeler Ridge WSD			
Average	0	206,600	0
1977	39,400	80,400	49
1989	0	205,000	0
1990	60,400	186,900	32
1991	41,400	67,900	61
Total			
Average	0	336,900	0
1977	82,900	168,100	49
1989	0	344,800	0
1990	98,300	295,000	33
1991	80,200	106,700	75
	Values in Acre-Feet (rounded to nearest 100)		

Sources: See Table 4.4

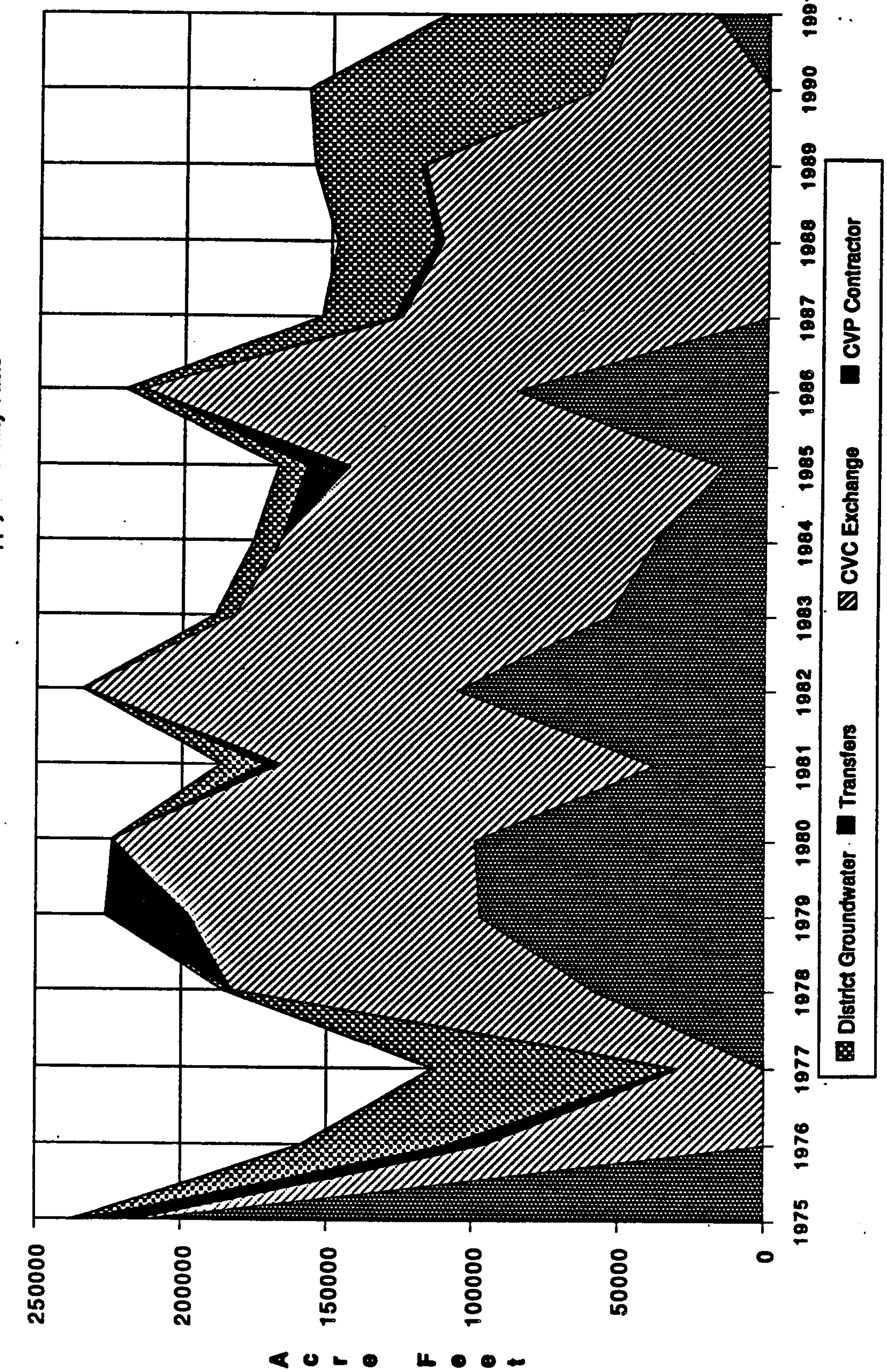
insight into each district's flexibility for supplementing project cuts with other water sources and, consequently, the actual "net" water shortages individual districts have faced. Figures 4.5 through 4.11 illustrate this information for each of the seven districts. It is clear that those districts with access to multiple sources of water (AEWSD, EID) or those with contracts that specify relatively small reductions in critical years (CCID, GCID) have fared best, whereas those districts highly dependent upon project water with little flexibility for augmenting supplies have fared worst (WWD, LHWD, WRM). In the remainder of this chapter, we will discuss the responses and adjustments that these districts have adopted in the face of "net" water shortages and identify the expected financial and economic impacts.

4.3 District Adjustment Mechanisms to Changes in Water Availability

There is a wide array of options available to water suppliers faced with water shortages. However, the desirability and feasibility of these options, both in the short and long-run, vary markedly among suppliers. Agricultural districts will tend to choose those options, or mechanisms, which provide the most reliable water supply for irrigation at the least cost to water users. This chapter describes these options, and associated constraints and impacts, for the case study districts, as follows:

Figure 4.5: District Water Supplies, Arvin-Edison WSD

Source: District Water Supply Availability Table



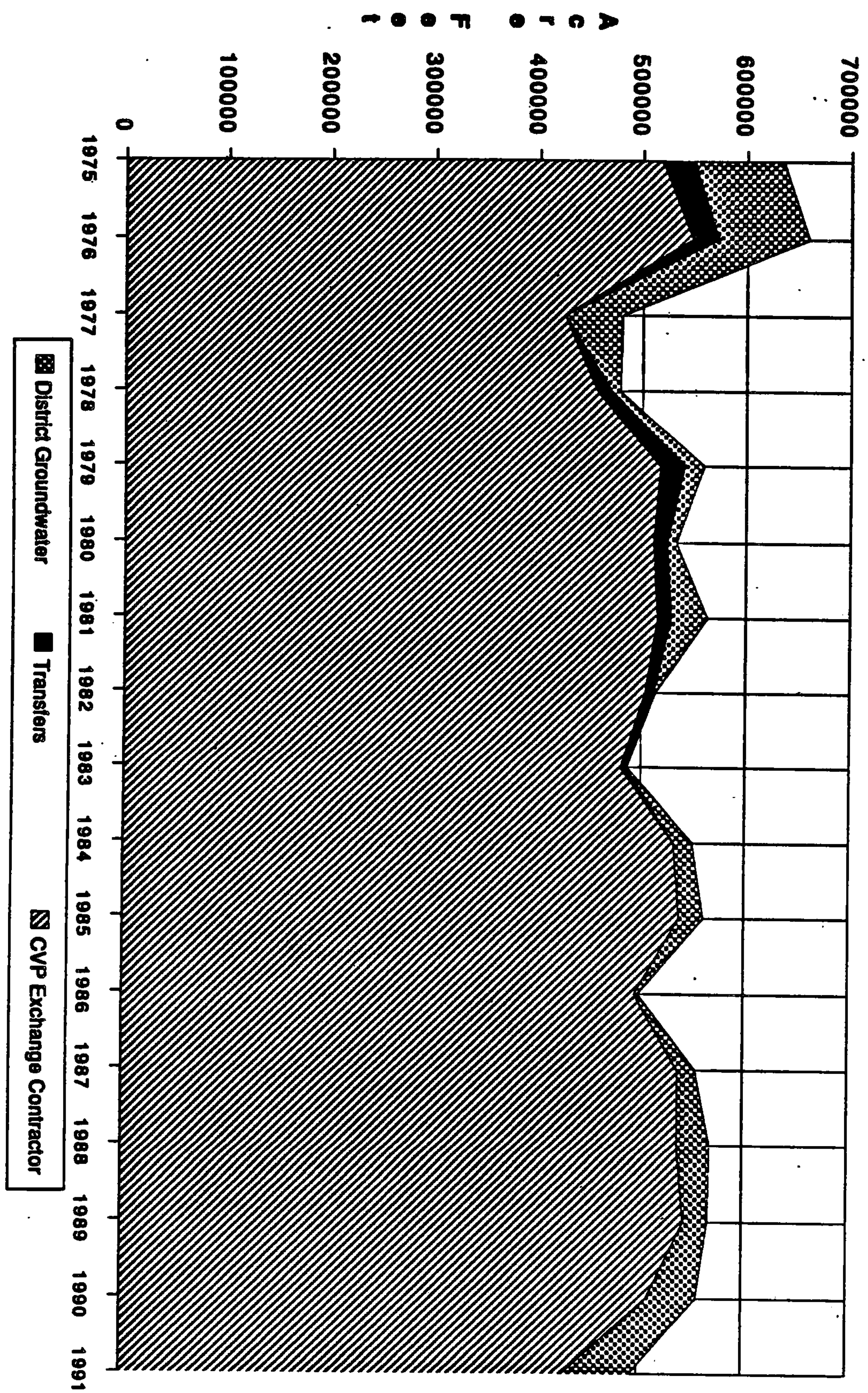


Figure 4.6: District Water Supplies, Central California ID

Source: District Water Supply Availability Table

Figure 4.7: District Water Supplies, El Dorado ID
Source: District Water Supply Availability Table

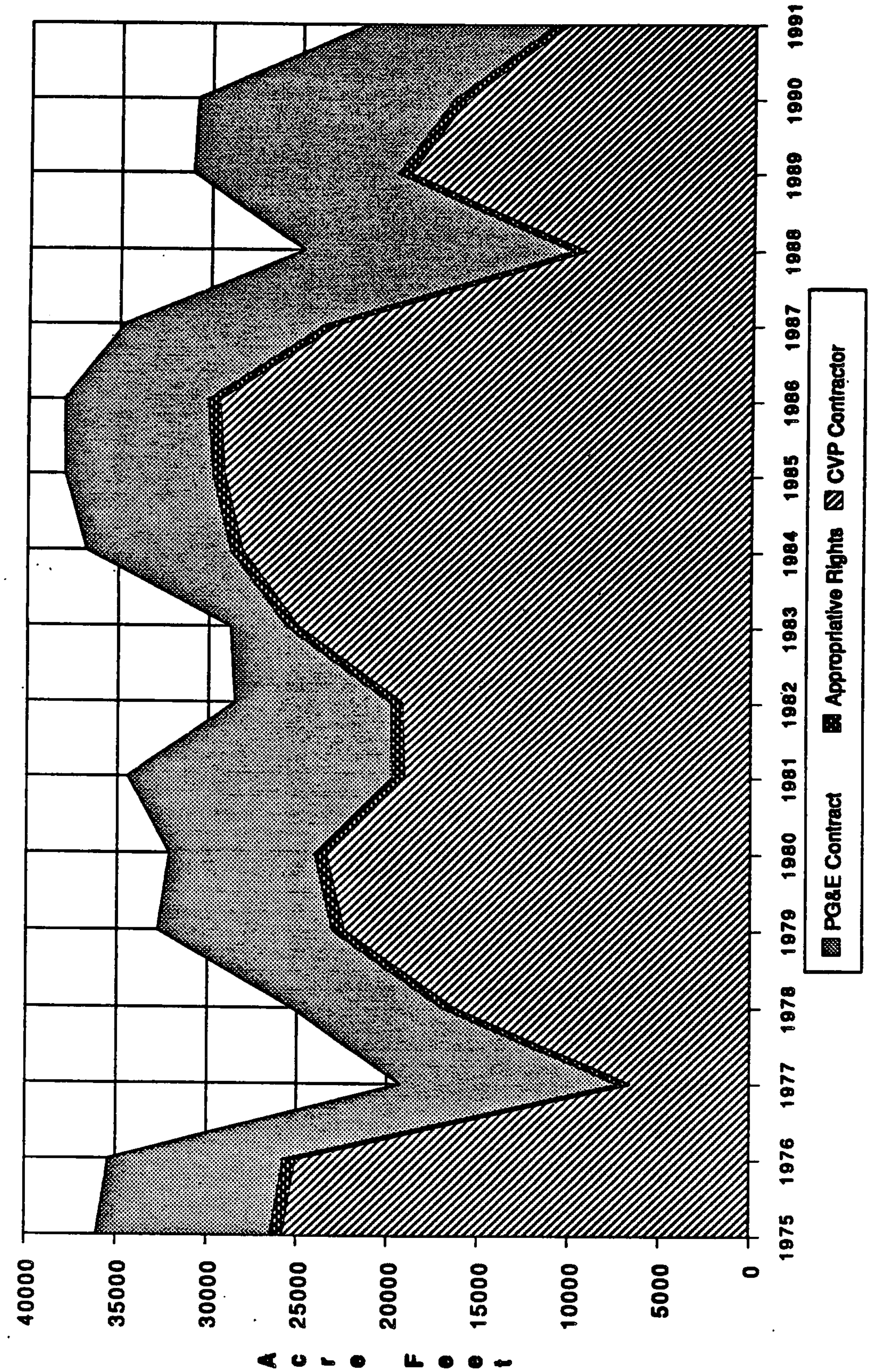
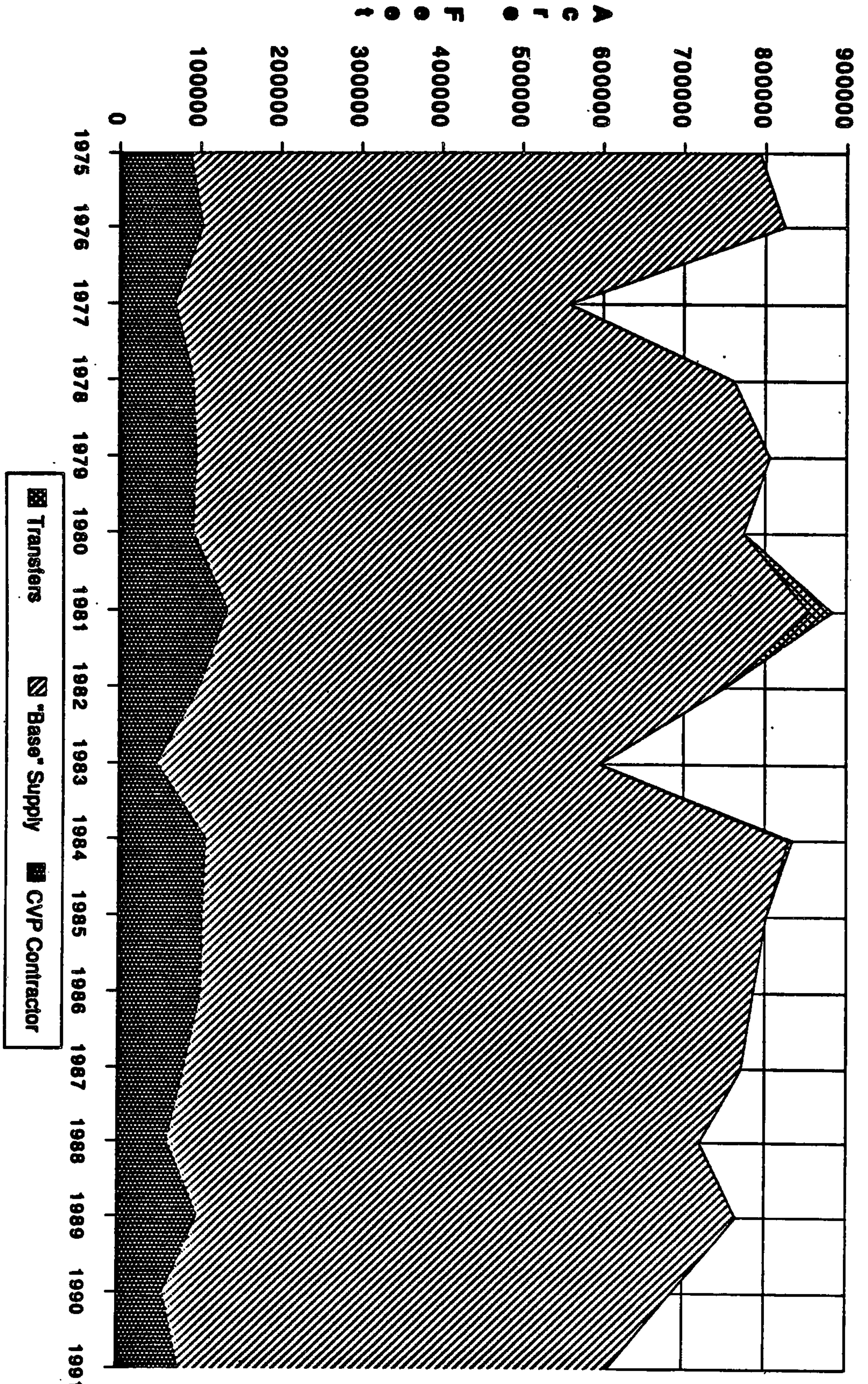


Figure 4.8: District Water Supplies, Glenn-Colusa ID

Source: District Water Supply Availability Table



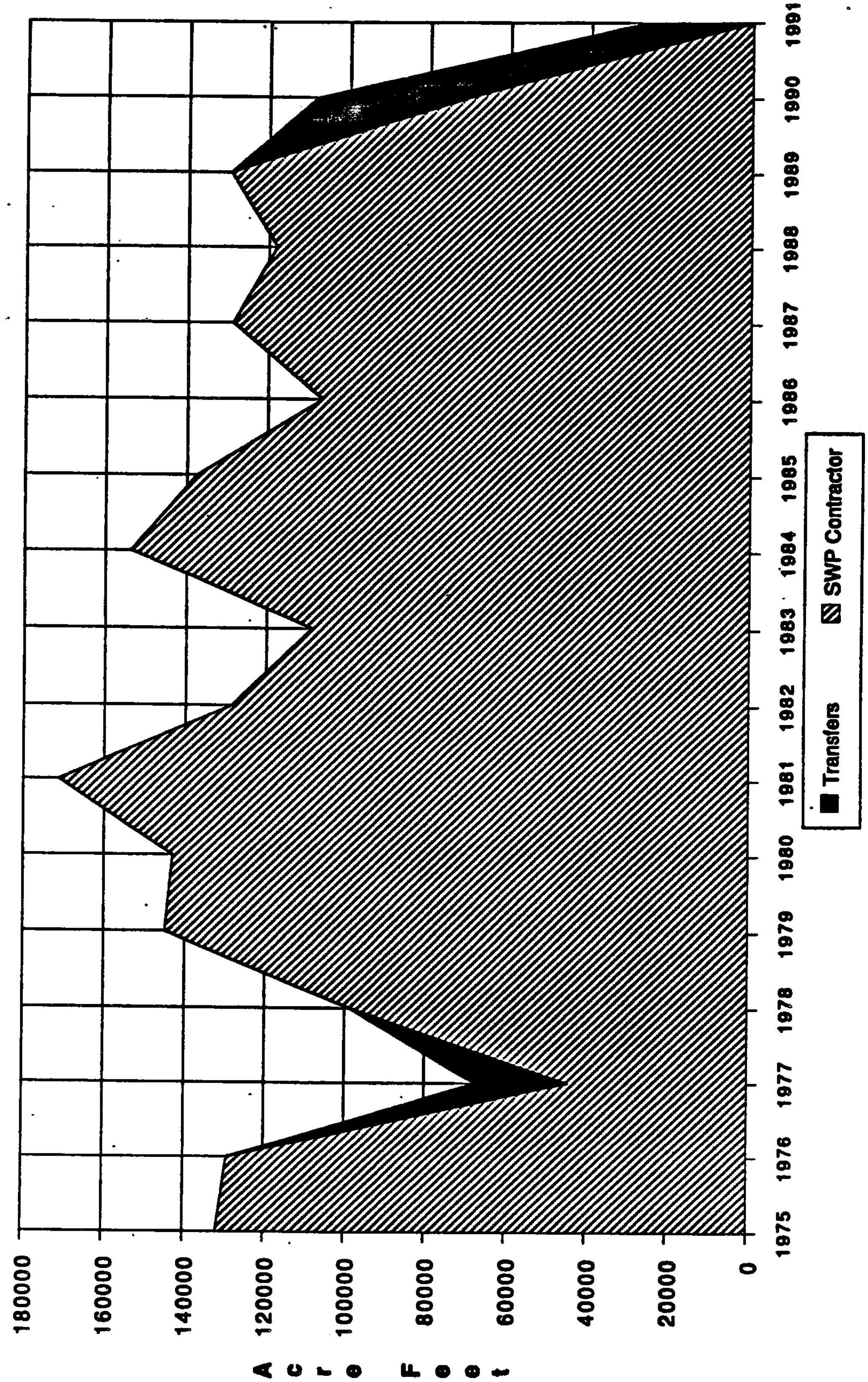


Figure 4.9: District Water Supplies, Lost Hills WD

Source: District Water Supply Availability Table

Figure 4.10: District Water Supplies, Westlands WD

Source: District Water Supply Availability Table

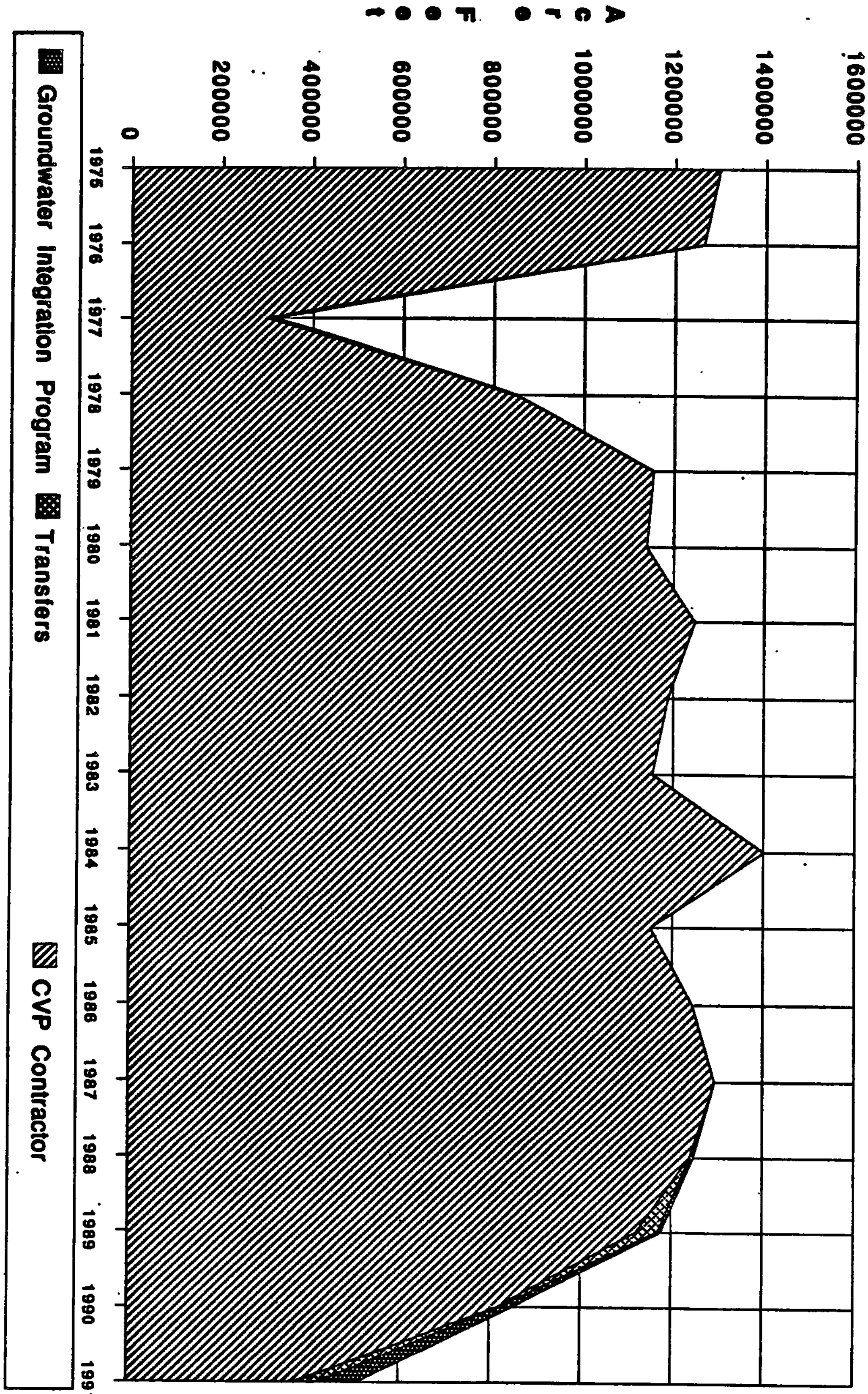
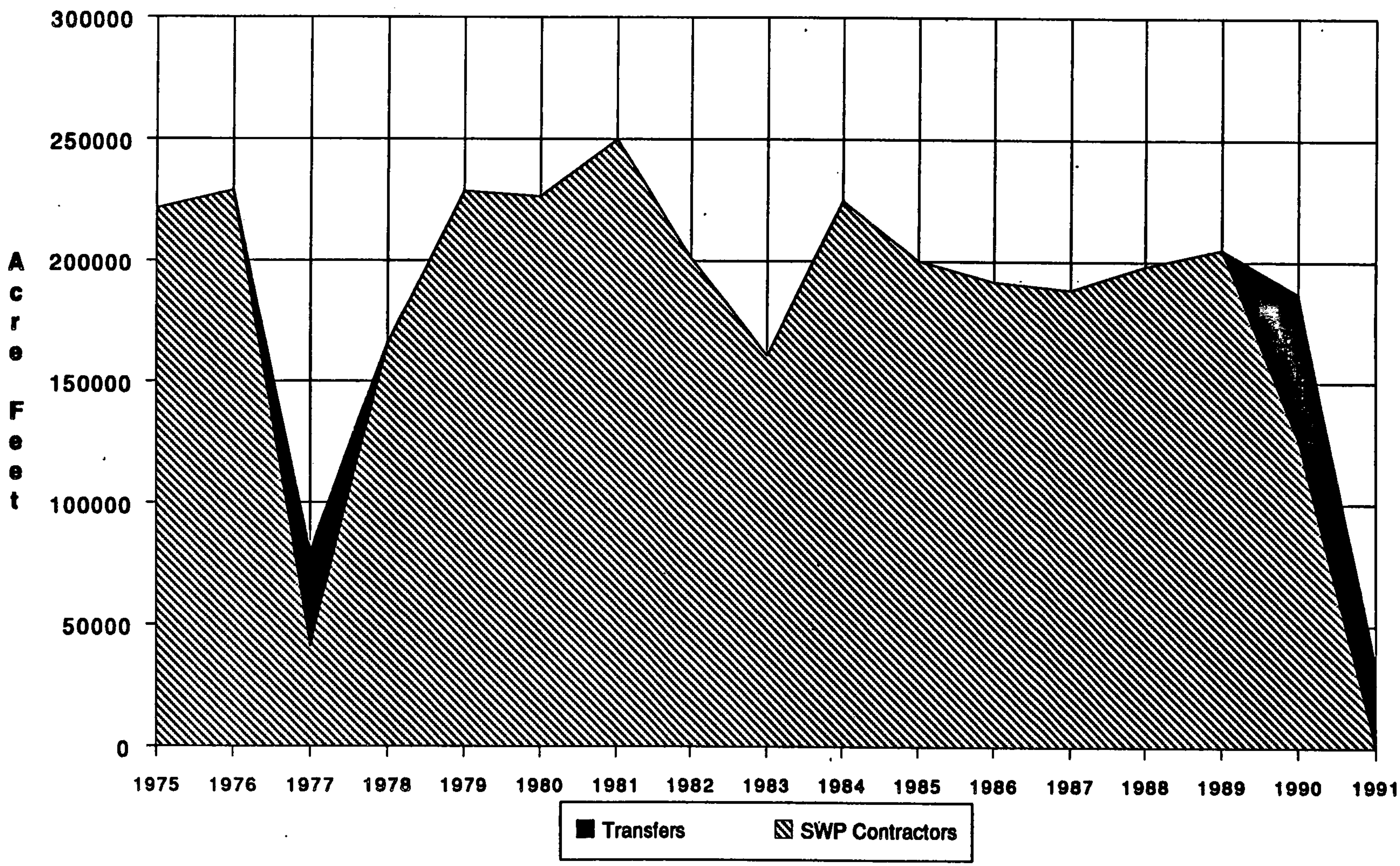


Figure 4.11: District Water Supplies, Wheeler Ridge-Maricopa WSD

Source: District Water Supply Availability Table



DISTRICT ADJUSTMENT OPTIONS

Maintaining Water Supply
- Groundwater Pumping and Integration
- External Water Transfers
- Exchanges and Banking
- New Projects and Contracts

Allocation of Available Supplies
- Water Allocations to Growers
- Timing of Deliveries
- Water Rates
- Intra-District Water Transfers

Efficiency Improvements in Water Delivery and Use
- Information and Technical Services
- Conservation Measures
- Delivery System Improvements

4.3.1 Mechanisms to Maintain and Enhance Water Supply and Improve Supply Reliability

4.3.1.1 Groundwater

Groundwater Pumping

Introduction—Groundwater pumping opportunities vary tremendously depending upon geological, hydrological and soil conditions in any given location in the Central Valley. Some water suppliers are located above inaccessible groundwater aquifers, or in areas where pumping is uneconomical because of low draw rates or high pumping lifts, and thus must rely solely on surface water sources. Where feasible, however, water suppliers facing adverse changes in surface water supply are likely to expand their existing groundwater pumping capacity or initiate new pumping activities. Some districts own and operate their own wells, while others lease wells or purchase well water from landowners. In water short years, districts are able to increase extractions by drilling new wells, refurbishing old wells and installing larger and/or more efficient pumps. Districts that do not pump groundwater themselves sometimes respond to shortfalls by facilitating intra-district groundwater transfers or by providing surface water "credits" to encourage groundwater integration and banking.

Increased groundwater pumping is an attractive source of supply for several reasons. First, the groundwater is locally available and thus can usually be used without constructing expensive new conveyance facilities. Second, because groundwater supplies are made up of both current recharge and accumulated groundwater reserves, supplies are available even when drought conditions have temporarily limited surface allocations.

Finally, the *practical* legal and institutional restraints on increased pumping are generally minimal. Increasing pumping, unlike augmenting surface supplies, does not require new permits or government contracts, thus avoiding the costly applications, studies, hearings and/or negotiations that often accompany the latter. Although California judicial law theoretically limits groundwater withdrawals to the "safe yield" of the aquifer and provides for the "adjudication" of individual groundwater rights, none of the groundwater aquifers in the study area has been adjudicated or is currently under judicial supervision. Water suppliers are thus effectively free at the moment to decide for themselves how much water they should pump at any given time, subject only to prevailing physical and capital constraints.

These physical constraints, however, can be very important. The high energy and maintenance costs associated with pumping from lower depths or at higher rates can significantly increase district costs. In addition, high pumping rates, over and above safe yields, can lead to deteriorating water quality. The type and degree of water contamination depend upon local hydrological and soil conditions and historical levels of overdraft, so that the level of pumping that will result in unacceptable water quality varies. Other resource quality impacts associated with heavy groundwater pumping are land subsidence and long-run aquifer depletion.

Conjunctive water use programs have the potential of avoiding these degradation problems by recharging the groundwater basin with surface water in wet years, and by limiting extraction rates to levels that maintain long-run groundwater stability. Conjunctive use programs, however, raise a variety of legal issues or constraints. Does the district, for example, have the power to limit private withdrawals from the aquifer in order to prevent "users" from effectively capturing the stored water? Although the California Supreme Court has held that a water supplier has the right to water that it stores (and typically to the recharge resulting from the overlying use of that water),[1] a water supplier may not be able to enforce that right absent regulatory power over the aquifer or a judicial adjudication of rights in the aquifer. Legal issues and constraints are also presented by (1) the various state laws regulating injection wells and groundwater quality; and (2) the specific authority that a supplier has to impose charges or assessments reflecting its conjunctive use program.

Observed Responses—In Arvin-Edison WSD, increased groundwater extraction is the principal response in water short years. In 1977, 1990 and 1991 the District increased its pumping operations significantly, reaching a high of 99,200 AF in 1990. Figure 4.12 displays the District's surface water supplies and groundwater extractions for 1975 through 1991, clearly indicating the increased reliance on groundwater.

Conjunctive use of surface and groundwater is an integral part of Arvin-Edison's Water Resources Management Program, illustrated in Figure 4.13. Two main spreading works and associated well fields are the principal facilities that enable the District to sustain this program. Managed percolation in normal and wet years provides the flexibility for pumping heavily in dry years without incurring serious overdraft. The storage accumulation shown in Figure 4.13 indicates that stored water in 1991, approximately 450,000 AF, slightly exceeded the 1975 level, after reaching a peak of nearly 700,000 AF in 1986. The District closely monitors well water depth and quality to assess the impact of pumping on long-term groundwater stability. In principle, extraction rates have an upper bound based on long-term recharge rates.

Arvin-Edison's conjunctive use program is feasible because it lies over a large natural aquifer with excellent storage potential and well production up to 2,400 gallons per minute. Its permeable soils are conducive for high water percolation rates. Conjunctive use has helped to mitigate past problems with water quality deterioration by stabilizing groundwater levels and through mixing higher quality surface water into the general supply pool for delivery to growers. District spreading and percolation activities also benefit private well owners, both contract and non-contract, by recharging the groundwater basin throughout the area.

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[1] City of Los Angeles v. City of San Fernando, 14 Cal. 3d 199, 258, 123 Cal. Rptr. 1, 537 P. 2d 1250 (1975).

Figure 4.12: Surface Water Supplies and Groundwater Extractions, Arvin Edison WSD

Source: District Water Supply Availability Table

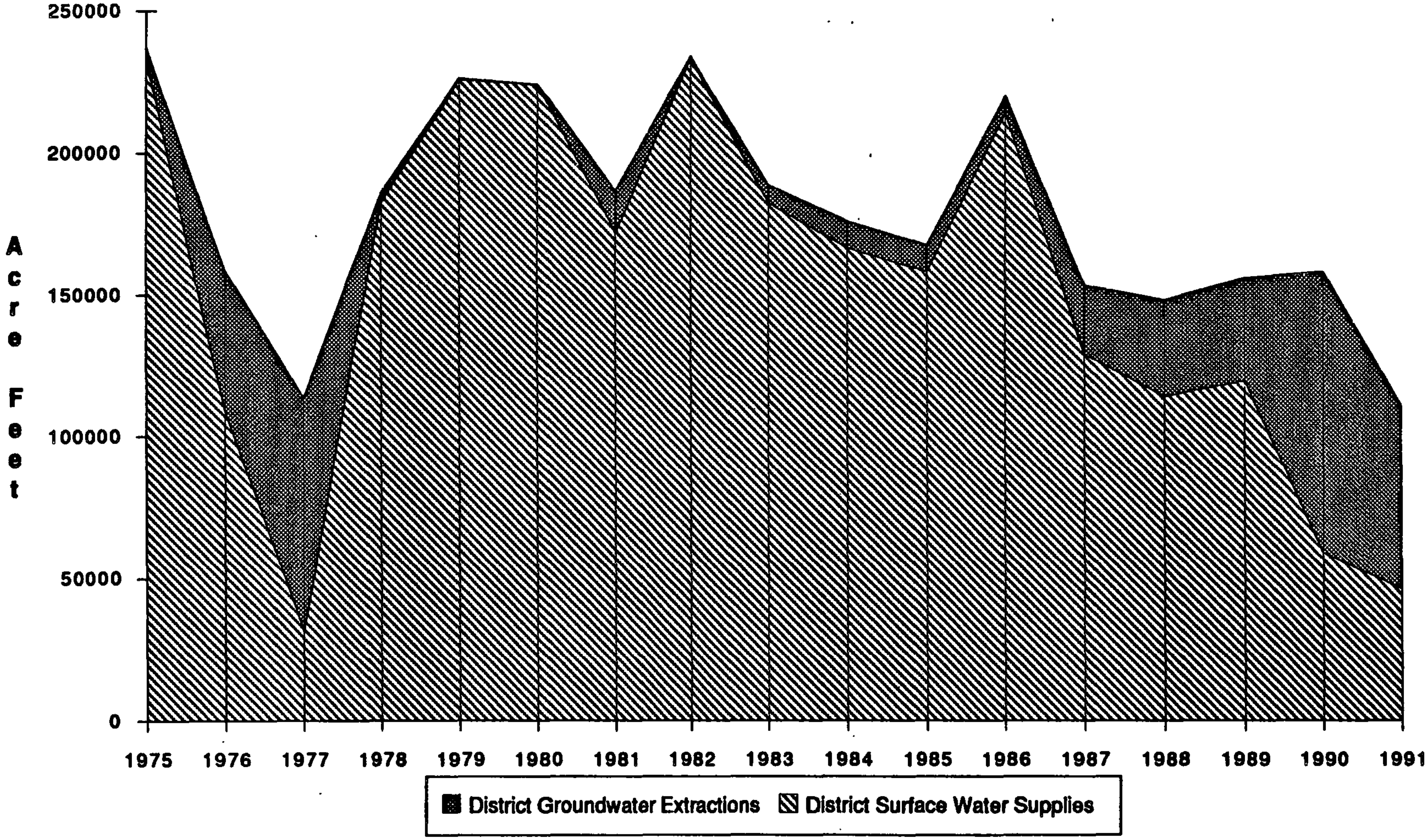
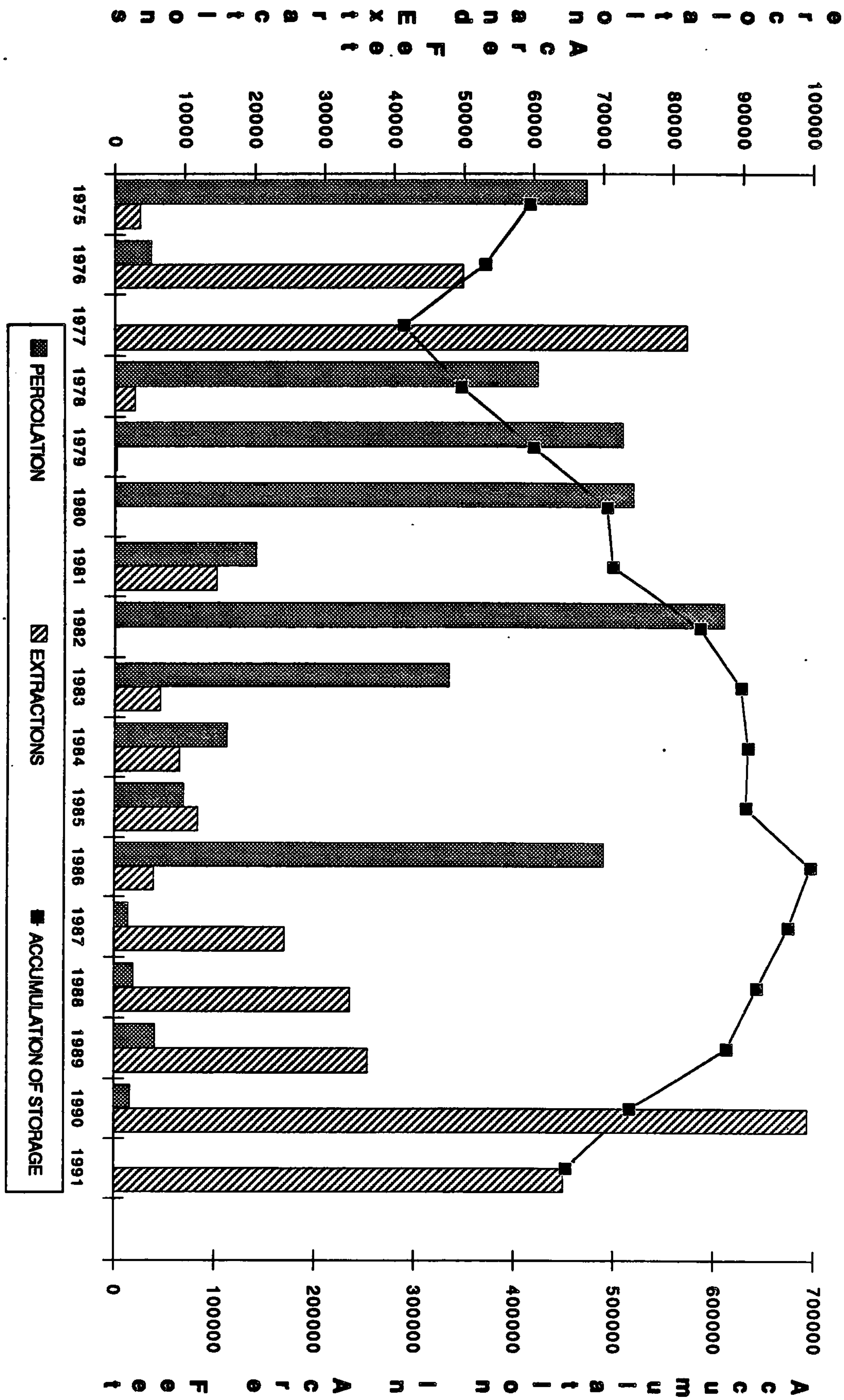


Figure 4.13: Groundwater Management Program, Arvin-Edison WSD

Source: "Operations Table," Arvin-Edison WSD



CCID also relies on groundwater pumping to supplement surface water supply during peak demand months, and in critically dry years. In normal years district groundwater extractions represent a small fraction of total water supply (about 5 percent) as shown in Figure 4.14. This proportion increased significantly in 1977, 1990 and especially in 1991, to approximately 13 percent, 9 percent and 14 percent, respectively. In 1991, CCID operated 40 deep wells with a total yield of 175 cfs. It also purchased private well water from landowners at $30.00/AF.

In 1990 and 1991, CCID lost the use of several of its deep wells from collapsed casings, poor water quality or uneconomical pumping lifts. During the same period, the District estimates that groundwater yield fell by 10 percent. As a result, CCID is concerned that current pumping rates are not sustainable in the long-run, and may not even be an option if the drought continues into 1992. Poor water quality also affects the eight towns within District boundaries that rely on groundwater for drinking water, including Los Banos. CCID claims the problem is aggravated by contaminated subsurface flows from Westlands WD into District and private wells, an issue which is currently under litigation.

El Dorado ID does not engage in groundwater pumping and there is minimal on-farm groundwater pumping by District growers. Underground water supplies are highly variable throughout the District service area, with even an "excellent" well producing only 60 gallons per minute. However, EID's ability to utilize multiple surface water sources partially mitigates its inability to turn to groundwater sources.

Glenn-Colusa ID does not currently engage in groundwater pumping for distribution, though some growers in the northern region of the District use well water on a limited basis. In 1989, GCID entered into an agreement with the DWR to determine the extent and variability of the groundwater resource underlying District land. Results from an experimental deep well drilled near the Main Canal indicate an excellent long-term yield potential of approximately 3,100 gallons per minute. The well proved most productive at 500 feet. Five monitoring wells were also drilled to gauge the effect of pumping from the main well on other well locations. Thus far, pumping at full capacity from the main well has had no effect on the other wells.

Until recently, there has been little incentive for GCID to explore or exploit its groundwater resource because surface water supplies have been abundant and inexpensive. If this situation were to change, the District plans to seriously consider the costs and benefits of installing groundwater pumping operations to supplement its surface supplies.

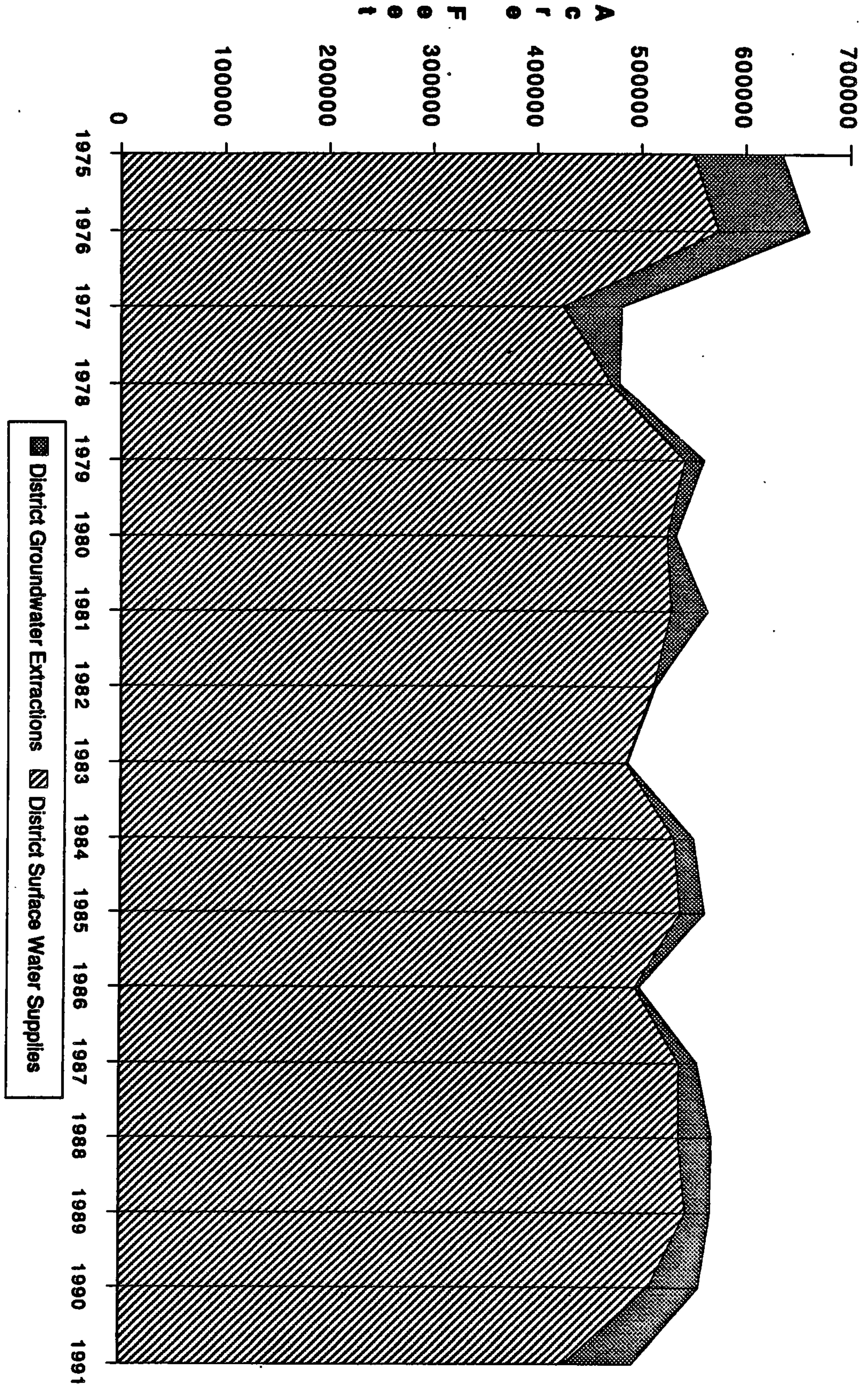


Figure 4.14: Surface Supplies and Groundwater Extractions, Central California ID
Source: District Water Supply Availability Table

Lost Hills WD, located on the far west side of the San Joaquin Valley, overlies a shallow aquifer with very low well yields and poor quality water. There is little potential for conjunctive water use. In 1977, some District growers responded to severe surface water shortages by drilling wells and pumping brackish groundwater to blend with surface water for irrigation. This practice was not repeated in 1991 because of the lack of surface water for mixing (100 percent SWP allocation cut). There is no District groundwater pumping.

Westlands WD's contract entitlement with the USBR is based on estimated groundwater safe yields (i.e. providing sufficient surface water to avert groundwater overdraft) of 100,000 AF to 135,000 AF per year. However, with the loss of surplus or "interim" water supplies after completion of the San Felipe Project in 1987 and the onset of drought-related allocation cuts, District growers have been forced to rely much more heavily on groundwater, as they did prior to the importation of CVP water.

Westlands WD does not own nor operate wells, but does encourage private groundwater pumping and facilitates intra-district and inter-temporal groundwater transfers among District growers. WWD's Groundwater Exchange Program is described in the next chapter.

Three major groundwater basins underlie Wheeler Ridge-Maricopa WSD: Wheeler Front (43 percent of District), Maricopa Flat (18 percent) and White Wolf Basin (32 percent). Similar to Westlands WD and Arvin-Edison WSD, WRM depended entirely on groundwater for irrigation prior to its 1970 KCWA contract for surface water from the State Water Project. Annual overdraft prior to 1970 was estimated to be 123,000 AF. This problem was essentially eliminated with the added supply of SWP surface water. Groundwater quality in all three basins has stabilized, although the quality gets progressively worse toward the west side of the District.

WRM does not own nor operate its own wells, though it does encourage intra-district groundwater transfers and exchanges. Approximately 40 percent of the District area depends solely on private well water for irrigation, plus any surface water transfers.

WRM's full SWP entitlement currently exceeds District irrigation needs by about 50,000 AF, such that in normal and wet years surplus water is available for groundwater storage by direct percolation or "in-lieu" deliveries. Between 1979 and 1983 the District used spreading ponds to augment groundwater recharge and has continued "in-lieu" deliveries when sufficient water was available to do so. Under Section 32006 of the California Water

Code, WRM can impose a charge for the use of groundwater that is furnished by the District. WRM is currently undertaking studies to determine: 1) the amount of groundwater that can be claimed as a result of District activities, and 2) the degree to which groundwater pumpers benefit from these activities. After the studies have been completed, the District's Board of Directors will consider the appropriateness of such a charge. WRM does not presently have the authority to regulate the pumping rates of growers with correlative rights as a means to avert groundwater overdraft.

Although WRM's full SWP entitlement exceeds current irrigation demands, the on-going drought has shown that this is not sufficiently dependable to meet minimal basic needs in critical years. The District is therefore attempting to develop groundwater extraction programs for critical dry years both within the District and in conjunction with the Kern County Water Agency and several of its other member units.

A large parcel of land in the District has been purchased by a developer who plans on constructing housing. Residential water demand created by developments of this type may compete with agricultural demand, an issue that will become increasingly important for District water planning as people continue to "spill out" of the Los Angeles basin towards the San Joaquin Valley.

Groundwater Integration and Transfer

Introduction—Water suppliers often encourage intra-district transfers among individual water users as a means to bring seasonal supply in line with seasonal demand. Growers with access to both surface water and groundwater may be in a position to transfer part of their District allocation to growers with deficit supply. Districts can facilitate these transfers by offering to convey water transfers at minimum charge and by "relaxing" rules and regulations governing such transfers.

Groundwater banking, pooling and integration programs have been implemented in recent years to increase total water availability to water suppliers faced with surface supply cuts and to facilitate inter-temporal and inter-spacial water deliveries. These programs generally provide financial incentives for growers with wells to bank groundwater in district facilities during peak demand months, to be claimed for use or transfer later in the year. Alternatively, some districts offer surface water "credits" to growers in exchange for providing their groundwater to the district for general distribution.

Observed Responses—As part of its 1991 "6 Month Allocation Program," and critical year policies, Arvin-Edison encouraged farm-level groundwater pumping, banking and transfer. Individuals could "pump in" or "bank" groundwater in the District canal for peak season delivery to themselves or their designates. District facilities were available to convey well water for use on any lands within the District boundaries. Wheeling charges were only imposed on transfers to non-contract lands. These actions (in addition to the "Firm Water Exchange Pool" discussed under surface water transfers) were designed to promote the conjunctive use of reduced surface water and groundwater to best meet individual water user needs.

CCID allows growers to pump into District canals for delivery to other fields owned by the well pumper or for transfer to land owned by others within the District. Wheeling charges are assessed and canal losses are deducted by CCID.

Westlands WD operates two groundwater programs to encourage the conjunctive use of surface water and groundwater, and inter-temporal and inter-spatial water transfers among District growers. The Groundwater Exchange Program, begun in 1987, allows growers to obtain credit for metered pumped groundwater that is substituted for surface water allocations. Participants may then sell their surface water allocation (up to the amount of the credit). Since 1988, these transfers can be made to any District grower at any price.

Westlands WD's Groundwater Integration Program (GIP), begun in 1990, allows qualified growers to pump groundwater into District pipelines (or the San Luis Canal, the Coalinga Canal or the Mendota Pool) and receive credits. These water credits can be sold to other growers or used to augment surface water allocations later in the irrigation season. The pumped groundwater is co-mingled with surface water for delivery to District growers, or flows south towards Los Angeles in exchange for USBR credits. During the 1990-91 water year, the GIP added 87,000 AF of water to the District system, or about 17 percent of total available supply (see Figure 4.9).

To qualify for the GIP, the contributed well water was initially required to meet potable drinking water standards, though these were subsequently relaxed to secondary potable standards in 1991. In addition, WWD must inspect and approve the pipeline hook-up and meter configuration, and USBR and DWR personnel must inspect and approve the transfer site, certifying that the project will not inflict harm on endangered species. These "transactions" can take several months, involving considerable expense and uncertainty for the grower.

Wheeler Ridge-Maricopa WSD, in response to the 100 percent cut in SWP deliveries in 1991, encouraged District growers to pump groundwater into the delivery system to augment district supplies and meet peak irrigation demand. As with Westlands WD, to qualify for the program groundwater had to meet potable water standards and pass inspection for possible harm to endangered species. In 1991, approximately 26,500 AF of groundwater were pumped from landowner wells into the District's distribution system and delivered as directed by the landowner, or in exchange for District provided surface water credits. This represents almost 40 percent of total water deliveries.

Impacts—The following impacts from groundwater pumping and integration, as a response to surface water shortages, have been identified for one or more of the case study districts. Both the magnitude of the impact and its increasing importance over time will vary widely among the districts, and for the Central Valley as a whole. As with other impacts to be identified in this chapter, a detailed analysis of the impact itself and associated policy issues will be an integral part of Phases III and IV of this study.

IMPACTS OF GROUNDWATER USE

Energy costs

- greater demand
  - —more use
  - —greater depth
- higher rates (with greater demand)

e.g. CCID pumping costs increased from $200 to $300 thousand in late 1980s to $900 thousand in 1991.

Costs of well development, refurbishing and maintenance

e.g. $150 to $400 thousand for new well, $35,000 for purchase or $2,000/month for lease of diesel pump.

Increase in district financial debt

Water quality deterioration

- well water
- mixed surface/well water
- water supply of local towns

e.g. increased concentrations of salt, boron, nitrates, selenium and other contaminants.

Land subsidence

Loss of aquifer capacity

Depletion of aquifer

Growth in well drilling and pump industries

Smoothing of supply fluctuations

4.3.1.2 External Water Transfers

Transfers and Exchanges

Introduction—Water suppliers facing significant water cuts that cannot be made up with intra-district groundwater pumping and transfers may attempt to purchase water outside of the district. Water suppliers or individuals with excess water may have an economic incentive to sell water to these excess demand areas. Government regulations regarding the sale and purchase of water have been relaxed somewhat in recent years, encouraging a trend toward increased "water marketing." State and local water agencies have also taken a number of steps to promote water transfers in the Central Valley. As explained in more detail below, the Kern County Water Agency actively fosters water transfers among its 16 member agencies. Contractors along both the Sacramento River and the Tehama-Colusa Canal, moreover, have set up water banks under which member suppliers contribute and withdraw water.

In response to the continuing drought in 1991, the Governor directed DWR to create a State Water Bank which served a number of the case study districts. Only agricultural water agencies facing water reductions of 50 percent or more were eligible. In 1991, the State Water Bank purchased water from interested water suppliers or individuals at $125/AF and transferred it to eligible parties throughout California at $175/AF, plus DWR wheeling charges ranging from $25-$40/AF and additional conveyance charges imposed by districts. Buyers also had to bear the cost of conveyance losses. The case study districts reported that it took from one to two weeks to receive the State Bank water after it was requested.

Despite these transfer activities, a number of legal and institutional obstacles still constrain water transfers between water suppliers or users. The transferability of a water right depends first on the type of right. A riparian right, for example, cannot be transferred separate from the riparian land to which it attaches unless the right has been "determined" and quantified in a statutory adjudication (and only a small fraction of riparian rights have been).[2] Transfers of appropriative rights that involve a change in the point of diversion, place of use and/or purpose of use from those specified in the appropriation permit require

[2] Cal. Water Code § 1740. Nevertheless, many of the DWR's State Water Bank transfers involved the sale of water by riparian users. They "left" the water in the river and the SWP "picked it up" as a means of reducing required releases from its storage reservoirs to maintain Delta water quality (R. Hoagland, DWR).

approval of the State Water Resources Control Board.[3] Approvals of "long-term" transfers of more than a year can require lengthy proceedings, often involving public hearings.[4] To help promote transfers, the legislature has provided for a more streamlined proceeding in the case of "temporary changes" of a year or less under which the Board will try to make a determination within 60 days.[5]

In the case of many proposed water transfers, the transferor will be a water supplier. Districts are authorized to transfer "surplus water," defined as water either which the district finds "will be in excess of the needs of [its] water users for the duration of the transfer" or of which "any water user agrees with the [district], upon mutually satisfactory terms, to forego use for the duration of the transfer."[6] Where the district holds an appropriative water right, however, it may again need Board approval as just discussed. Before approving a transfer, moreover, the Board must find that the transfer will not "unreasonably affect the overall economy of the area from which the water is being transferred."[7] State laws limiting the power of various types of districts, as well as district rules and regulations, can also constrain water transfers.

Transfers of CVP water raise additional issues. The Bureau has long permitted transfers of water among CVP contractors, and is in the process of liberalizing its rules for water transfers. As shown in a draft "Policy Option Paper" issued last year by the Bureau's Mid-Pacific Regional Office, however, transfers of CVP water will still be subject to greater constraints than most other sources of supply. Generally, for example, a CVP contractor will be able to transfer water only to another entity with a Bureau contract. Where the transfer will be for more than one year, moreover, both the transferor and transferee will need to amend their contracts to adjust relative water entitlements and payments. The transferee will need to pay a rate that at least meets the operation and maintenance costs associated with the transferred water, and if the water will be put to a different use than before, cannot take advantage of any repayment subsidies associated with the old use.

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3 Cal. Water Code § 1701.

4 Cal. Water Code § 1735-36.

5 Cal. Water Code § 1726-27

6 Cal. Water Code § 383(1)-(b). In 1991, the legislature responded to the continuing drought by granting districts new authority to transfer water, but the authority expires no later than January 1, 1993.

7 Cal. Water Code § 386.

Transfers of SWP water for use outside a district requires the approval of the Department of Water Resources, but the Department has been quite supportive of transfer proposals. As a matter of policy, the Department has opposed transfers only where a contractor proposes selling water that has not previously been put to beneficial use or the transfer might injure other contractors or jeopardize the financial integrity of the SWP.

Physical constraints can also limit water transfers. Any transfer, for example, must not exceed Delta pumping capacity nor violate prevailing flow standards. Transfers are also limited by the availability of conveyance facilities and facility capacity.

These legal and physical constraints help explain various of the characteristics common to transfers that have occurred in the study area. Almost all of the transfers, for example, have been "temporary," involving transfer periods of no more than a year. As a result of capacity and flow constraints, moreover, most north-to-south water transfers take place after peak irrigation demand from early September through mid-October. The transferred water is stored for distribution and use during the upcoming water year. Thus, water suppliers must negotiate and obtain approval for transfers during summer and fall, before the next year's water supply is known. This lack of flexibility in the system can impede efficient water planning.

Observed Responses—As noted, KCWA helps facilitate water transfers among its member agencies (which include both Lost Hills WD and Wheeler Ridge-Maricopa WSD). In 1986, the KCWA adopted a "Plan for Redistribution of State Water Project Contract Entitlement," which promotes transfers of water from member agencies with excess water to other suppliers within Kern County that are encountering water shortages. In line with this policy, districts on the eastern portion of Kern County with good groundwater supplies are encouraged to pump more heavily during dry years and release part or all of their surface entitlements, for a fee, to west side water users who face supply shortfalls. Under KCWA's redistribution plan, the "first priority in dealing with excess water is to assure that the State Project allocation to Kern County remains available to Kern County users." Although transfers outside Kern County will not be considered if any member agency has need for the available water, the KCWA did approve a short-term transfer of water to Westlands Water District during the current drought. As explained in the next chapter, the KCWA has also created an Emergency Groundwater Pool program in which the Agency stores underground water for emergency distribution to its member agencies.

Wheeler Ridge-Maricopa WSD has both sold and purchased water. In 1988, for example, WRM permanently transferred a portion of its SWP entitlement to Improvement District No. 4, which is also a member unit of the KCWA. During drought years, WRM has also occasionally purchased water to help meet its farmers' needs. Transfers accounted for nearly 50 percent of WRM's total supply in 1977, 32 percent in 1990 and 61 percent in 1991 (see Table 4.6). The KCWA Emergency Groundwater Pool furnished 34,000 AF of transfer water in 1991; the remaining 7,400 AF were privately arranged transfers.

In normal years, Lost Hills WD does not engage in external transfers. When faced with severe KCWA allocation cuts in 1977, 1990 and 1991, however, the District was forced to look outside the District for alternative sources of water supplies. As shown in Table 4.6, nearly 50 percent of total water supply came from external transfers in 1977, 35 percent in 1990 and 100 percent in 1991—22,600 AF from the KCWA Emergency Groundwater Pool, 6,000 AF from the State Water Bank and 10,200 AF in private transfers.

In an average year, Arvin-Edison WSD receives less than one percent (see Table 4.5) of its total supply from external transfers. This amount increased somewhat in the last two years to a high of 5,500 AF (five percent of total) in 1991. Arvin-Edison does not allow landowners to transfer surface or groundwater outside of District boundaries, but does allow privately arranged external transfers into the District. The District will wheel outside water to any contract or non-contract lands if it is metered before reaching the delivery canal.

During water short years, CCID did not purchase water from outside the District, and in average years external transfers represent less than two percent of total water supply (see Table 4.5). CCID does not look favorably on landowners selling water outside of the District, although the District itself sold 10,000 AF in 1990. It is thought that such transfers would have negative effects on farm production and the local economy, especially from the loss of permanent, skilled labor.

A transfer issue of particular importance to CCID is whether a particular transfer might trigger the Reclamation Reform Act of 1982. As noted, CCID is an "exchange contractor" and thus is not currently required to pay the federal government for its water and is not subject to acreage limitations pursuant to reclamation law. Because CCID's contracts do not explicitly permit transfers, there is concern that the Bureau might insist on an amendment before allowing a transfer and thus trigger the Reclamation Reform Act which would subject farmers in CCID to acreage limitations.

El Dorado ID has not had to purchase water outside the District in any year. Before the "residential boom" of the 1980s, EID marketed excess water regularly. However, recent urban demand has consumed all excess supply.

Glenn-Colusa ID participates in water transfers through the Sacramento River Water Contractors Association (SRWCA). This association handles water transfers among more than thirty CVP contractors along the Sacramento River. On April 15 of each year, participating contractors may put in a request for water, or commit water to the SRWCA Pool. Those who draw water pay a nominal fee to cover USBR charges. Pool contributors have traditionally been prohibited from making a profit on such transfers. Under new USBR regulations, however, the Bureau will generally no longer concern itself with the "financial terms" of proposed transfers and will avoid imposing any "economic disincentives."[8]

In 1989 and 1990, GCID committed 20,000 AF and 25,000 AF to the SRWCA Pool, respectively. The 1990 contribution was unexpected and made only after the projected 25 percent cut in CVP entitlement was cancelled after late spring rains restored inflow into the Shasta Reservoir to a non-critical level. Many of the District's growers had already made their planting decisions based on the expected reduced water supply, thus leading to an eventual water surplus.

Few GCID landowners expressed interest in selling water to the State Water Bank even at $125/AF, a far higher price than their retail water rate. Several constraints became apparent and, upon considering the option no producers ended up participating. Rice growers' obligations to provide an adequate supply to rice drying and milling operations (their own and others) diminish their flexibility to engage in short-term water transfers. Furthermore, rice growers in the area are very concerned about maintaining their domestic market share for long and medium grain varieties; supply fluctuations could impact negatively on market share.

GCID staff claim that unencumbered water marketing would make District-level water supply planning very difficult. In other words, individual water marketing could have

8 U.S. Department of the Interior, Bureau of Reclamation, "Voluntary Water Transactions: Criteria and Guidance," 1989.

negative consequences for the "collective good." The District, which as an irrigation district is governed by a Board elected by the resident voters—not just landowners, is also concerned about possible negative impacts of water transfers on the rice-dependent local economy.

In light of the drought and loss of "interim" water with completion of the San Felipe Project in 1987, Westlands WD is always "on the lookout" for additional water supplies. In fact, the District pays a $0.50/AF "finders fee" for water found and eventually delivered to the District. WWD has not been in a position to sell water outside of the District for over a decade.

As Table 4.5 shows, Westlands WD and individual growers substantially increased their reliance on external transfers to meet irrigation demand in 1991. An estimated 61,000 AF were purchased, equal to 12 percent of total supply, as compared with 16,100 AF or less than 2 percent of supply in average years. The number of external transfers increased from 26 in 1989 to 40 in 1990, and down to an estimated 21 by October 1, 1991. Transfers have originated from the KCWA, Oroville –Wyandotte ID in Butte County, Placer County Water Agency and Yuba County Water Agency, among others. Individual growers have negotiated transfers from Yolo County as well. Water transferred during the fall is stored in the San Luis Reservoir for use during next year's irrigation season.

Westlands WD participated in the State Water Bank program in 1991 on behalf of interested District growers. From April through July, Westlands growers ordered 9,600 AF of State Bank water at between $210 and $225 per AF including DWR conveyance charges. In general, this high price water was used as incremental supply to meet critical late season irrigation requirements. The average price of water remains fairly low. As of July, WWD began to order slightly more Bank water than requested to guarantee a secure, timely supply.

The "total" figures in Table 4.5 indicate that, aggregately, the contribution of external transfers to total water availability for the CVP districts is small—about one percent on average, increasing to just under four percent in 1991. However, the comparable figures in Table 4.6 show the critical importance of external transfers to the two SWP districts in each of the dry years, especially in 1991 when transfers represented almost 75 percent of total supply, including private transfers.

Impacts—The impacts of external water transfers are outlined at the end of the next section.

Groundwater Banking and Exchanges

Water suppliers can also benefit from groundwater banking and exchanges where water in wet years is "banked" in underground aquifers for use in future dry periods. The DWR, for example, is establishing the Kern Water Bank that will purchase, store and sell water to Kern County water suppliers. DWR recently purchased 20,000 acres of land from Tenneco for the operation of spreading ponds and well fields.

The Kern County Water Agency (KCWA) also operates an underground storage facility near Bakersfield for emergency distribution to its SWP subcontractors. In 1991, KCWA provided water to four districts through its Emergency Groundwater Pool program: Lost Hills WD, Wheeler Ridge WSD, Berrenda Mesa WD, and Belridge WSD. KCWA invested $14 million for the installation of new wells and an improved conveyance system to deliver water from the Emergency Groundwater program and better serve its "retailers" in the outlying Kern County districts. In normal supply years, KCWA encourages its member suppliers to secure their water supply in short years by regularly "banking" with the Agency. Withdrawals are expected to cost about $26/AF plus conveyance fees.

In addition to external water transfers and water banking, some districts have negotiated water "exchanges" with other agencies as a means to solve long-term inter-temporal supply problems. These exchanges usually involve storing surplus water during wet periods in one area or basin, for recovery, transport and use in another area during dry periods.

Incentives to engage in water exchanges include: 1) inadequate local surface and/or underground storage; 2) surplus water supply in wet years and deficit or unreliable supply in dry years; and 3) need for increased groundwater recharge rates and accumulation to improve conjunctive water use management. Water exchanges can involve substantial outlays of capital from one agency to another to finance the costs of building and maintaining the necessary "exchange" facilities. This is especially common in exchanges between urban and agricultural water supply districts.

Observed Responses—Arvin-Edison WSD could secure a significant additional source of irrigation and recharge water if its proposed exchange agreement with the Metropolitan Water District (MWD) is successfully negotiated. The Arvin-Edison WSD – MWD Water Storage and Exchange Agreement would benefit both parties by providing additional storage water for AE in wet years and additional distribution water for MWD in dry years. In essence, available MWD State Water Project entitlement water would be delivered to AE through the Cross Valley Canal (CVC) for use in irrigation and spreading operations. In exchange, MWD would receive Arvin-Edison's firm CVC water allocations in dry years. AE would make up the deficit with additional District groundwater pumping from its recharged aquifer. MWD has agreed to finance the necessary physical facilities for the exchange: additional spreading ponds, new wells and booster pumps.

This exchange agreement is currently in the environmental review process. Since Arvin-Edison has already paid off its long-term debt to the USBR, it is free to negotiate the exchange, using District conveyance facilities, without USBR approval. The Exchange Agreement has a provision that guarantees that Arvin-Edison WSD would be left with a minimum of 25,000 AF additional water in its aquifer at the completion of the Agreement.

Lost Hills WD is currently seeking to negotiate a long-term water exchange or banking agreement which will enable it to bank water outside the District during normal and wet years for delivery within the District during dry years.. The details of these negotiations are not known. As noted above, both Lost Hills WD and Wheeler Ridge-Maricopa WSD obtained water from the KCWA Emergency Groundwater Pool Program in 1991, equal to 58 and 50 percent of their total water supply, respectively.

Impacts—The impacts identified below include some that have been observed in the short-run and others that are potential in the long-run.

IMPACTS OF WATER TRANSFERS

High marginal water costs

e.g. State Water Bank: $175/AF + wheeling + losses;
KCWA Groundwater Emergency Pool Program:
$155–$200/AF + wheeling;
other external transfers: $100–$200/AF.

High transactions costs

- finding appropriate sellers and buyers, "finders fees", negotiating contracts
- institutional approval requirements, lag time, delays (SWRCB, USBR, DWR, KCWA)
- conveyance losses and costs

Potential groundwater overdraft

- substitution of groundwater for "transferred" surface water

Potential local economy impacts

Transferor Areas

- loss of permanent, skilled agricultural labor
- decline in agriculture related industries
- reduced local tax revenue base

Transferee Areas

- increased employment and revenue
- greater production stability

4.3.1.3 New Water Supply Projects and Contracts

Introduction—Some water suppliers are exploring options for investing in new water projects to augment total supply. Districts with appropriative water rights may petition for additional diversion or storage rights, and plan distribution systems to deliver the new supply. CVP or SWP contractors may try to renegotiate contracts for larger entitlements and/or more reliable supply, although this option is increasingly limited by total water availability and pumping and conveyance constraints. Districts with sufficient funds can invest in physical system improvements to partially "relax" these constraints.

The option to build major new water supply projects, either on a district or state level, is much more costly and constrained today than in previous decades. The environmental review process for these kinds of projects has become very laborious and expensive, and acts as a deterrent for initiating such projects. Furthermore, agriculture expects to face greater competition from urban water demand in the future, and is therefore likely to encounter major challenges to petitions for additional water rights and/or state contract water.

Observed Responses—El Dorado ID is unique among the case studies in that the majority of its water is delivered to municipal users, primarily to suburban and semi-rural residences. District figures show that in the last five years approximately 5,100 AF per year, 20 percent of annual average diversions, have been used for agriculture. The trend in El Dorado County is toward greater urban development, and fewer and smaller farms.

In March of 1990, El Dorado ID declared a water emergency that halted any new meter hook-ups until additional water supplies could be secured. This emergency was declared because the District found that growing urban-driven water demand was outpacing supply and planned steps to avoid a crisis situation were necessary.

New water supply projects and contracts being pursued by the District include:

1) Water rights acquisition for the South Fork of the American River (SOFAR) Project to permit the construction of a storage facility for up to 200,000 AF of water on Alder Creek. The Small Alder Project would build a 31,000 AF capacity reservoir on Alder Creek. However, this Project faces strong opposition from environmental groups and downstream water users.

2) The White Rock Penstock Project would bring water from the Sacramento Municipal Utility District's (SMUD) diversion point at White Rock on the American River through about four miles of pipeline for storage, treatment and distribution at the Bray Reservoir site. The Project would supply an estimated 17,000 AF safe yield and cost approximately $20 million.

Final approval for the White Rock Project is contingent upon obtaining consumptive use rights to divert water at White Rock during non-peak months for storage and distribution throughout the year. Currently both consumptive and non-consumptive use rights at White Rock are held by the City of Placerville and the Sacramento Municipal Utility District (SMUD), respectively.

The El Dorado County Water Agency (CWA) is handling all water rights negotiations for EID as part of its "lead" responsibility for guaranteeing adequate water supplies for the entire County. The CWA has several advantages with respect to its water rights petitions: watershed of origin, county of origin and early priority appropriative rights. It is aggressively pursuing timely approval of its petitions having hired environmental, legal and engineering experts to expedite the process. In addition, the CWA has formally protested water rights petitions by SMUD and the City of Placerville that pose potential threats to County water supplies.

3) In connection with the White Rock Project, EID and CWA are pursuing rights to appropriate water stored in PG&E reservoirs in the upper basin of the South Fork of the American River. If approved, the water would be conveyed to the District from the PG&E diversion at El Dorado Intake near Kyburz through EID's Hazel Creek Tunnel to Sly Park Reservoir, or from White Rock Penstock through four miles of pipeline to Bray Reservoir. In the short-run, EID is seeking to purchase additional water from the PG&E Forebay, paying compensation for lost power generation.

4) The Texas Hill Project would store water diverted from Weber Creek, a tributary of the South Fork of the American River, at Texas Hill Reservoir. The Project would be financed entirely by private developers in exchange for rights to generate power and earn power revenues. Progress with Texas Hill is stalled until water rights to divert from Weber Creek are secured, and certain environmental concerns are satisfied.

5) The Board of Directors of EID has expressed interest in buying the USBR owned and operated Sly Park facility, which is also an important recreation area (Jenkinson Reservoir). This purchase could potentially increase water

supplies for the District if, as owner, it allowed more reservoir pumping in dry years than currently allowed under USBR regulations. The purchase of Sly Park is still in an early stage of negotiation.

6) The El Dorado County Water Agency is currently seeking a legislative amendment (H.R. 5019) to the USBR contract with EID to provide an additional 15,000 AF of water from Folsom Reservoir. This amendment is being sought on the grounds that the USBR has an obligation to provide adequate water to the EID service area based on "county of origin" statues, federal authorizations and the terms and conditions stipulated by the SWRCB for maintaining USBR water rights permits.

In sum, EID plans to meet short-run projected water deficits with public education, conservation, physical system improvements and anticipated additional supplies from the PG&E Forebay and Folsom Reservoir. In the long-run, EID, together with the CWA, are hopeful that water rights will be secured to build one or more new diversion and storage projects on the South Fork of the American River. The new projects will likely face formidable institutional and environmental obstacles before final government approval is obtained.

Lost Hills WD filed a petition for appropriative water rights to the Kern River in 1988. The petition has not been approved because of on-going disputes and litigation among Kern River riparian and appropriative rights holders. The final SWRCB decision remains uncertain.

Westlands WD is not involved in any new water supply projects other than plans to construct an intertie facility to pump water from the Delta Mendota Canal to the California Aqueduct for conveyance to the San Luis Reservoir. The proposed intertie would facilitate pumping of up to 125,000 AF of interim CVP water for use in Priority Area II, which meets only about one-half its irrigation requirements with firm supplies. The facility would alleviate inter-temporal capacity and conveyance constraints in the Delta-Mendota Canal, allowing greater flows of interim and transferred water during peak irrigation months. The project is in the environmental review process and is "on hold" until various environmental concerns are resolved.

The other case study districts are not involved in any major projects to secure additional water supplies.

Impacts—It is generally expected that the costs of engineering and constructing new water projects will be much higher today than in the past, and such projects, whether public or private, will not likely be eligible for financial subsidies. Consequently, benefitted water users will have to pay considerably higher water rates than under current schedules. The environmental impacts of water projects in the planning stage remain uncertain and depend upon the rigor of the environmental review process, on the one hand, and the negotiated "mitigations" on the other.

IMPACTS OF DEVELOPING NEW SUPPLIES

Increase in district expenses and long-term debt

- legal and engineering expenses
- environmental "mitigation" expenses
- long-term financial debt
- deferral of other district investments

Higher water costs

- O&M charges
- fixed per acre assessments
- special project fees

Uncertain environmental impacts

e.g. fish and wildlife habitat, river recreation, instream water quality, etc.

Potential reduction in water supply for competing uses

4.3.2 Mechanisms to Allocate Available Water Supplies

4.3.2.1 Water Allocations to Growers

Introduction—Water suppliers faced with shortages can also try to mitigate the impacts of reduced supplies by reallocating water among current users. The level of discretion that a supplier enjoys to reallocate water depends on its legislative authority and local rules and regulations. Under state law, irrigation and water districts *as an initial matter* must allocate water among users in proportion to the users' property assessments.[9] If the district charges for the water, however, water in an irrigation district "shall be distributed equitably as determined by the board among those offering to make the required payment";[10] water districts similarly must apportion water "ratably to each holder of title to land making application therefore under such rules and regulations as the board from time to time establish [sic]."[11]

Water storage districts also enjoy considerable discretion in allocating water. Districts must "establish equitable by-laws, rules and regulations for the distribution and use of water within the district."[12] If there is inadequate water in any year to meet the need of all inhabitants of the district,

> the deficiency shall be borne ratably by all the land, except insofar as priorities in the right to water as between different lands may prevent. The board may make rules and regulations to provide for distributing the burden of the deficiency and for the most economical and efficient use of the water which is or probably will be available.[13]

As a general matter, district boards would appear to have considerable authority to allocate water to meet shortages in the most equitable and efficient way, subject to physical constraints. These constraints include the scheduling of water received from outside

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9 Cal. Water Code § 2250.

10 Cal. Water Code § 2252.

11 Cal. Water Code § 35421.

12 Cal. Water Code § 43003

13 Cal. Water Code § 43004.

suppliers (i.e., maximum monthly entitlements and flow rates) and intra-district delivery system conveyance and capacity limitations.

Observed Responses—Water allocations to growers reflect the degree to which each district was subject to CVP/SWP entitlement cuts, and more importantly, the reduction in total water availability in 1991. All of the districts except El Dorado ID were forced to reduce water allocations to some degree, ranging from just 15 percent for CCID growers to up to 87 percent for some Wheeler Ridge-Maricopa WSD growers. Table 4.7 presents information on case study district water allocations to growers in a "normal" year as compared with 1991. The last column shows the extent of the 1991 reductions in percentage terms.

Arvin-Edison WSD has individual water contracts with all of its growers in the surface water service area, ranging from 2.5 to 3.75 AF per acre at full allotment. In 1991, the District adopted a "6 Month Water Allocation Program" for the peak demand months (March - August) in response to drought conditions. Per acre surface water allocations to contractors were reduced to 1.5 AF per acre "across the board" for distribution before August 31.[14] This reduction represents a range in cuts from 40 to 60 percent depending upon the individual contract. Water users with contracts exceeding 3.0 AF per acre will receive surface water credits for next year to compensate for their disproportionate losses this year. Arvin-Edison WSD continued to deliver groundwater and any "returned" surface water to growers after August 31.

CCID rules stipulate that water users are entitled to a proportionate share of the available water, equal to approximately 3.25 AF per acre in normal supply years. CCID water users do not have individual contracts with the District. In 1991, per acre allocations were reduced "across the board" by 15 percent to 2.75 AF per acre (2.25 AF of surface supplies, 0.50 AF of District groundwater). Requests for additional water are filled on an "if and when available" basis at a higher water rate. The District has been able to meet these requests satisfactorily in 1990 and 1991.

El Dorado ID does not normally "allocate" water to its agricultural water users, but provides water through its metered delivery system "on demand." There was sufficient water in 1991 to continue this system without change.

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14 The Arvin-Edison WSD general manager explained that the District is managed as a cooperative; gains and losses are averaged among landowners in a "risk-sharing" framework.

Table 4.7: District Water Allocation Per-Acre

District	Normal Year	1991	Percent of Normal
Arvin-Edison WSD	2.5 to 3.75 (a)	1.50 (b)	40 to 60
Central Calif. ID	3.25	2.75 (c)	85
El Dorado ID	On Demand (d)	On Demand	na
Glenn-Colusa ID	On Demand	3.85	na
Lost Hills WD	2.87 (e)	0.60	21
Westlands WD	2.6 (f)	0.60	23
	1.3	0.30	23
Wheeler Ridge WSD	1.71 to 3.53 (a)	0.45	13 to 26
	Values in Acre-Feet Per Year		

Footnotes: (a) Arvin-Edison WSD and Wheeler Ridge-Maricopa WSD allocate water on the basis of water service contracts that specify the amount of water that will be delivered to a particular tract of land. (b) Producers with contracts exceeding 3.0 acre-feet/acre will receive credit for deficient deliveries in 1991. (c) This allocation is composed of 2.25 acre-feet/acre from surface water supplies and 0.75 acre-feet/acre from District provided groundwater supplies. (d) The District's "Irrigation Management Service" program encourages producers to apply only the amount of water that is necessary for the crop. (e) This is the average per-acre allocation based on full SWP deliveries of 140,000 acre-feet/year. (f) Westlands WD is divided into three "Priority Areas." Priority Area I (2.60) and Priority Area II (1.30) are listed here. Priority Area III is not entitled to "firm" contract water.

Sources: District documents and personal communications.

Similarly, Glenn-Colusa ID normally does not allocate water to its growers, but makes it available "on demand." In 1990 and 1991, the District imposed a limit of 3.85 AF per "deeded" acre, based on projected total water availability and an estimated delivery efficiency rate of 70 percent. Since most District acreage is planted to rice, which requires more than the maximum allocation of 3.85 AF, the limit essentially forces rice growers to fallow a portion of their land. Growers with adequate soils may also plant more acreage in less water intensive crops, given profitable market conditions, as occurred with increased acreage in processing tomatoes both in 1977 and after 1988.

In Lost Hills WD, water is normally allocated on a pro-rata basis, averaging 2.87 AF per acre. In 1991, the KCWA Emergency Groundwater Pool water, LHWD's only supply, was allocated on a fixed basis at 0.60 AF per acre. This represents a reduction of nearly 80 percent over the average allocation. To ensure better information on annual water demand, Lost Hills WD is considering adopting the use of water service contracts similar to Arvin-Edison WSD and Wheeler Ridge-Maricopa WSD.. Fixed water contracts with growers would assist long-term water planning, increase the District's financial security and help producers to determine their annual water needs more precisely.

In a normal water year, Westlands WD allocates 2.6 AF per acre to its Priority Area I growers and 1.3 AF per acre to its Priority Area II growers. The 1986 "Barcellos Judgment"[15] stipulates the terms under which water must be allocated between the two Priority Areas. Growers in Priority Area III (land annexed to the District after 1965) rely exclusively on "interim" CVP water (unavailable for purchase since 1989) and on private well water and transfers. The District responded to the severe cut in CVP deliveries in 1991 (75%) by reducing per acre allocations to 0.6 AF for Priority Area I and 0.3 AF for Priority Area II. This represents a pro-rata reduction of 77 percent over normal year allocations for both areas.

Westlands growers in both priority areas have been able to obtain additional water through on-farm groundwater pumping, intra-district groundwater transfers, purchases from the State Water Bank and other external sources and access to USBR "hardship" water for permanent plantings. The USBR hardship water has been particularly beneficial to growers of permanent crops in Priority Area II, who were offered up to 1.2 AF per acre to

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15 The 1986 Barcellos Judgment ended an eight-year legal dispute between WWD, its landowners and water users and the U.S. Department of Interior.

maintain their trees and vines, bringing their 1991 total allocation to a higher level (1.5 AF/acre) than their normal allocation (1.3 AF/acre).

WRM has separate water service contracts with all growers in the surface water service area, covering 80,188 acres of cropland. Contracts range from 1.71 AF to 3.53 AF per acre, and average about 2.80 AF per acre. District water service contracts and rules and regulations state that in years when less than 2 AF per acre of water is available to the surface water service area, water shall be apportioned on a pro-rata basis to each acre of land with a firm water contract. In 1991, the sharp reduction in District water supplies translated into a per acre allocation of just 0.45 AF per acre, representing a cut over normal levels of between 74 percent and 87 percent, depending on the individual contract.

Impacts—Districts may face "equity" objections from growers who receive disproportionately high reductions in entitlements or from those who are already highly efficient and receive the same reduction as those less efficient. Districts may try to stave off these types of objections by offering future compensation (water credits), as in the case of Arvin-Edison WSD. Another likely impact of reduced surface water allocations is to induce greater groundwater extractions, both at the district and farm-levels.

IMPACTS OF SURFACE WATER ALLOCATION RULES

Potential intra-district allocation equity issues/disputes

e.g. from variable contract allocations to fixed per acre allocations—"equal pain" (AE, WRM)

Induce conjunctive water use by districts and growers

- increased district groundwater pumping
- increased on-farm groundwater pumping
- increased intra-district groundwater transfers

Induce land fallowing, plant stress, crop shifts

e.g. fallowing and crop shifts by growers in GCID, LHWD, WRM

4.3.2.2 Timing of Deliveries

Introduction—Water supply districts are concerned about regulating water deliveries to meet the seasonal demands of their water users. In water short years, the timing of deliveries can be especially critical to ensure that peak irrigation demand is met to the fullest extent possible. Several factors determine a district's ability to alter the timing of their deliveries. The physical delivery system of each district determines maximum water flow over a given time period, which, in turn, determines each district's flexibility for increasing water delivery efficiency through improved scheduling. Districts are further constrained by timing and flow restrictions on water diversions, in the case of appropriative rights holders, and on contract deliveries, in the case of federal and state water contractors.

Observed Responses—Arvin-Edison WSD, as mentioned earlier, instituted a "Six Month Allocation Program" in response to the 1991 critical dry year. In order to maximize water supplies to growers during the peak demand months, March-August, the entire supply of imported water was allocated during these months and District wells were pumped at maximum capacity. In addition, intra-district transfers of allocation water and "banking" of private well water in the District canal were facilitated. Under the Program, the District encouraged growers to use fully or "return" all surface water during the peak demand months by offering to buy "returned" allocation water at $100/AF before August 31, and lowering the buy-back price on September 1 at which time all unused allocations were purchased by the District at $50/AF. During the non-peak months, September–February, Arvin-Edison WSD continued to meet irrigation needs with District groundwater.

The USBR exchange contract with the "four entities", one of which is CCID, divides water deliveries into two allocation periods: April–October (seven months), during which time deliveries cannot exceed 719,000 AF, and November–March (five months), during which time deliveries cannot exceed 121,000 AF. Water cannot be carried over between the two periods. The federal exchange contract also specifies maximum monthly entitlements and flow rates. Water must be ordered 48 hours in advance of service.

CCID believes that some operational efficiencies could be realized if their contract were amended. For instance, the District would like to be able to carry over monthly allocations so it is not put in a position to "use or lose" water each month. This type of flexibility has the potential for improving delivery efficiency and reducing overall water use. As noted earlier in connection with water transfers, however, any amendment of CCID's contract with the Bureau of Reclamation raises the possibility that CCID would become subject to federal reclamation law pursuant to the Reclamation Reform Act of 1982. This would subject CCID farmers to federal acreage limitations.

Like CCID, Glenn-Colusa ID is subject to monthly delivery schedules for both its base supply diversions and CVP contract water. There is some flexibility in monthly base supply deliveries, however total supply from April through October cannot exceed the maximum diversions allowed aggregately for that period. CVP project water is delivered as follows: 75,000 AF between July and August and the remaining 30,000 AF at any time of the year. These time-of-delivery restrictions are necessary to ensure adequate flow in the Sacramento River during the summer months, and are adjusted to reflect District entitlement cuts during dry years.

In Lost Hills WD, where water supplies were severely cut in 1991, growers began requesting water deliveries during the night as a conservation measure. These requests required the District to change its delivery schedule with the DWR for water from the California Aqueduct.[16]

In Westlands WD, growers can order water any time that they need it with 24 hours notice. This policy did not change in critical years when allocations were sharply reduced. Farmers in the area tend to postpone their surface water orders until late in the summer when crop demand for timely, frequent irrigation is greatest. High cost transfer water is also usually reserved for the critical last few irrigations in the late summer season. Groundwater is used more heavily during the cooler months.

Wheeler Ridge WSD rules and regulations also require a 24 hour notice for on-farm water deliveries to ensure adequate coordination with SWP deliveries to the Kern County Water Agency. Water users may request irrigation runs shorter than 24 hours. During plant germination, for instance, six hour runs during plant germination are permitted. This flexibility helps farmers to meet plant water requirements more precisely, increasing overall irrigation efficiency. There have been no policy changes in the timing of deliveries during water short years.

4.3.2.3 Water Rates

Introduction—All three types of water suppliers involved in our case studies—irrigation, water and water storage districts—are empowered by the California Water Code to assess property within their borders.[17] All districts can also impose water charges in lieu, in whole or in part of property assessments.[18] District boards would appear to enjoy considerable discretion in setting these charges.[19] As a general matter, suppliers can charge for water by acre, connection or metered use; they can also vary charges by time and locale to reflect differences in the cost or value of water. In July 1991, moreover, the California

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16 The DWR agreed to supply LHWD with SWP water from the Aqueduct, located adjacent to the District, in exchange for KCWA Emergency Groundwater stored farther south.

17 Cal. Water Code §§ 22078 (irrigation districts), 35401 (water districts), 43000 (water storage districts).

18 Cal. Water Code §§ 22280 and 25655 (irrigation districts), 35470 (water districts), and 43006 (water storage districts).

19 The general statutory provisions are found in Cal. Water Code §§ 22283 (irrigation districts), 35470 and 35474 (water districts), and 43006 (water districts).

legislature expressly authorized agricultural water suppliers to establish pricing structures "to encourage conservation."[20] Any water charges, however, must reflect both (1) the need of a supplier to meet its cost; and (2) the non-profit status of governmental districts.

The water rates that suppliers charge their water users usually consist of several components, including fixed repayment charges, charges to cover variable administration, operation and maintenance costs, and special project and standby charges. Although agricultural charges have traditionally been assessed on a flat rate basis, several districts have recently switched to inclining tiers whereby per unit water rates increase with increased per acre water use. Such changes in pricing structures can be used as a means to encourage on-farm conservation and reduced water demand, either as a temporary measure or as part of a long-run strategy to improve water use efficiency.

A summary of district expenses and revenues for the case studies is presented in Table 4.8. With respect to district revenues, water sales represent the principal source of revenue among the five CVP contractors (AEWSD, CCID, EID, GCID, WWD), whereas fixed producer charges represent the principal revenue source for the two KCWA subcontractors (LHWD, WRM). Other sources of revenue include interest income, penalties, development fees and other types of revenue not related to water service. In terms of financial size, total annual revenues among the case studies range from less than $5 million (GCID) to nearly $28 million (WWD).

The principal expense categories include general and administrative, sources of supply (water payments), pumping plant, transmission and distribution and "other." The relative importance of each category varies widely among the case studies. For instance, sources of supply account for more than 60 percent of total expenses for the KCWA subcontractors that rely on SWP water (LHWD, WRM), but account for less than 15 percent of expenses for El Dorado ID, Glenn-Colusa ID and Central California ID. Transmission and distribution expenses also vary widely, from only four percent of total (WRM) to over 50 percent of total (CCID), depending on the physical size and configuration of the delivery system.

Clearly, if water sales represent an important source of revenue for the case study districts and most agricultural water suppliers, significant reductions in wholesale supplies for retail delivery can seriously affect district revenues. Districts that rely on groundwater pumping

20 Cal. Water Code § 10522(b)(4).

Table 4.8: Summary of Case Study District Finances, Selected Years (a)

District	AEWSD	CCID	EID	GCID	LHWD	WWD	WRM
EXPENSES							
General and Admin.	964	728	2,015	1,644	551	5,539	2,591
% of total expenses	8	17	19	33	5	20	12
Sources of Supply	4,770	509	614	443	6,526	13,028	12,957
% of total expenses	41	12	6	9	65	48	61
Pumping and Power	868	0	569	687	636	189	3,391
% of total expenses	7	0	5	14	6	1	16
Trans. and Dist. (b)	2,689	2,267	1,025	1,740	1,004	3,839	844
% of total expenses	23	53	10	35	10	14	4
Other Expenses (c)	2,317	753	6,187	483	1,307	4,577	1,410
% of total expenses	20	18	59	10	13	17	7
Total Expenses	11,608	4,257	10,410	4,997	10,024	27,172	21,193
REVENUES							
Water Sales Revenue	9,538	3,971	5,178	2,697	3,770	22,126	5,985
% of total revenue	89	70	42	57	38	79	27
Fixed Prod. Chgs (d)	685	0	3,076	1,303	5,110	5,073	16,076
% of total revenue	6	0	25	27	52	18	72
Other Revenue (e)	520	1,686	4,210	743	1,014	699	418
% of total revenue	5	30	34	16	10	3	2
Total Revenue	10,743	5,657	12,464	4,743	9,894	27,898	22,479
	Figures in Thousands of Dollars						

(a) District fiscal years vary. The information in this table was taken from the following financial statements: Arvin-Edison WSD, "Financial Statement" (3/1/90 - 2/28/91); Central Calif. ID, "Financial Statement" (1/1/90 - 12/31/90); El Dorado ID, "Audit Report" (1/1/89 - 12/31/89); Glenn-Colusa ID, "Financial Statement" (10/1/89 - 9/30/89); Lost Hills WD, "Financial Statement" (1/1/90 - 12/31/90); Westlands WD, "Financial Statement" (3/1/90 - 2/28/91); Wheeler Ridge-Maricopa WSD, "Financial Statement" (1/1/90 - 12/31/90). (b) Transmission and distribution includes repairs to district conveyance facilities, heavy equipment and other costs including salaries on an apportioned basis. (c) EID also provides sewer service and drinking water in its service area. As a consequence, costs apportioned to "other expenses" are quite large and include: water treatment costs, sewer collection and sewage treatment. (d) Fixed producer charges include assessments, standby charges, service charges and property taxes. (e) The category of "other revenue" includes interest income, penalities, development fees and other forms of revenue not related to water service.

and/or external water purchases to supplement contract entitlements, moreover, will face higher than average energy and/or water expenses. Districts may choose to raise water rates or fixed producer charges to compensate for lost sales volume and increased expenses, or alternatively, use district reserves and adopt cost-cutting measures to make up the deficit. Costs can sometimes also be deferred to future years. Changes in case study district revenues and expenses over the last few years, particularly in 1991, and potential consequences for the long-run operational and financial well-being of the districts will be documented and analyzed during Phase III of the study.

Observed Responses—Table 4.9 shows the average retail water rates for contract water charged by the case study districts in 1985 through 1991. The rates reflect average charges per AF of water (except for GCID which charges on a per acre basis) and are calculated based on different cost formulas for each district. In 1985, a "normal" water supply year, the range in rates varied from $7.00 per AF in CCID to almost $100 per AF in Wheeler Ridge-Maricopa WSD. These rates increased in five districts over the next six years, most significantly in Westlands WD, changed little in El Dorado ID and decreased in Lost Hills WD. Water rates remained relatively low in CCID and GCID, even after 1990.

Arvin-Edison WSD has not increased its water rates significantly as a result of the drought. The Board of Directors made the decision to "dip into" District reserves and control costs to compensate for lost sales revenues and increased pumping costs rather than raise rates to growers. The variable Water Use Charge, equal to $10.00 per pumping lift, has not been raised since 1987. The Water Availability Charge, covering non-power District delivery costs, was increased gradually from $16/AF in 1978 to the current rate of $29/AF. Total average water charges for 1990 and 1991 were $64/AF and $69/AF, respectively, plus $6.65 per acre for General Administrative and General Project Service Charges levied on benefitted lands. The $5/AF increase from 1990 to 1991 was to cover an increase in the USBR O&M rate charged the District.[21]

CCID has historically charged water users a flat rate per acre-foot of water, ranging from $4.00 to $7.00 between 1978 and 1988. In 1989, the District implemented a tiered water rate system. In 1991, water users paid $5.50/AF up to 2.25 AF per acre, $16.00/AF for the next 0.5 AF and $40.00/AF for quantities greater than 2.75AF per acre on an "if and when available" basis. Water rates were increased to raise additional District revenues to

21 Arvin-Edison WSD and other affected parties (Friant Water Users Association, CVPWA) have filed a joint suit challenging the basis for these increased charges.

Table 4.9: Average Retail Water Rates for Contract Water, Case Study Districts

District	Water Rates in Dollars Per Acre-Foot (a)						
	1985	1986	1987	1988	1989	1990	1991
Arvin-Edison WSD	54.00	54.00	57.00	57.00	59.00	64.00	69.00
Central Calif. ID	7.00	6.00	5.50	5.50	5.50	7.72	9.58
El Dorado ID	19.60	19.60	19.60	19.60	19.60	19.60	20.91
Glenn-Colusa ID	25.00	25.00	25.00	25.00	25.00	30.00	35.00
Lost Hills WD	na	na	67.10	66.50	61.10	62.10	(b)
Westlands WD	18.69	19.51	21.63	25.57	37.18	47.77	30.69
Wheeler Ridge WSD	96.03	95.41	99.64	98.53	103.85	106.49	(b)

Footnotes: (a) Water rates are per acre-foot except in Glenn-Colusa ID where water is sold by the acre. Water rates in all districts are based on annual budgets and may be subject to minor adjustments. In Arvin-Edison WSD, rates assume three pumping lifts. In Central California ID, tiered water rates in 1990 and 1991 are averaged using figures for expected water use displayed in the District's 1991 Budget. In El Dorado ID, rates are for "commercial metered irrigation" with no pumping. In Glenn-Colusa ID, rates are based on the per-acre charge for water delivered to rice fields. For Lost Hills WD, rates are for Service Area #1. In Westlands WD, rates assume 900,000 AF delivered to Area 1 and 250,000 AF to Area 2 except for 1990 and 1991. In Wheeler Ridge-Maricopa WSD, rates include water use and water availability charges as presented in the 1985-1990 District budgets.
(b) No State Water Project Water was delivered to Lost Hills WD and Wheeler Ridge-Maricopa WSD in 1991.

Sources: Arvin-Edison WSD: "History of Average Water Service Charges" (1990) and personal communications with District staff. Central California ID: "1978 Through 1990 Water Rates" (1990) and "Budget -- 1991." El Dorado ID: "Schedule of Rates and Charges for Service" (10/22/86) and "Rate Schedule 5.6 percent Increase" (2/25/91). Glenn-Colusa ID: "Official Statement of GCID for Offering Certificates of Participation" (8/10/88) and "Water Rates and Due Dates Adopted by the Board of Directors" (1989-1991). Lost Hills WD: "Summary -- Assessments and Water Delivery Charges" (1987-1991). Westlands WD: "Average Water Rates 1985-1991/2" (1991). Wheeler Ridge-Maricopa WSD: "Average Costs Per Acre-Foot By Various Cost Components" (1982-1991).

cover the increased costs of providing water and "to encourage water conservation."[22] Water users paying the second and third tier rates are contacted by CCID staff for suggestions on ways to reduce water use and their water bills.

Currently, there are over 90 different water rates in operation in El Dorado ID, many of which were assigned on an ad hoc, inequitable basis according to District staff. M&I (municipal/industrial) customers, who account for 90 percent of the accounts and approximately 80 percent of water consumption, are generally charged on a declining block rate basis. These accounts include water used for "domestic irrigation" on properties under five acres. This declining block structure provides no incentive for conservation. Agricultural accounts are charged on a flat rate basis and currently stand at $21/AF. There was no increase in charges resulting from drought conditions.

El Dorado ID is in the process of revising its water rate structure as part of an overall new management strategy. Public hearings on the new rate schedules were planned for December 9, 1991. The new system will be considerably more streamlined and probably apply a flat rate system to domestic use as well as agricultural use.

Glenn-Colusa ID charges its growers on a per acre basis rather than per AF because of lack of water metering. Different crop categories are assessed at different rates, generally corresponding to water use intensity. Billing is computed using aerial photographs of cropped acreage. For instance, in 1991, growers paid $35 per acre of rice, $25.50 per acre of sugar beets and tomatoes and $21 per acre of pasture and orchards. In addition, water users pay standby and land assessment fees. Water rates were increased by 20 percent in 1990 and an additional 17 percent in 1991 in response to shortfalls in District revenues resulting from reduced water deliveries.

Water charges for Lost Hills WD growers declined somewhat in 1988 and 1989, increased slightly in 1990 and rose dramatically in 1991 when SWP deliveries were cut 100 percent, motivating the purchase of higher-cost water from outside the District. KCWA Emergency Groundwater and State Bank water were purchased at $140/AF and $175/AF (+ conveyance charges), respectively. Lost Hills delivery charges varied from $15 to $44 per AF in 1991. In addition, per acre *ad valorem* and standby charges ranged from $88 to

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22 In July 1991, the California legislature passed the Agricultural Water Conservation and Management Act (AB 1160). Part of that Act expressly authorizes agricultural water suppliers to establish "a pricing structure for water delivered to encourage conservation".

$118. These high water rates, averaging about $200/AF, compare with normal year water rates ranging from $50 to $70 per AF. These rates include assorted fixed and variable charges. Lost Hills WD currently assesses water charges on a flat rate basis. It is considering, however, adopting an inclining block rate pricing structure to encourage water conservation.

During water short years, KCWA subcontractors must pay their portion of SWP fixed costs whether or not they receive their normal water allotment. This imposes a substantial financial constraint on SWP contractors, especially as the fixed portion of water costs has increased substantially in recent years. In order to lesson the burden of this charge (approximately $100 per acre) on District growers, Lost Hills WD deferred its 1991 SWP fixed payment obligations, to be paid back over the next five years.

Westlands WD increased its water rates about 160 percent between 1985 and 1990. In 1991, the District Board of Directors elected to "balance the budget" with a series of cost-cutting measures and depletion of District capital reserves, rather than raising rates again. These measures included: foregoing capital investments, laying-off temporary staff and deferral of certain maintenance projects as well as COLA and merit raises.

WWD operations and maintenance (O&M) charges are set by the Board each year to cover short-term operating and non-operating costs. There are ten different flat water rates in the District based on Priority Area, number of acres farmed and compliance with the Reclamation Reform Act. Landowners that farm more than 960 acres pay the "full cost" water rate, about $64/AF, for water applied on acreage over the 960 acre limit. District O&M charges were maintained nearly constant in 1990 and 1991. Certain fixed special project and drainage fees were temporarily deferred in 1991, lowering the total charge as compared with 1989 and 1990. The 1991 water rate, a weighted average of all charges, was $30.69 per AF.

The average cost of surface water for Wheeler Ridge-Maricopa WSD surface water contractors increased gradually during the 1980s from $73.37/AF in 1982 to $106.49/AF in 1990, including SWP fixed payment obligations. Water costs increased sharply in 1991, when growers were forced to purchase high-cost water from the KCWA Emergency Groundwater Pool at between $155/AF and $200/AF, plus an additional intra-district conveyance charge of up to $141/AF. This puts the total average water cost at well over $200/AF, not including SWP fixed payment obligations. Producers in WRM, like those in

Lost Hills WD, deferred their SWP fixed payment obligations in 1991, which averaged $183.31 per acre of land under contract.

Impacts—Water suppliers may increase water rates or adopt tiered pricing to compensate for reduced water sales in dry years, or to raise additional funds for conservation programs and other district improvements. Alternatively, suppliers may choose to absorb revenue losses by depleting reserves and cutting the operating budget. If water rates are increased there are several potential impacts on growers. Per acre crop production expenditures on water and energy may increase, as well as fixed per acre costs, depending upon total water consumption. There may be a decline in net farm returns depending on prevailing output prices. Higher water costs may also provide an economic incentive, where feasible, to: 1) reduce water application rates; 2) adopt more efficient irrigation systems; 3) shift to less water intensive crops; and 4) "stress" plants or fallow land.

IMPACTS OF DISTRICT WATER RATE POLICIES

Change in district revenues:

- increase/decrease in funding for district and on-farm conservation
  (CCID–tiered structure))
- increase/decrease in district reserves
- increase/decrease in operating budget

Increase in per acre crop production costs (water, energy, fixed payments)

Potential decline in farm net revenues

Potential economic incentive to reduce water demand

- reduce water application rates
- change irrigation technology
- shift crops
- stress plants and/or fallow land

4.3.2.4 Intra-District Surface Water Transfers

Introduction—Intra-district surface water transfers are another mechanism for helping to bring reduced water supplies in line with individual grower water needs. Typically, growers with access to well water are encouraged to sell part of their surface water allocation to growers without well water or with inadequate total supplies. In general, intra-district transfers are negotiated without district intervention under "free market" conditions, subject to some restrictions. Districts may facilitate such transfers by: 1) bringing buyers and sellers together; 2) managing the financial transactions; and 3) through transporting transferred water in district conveyance facilities at minimum charge.

Observed Responses—Arvin-Edison WSD did not allow "free market" transfers of surface entitlement water between March and August 31, 1991. However, through its Firm Water

Exchange Pool, it encouraged "contributions" of and "requests" for entitlement water during this six month period. To motivate growers to contribute surplus water during peak demand months, the District paid \$100/AF between March and August, decreasing to \$50.00/AF on September 1. As of June 1991, returned water exceeded requests for water by about 2,000 AF.

Glenn-Colusa ID allows "free market" intra-district water transfers. Although transfers must be on record with the District, GCID is not involved in setting prices. It is estimated that the current going rate for transferred water (\$40-\$50/acre) is nearly twice District water rates.

Landowners in Lost Hills WD are free to transfer water within the District at any price. The District bills the landowner from whom the transfer originates for the cost of the water and conveyance fees. Intra-district transfers were quite common during the District's "build-up" period in the 1980s. In 1991, due to the extreme shortage of water, such transfers were limited.

Westlands WD's informal intra-district "water market" has played a very important role in helping District growers to cope with sharp reductions in surface water deliveries, especially in 1991. During the 1990-91 water year, about 4,500 water transfers were negotiated, primarily surface water transfers among Priority I growers. Transfers within each priority area are permitted at all times. Surface water transfers between priority areas, however, are only permitted after Priority Area I growers have received their full allocation, (2.6 AF per acre). Westlands WD does not monitor water transfer prices, but District staff estimate that such prices exceed District water rates significantly. WWD facilitates intra-district transfers by posting notices of water requests and contributions, and by transporting such transfers through the District's delivery system for a wheeling fee.

Wheeler Ridge-Maricopa WSD has not historically allowed free market transfers of State Project entitlement water. During 1991, when entitlement water was suspended, intra-district transfers were permitted of groundwater pumped from landowners' wells. These transfers were delivered through the District's conveyance system.

4.3.3 Mechanisms to Improve the Efficiency of Water Delivery and Use

4.3.3.1 Information, Technical Services and Conservation Measures

Introduction—As more knowledge and information on crop water requirements and technologies for improving irrigation efficiency become available, some water suppliers are upgrading their information and technical service programs directed toward water users. Information on site-specific meteorological and soil conditions, crop evapo-transpiration (ET) rates, low volume irrigation technologies and irrigation system losses can help growers optimize their irrigation practices, especially in water short years. Some water suppliers encourage long-run water conservation at the farm-level by offering economic incentives to adopt conservation practices, such as tiered water pricing and low interest loans for irrigation efficiency improvements. Improved irrigation efficiency will tend to reduce per acre water demand—an important outcome for managing water shortages at the district-level.

Observed Responses—Arvin-Edison WSD provides information to growers on groundwater levels and quality on a monthly basis as part of its conjunctive water use management program. Information is also available on pumping requirements to irrigate one acre of land, varying by crop. The District does not provide crop ET data nor does it make specific water use recommendations to its growers.

CCID supports a publication, entitled the New Irrigator, which provides information to growers on new methods to improve water management. The District also supports a local Soil Conservation Service (SCS) mobile lab that evaluates water users' irrigation systems and makes recommendations for efficiency improvements. However, CCID does not make water use recommendations to growers, nor does it provide information on ET rates or weather conditions.

In 1989, CCID instituted a Conservation Loan Program (CLP) to help District growers finance on-farm conservation projects. The Program offers five year loans up to $50,000 or $500 per acre, at three percent simple annual interest. Loans may be used for such projects as: concrete lining of ditches, surface or subsurface irrigation water recovery systems, sprinkler or drip irrigation systems, land leveling and community ditch upgrading. Lining of community canals (two foot bottoms, one foot slope) costs approximately $8 per foot. CCID estimates that CLP loans made in 1990 will conserve 3,000 AF of water per year. The Program also has the potential for reducing the District's drainage problems.

The CLP is currently oversubscribed. Funds for the Program are made available through revenues generated from the District's tiered water pricing structure.[23] If and when excess funds become available, CCID plans to invest in District-wide conservation projects.

El Dorado ID began an Irrigation Management Service (IMS) Program in 1976 that has become one of the most sophisticated irrigation technical assistance programs in California. The IMS Program is financed by EID and run by an irrigation consultant to the District. It is intended to optimize irrigation practices at the field level and to maximize agricultural yield and quality with a minimum of water waste. Participating growers have neutron probe access tubes and tensiometers placed in their fields to monitor soil moisture depletion at different depths. From the readings of these instruments and precise data on daily weather conditions (CIMIS) and field data on elevation, slope, crop type, growth stage and cultivation practices, weekly crop water requirements are generated from a computer model. These computerized irrigation reports, containing irrigation timing and duration recommendations for each field, are sent weekly to all IMS growers.

When farmers decide to participate in the IMS program, their irrigation systems are inspected and farmers are helped to detect and repair leaks and other system inefficiencies. IMS consultants also provide one-on-one field level assistance for changing to water-conserving irrigation technologies, primarily permanent sprinkler and drip systems. EID believes that the IMS program has increased irrigation efficiency from about 50 percent, on average, to nearly 70 percent. In aggregate, demonstrated agricultural water savings resulting from the IMS program amount to approximately 2,000 AF per year (0.67 AF/acre). Over half of EID's eligible agricultural accounts participate in the IMS Program.

Grower interest in the Program appears to be twofold: 1) on an individual level—to improve irrigation efficiency and cut water costs; and 2) on a sectorial level—to improve

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23 A frequently mentioned "obstacle" to tiered pricing structures designed to encourage conservation is the non-profit status of public water agencies. Districts have sufficient discretion both in setting rates and use of revenues, however, that their non-profit status should pose no legal problem. To the extent that revenues exceed ordinary operating and capital expenses, the "excess" could be used to fund conservation projects in the district or to accumulate a "drought reserve" (Cal. Water Code S10522).

agriculture's public image in El Dorado County as a defense in potential confrontations between the County's farmers and urban development interests.

There is considerable tension between factions favoring protection of the "agricultural flavor" of El Dorado County and those that do not want to put barriers in the way of growth and development. This tension is felt on the EID Board of Directors and the County Board of Supervisors. For the time being, agriculturalists have felt that their interests are fairly well represented by EID. However, they are nervous about what the future holds for them, particularly in light of the financial power behind the pro-development faction. Agriculture does have on its side, in addition to open space and quality of life issues, its importance as a leading industry in El Dorado County. There is strong public interest in retaining the prime agricultural soils for agricultural purposes.

El Dorado ID provides information to its water users through its Public Awareness and Education Programs. Residential and agricultural water conservation information is offered in regular billing inserts (since 1973), and reservoir levels and EID conservation measures are described in bi-annual "Water News" pamphlets. The District also distributes materials on water efficient landscape design.

Glenn-Colusa ID supports a publication, Waterline, that reports periodically on District news and includes water conservation information. In 1991, the District Board approved a new "Water Conservation Incentive Plan" in response to water shortage conditions. This plan is aimed at improving irrigation efficiency at the field level. The Conservation Plan offers an eight percent refund on water charges to users who adopt "best management practices" that improve water application efficiency. To be eligible for the refund, growers must certify that they have adopted two out of nine possible conservation measures: reduction of spills, installation of a recirculation system, use of drip or sprinkler irrigation systems, use of an irrigation scheduling program, capture and reuse of drain water, application of techniques approved by USDA's Soil Conservation Service or Agricultural Stabilization and Conservation Service, maintenance of private laterals, use of laser leveling or application of any other GCID approved water conservation techniques. Growers cited for wasting water, after two warnings, lose refund eligibility. Since the Plan began early in 1991, 30 to 40 percent of the District landowners have signed up to participate. Estimates of water savings from the Conservation Plan are not yet available.

In recent years, Lost Hills WD has shown considerable interest in identifying areas to improve growers' irrigation efficiency. It hired an irrigation specialist to review daily irrigation meter readings at each turnout to determine water applications per field. These application levels are compared with estimated crop requirements to ascertain irrigation efficiency rates. Furthermore, Lost Hills funds and utilizes the DWR sponsored mobile lab program which evaluates the distribution uniformity and annual irrigation performance of each of the major irrigation systems employed in the District. Both the irrigation specialist and the mobile lab program provide information that can help individual growers to optimize their irrigation systems.

Lost Hills WD personnel are trained to use AgWater, a computer program that is designed to provide information on specific crop water needs throughout the growing season based on site-specific weather, soil type and soil moisture conditions. This information is distributed to interested producers to optimize their irrigation scheduling. Further technical information is available through District reports on various water management techniques, such as furrow shortening and soil compacting.

Despite these programs, the high price of water remains the main incentive for on-farm water conservation in Lost Hills. Consequently, there is considerable technical innovation among District producers to improve irrigation efficiency. In 1990, LHWD applied for, and won, an award on behalf of District growers for their innovative water management improvements. This award was granted by the Association of California Water Agencies' Water Management Awareness Program.

Westlands WD initiated a Water Conservation Program in 1972 in response to the District's on-going water shortages in Priority Areas II and III. This Program evolved over almost 20 years to include a variety of information, monitoring and technical assistance services to growers. Since 1978, the District has provided weekly bulletins to growers with crop water requirement information, including estimates of water needs for the following ten days. It also publishes a bi-monthly newsletter highlighting on-farm conservation efforts by District growers. The District's Water Conservation Handbook, created in 1981, provides information on water budgeting for individual fields and salinity management. Two full-time water management specialists employed by the District are available to provide on-farm technical assistance. Westlands has continued to provide these information and technical services during the current drought.

Wheeler Ridge-Maricopa WSD does not sponsor specific public information or water conservation programs. However, the District did recently commission a study to determine how to improve irrigation efficiency. At present, irrigation efficiency in the

District is estimated to be approximately 80 percent, on average. As with Lost Hills WD, the high cost of water is the main incentive for water conservation in WRM. According to District personnel, "Price is our conservation program."

Impacts—District efforts to provide information, technical support services and conservation incentives to water users often have beneficial impacts in terms of improved irrigation efficiency, reduced water application rates and lower demand for district water. These benefits will generally exceed the associated costs if the services provided are distributed widely and in a timely and useful manner.

IMPACTS OF IMPROVED INFORMATION SERVICES AND CONSERVATION MEASURES

Increase in district operating expenditures

Improved irrigation efficiency rates

e.g. estimated 20% increase in efficiency rate (from 50% to 70%) after five years of the IMS Program (EID)

Lower on-farm water application rates

e.g. annual water savings = 2,000 AF or 0.67 AF/acre (EID's IMS), = 3,000 AF (CCID's CLP)

Reduced demand for district water

4.3.3.2 Physical System Characteristics and Improvements

Introduction—In the short-run, water suppliers typically adjust to reduced water supplies with increased monitoring and maintenance of the delivery system as a means to check and reduce system losses. Long-run adjustments to changes in water supply conditions may require investment in physical system improvements and technologies that conserve existing supplies. Such investments, at the district level, can include: replacement of leaky pipelines, lining of leaky canals and installation or improvement of tailwater and drain water recapture systems. The benefits of these measures, in terms of water savings, have to be evaluated against the investment costs. To the degree that water seepage is recoverable from the groundwater basin, eliminating or reducing leaks is less beneficial. Seepage losses also supply water for riparian vegetation and wetlands habitat in certain areas. Furthermore, tailwater and drain water recapture systems limit users' diversions from drains.

Other sorts of physical system improvements are aimed at increasing the accountability of water use, such as replacement or repair of inaccurate water meters and installation of flow measurement devices. Water accountability has become an increasingly important "public image" issue since the onset of the current drought.

Observed Responses—Arvin-Edison WSD has made many improvements to its physical delivery system since it was first built between 1964 and 1968. In the last two years alone, the District spent $750,000 on maintenance of the main pumping plant, including repairs to the electrical system and installation of "fallback" mechanisms in case of power outages. The District supports continuous engineering, operations and maintenance activities to improve water delivery. These include the surveying and adjusting of all standpipes and on-going monitoring and repair of all pumps and wells. Other routine physical system maintenance and improvements include: plugging pipeline leaks, fence repair, canal grading, periodic drying and filtration of spreading ponds and rodent control. The District has also invested in replacing inaccurate water meters with more reliable models.

Arvin-Edison WSD can account for about 7,600 AF per year in non-beneficial water losses: 1) 4,600 AF in surface water evaporation and spreading grounds vegetative consumptive use; and 2) 3,000 AF from seepage from the Intake Canal.

CCID owns and operates 270 miles of canals that wind through the District following the contour of the land. These canals are unlined, and the District estimates that between 60,000 and 80,000 AF of water per year are lost through seepage, some of which is recoverable from the groundwater basin. In addition, the District maintains but does not own approximately 300 miles of unlined community ditches. Lining the big canals would cost approximately $200 per foot, while lining the community ditches costs $8 per foot. Taking into consideration the current benefits and costs of lining its major canals, CCID management has elected to forego this option for the time being.

In 1991, CCID abandoned several of its 45 wells because of collapsed casings, uneconomic pumping costs and poor water quality. District wells will require substantial rehabilitation if high pumping rates continue in the future.

El Dorado ID's current five year plan of capital improvements contemplates $50 to $60 million dollars of new building, physical improvements and maintenance. The County's high urban growth rate has attracted sufficient interest by developers to underwrite these types of investments. New projects are generally financed by developers and future beneficiaries, while maintenance is covered by all rate payers.

EID delivers water through 774 miles of pipeline and 59 miles of conveyance ditches. The District has had a long-standing problem with unaccounted for water losses, primarily from leaky ditches and inaccurate meter calibration (also evaporation, percolation and unauthorized use). During 1989, water losses totaled an estimated 10,000 AF or 32.3 percent of total supply.

The District has recently undertaken efforts to trace the exact system components and operations procedures responsible for these losses, and has estimated the costs and potential water savings for several corrective actions. These include: pipeline repair and replacement, meter upgrading, conversion of open ditches to alternative means of conveyance, supervisory control and data acquisition. The District has also implemented a Flow Monitoring Program to assist in quantifying pipeline losses and unauthorized use, and to determine daily fluctuations in water usage. Between 1985 and 1990, EID estimates that it has saved 6,738 AF from replacement of leaky pipes.

An on-going EID improvement program is its Water Meter Repair and Replacement Program which tests, calibrates, and replaces master water meters to insure accurate water consumption accounting. To assist in prioritizing meter replacements, EID installed a computer system that monitors water use fluctuations. In 1990, the District replaced 12 large compound meters at a cost of $7,900, which is expected to save 70 AF of water per year. Another recent improvement was the installation of float-control valves at most of the District's reservoirs to eliminate water loss associated with overflow. As a result of these various improvements the rate of water loss in 1991 was reduced to 27.9 percent of total supply.

The EID Crawford Ditch Renovation project, completed in 1990 at a cost of $3.87 million, was financed by developer fees (FCCs) of $4,500 per new meter. This project widened, reinforced and cleaned 19 miles of District ditches, increasing its water supply by approximately 2,800 AF per year. In some locations, ditch and old pipe were replaced with new buried pipe. However, the "riparian folks" who own property overlooking

Crawford Ditch have opposed plans to convert to pipeline those parts of the ditch that would result in the loss of their "creekside" view. Their opposition has succeeded in stalling further conversion to pipeline, at least temporarily.

Glenn-Colusa ID owns and operates the 65 mile long unlined Main Canal with 14 cross-check stations that control and measure water flow. The District also owns and maintains 420 miles of laterals, most unlined, that carry water directly to farmers' fields. In addition, the District operates a drainage recapture system with a total capacity of 1,257 cfs that pumps drain water into the distribution system for reuse. This water source is especially important for augmenting supply in dry years. GCID maintains two "interties" between the Tehama-Colusa Canal and its Main Canal with a total capacity of 1,130 cfs. These interties can supply additional water during peak demand months (April and May) on an "if and when available" basis at $4.25/AF paid to the USBR.

In 1980, District landowners approved a $17 million dollar loan from the USBR under the Small Reclamation Projects Act of 1956 (P.L. 984) to rehabilitate District facilities, including the main pumping plant and the Main Canal (the loan was "privately" refinanced in 1988). In addition, GCID contributed $4 million in District reserves that had been set aside for the purpose of implementing the "Master Water Plan" developed in the 1960s.

Glenn-Colusa ID does not meter water usage by its customers; users pay for water on a per-acre basis. The District's flat topography keeps the flow velocity in the canals too low to activate enough head to spin water meters. Furthermore, the flood and trickle irrigation system for rice would require two types of measuring systems, one for the flooding period and the other for maintenance (trickle or drip). These types of wide range meters are not currently available. However, the District is interested in improving its water measurement capability in the future. Average water delivery efficiency at present is about 70 percent, including drainage recapture.

In the past, GCID has dredged the diversion channel from the Sacramento River to the District's main pumping plant in order to remove accumulated silt and ensure adequate flow rates. In 1986, the District's permit from the Army Corp of Engineers to engage in dredging activities was contested by the U.S Fish and Wildlife Service until completion of further research on the potential damage to fish passing through the channel, in particular, the winter run Chinook salmon, a threatened species.

February 14, 1992 PHASE II DRAFT

IMPACTS OF PHYSICAL SYSTEM INVESTMENTS

Increase in long-term district debt
- decline in reserves and/or credit for other district investments

District water savings from
- reductions in delivery system losses
- greater accountability of water usage

Increase and/or decrease in district revenues
- (increase) from annual water savings, more efficient charging for water use
- (decrease) from higher variable expenditures on routine maintenance and monitoring, environmental studies, etc.

Improved public image of district

Potential loss of seepage-supported riparian habitat

Potential impairment of drain-water diverters

4.4 Concluding Remarks

This chapter has reviewed the principal short-run responses and long-run adjustments to changes in water availability adopted by the case study districts. The evidence shows that these adjustments vary tremendously from district to district, reflecting differences in the total water supply situation in both "normal" and water short years, and the district-specific opportunities and constraints for successfully adopting one adjustment or another. It was shown that those districts that have been reasonably able to "maintain" water supply, despite substantial reductions in project entitlements, fared best in terms of continuing to provide adequate, low cost service to water users. Groundwater pumping, external water transfers and participation in water exchange and banking programs were the principal mechanisms for maintaining water supply.

In addition to augmenting water supplies, the case study districts have all adopted, to varying degrees, mechanisms to allocate available supplies to growers in the most efficient and equitable manner. However, districts often face constraints on the timing and flow of deliveries imposed by wholesaler contracts and physical conveyance and capacity limitations. Such constraints reduce their flexibility for adjusting to water shortages. One particularly successful allocation mechanism is the encouragement of "free market" intra-district surface water and groundwater transfers between "surplus" and "deficit" growers.

Most of the case study districts are also involved, again in varying degrees, in efforts to improve the efficiency of water delivery and use. If water supplies become increasingly more scarce and expensive, this may be the most feasible long-run strategy for ensuring adequate water availability for agriculture. Some districts have increased their delivery efficiency to very high levels, 80 percent and above, while others still have considerable room for improvement. The motivation to invest in the kinds of physical system improvements needed to reduce system losses and improve water accountability depends upon the benefits and costs of the expected water savings. Districts have also been involved in assisting growers to achieve higher rates of irrigation efficiency through information and technical support services and economic incentive programs. Some of these programs have resulted in significant water savings.

The next chapter reviews adjustments, constraints and impacts to changes in water availability at the farm-level. To the degree that growers have been able to adjust to water shortages without significant harm to their crops or net revenues the credit must be shared, at least partially, with the water supply districts for their successful efforts to meet the needs of their water users in critical years. However, where growers have faced greater hardship, the suppliers may need to also accept partial blame for inadequate water planning and conservation.

5.0 PRODUCER ADJUSTMENTS, CONSTRAINTS AND IMPACTS FROM CHANGES IN WATER AVAILABILITY

5.1 Introduction

Some of the most significant impacts resulting from changing water availability occur at the farm-level. These impacts are associated with short-run responses and long-run adjustments made by producers faced with reduced or less reliable water supplies. This section reviews these responses and adjustments observed in the case study districts and identifies significant constraints to the adjustment process. This information provides the foundation for identifying potential producer impacts. As noted in the previous section, more detailed analysis of these impacts is a task for Phase III of the study.

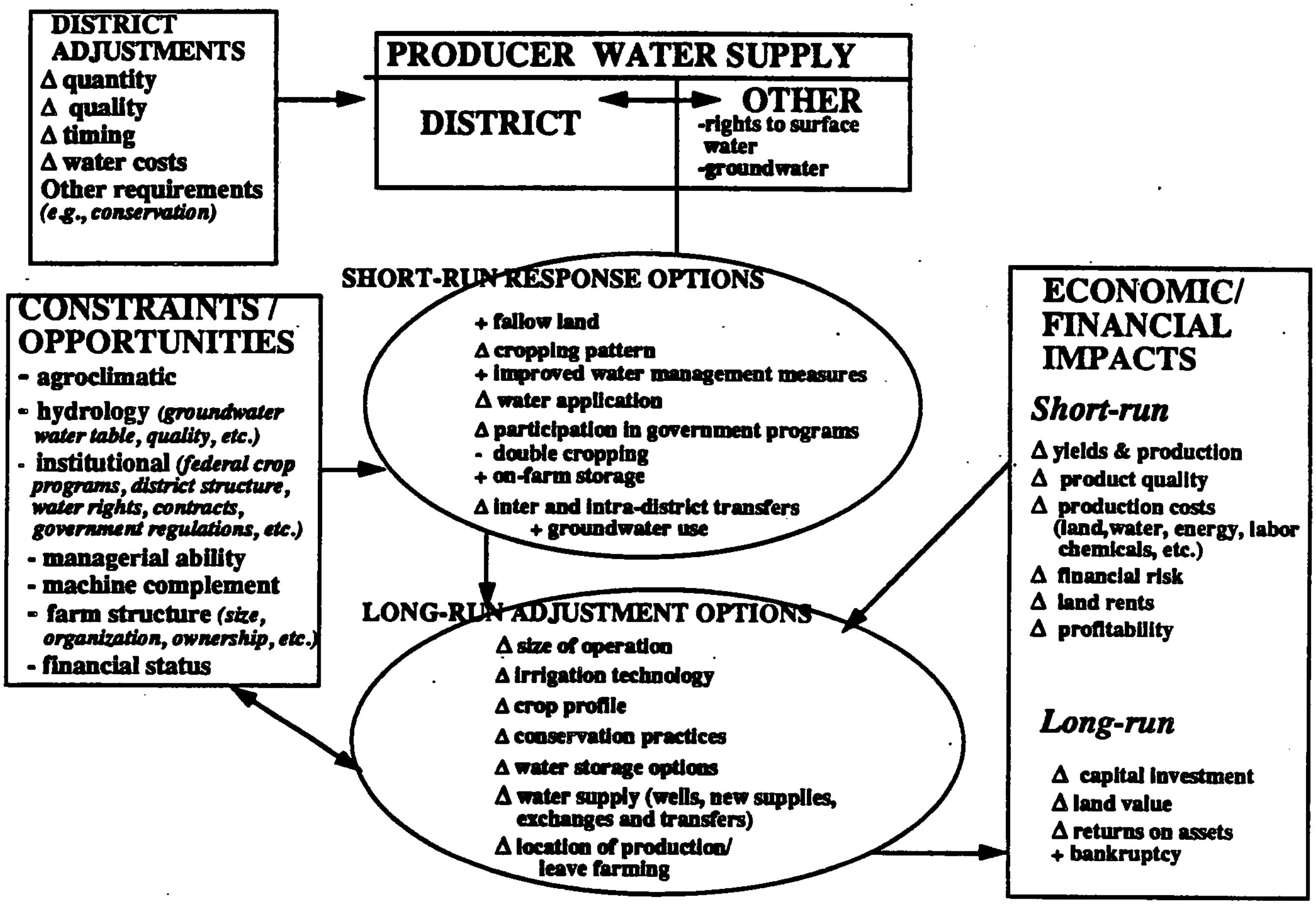
The scope and objectives of the study did not include developing a farm-level data base. During Phase III, case study data collection will be completed, including more specific information on producer adjustments, constraints and impacts through "focus group" interviews and existing data bases.

5.1.1 Producer Adjustment Mechanisms: Short-Run Responses and Long-Run Adjustments

Producers facing water supply reductions will alter their operations to meet their objectives within existing constraints. These responses and adjustments take place within a dynamic and uncertain framework such that each production decision has both expected and unexpected impacts which occur over time. Producers adjust, and then re-adjust, as interactions between production variables, including relative prices and technology, are revealed and better information becomes available.

District-level changes in water availability establish the initial conditions that lead to on-farm responses and adjustments (see Figure 5.1). Such responses and adjustments to surface supply reductions can be placed into three categories: (1) obtaining alternative sources of supply to supplement reduced surface water allocations; (2) matching demand to

FIGURE 5.1: PRODUCER ADJUSTMENTS, CONSTRAINTS AND IMPACTS



supply to meet financial objectives; and (3) increasing water use efficiency. These can be further broken down into short and long-run options.

In the short-run, defined as the period within which capital investment is fixed, producers can respond to water scarcity in various ways, including: substituting groundwater for imported surface water, fallowing cropland, changing cropping patterns and increasing water application efficiency through improved management. These "short-run response options" are identified in Figure 5.1.

In the long-run, allowing for capital investment and institutional changes, a larger number of adjustment options become feasible. These include changing the size of operation, adopting new production and irrigation technologies, practicing improved conservation, augmenting water storage facilities, developing additional water supplies, changing the location of production or leaving farming altogether. These are listed as "long-run adjustment options" in Figure 5.1.

5.1.2 Opportunities and Constraints

The short-run farm-level adjustment process is generally constrained by physical, institutional, legal and financial factors that vary widely across regions and even across producers within the same region. Possible constraints include agronomic conditions, climate, hydrology, federal commodity program rules, processor contracts, water district policies, managerial ability, farm structure, farm practices, financial status and market conditions. These are listed as "constraints" in Figure 5.1. Many constraints remain binding in the long-run, even allowing for significant capital investments.

5.1.3 Identifying Impacts

The adjustment mechanisms adopted by producers facing reductions in available water supplies have certain impacts that are important to identify and evaluate. These impacts affect the financial position of producers, the local economy and resource quality. In this report, both observed and potential impacts resulting from producer adjustments will be identified. The quantification of these impacts, however, will be left to Phase III when additional data necessary for this analysis will be collected.

5.2 Farm-level Characteristics Likely to Affect Adjustments

The heterogeneity in farm-level characteristics will influence specific producer responses and adjustments to changes in water supply conditions. In Phase II of the study, data on cropping patterns, farm size and some preliminary information on production and land values were collected. More detailed information on organizational structure, production practices and technology and net farm income will be collected and analyzed during Phase III.

5.2.1 Cropping Patterns

The case study districts exhibit a wide variety of cropping patterns. Listed below are the key characteristics of those patterns including total planted acreage, major crops, portion of cropland planted to permanent crops and important trends in acreage distribution over the last decade or so. Figure 5.2 shows trends in acreage planted to annual and permanent crops aggregately for all of the case study districts over the last 16 years. Note that while annual crop acreage has declined in the last few years, especially in 1991, acreage in permanent crops has remained very stable. Data on acreage trends for individual crops are presented in Figures 5.3 (cotton), 5.4 (alfalfa), 5.5 (vegetables) and 5.6 (tomatoes).

In Arvin-Edison WSD, 92,818 acres of land were planted to crops in 1989. The crops occupying the largest proportion of land in that year were grapes (24 percent), potatoes (17 percent) and cotton (16 percent). Other major District crops included vegetables, orchard crops and citrus. Approximately 46 percent of the District cropland was planted to permanent crops. Important trends include an increase in citrus acreage and more fallowed land. See Table 5.1 and Figure 5.7 for more detailed information.

In Central California ID, 149,047 acres of land were planted to crops in 1989, including double cropping. The crops planted to the largest proportion of land were cotton (22 percent), alfalfa (20 percent), beans (9 percent) and grain (8 percent). Other major District crops included corn, orchards and melons. Approximately nine percent of the District's cropland was planted to permanent crops. Important trends include increased melon acreage and a decline in rice and grain acreage. See Table 5.2 and Figure 5.8 for more detailed information.

Figure 5.2: Cropping Trends, Annual and Permanent Crops, Case Study Districts
Source: District Crop Reports

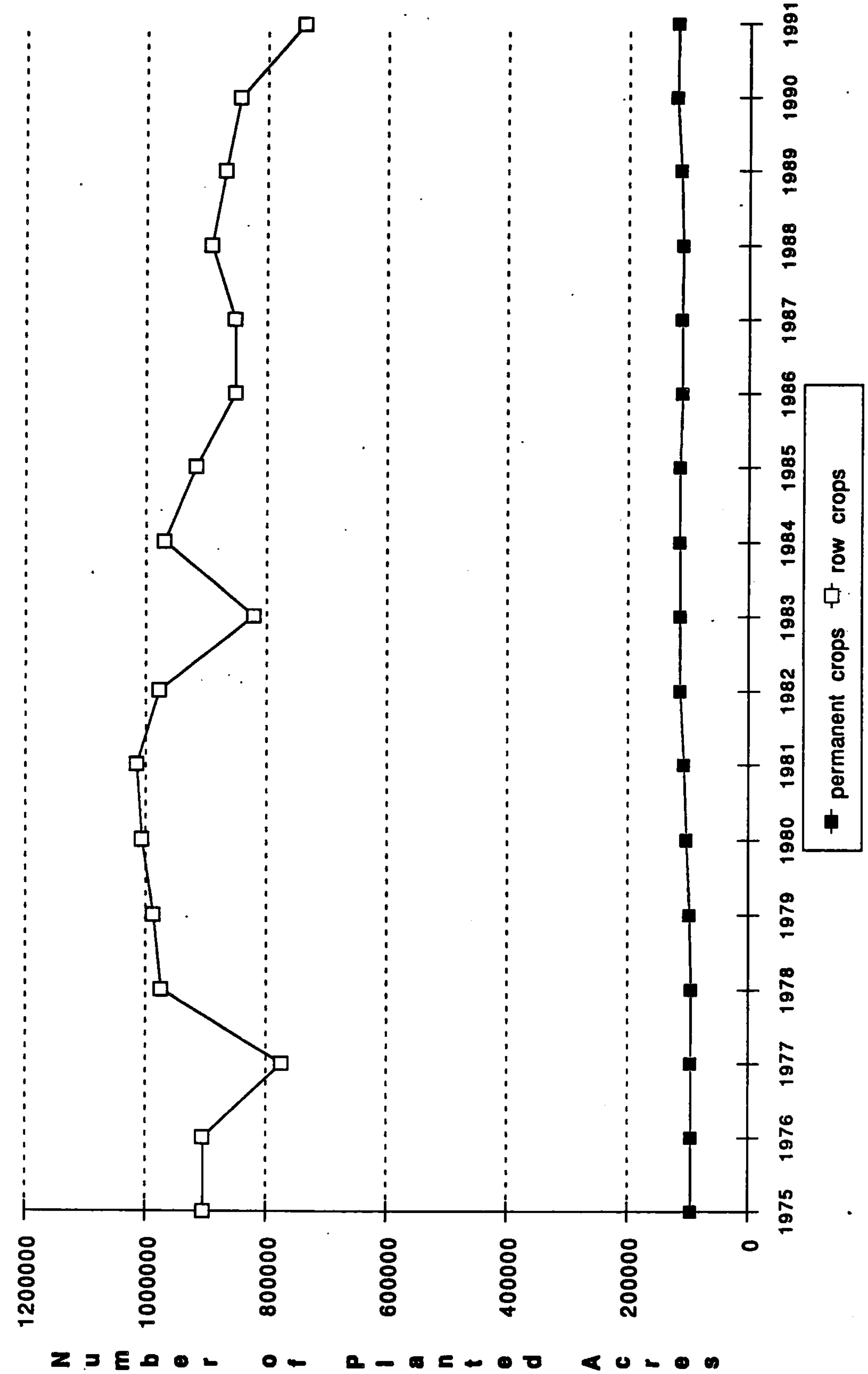


Figure 5.3: Cotton Acreage, Case Study Districts
Source: District Crop Surveys

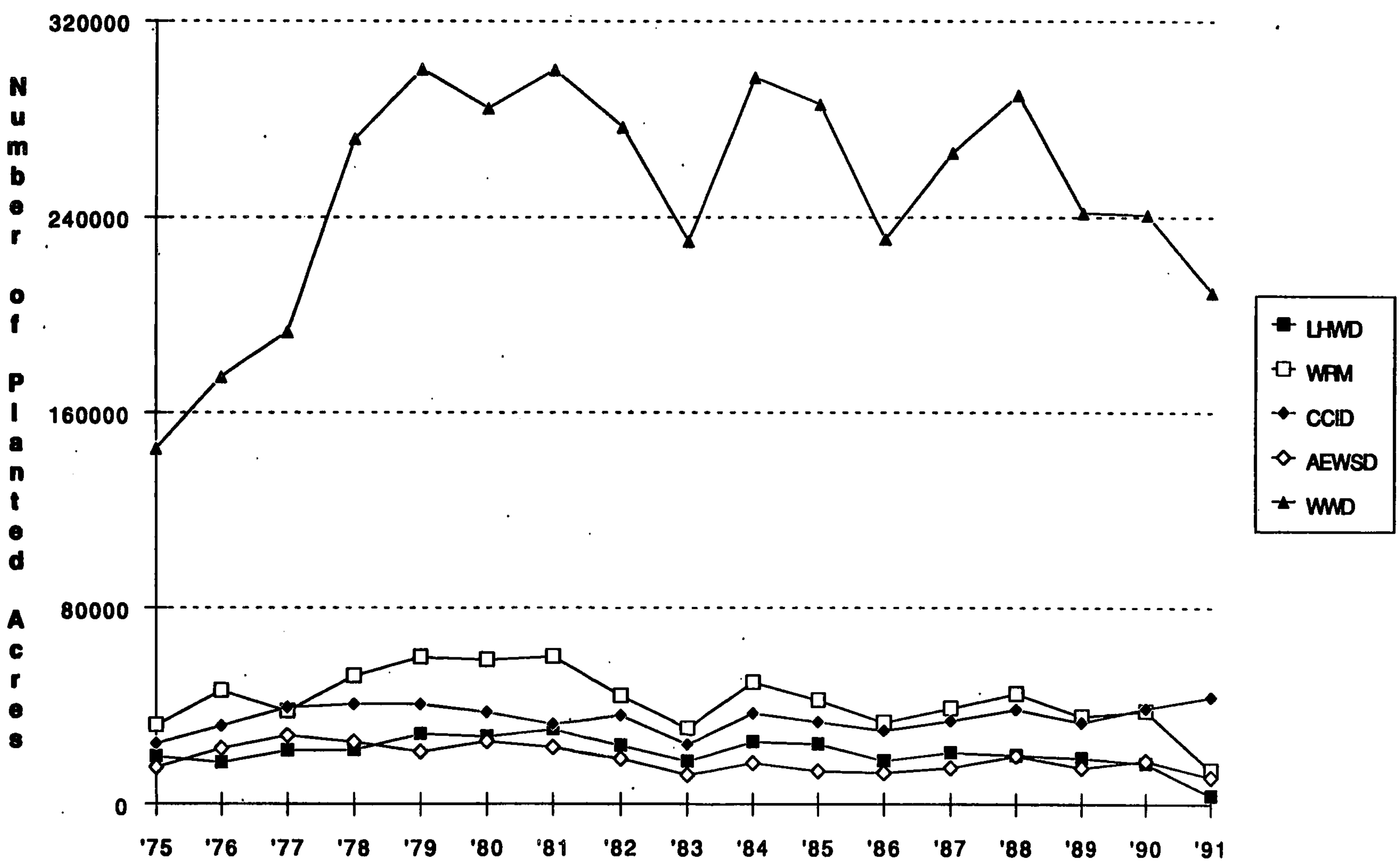
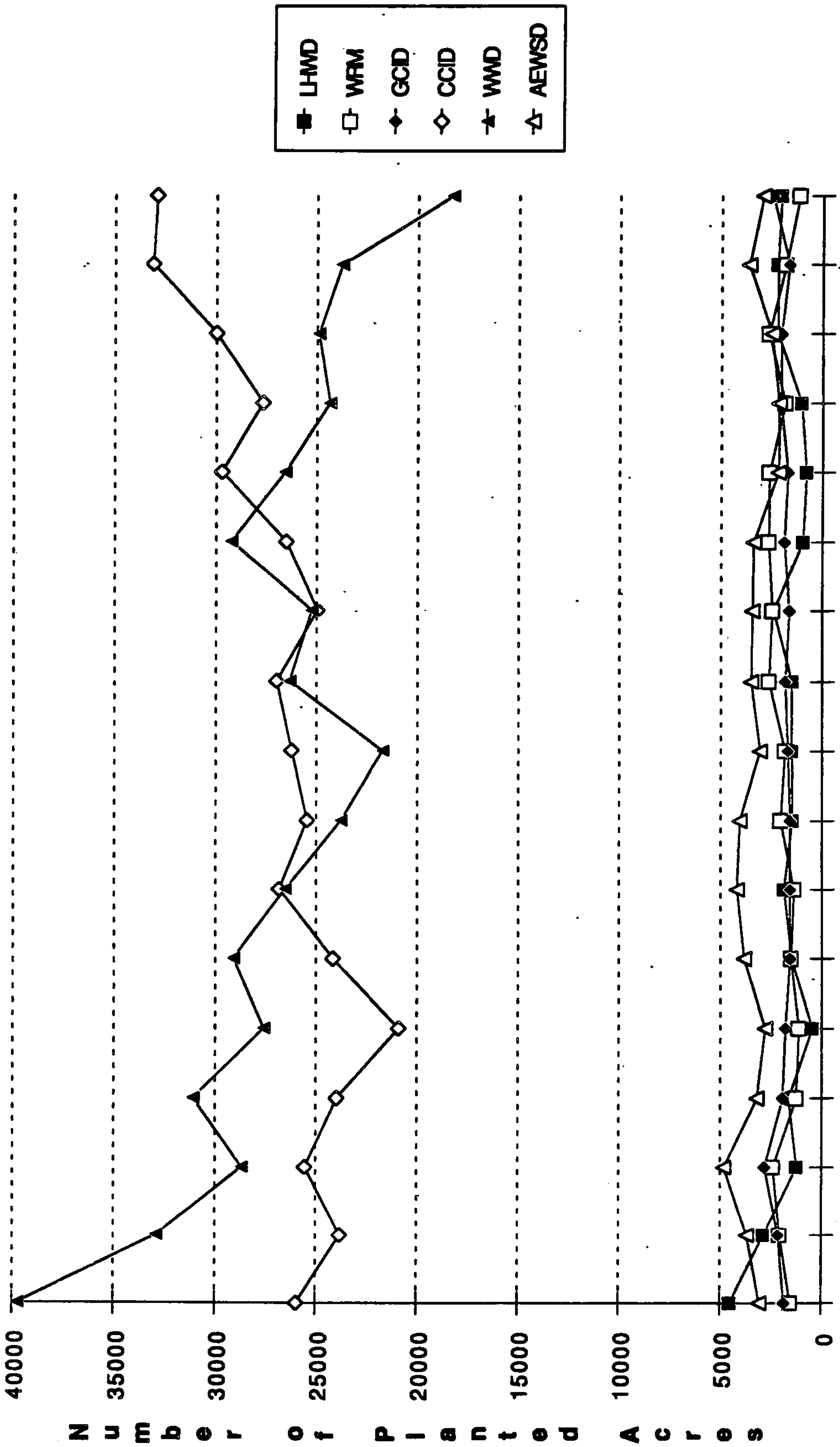


Figure 5.4: Alfalfa Acreage, Case Study Districts

Source: District Crop Surveys



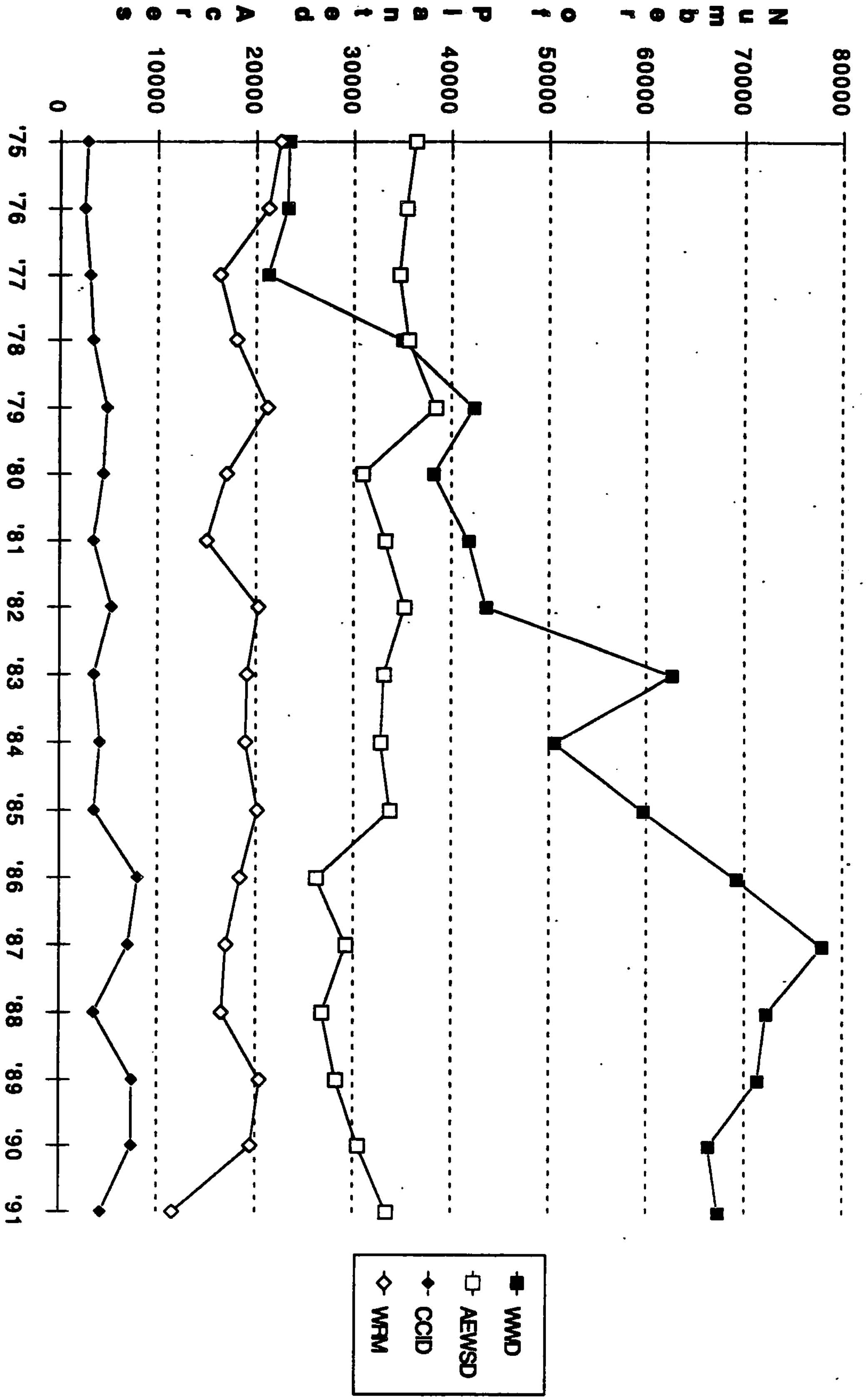


Figure 5.5: Vegetable Acreage, Case Study Districts
Source: District Crop Surveys

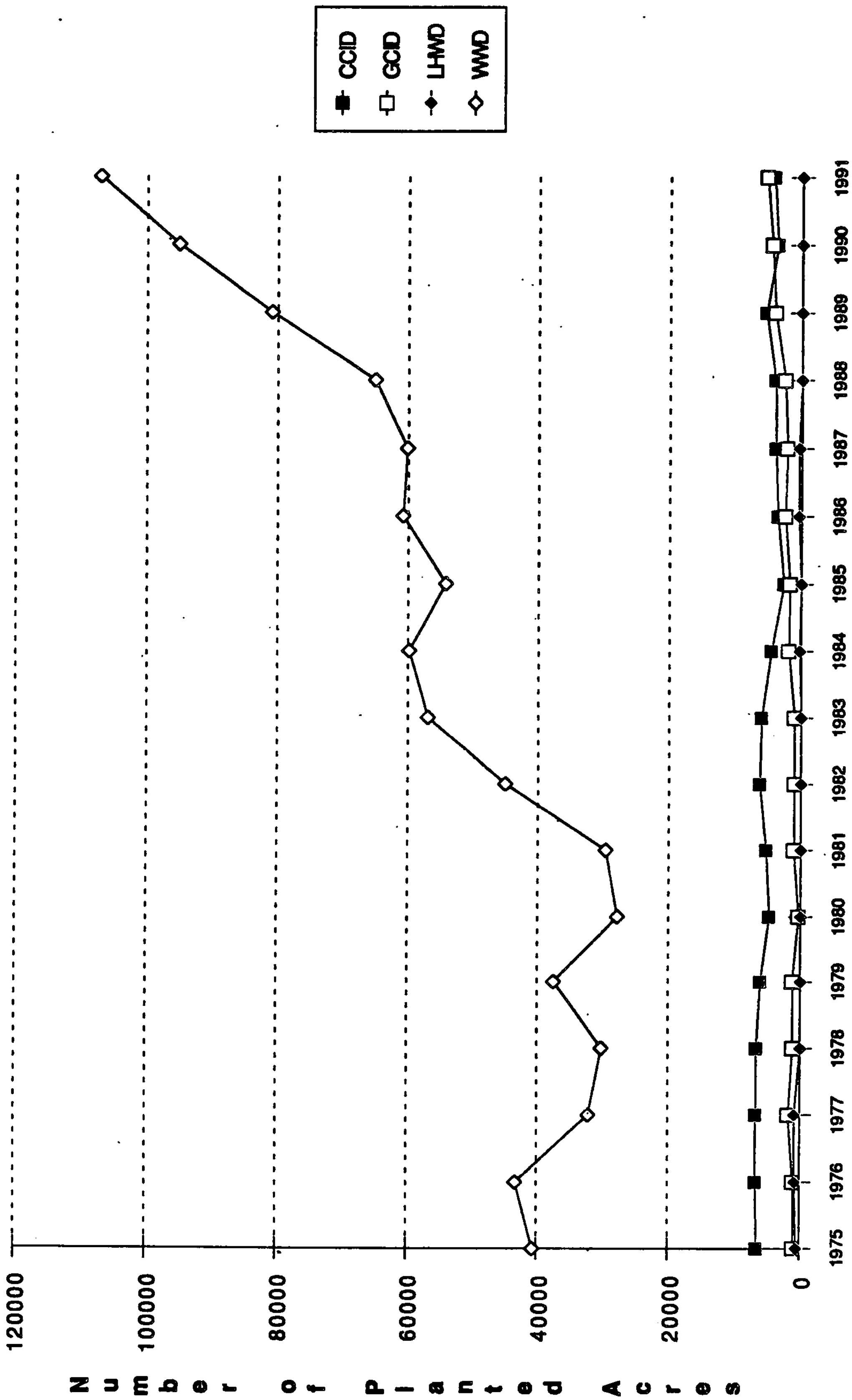


Figure 5.6: Tomato Acreage, Case Study Districts

Source: District Crop Surveys

Table 5.1: Acreage by Crop, Arvin-Edison WSD

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
cotton	15076	22805	28082	25495	21350	25696	23276	18450	11987	16706	13438	12881	14940	19776	14828	17579	11188
potatoes	19015	23010	19727	19265	20138	16521	20301	18822	18327	18839	20804	15278	16376	14578	15695	18909	16433
alfalfa	3066	3707	4816	3202	2787	3826	4192	4055	3070	3505	3454	3396	2195	2148	2515	3643	2969
grain	10710	6928	1673	1277	2455	5380	3902	4477	4085	4308	2881	3572	2030	2353	3610	2541	2060
sugar beets	2441	2162	1259	1134	1018	1245	1654	376	216	259	288	409	392	416	266	536	458
grapes	26649	24453	24069	24128	25838	27515	28346	29438	29936	29975	27446	24483	23361	22721	22446	22445	23386
vegetables	17275	12348	14941	16329	18293	14374	12905	16407	14804	13920	12936	10897	12806	12202	12495	11549	16972
orchard	8404	8936	8836	8513	8338	9530	10926	11088	11598	11456	11038	10906	10943	11343	11628	10561	10865
citrus	5121	5117	5100	4645	4780	4775	4834	4551	5101	5520	6074	6238	7232	7755	8615	9934	10479
misc	1976	1398	1252	1936	1057	1071	979	1009	545	1134	892	474	802	662	720	259	561
total	109733	110864	109755	105924	106054	109933	111315	108673	99669	105622	99251	88534	91077	93954	92818	97956	95371
fallow	2058	1728	2347	5674	4952	683	285	3215	11133	2127	8996	12144	7405	6451	7119	5736	2201

Source: District Crop Surveys. Data for 1991 is preliminary.

Figure 5.7: Distribution of Crop Types, Arvin-Edison WSD

Source: District Crop Surveys

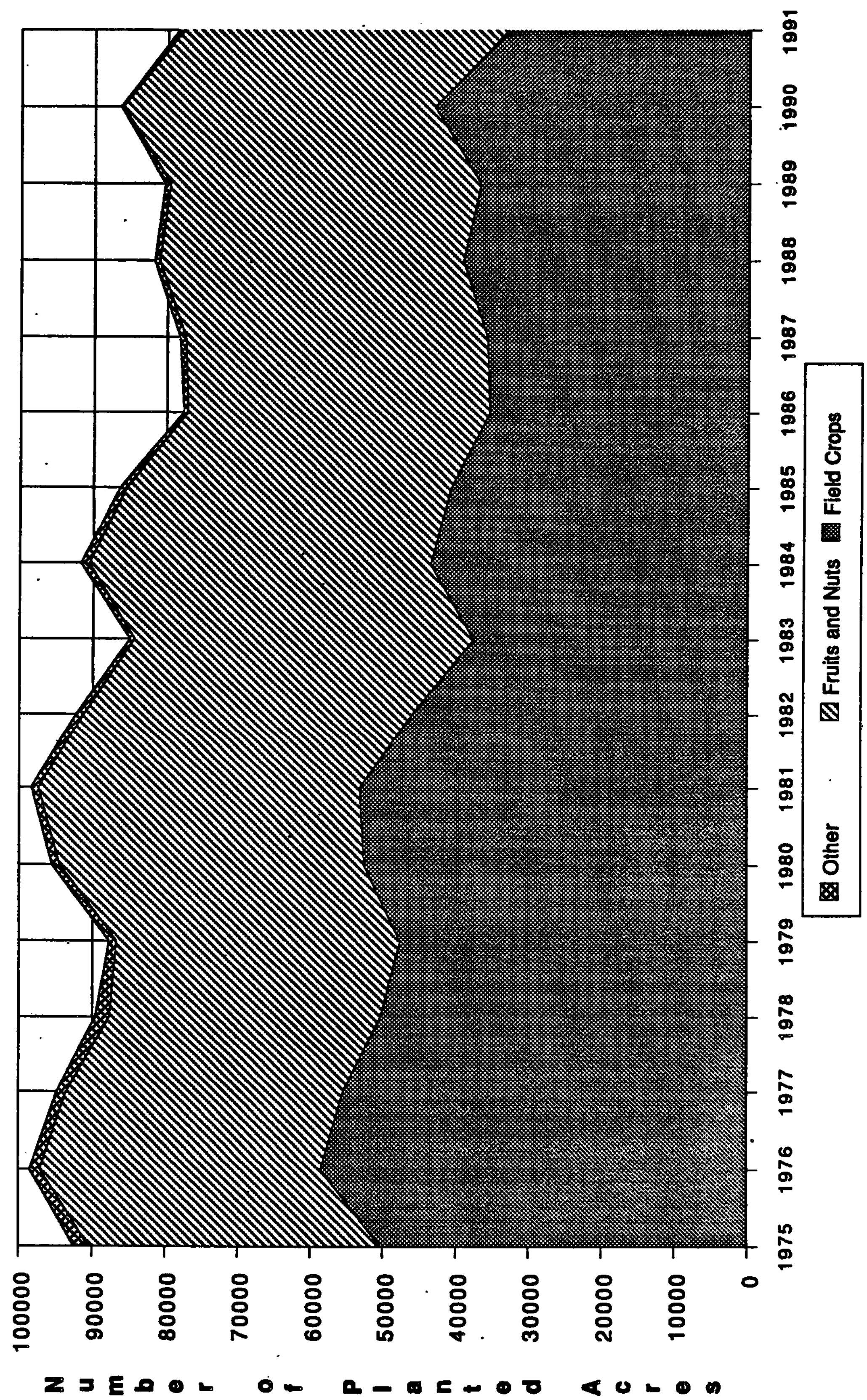
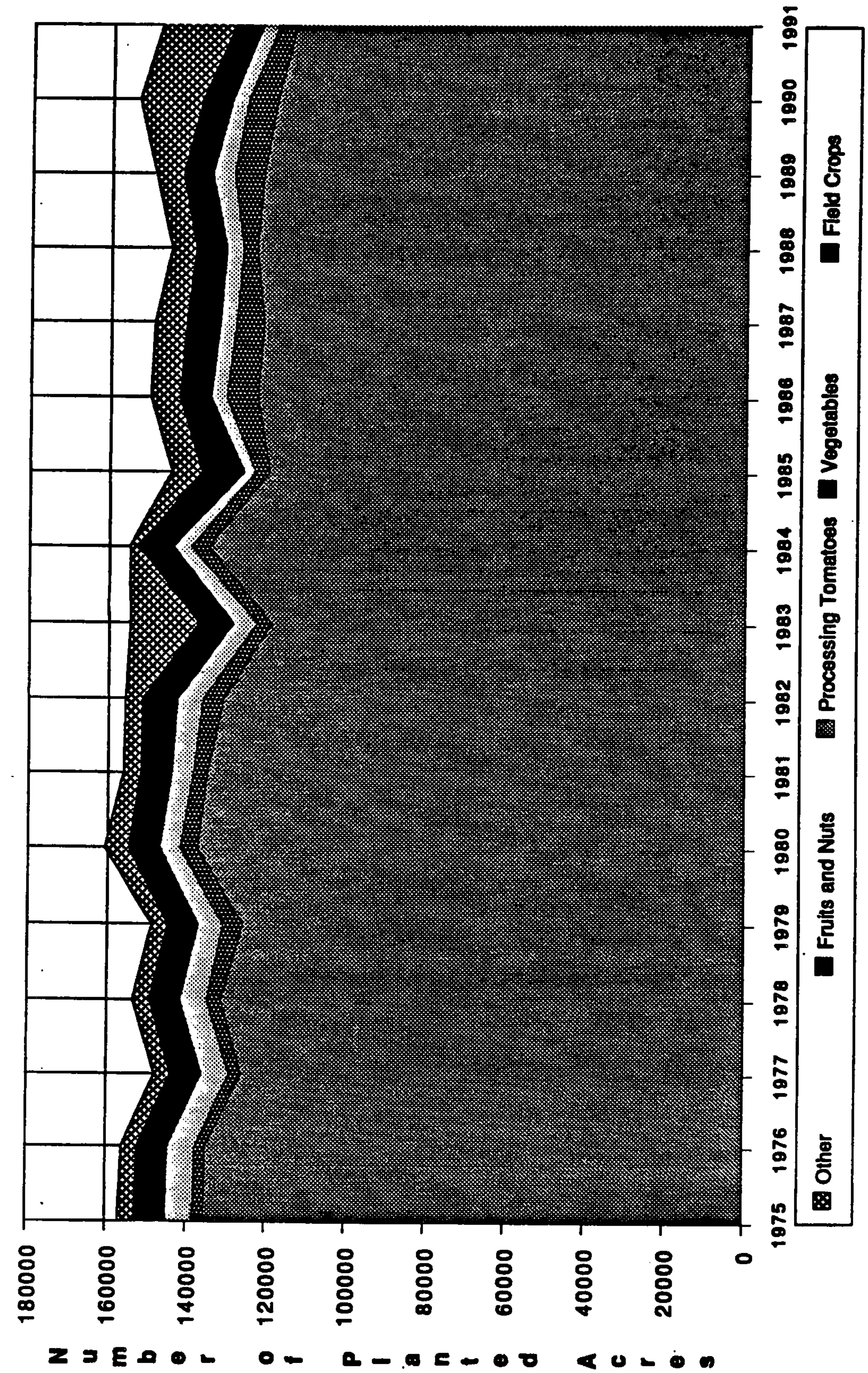


Table 5.2: Acreage by Crop, Central California ID

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
alfalfa	25974	23814	25562	24004	20906	24188	26852	25490	26258	26986	24981	26532	29707	27686	29988	33135	32940
grain	21589	24079	17474	14844	13667	26190	27283	16463	16662	18496	17355	16269	15300	13913	12472	1304	550
perm pastr	13385	11373	9542	8636	8081	7543	7037	6766	6137	6167	5781	6390	6188	5779	5770	5816	6026
cotton	24812	31932	39455	40819	40848	37597	32605	36087	24395	37098	33654	30017	33985	38624	33308	39048	43616
rice	9178	7529	4150	6763	5068	5815	5557	7016	5226	5845	5332	5273	3506	4934	5582	4515	3779
beans	11575	11795	13424	16314	17272	14410	12324	15058	14573	13566	12338	13924	12861	11636	12673	12634	10047
corn	11129	12390	7660	8358	9987	10788	11986	11513	11358	13737	9141	11429	10381	7622	9445	8466	6531
orchard	8022	7907	8006	7893	8014	8167	8058	8882	8799	8703	10852	8127	8630	7928	7552	7788	6983
grass	276	265	243	153	153	153	60	173	2695	689	282	118	291	0	19	0	0
peas	2562	1420	1729	2467	1876	1397	1107	2427	1875	1344	2004	1298	1692	1252	1600	2553	4262
sudan	2227	2763	510	777	615	861	540	267	404	601	339	446	196	237	749	1047	234
sugar beets	7127	7026	5460	6812	6432	8363	9908	8224	9742	9416	8706	11318	7546	11752	10154	10202	5768
tomatoes	6558	6678	6744	6646	6060	4788	5243	6199	6009	4497	2646	3624	3954	4002	5438	3689	4227
melons	2825	2566	3101	3429	4863	4483	3506	5285	3512	4163	3563	7992	7000	3559	7430	7368	4256
safflower	5526	711	996	1581	1255	237	0	1693	0	1368	82	137	0	80	219	81	316
all others	4180	3908	4000	4172	3821	5840	4156	4311	17035	2334	7405	7058	7887	5937	6648	15658	18184
total	156905	156156	148385	156665	148909	160819	156220	155794	154680	155010	144461	149952	149124	144941	149047	153304	147719

Source: District Crop Surveys. Data for 1991 is preliminary. "Total" includes double cropping.

Figure 5.8: Distribution of Crop Types, Central California ID
Source: District Crop Surveys



In El Dorado ID, 7,086 acres of land were planted to crops in 1989. Crop acreage figures are based on data obtained from the El Dorado County Agricultural Commissioner. Adjustments were made to reflect crops that are grown in the County, but outside the District. County data for 1991 will not be available until mid-winter 1992. Estimates for 1991 crop patterns were made based on past trends and District interviews. The crops planted to the largest proportion of land were irrigated pasture (61 percent), pears (11 percent), apples (10 percent) and hay (9 percent). Other major District crops included grapes, plums and cherries. All of the cropland in the District is planted to permanent crops. Important trends include decreased acreage in crops generally, and specific reductions in pears, hay and irrigated pasture. Grape acreage has increased. See Table 5.3 and Figure 5.9 for more detailed information.

In Glenn-Colusa ID, 111,704 acres of land were planted to crops in 1989. The dominant crop was rice (73 percent of cropland). Other major District crops included clover and tomatoes. Less than two percent of the cropland in the District was planted to permanent crops. Important trends include increased processing tomato acreage and a decline in corn acreage. See Table 5.4 and Figure 5.10 for more detailed information.

In Lost Hills WD, 44,136 acres of land were planted to crops in 1989. The crops occupying the largest proportion of land included cotton (43 percent), barley (16 percent) and pistachios (11 percent). Other major District crops were grapes, almonds, alfalfa and beans. Approximately 30 percent of the cropland in the District was planted to permanent crops. Important trends include decreasing acreage in olives, barley, alfalfa and cotton and increased acreage in pistachios. More broadly, over the past ten years total planted acreage in the District has declined by approximately 10,000 to 15,000 acres. This is partially explained by the loss of 12,000 acres in Service Area 6 resulting from growers' financial difficulties in the mid 1980s; the majority of these lands were eventually taken over by the District. See Table 5.5 and Figure 5.11 for more detailed information.

In Westlands WD, 567,817 acres of land were planted to crops in 1989, including double cropping. The two leading crops in acreage were cotton (42 percent) and tomatoes (14 percent). Other major District crops included alfalfa, cantaloupes, wheat, barley and lettuce. Approximately three percent of the cropland in the District was planted to permanent crops. In the last decade, there has been a marked long-run trend toward increased acreage in vegetables and fruits, and decreased acreage in grains and cotton. This trend toward higher-value and higher-risk crops is essentially profit and market driven. The District's cost-competitiveness for vegetable production as compared with the Salinas

Table 5.3: Acreage by Crop, El Dorado ID

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
pears	2180	2192	2168	1933	1538	1538	1432	1293	1293	1293	1080	996	881	841	778	672	650
apples	508	508	508	508	547	563	563	563	599	599	661	663	663	689	689	689	689
cherries	52	52	52	52	27	47	47	47	47	47	47	59	71	105	105	126	130
peaches	8	8	13	13	7	8	8	8	15	15	20	23	23	28	36	36	36
plums	65	72	73	64	76	76	79	79	113	113	113	125	125	125	125	104	104
grapes	78	80	80	80	112	131	206	261	281	281	311	321	321	321	338	401	420
nursery	36	61	61	61	42	31	33	44	45	45	42	44	55	63	66	77	77
hay	4000	4000	4000	4000	4000	2000	1700	1500	1200	1200	1300	1300	650	650	650	400	400
irrgtd pasture	5700	5800	4900	6000	4000	4500	4500	4500	4750	4750	4750	4600	4000	4000	4300	3000	3000
total	12626	12773	11854	12710	10349	8893	8568	8295	8344	8344	8324	8131	6789	6821	7086	5504	5506

Source: El Dorado County Agricultural Crop Reports. Note: According to Edio Delfino, El Dorado County Agricultural Commissioner, EID has no walnuts, 50 percent of the grapes and 90 percent of the stone and pome fruit in the County. These figures reflect those assumptions. Data from 1991 is extrapolated from earlier crop reports and from District interviews.

Figure 5.9: Distribution of Crop Types, El Dorado County

Source: El Dorado County Agricultural Commissioner's Reports, 1975-1990

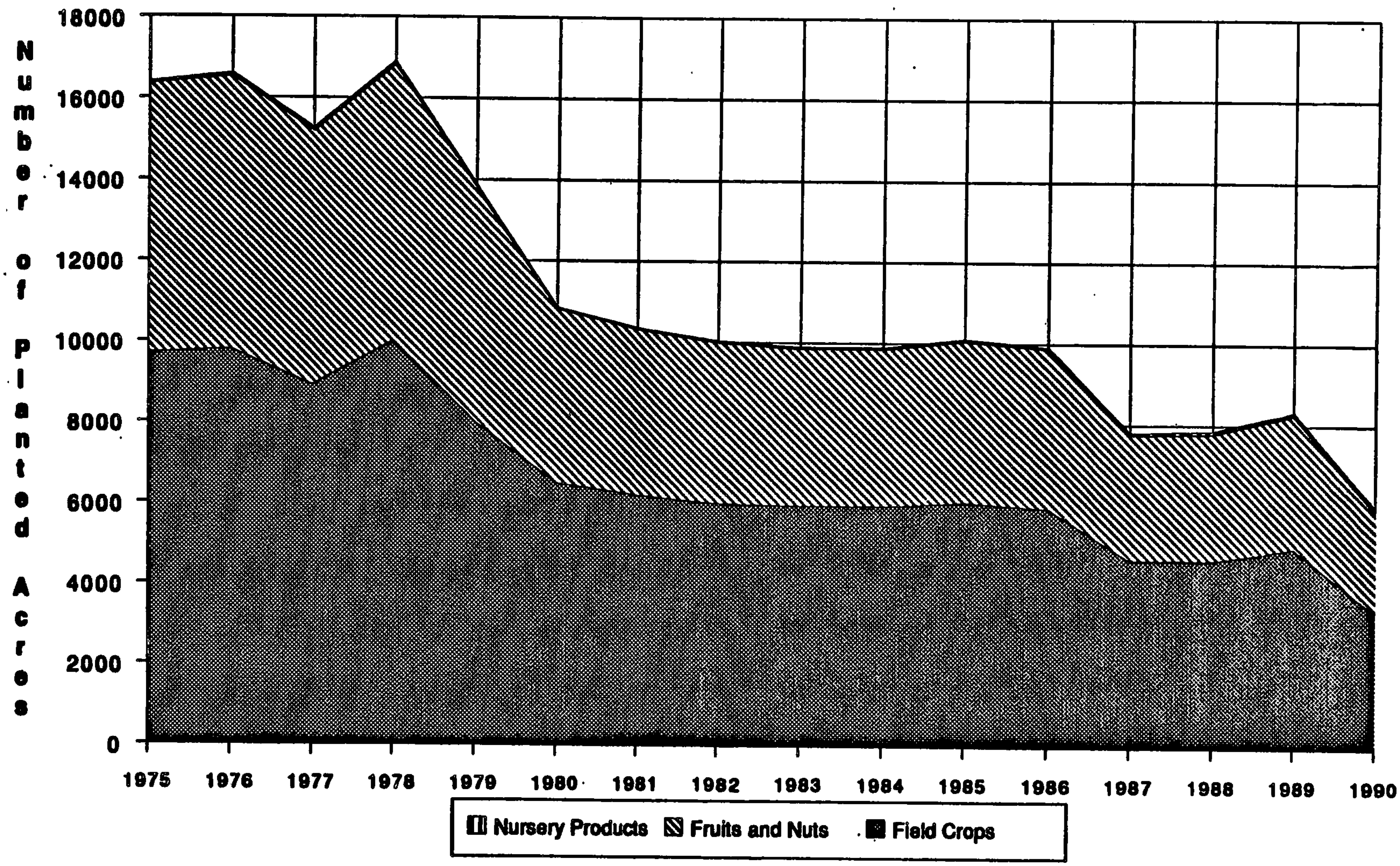


Table 5.4: Acreage by Crop, Glenn-Colusa ID

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
rice	93326	81190	52930	90609	96470	99197	105902	100880	62590	82677	76800	72058	71547	82865	81746	66827	62251
tomatoes	1005	1032	1787	1169	1215	356	1080	977	926	1841	1746	2415	2208	2535	4028	4495	5370
sugar beets	1633	1572	1199	853	567	566	758	472	622	981	948	1045	1984	1789	1387	884	600
clover	5646	5182	4605	4729	4691	4535	4242	3921	4280	4112	4183	4369	4469	4596	4510	3950	120
alfalfa	1845	2161	2828	1942	1787	1579	1585	1593	1697	1832	1635	1878	1707	2087	2033	1660	2495
corn	1944	6217	2924	1638	1841	2538	2211	1891	1621	1991	1382	1561	906	591	926	976	1062
orchard	1797	1874	1766	1744	1706	1921	1896	1927	1746	1660	1746	1472	1493	1545	1640	1619	1459
general	6293	15466	9958	11136	10193	7660	9463	7899	4507	7783	8548	5477	7003	5617	7384	6327	9208
duck pond	2392	2733	2328	3023	3378	3575	3641	3470	2626	4520	4721	4919	5030	5084	4780	4692	2618
one irrigation	8281	11460	26312	7030	7086	8931	7483	4516	8401	6088	6879	4552	5195	6123	3270	8327	5519
total	124162	128887	106637	123873	128934	130858	138261	127546	89016	113485	108588	99746	101542	112832	111704	100470	90702

Source: District Crop Surveys. Data for 1991 is preliminary. "One irrigation" includes several crops that received one irrigation and are not counted elsewhere.

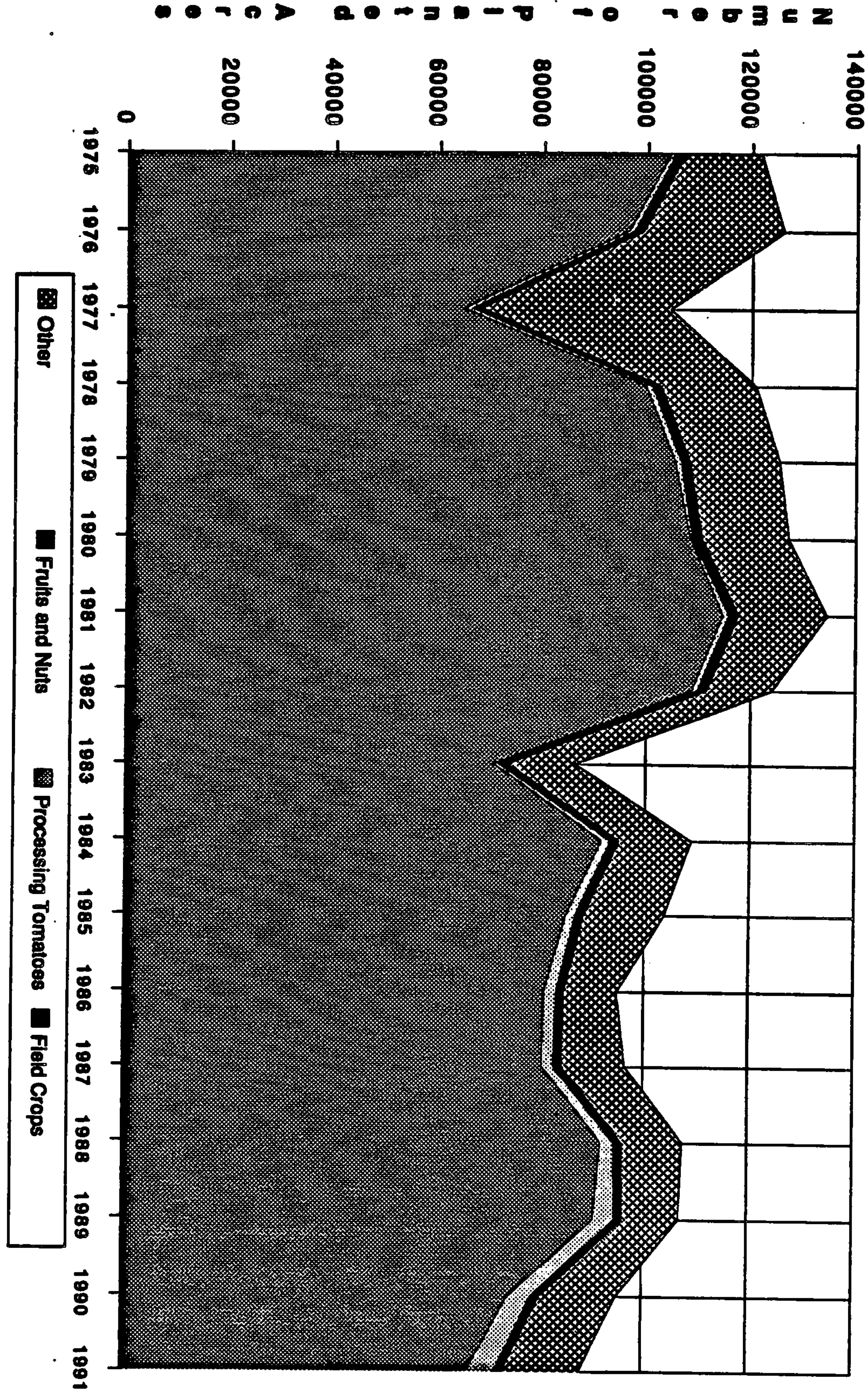


Figure 5.10: Distribution of Crop Types, Glenn-Colusa ID

Source: District Crop Surveys

Table 5.5: Acreage by Crop, Lost Hills WD

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
cotton	19470	16954	21905	22150	28668	27625	30560	23815	17470	25352	24497	17760	21092	20000	18787	16569	3520
alfalfa	4510	2870	1240	1620	480	1490	1885	1470	1480	1490	2415	980	820	1050	2200	2227	2067
barley	10690	15377	4795	12568	14110	12735	11425	12835	6866	9927	8492	8889	5172	6488	6859	5895	5159
beans/peas	0	0	0	0	40	0	0	425	310	0	308	250	1986	2024	2310	1201	2464
safflower	805	0	0	620	1750	180	0	0	0	263	0	0	0	275	439	439	2827
wheat	3060	1130	0	0	0	1260	3250	2909	554	3171	1070	160	320	254	686	0	0
sugar beets	480	560	620	0	320	2375	2155	1737	1238	1641	860	300	0	0	0	0	0
tomatoes	520	810	920	0	0	0	0	0	0	200	0	380	440	0	0	0	0
corn	80	70	0	0	0	0	0	0	567	1953	320	0	0	0	0	0	0
dbl crops	3265	1905	0	0	0	0	0	0	4403	2651	1268	0	0	0	0	0	0
other crops	1425	480	240	3365	1770	20	680	280	100	602	337	15	210	42	62	45	160
row crop tot	44305	40156	29720	40323	47138	45685	49955	43471	32988	47250	39567	28734	30040	30133	31525	26376	16197
almonds	315	795	2477	2357	2320	2335	2595	2648	2679	2653	2653	2682	2679	2679	2679	2579	2659
figs	320	320	433	431	475	600	630	530	511	526	526	526	510	510	510	510	510
grapes	990	1082	1108	1108	1318	1390	1195	2513	2434	2395	2365	2365	2510	2510	2510	2510	2315
olives	4520	4520	4433	4433	4330	3690	2500	1879	1769	1745	1252	1423	1971	1970	1794	1619	1619
pistachios	3470	3470	3459	3459	3503	3420	4345	3988	3325	3316	3655	4548	4645	4645	5049	7385	7585
pomegranate	0	0	0	0	0	0	0	0	0	78	78	76	69	69	69	79	79
perm crops	9615	10187	11910	11788	11946	11435	11265	11558	10718	10713	10529	11620	12384	12383	12611	14682	14767
grand total	53920	50343	41630	52111	59084	57120	61220	55029	43706	57963	50096	40354	42424	42516	44136	41058	30964

Source: District Crop Surveys. Data for 1991 is preliminary. In 1991, the only row crop to receive irrigation water was cotton. The remaining crops were planted, but then abandoned or dry-farmed.

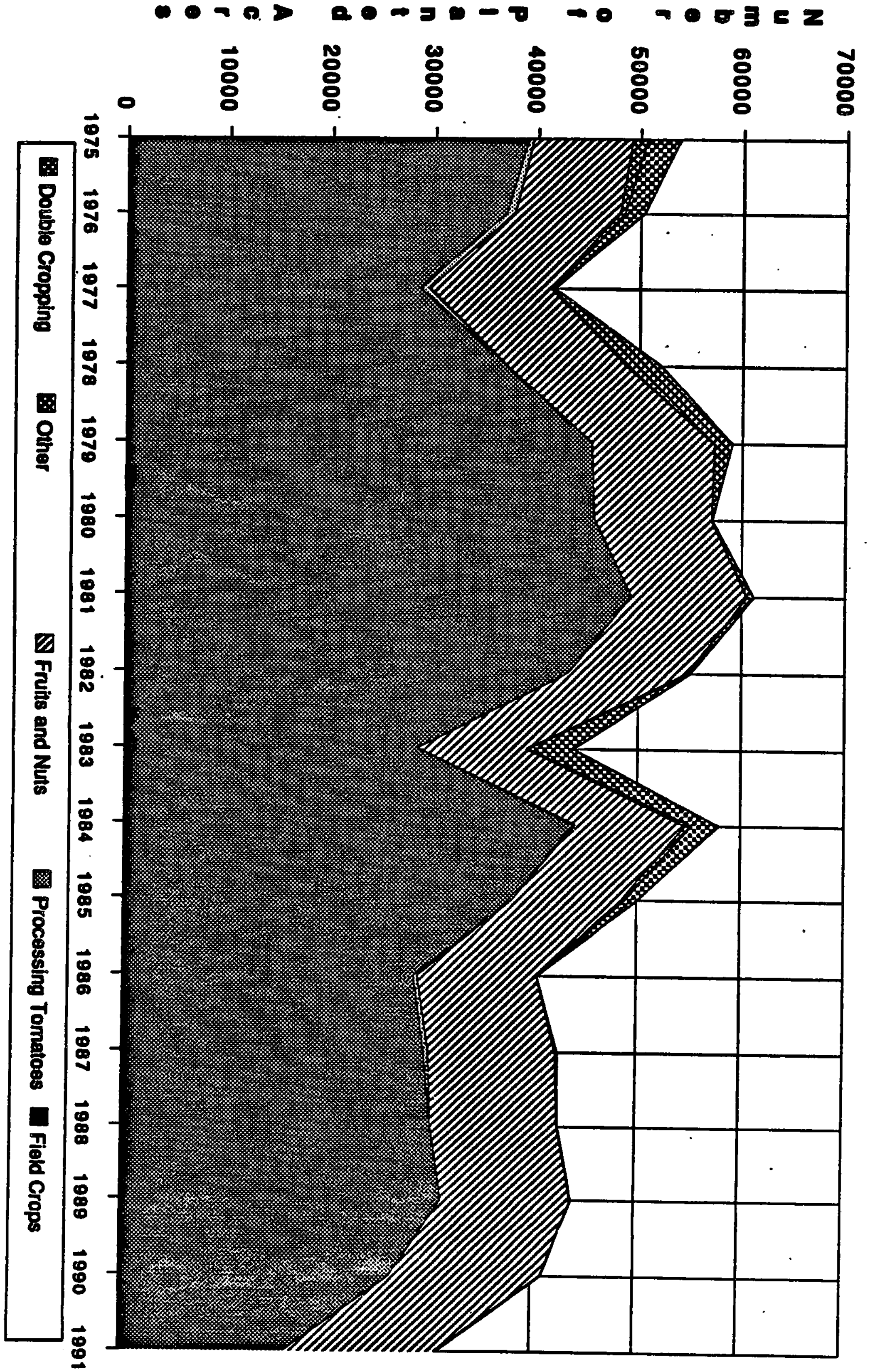


Figure 5.11: Distribution of Crop Types, Lost Hills WD

Source: District Crop Surveys

Valley, for example, has increased in recent years as a result of the widening gap in annual land rents between the two areas ($200-$300/acre in Westlands WD versus $800-$900/acre in Salinas). Table 5.6 and Figure 5.12 present more detailed information on District cropping patterns.

In Wheeler Ridge-Maricopa WSD, 88,937 acres of land were planted to crops in 1989. The crops planted to the largest proportion of land were cotton (40 percent) and vegetables (23 percent). Other major District crops included grapes, fruit and nut orchards and citrus. Approximately 28 percent of the District cropland was planted to permanent crops. As with Westlands WD and other districts, long-run changes in irrigated acreage and cropping patterns in WRM are most directly related to market and institutional factors (i.e. commodity prices and subsidy programs). The trend has been to move into high-value crops—vegetables, vineyards, fruit and nut trees—and to reduce acreage in grains and sugar beets. Acreage in cotton increased over the last decade, but during critical water years cotton is the "swing" crop that is forfeited (fallowed) to ensure adequate water for the higher-value crops. Fallowed acreage increased significantly after 1985; however, only in 1990 and 1991 was this change attributable to water shortages.[1] See Table 5.7 and Figure 5.13 for more detailed information on Wheeler Ridge WSD.

5.2.2 Gross Value of Production

As would be expected from the wide variation in planted acreage and cropping patterns among the case study districts, the gross value of production (output times price) measured in total or per acre also varied widely. These value of production estimates, given in Table 5.8 and shown graphically in Figures 5.14 and 5.15, were calculated using district provided data on planted acreage and yield and price date from the latest County Agricultural Crop Reports. The calculations were made for 1989, the last year before "critical" year reductions in CVP and SWP water allocations were instituted.

In terms of total value of production in 1989, the case studies range from a high of over $707 million (Westlands WD) to a low of just over $10 million (El Dorado ID). The per

1 Farmer decisions on cotton acreage are also affected by federal commodity program options (e.g., 0/92 and 50/92). The participation ratio of WRM growers in these programs was not determined, but will be explored and analyzed in Phase III of the study (along with other districts).

Table 5.6: Acreage by Crop, Westlands WD

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
alfalfa hay	14793	18250	16855	13771	13450	10182	11438	6256	10887	11136	10768	10134	8738	10042	11482	10716	7628
alfalfa seed	24943	14675	11841	17337	14162	18925	15103	17552	10832	15235	14486	19130	17839	14321	13453	13049	10665
almond	4220	6108	6023	6531	6991	7738	8038	8116	7586	7940	7959	8301	7972	7363	8381	7159	9302
apple	0	0	15	63	15	15	18	18	18	17	18	14	70	0	411	360	na
apricot	0	0	0	0	0	0	0	22	95	101	122	122	135	151	172	236	na
asparagus	461	750	795	54	0	0	0	0	483	412	352	382	443	477	642	547	na
barley	113398	120126	104138	126862	78840	76547	54206	45818	21004	22674	24901	22996	12866	10678	15953	8587	4468
bean-dry	1615	3092	661	1873	1090	2149	2755	4033	101	3872	7545	6074	3740	8691	10052	6259	4537
bean-green	2525	0	1185	2370	4739	3735	4730	2368	7869	0	477	0	2282	0	2070	1127	3444
broccoli	0	0	35	38	261	25	0	0	259	1307	2308	4130	6413	5137	2175	1003	na
cabbage	0	10	0		0	0	0	0	0	0	0	0	111	464	361	26	na
cantaloupe	11587	13765	11136	19929	19467	18037	16641	17237	21523	21008	20190	25345	23152	18603	21310	20402	19634
carrots	180	175	0	0	0	585	120	0	706	946	1176	1990	2412	2749	1930	1262	na
cauliflower	0	0	25	193	436	100	477	0	0	338	155	229	435	1136	170	0	na
corn	1025	1300	77	298	1193	2296	3974	6308	6645	7974	8024	9683	4726	2528	1977	1638	1168
cotton	145537	174733	193346	272061	300563	284688	300309	277064	230307	297174	286169	231142	266483	290062	241995	241076	209385
cucumber	0	25	0	0	0	0	155	106	0	26	0	0	20	0	0	234	na
eucalyptus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	53	280	na
garlic	1499	1396	1737	1856	2670	3427	4602	7510	9118	8132	8670	9011	11583	11345	12338	14500	14970
grapes	3814	4148	4410	4566	4924	4882	5683	6324	5417	6767	6633	6363	6416	5796	5821	5867	4224
honeydew	120	0	0	100	150	0	0	0	399	348	225	624	1881	1198	1582	1825	1832
jojoba	0	0	0	0	0	0	0	0	0	0	0	0	10	10	11	11	na
lettuce	2888	2744	4079	7358	8876	7490	7330	6491	11510	7971	14692	13426	14603	16112	15231	12811	17652
nectarine	0	0	0	0	0	0	0	74	75	116	72	242	171	193	193	248	na
oats	0	280	162	677	0	0	0	174	0	0	255	942	0	446	1853	0	na
olive	106	255	247	423	423	412	423	423	423	423	423	422	413	413	413	583	na
onion	3243	3741	2047	2433	4320	3803	6393	8772	9070	8921	9954	11357	12230	12704	12839	11442	9783
orange	0	160	157	157	157	157	157	157	157	182	163	168	167	167	190	207	na
pasture	0	0	218	1697	227	210	254	501	382	344	261	355	540	631	482	474	na
peach	0	0	0	0	0	0	0	30	58	51	54	20	0	20	126	190	na
peas	0	1542	1623	1157	1372	1259	299	617	1535	2320	231	301	0	0	2009	1109	1281
peppers	562	453	76	532	877	972	1321	1110	1498	1039	1392	2320	2202	2253	547	993	na

Table 5.6 (continued)

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
pistachio	70	347	757	565	584	572	886	2243	1968	2102	2252	2534	3215	2403	3365	3120	5039
pomegr.	564	564	485	669	724	722	580	547	473	504	521	499	542	594	700	797	na
potatoes	200	130	116	0	405	0	0	0	0	0	0	0	0	0	0	0	na
rice	3523	2418	0	1080	638	1649	1676	435	291	388	37	153	84	0	0	0	na
safflower	14670	2843	5745	9393	14550	9982	7219	10507	9573	8161	3846	13447	4127	4776	8531	13541	5482
seed crops	0	200	146	631	1098	412	467	665	106	2584	434	543	745	1196	1448	1234	576
sorghum	9261	720	280	5813	555	635	442	2680	276	1060	0	323	0	0	0	0	na
spinach	0	0	0	75	133	0	0	0	0	0	0	0	0	0	78	0	na
sugar beet	18506	16327	3516	6746	9901	11194	11455	7046	5203	5699	8841	11880	9730	8337	7806	7393	1959
tomatoes	40691	43314	32217	30224	37504	27857	29656	45000	56949	59817	54211	60816	60095	65040	80903	95159	107156
walnut	76	70	63	38	21	82	133	124	137	33	150	248	252	250	252	264	na
watermelon	80	0	0	0	0	0	0	0	220	105	63	390	109	25	65	120	na
wheat	38683	29093	3625	1591	16051	55637	60507	62528	49045	50314	49989	36118	26595	24641	23399	26407	13526
no bearing	1935	0	0	0	533	275	128	617	1286	15	558	821	236	2497	1647	6081	3428
nonhrvstd	0	0	0	0	609	347	707	3278	1464	773	3245	821	449	1578	743	4530	na
misc	723	0	0	0	0	0	12	10	5000	60	0	394	210	0	0	47	na
double crop				9021	8202	8806	13196	14850	11537	6532	13847	13053	13834	12576	11921	7069	na
total	465795	465325	477316	566475	566050	564719	563301	564039	567184	568197	568554	568986	566844	568083	567817	568389	na
fallow	4297	0	69548	36335	25743	16527	18203	26128	88773	16340	30579	67829	66236	45632	64579	52544	104000

Source: District Crop Surveys. Data for 1991 is incomplete and preliminary. Crop surveys in 1975-77 did not include the entire District.

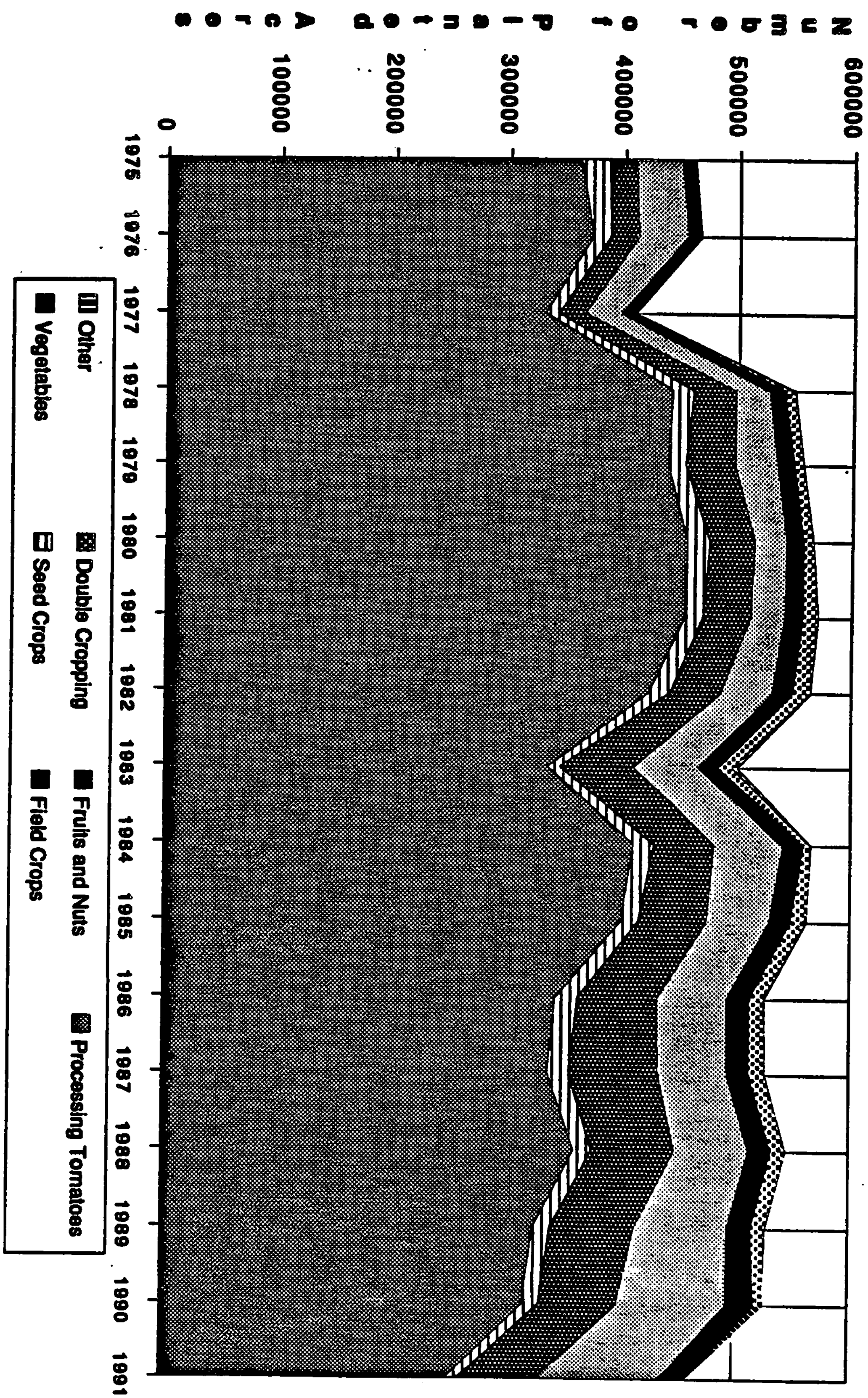


Figure 5.12: Distribution of Crop Types, Westlands WD

Source: District Crop Surveys

Table 5:7: Acreage by Crop, Wheeler Ridge-Maricopa WSD

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
cotton	32141	46368	38066	52329	59953	58933	60235	44175	31245	49549	42435	33251	39137	44999	35809	38071	16044
green feeds	1566	2065	2417	1286	1131	1510	1393	2042	1841	2636	2460	2652	2633	1864	2656	2482	1827
grain	18429	13655	5182	13133	4906	9651	10931	14379	8465	10431	10678	9462	4594	3120	5031	2692	3447
sugar beets	4058	3107	1390	1052	1321	2684	2596	1325	1060	713	981	716	486	293	75	723	745
grapes	9035	8802	8141	8628	8887	10693	10419	11276	12296	12711	12644	12618	12718	10714	10648	10719	11011
vegetables	22484	21279	16306	18043	21255	17021	15009	20263	19113	18966	20180	18383	16983	16541	20428	19504	17329
fruits/nuts	7267	7512	7491	6782	7099	7421	9407	9405	9454	9286	8996	9035	8539	8424	8786	9182	9182
misc	92	104	58	42	0	0	0	0	0	0	0	0	0	0	6	10	10
citrus	5231	5504	5125	4689	4191	4115	3933	3895	3983	4017	3900	4425	4619	5208	5498	6212	6288
subtotal	100303	108396	84176	105984	108743	112028	113923	106760	87457	108309	102274	90542	89709	91163	88937	89595	65883
double-crop	8365	8306	2862	4750	9568	4867	6034	6842	4425	6220	4490	4420	5720	4810	6035	5314	4090
total	91938	99736	81314	101234	99175	107161	107889	99918	83032	102089	97784	86122	83989	86353	82902	84281	61793
fallow	4541	717	21424	4385	10177	1527	1601	10170	29863	9734	13669	25929	27501	25427	28611	27588	56540

Source: District Crop Surveys. Data for 1991 is preliminary.

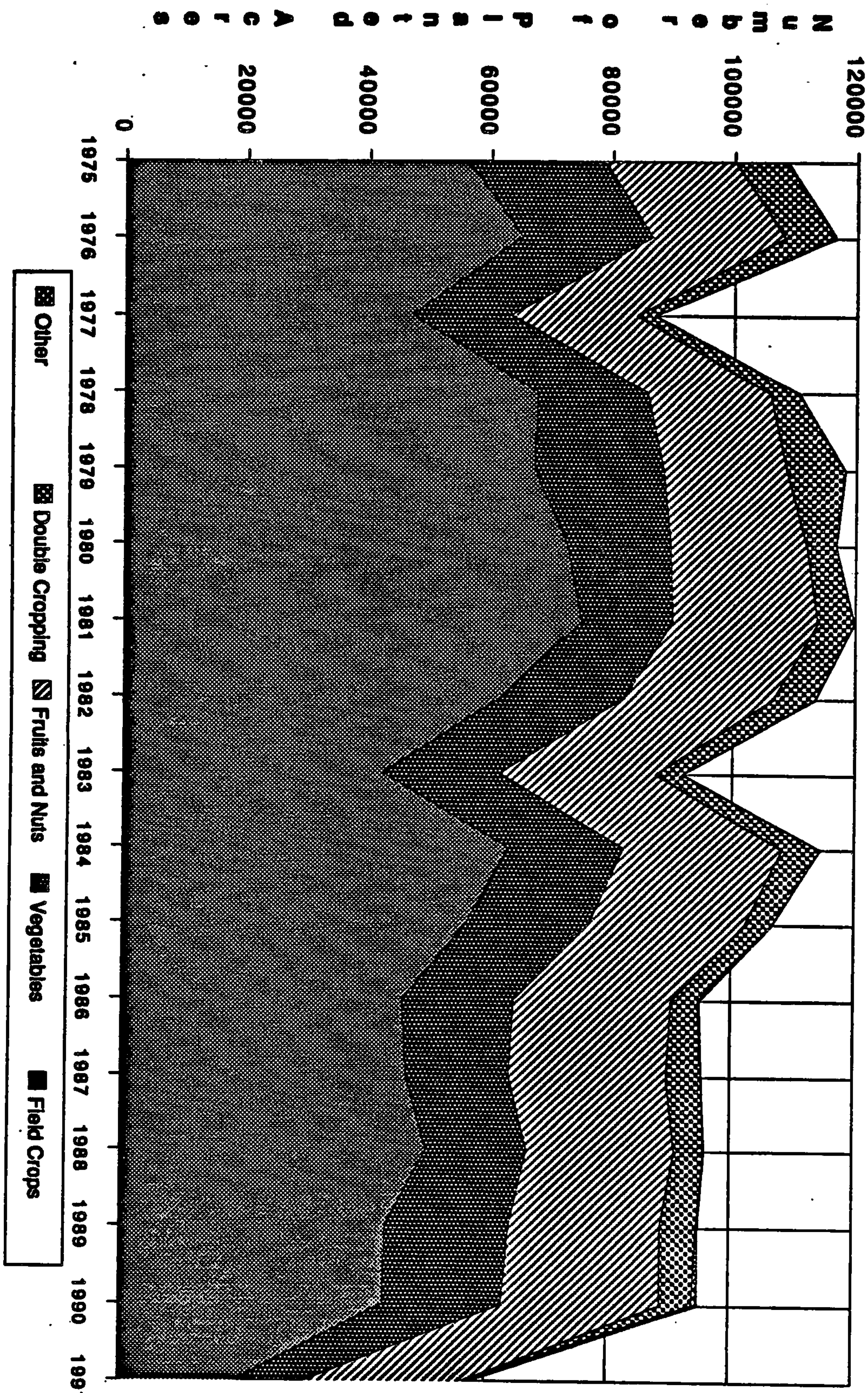


Figure 5.13: Distribution of Crop Types, Wheeler Ridge-Maricopa WSD
Source: District Crop Surveys

Table 5.8: Gross Value of Production, Case Study Districts, 1989

District	Total Value (thousands)	Value Per Acre	Leading Crops by Value of Production
Arvin-Edison WSD	$312,424	$3,392	Grapes, Potatoes
Central California ID	$116,911	$821	Cotton, Alfalfa
El Dorado ID	$10,010	$1,436	Apples, Nursery
Glenn-Colusa ID	$84,103	$811	Rice, Tomatoes
Lost Hills WD	$48,341	$1,101	Cotton, Grapes
Westlands WD	$707,684	$1,246	Cotton, Tomatoes
Wheeler Ridge-Maricopa WSD	$203,211	$2,285	Vegetables, Grapes

Footnotes: Total gross income and gross income per acre were calculated using district crop surveys for data on planted acreage and County Agricultural Crop Reports for data on yields and prices. Adjustments were made to match crop categories used by the districts with the crop categories in the Agricultural Crop Reports. For example, several districts recorded "grapes" as a crop, while the Agricultural Crop Reports distinguish between raisin, table and wine grapes. In this case, simple average prices and yields for all three kinds of grapes were used in determining the gross value of "grapes" in each district. These adjustments were made to several other crop categories including "fruits and nuts," "vegetables" and "grains."

Sources: Arvin-Edison WSD: District Crop Surveys and the Kern Cty. Ag. Crop Report, 1990. Central California ID: District Crop Surveys and the Merced Cty. Annual Report of Ag., 1990. El Dorado ID: Acreage, price and yield data were obtained from the El Dorado County Agricultural Crop Report, 1990, and personal communications with Edio Delfino, El Dorado County Agricultural Commissioner. Glenn-Colusa ID: District Crop Surveys and the Agricultural Crop Report, County of Colusa, 1990. Lost Hills WD: District Crop Surveys and the Kern County Agricultural Crop Report, 1990. Westlands WD: All data were provided by the District. Yield and price data were verified using the 1990 Fresno County Agricultural Crop and Livestock Report. Wheeler Ridge-Maricopa WSD: District Crop Surveys and the Kern County Agricultural Crop Report, 1990.

Figure 5.14: Gross Total Value of Production, Case Study Districts, 1989

Source: District Crop Surveys and County Agricultural Crop Reports

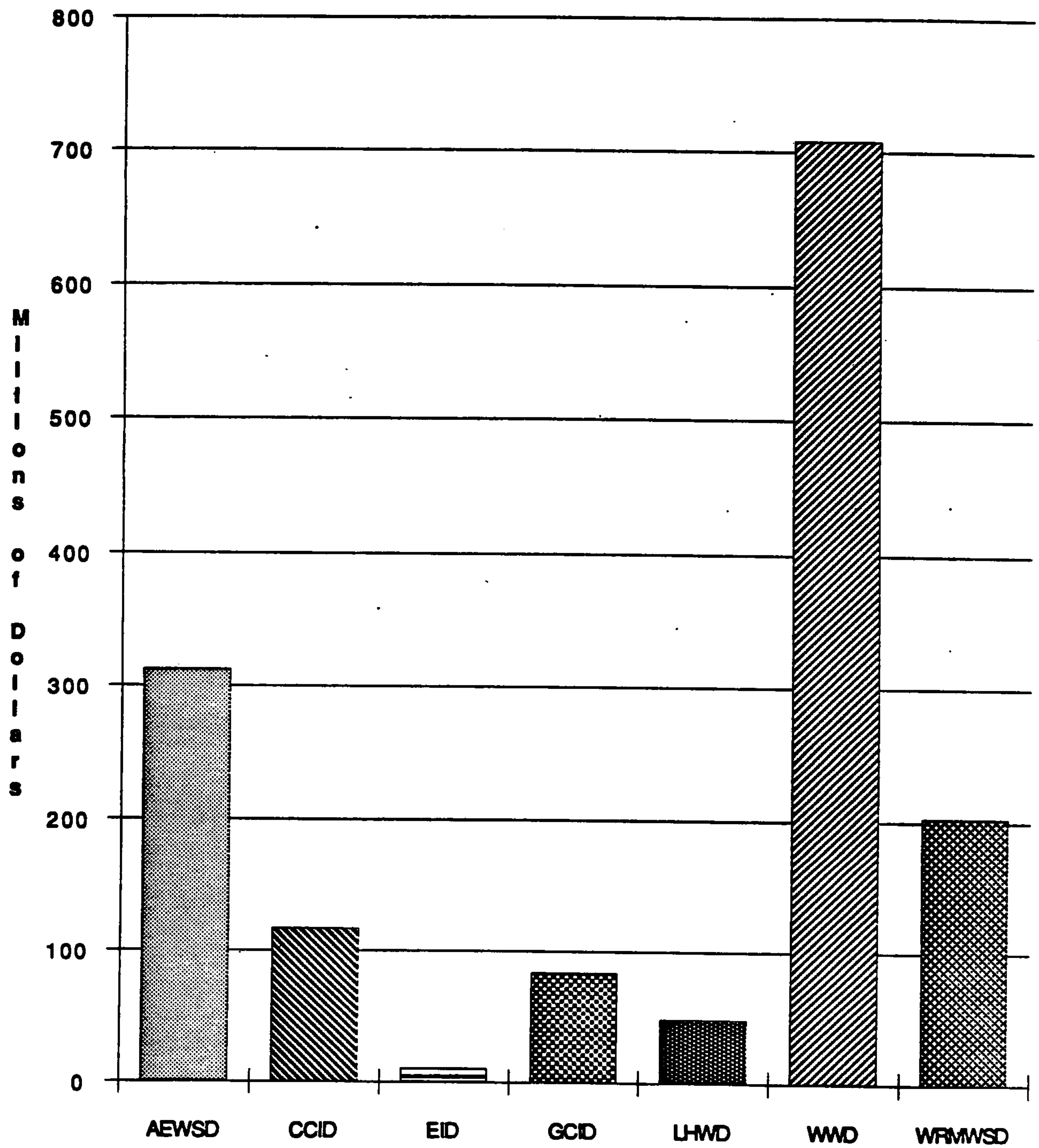
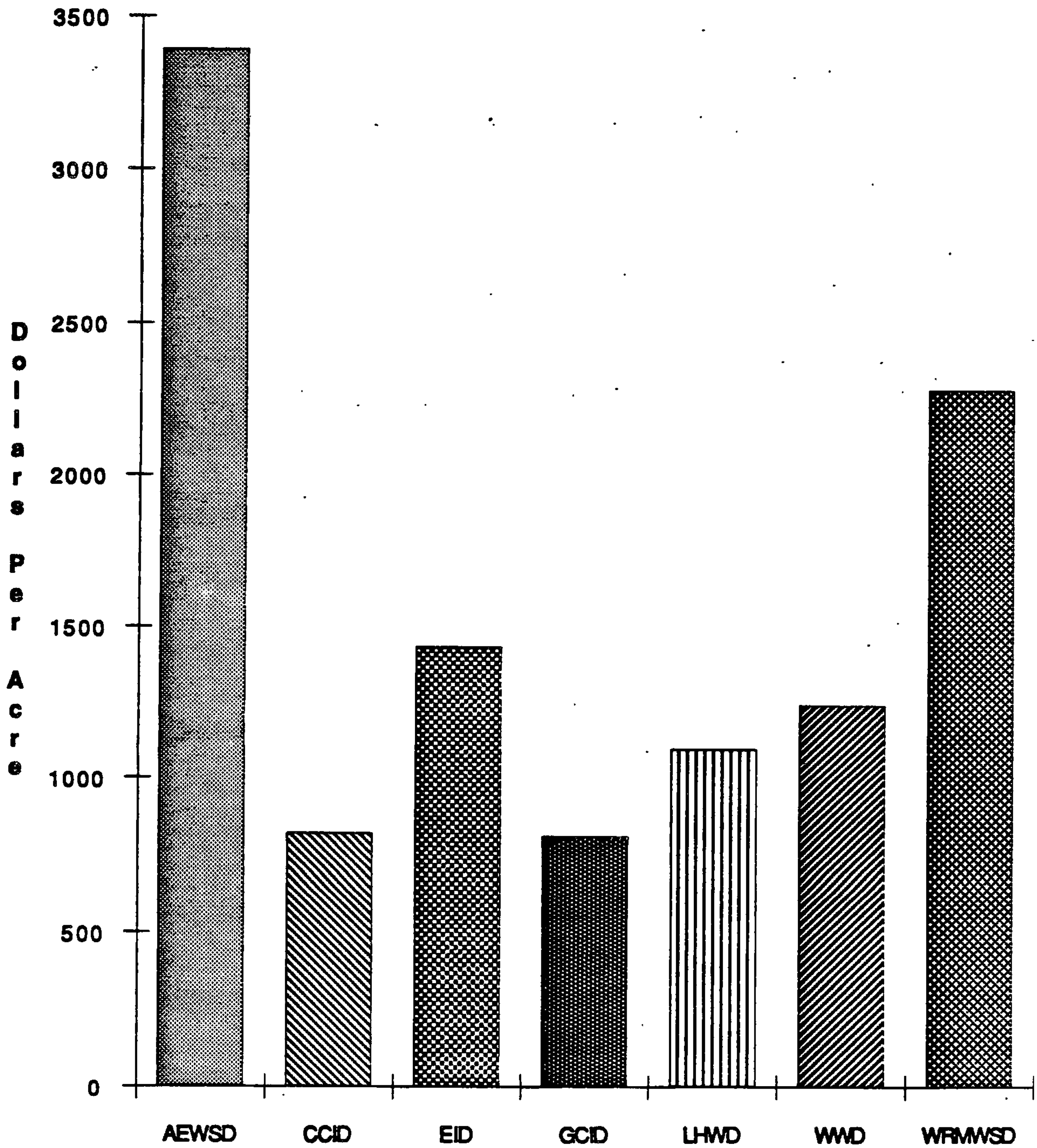


Figure 5.15: Gross Value of Production Per Acre, Case Study Districts, 1989

Source: District Crop Surveys and County Agricultural Crop Reports



acre value estimates indicate that Arvin-Edison WSD and Wheeler Ridge WSD in Kern County and El Dorado ID in the Sierra foothills grow the highest value crops per unit of land (principally grapes, potatoes, vegetables, fruit trees), while Central California ID and Glenn-Colusa ID grow the lowest value crops (principally cotton, alfalfa, rice). Lost Hills WD and Westlands WD fall somewhere in between with principal crops including both lower-value crops (cotton) and higher-value crops (grapes, tomatoes). In 1989, gross value of production per acre ranged from $3,392 (AEWSD) to just over $800 (CCID, GCID).

Expected crop profitability (gross value of production minus costs), perhaps more than any other variable influences farmers' cropping decisions. However, shifting into more profitable crops often involves considerable financial risk and may be constrained by unfavorable soil and climatic conditions. Water scarcity and higher water costs can affect net crop returns both positively and negatively depending upon demand elasticities of production and market share. In Phase III of the study, net crop returns for producers in the case study districts will be calculated for a "base" water year and compared with net returns in moderate (1990) and severe (1991) water short years, as an indicator of both ability to shift cropping patterns in the short-run and constraints on shifts likely to affect long-run adjustments.

5.2.3 Number of Farms and Indicators of Farm Size

Farm size is likely to influence several aspects of the water shortage adjustment process. Size can be defined both in terms of gross acreage and gross value of production. These measures result in very different notions of size. Orchards and vineyards, for example, may be relatively small in terms of acreage but high in per-acre value of production. Cotton production, on the other hand, generally takes place on larger landholdings but the per-acre value of production is considerably lower.

Larger farm entities are likely to have greater flexibility for adjusting to changes in water supplies than smaller farms. Greater financial resources provide the opportunity to make large capital investments, including well development and purchases of specialized equipment. Adequate financial resources are also necessary to make use of high cost water options. Larger farm entities may employ irrigation specialists and other consultants who can guide the adjustment process, spreading the costs of this expertise over more acres.

They are also more likely to receive water from more than one source by owning land in more than one irrigation district.

Smaller producers, on the other hand, may be able to take advantage of production and irrigation techniques that require "hands on" supervision and management. These techniques can be especially effective in a water-constrained environment. Also, producers who lease their land or equipment face less financial risk than operators with large fixed investments.

Data on farm size were tabulated by the case study districts using one of two criteria: farm operations and land ownership. A farm "operation" is defined as the land that is controlled by an "operator," that is, "a person who operates a farm, either doing the work or making day-to-day decisions" and can include owners, managers, tenants, renters and sharecroppers (U.S. Department of Commerce). Thus, there can be several owners of a single operation, or several operations owned by the same landowner. The size distribution of farming operations for Central California ID, Lost Hills WD and Westlands WD is presented in Table 5.9. The size categories were dictated largely by the need for consistency between the district data sets.

Central California ID is characterized by smaller farming operations. More than 80 percent of the operations in the District have fewer than 320 acres and less than five percent have more than 961 acres. In all, there are 684 operations in the District.

Lost Hills WD has a mix of both small (less than 320 acres in this case) and large operations. Six of the seventeen operations in the District have less than 320 acres, while ten have more than 961 acres.

In Westlands WD, more than half of the operations are between 321 and 960 acres. The remainder is equally distributed between farms under 320 acres and over 961 acres. The number of Westlands water users, defined as the number of water bills that are sent out by the District, is 618 (WWD, November 1991).

The four other case studies (Arvin-Edison WSD, El Dorado ID, Glenn-Colusa ID, and Wheeler Ridge-Maricopa WSD) provided the study with land ownership data. Individual landholdings are often smaller than farming operations and thus cannot be directly compared to the farm operation data presented above. Information on land ownership is presented in Table 5.10.

Table 5.9: Farming Operations in Selected Case Study Districts

District	Distribution of Acreage (percent)					Total Number of Operations
	<320	321-960	961-1,280	1,281-5,000	>5,000	
Central Calif. ID	83	14	1	2	0	684
Lost Hills WD	35	6	12	29	18	17
Westlands WD (a)	21	53	20	5	1	na

Footnotes: (a) Data is from a random sample of 613 farming operations.

Sources: District documents and personal communications.

Table 5.10: Land Ownership Patterns in Selected Case Study Districts

District	Distribution of Acreage (percent)					Total Number of Operations
	<320	321-960	961-1,280	1,281-5,000	>5,000	
Arvin-Edison WSD	79	16	4 (a)	2 (b)	0	456
El Dorado ID	100	0	0	0	0	217
Glenn-Colusa ID	91	8	1	1	0	1,088 (c)
Wheeler Ridge WSD	73	17	4	4	2	171 (d)

Footnotes: (a) Includes landholdings between 960 and 1,920 acres. (b) Includes landholdings over 1,920 acres. (c) Data is from a sample of 615 landholdings in the District. (d) Includes only landowners in the surface water service area.

Sources: District documents and personal communications.

Arvin-Edison WSD is characterized by relatively small landholdings. Nearly 80 percent of the parcels are less than 320 acres, sixteen percent of the landholdings are between 320 and 960 acres and approximately five percent are larger than 960 acres. In all, there are 456 landowners in the District.

In El Dorado ID, one hundred percent of the parcels are less than 320 acres; most are less than 40 acres. In all, there are 217 landowners in the District who currently are eligible for "commercial metered irrigation" water rates (>5 acres).

In Glenn-Colusa ID, more than 90 percent of the parcels are less than 320 acres. Of the remainder, eight percent are between 320 and 960 acres and one percent are larger than 960 acres. In all, there are approximately 1,000 landowners in the District, including some houses and lots that are not irrigated.

Approximately 73 percent of the parcels are less than 320 acres in Wheeler Ridge-Maricopa WSD, 17 percent of the parcels are between 320 and 960 acres and 10 percent are larger than 960 acres. In the "surface water service area" there are 171 landowners. Information was not available on the number of landowners in the "groundwater service area."

5.2.4 Land Values

Land values may be important in the adjustment process to the degree that they are affected by water availability. Land values are determined by the returns (i.e. profits) that can be generated by the most profitable enterprise that the land can support, and are revealed through market transactions. They can also be determined by calculating the present net value of the stream of future income derived from the land (after all other resources have been paid at economic rates). Since future income is uncertain, however, land values are somewhat subjective. In addition, site-specific characteristics of a particular parcel of land, such as soil type, drainage problems and microclimate, can greatly affect its value.

Anecdotal information about current land values was obtained in five of the seven case study districts. This information is by no means comprehensive and the study team did not attempt to confirm land value estimates, though this task will be important during Phase III of the study.

In Arvin-Edison WSD, cropland values are estimated to range widely from $1,000 to $4,000 per acre. The average cost of renting is approximately $150 per acre per year. Land values are relatively high in the District because of its conjunctive use water management program, excellent soils, warm winters that allow early harvesting and the District's proximity to Bakersfield and the Los Angeles basin.

In Central California ID, the better cropland is estimated to be worth approximately $4,500 per acre. The cost of renting is approximately $150 per acre per year. Land values are sustained, in part, by the relatively secure water rights derived from the District's "exchange contract" with the USBR and by groundwater pumping opportunities. In a few locations, land values are elevated by increasing demand for residential housing. A producer interviewed for the study claimed that land with the same characteristics in the adjacent San Luis Water District, a CVP service contractor, is valued at only about $1,500 per acre.

In El Dorado ID, prime cropland in the "Apple Hill" area of the District is estimated to be worth approximately $10,000 per acre. Other parts of the District have good agricultural land worth approximately $6,000 per acre (Edio Delfino, El Dorado County Agricultural Commissioner). These high land values reflect investments in high-value orchard crops, relatively secure water rights and, perhaps most importantly, increasing residential development in the area.

In Glenn-Colusa ID, cropland is estimated to be worth approximately $4,000 per acre. This relatively high value reflects both the District's reliable water supply through secure water rights and the capitalized value of future commodity program benefits paid to rice producers.

In Westlands WD, average cropland is estimated to be currently worth about $2,000 per acre. This is below levels recorded four years ago of approximately $2,500 to $2,800 per acre. The cost of renting an acre of cropland was estimated to be $200 to $300 per acre. Land values are linked to the three "priority areas" that receive different water allocations from the District.

Information on land values was not obtained from Lost Hills WD nor Wheeler Ridge-Maricopa WSD. This information will be collected in Phase III of the study.

5.3 Farm Level Surface Water Supplies

In a "normal" water year, producers in the case study districts generally are allocated between 1.30 and 3.75 AF of water per acre of cropland (see Table 4.9: Water Allocations by District). In two case study districts, Glenn-Colusa ID and El Dorado ID, water is available "on demand," meaning that no fixed limitation in water deliveries has been established by the Districts. Water is allocated on a "pro-rata" basis in Central California ID and Lost Hills WD. In Westlands WD, a fixed amount of water is allocated to three separate "priority areas" according to contractual agreements, and then on a pro-rata basis to producers within each priority area. Finally, Arvin-Edison WSD and Wheeler Ridge-Maricopa WSD allocate water on the basis of water service contracts with producers that specify the amount of water that is delivered to each acre of cropland.

Reductions in district allocations of surface supplies have had disparate effects on producers in the case study districts. As a consequence, farm-level adjustments should vary. For instance, in 1991 El Dorado ID did not reduce its supply of water to agriculture and few short-run changes related to water supply reductions have occurred. In contrast, producers in Lost Hills WD, Westlands WD and Wheeler Ridge-Maricopa WSD received approximately one-fifth of their normal surface supplies, though the reductions were partially mitigated in some areas by groundwater pumping and water purchases.

5.4 Mechanisms to Maintain and Enhance Water Supplies

As with districts, a key objective of producers is to maintain a stable water supply. Faced with allocation reductions, producers will have to make fewer changes in their farming operation if replacement supplies can be found at a reasonable price. Even if the marginal cost of replacement water is high, producers may still find it prudent to assume the expense. If annual crops have already been planted or permanent crops predominate, producers must purchase more expensive water at the margin to protect their investment.

In the longer-run, the decision to rely on alternative sources of water is more complicated, particularly if average water costs escalate. Other strategies for coping with water supply reductions (e.g. changing cropping patterns or increasing efficiency) are likely to be evaluated to determine the most profitable path of adjustment. In some cases, adoption of all three strategies might be the most efficient adjustment mechanism.

5.4.1 Extraction of Groundwater by Producers

5.4.1.1 Introduction

During normal water years, a significant portion of California agricultural water supplies are pumped from underground sources, generally varying between 20 and 40 percent. Some producers have no other supply of water for meeting crop needs. Other producers use groundwater to supplement surface supplies during peak demand months. In critically dry years, groundwater is pumped at significantly higher rates. In 1991, an estimated 20 million acre feet of groundwater was extracted throughout the state, of which agriculture utilized a dominant share (DWR Drought Hotline, 1991).

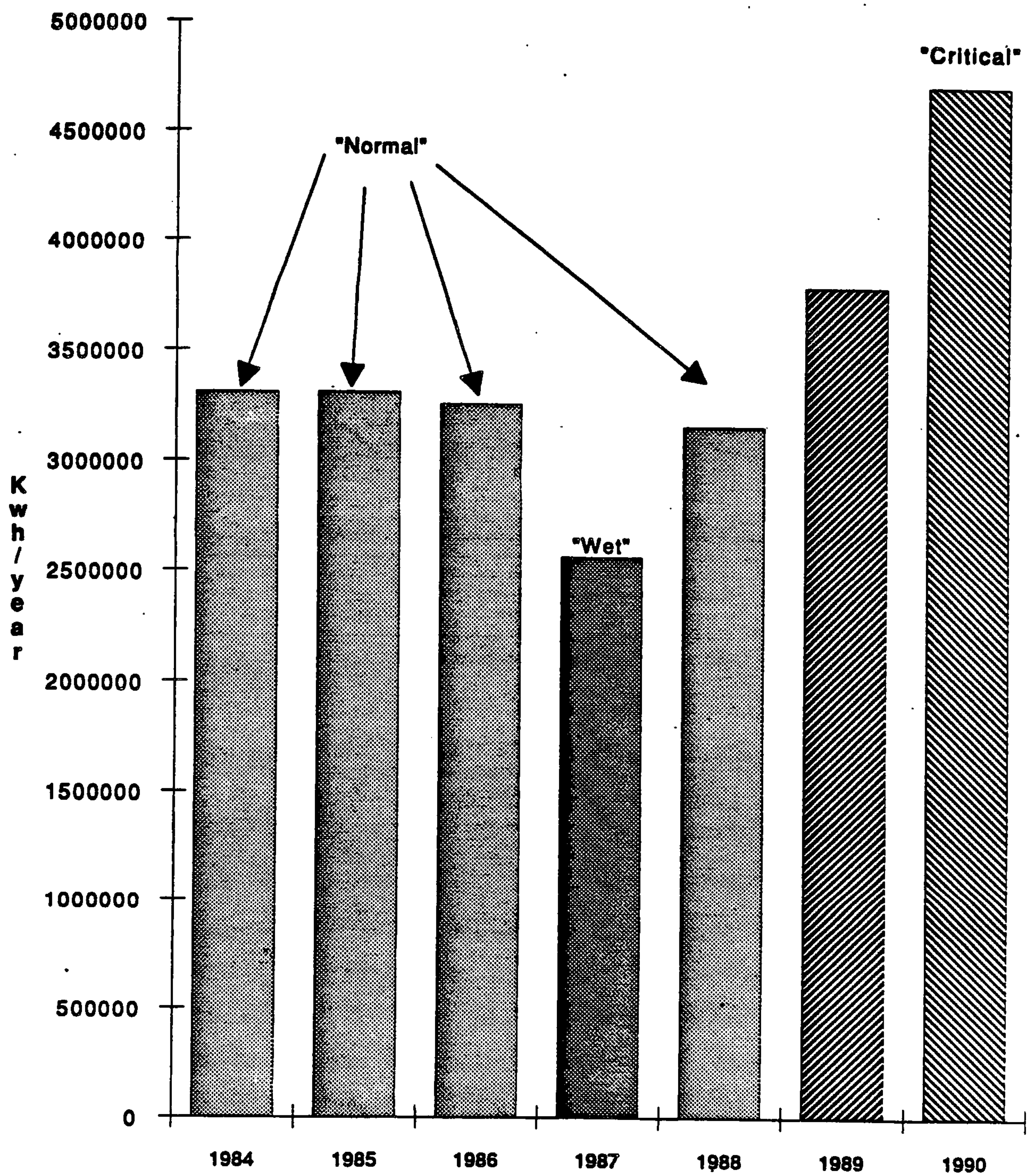
It is difficult to determine on-farm groundwater extraction rates. Many wells were constructed before DWR required notification. Even when the location of a well has been recorded, it is not always possible to obtain information on time of operation, groundwater yields and pumping lift.

To overcome these information limitations, groundwater extraction levels by agricultural producers can be estimated using one of three methods. First, if the amount of electricity consumed by producers can be determined over a period of time, pumping can be estimated by making assumptions about non-pumping electricity use, pump efficiencies, pump lifts and the proportion of wells with electric pumps. Estimated electricity use by agricultural producers in PG&E's California Service Area, presented in Figure 5.16, shows that electricity use is negatively correlated with high runoff and precipitation levels. Approximately 80 percent of agricultural electricity use is for irrigation (PG&E, various reports).

Second, if cropping patterns and surface water supplies are known, a derived demand methodology can be used whereby surface supplies are subtracted from the estimated water application rate, leaving a residual estimate of groundwater pumped. As will be noted below, Westlands WD and Wheeler Ridge-Maricopa WSD use this derived demand methodology to estimate groundwater pumping by their producers.

Third, farm surveys can be used to ask producers how much groundwater they pump or to test sample wells. This method is not necessarily reliable since most producers do not have water meters on their wells nor good records on flow rates.

Figure 5.16: Electricity Use by California Agricultural Customers in PG&E's Service Area



Source: Pacific Gas and Electric

Aggregate data on irrigation well development for the San Joaquin Valley indicate that a large number of new irrigation wells were drilled in response to the drought in 1976-77. Since then, the Department of Water Resources has required notification when new wells are constructed. These data are presented in Figure 5.17 which shows the number of new wells constructed in the San Joaquin Valley over the period 1977-1991. Well development activity has been increasing with the current protracted drought (1987-1991).

5.4.1.2 Advantages of Groundwater

For producers attempting to adjust to shortfalls in surface supplies, groundwater pumping has a number of advantages over other alternatives. First, groundwater is widely available in the Central Valley; producers in five of the seven case study districts have access to recoverable groundwater. Second, producers can usually pump groundwater near the point of use, thus reducing conveyance costs and losses. Third, groundwater supplies are generally reliable during drought years, even though increased pumping may lead to a drop in groundwater levels over time.

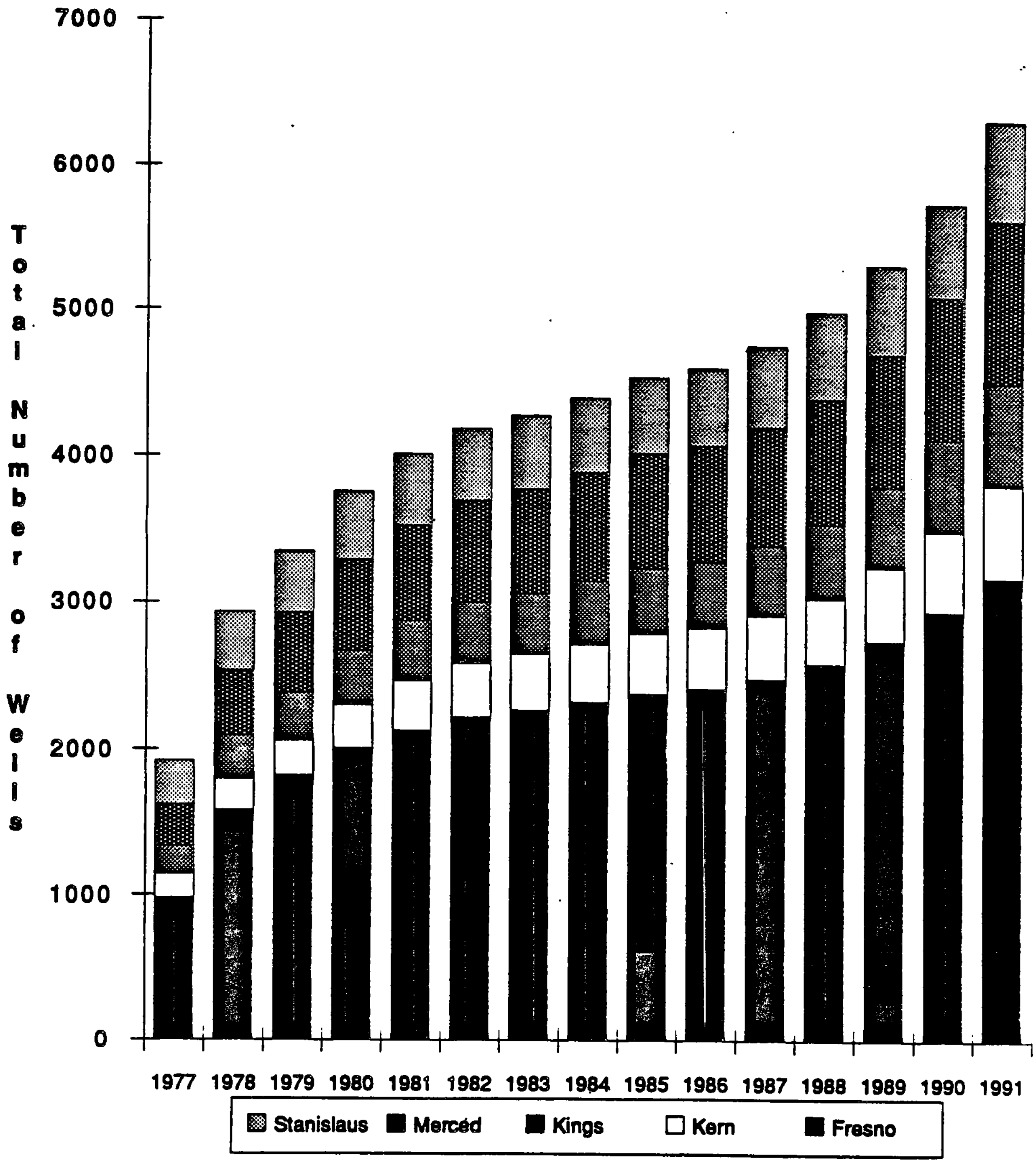
In addition, producers can usually drill new wells and/or increase their pumping without encountering legal, institutional or governmental constraints. None of the case study districts limits, regulates or taxes groundwater withdrawals by its producers. Indeed, none as yet has statutory authority to regulate or tax groundwater (except perhaps in connection with recharge operations). Neither irrigation nor water districts have any express powers to monitor, tax or restrict groundwater pumping. Water storage districts are authorized to "fix tolls or charges for the use of water, including the use of groundwater, or for any other service of any type or nature, whether or not related to water use, *rendered by the District*" (Cal. Water Code section 43006) (emphasis added).

At the state level, producers do not need to obtain a permit or license to drill new wells or increase their pumping. Notice of new well drilling must be filed with the DWR and the County both before and after finishing the well, but the DWR is not authorized to determine whether or not the well should be drilled or to limit its use.

As discussed in Chapter 3, California judicial law theoretically limits the amount of water that any groundwater user can withdraw. Overlying owners are limited to a "fair and just" share of the safe yield. To the extent that overlying owners do not consume the entire safe

Figure 5.17: Cumulative Well Development in the San Joaquin Valley, Selected Counties

Source: DWR Water Well Driller Reports



yield, the surplus can be appropriated for use on non-overlying land. In no case is the safe yield of an aquifer supposed to be exceeded. These judicial limitations, however, are currently enforced only through complex, costly and lengthy court adjudications. Because of the drawbacks of these adjudications, few have been filed in California.

5.4.1.3 Costs of Groundwater Development

Although increased groundwater pumping is largely unregulated and carries a number of advantages, anecdotal evidence from district interviews suggests that development of groundwater supplies is costly. Drilling a test well in Westlands WD is reported to cost as much as $10,000. Depending on well depth, soil characteristics and the type of pump, new wells in Westlands WD cost between $150,000 and $400,000. The cost to refurbish an existing well can exceed $50,000. The cost of a new diesel pump is around $35,000 and rental rates are approximately $2,000 per month, depending on size and location. Pump owners must commit to a standby agreement with the utility company, which may apply before and beyond the use period. Standby charges, maintenance and other incidental costs add to the cost of groundwater extraction. PG&E standby charges for a producer in Westlands WD, for example, were approximately $1,000 per month in 1991.

The variable costs of groundwater pumping depend on well depth, pump efficiencies, electricity rates and other factors. Arvin-Edison WSD estimated that the energy cost for pumping 1 AF of groundwater through its high-capacity wells is approximately $0.12 per foot of lift. With an average lift of 450 feet, the electricity to extract groundwater costs approximately $54 per AF.

Small producers are likely to use less powerful, less efficient pumps, many of which were purchased during the 1976-77 drought. A producer in Westlands WD pumping from 450 feet below the surface, for example, estimated that the cost of electricity to extract 1 AF of groundwater was $70, or $0.16 per foot of lift, plus an additional $20/AF in maintenance and other variable expenses. Increasing electricity rates are convincing some producers to rent or purchase diesel pumps which have lower operating costs, though the purchase price and maintenance costs are considered higher than for electric pumps.

Observed Responses—In only two case study districts, Westlands WD and Wheeler Ridge-Maricopa WSD, are estimates of producer groundwater extraction available. These estimates were made by the districts using a derived demand methodology, which relies on cropping patterns and available surface supplies to calculate the groundwater contribution to total water application. Anecdotal information on pumping levels was obtained for the other districts. Phase III of the study will include a more detailed examination of groundwater extraction, including estimates of producer pumping in all districts.

Producers in Arvin-Edison WSD extract significant amounts of groundwater, particularly in water short years. However, not all producers in the District have access to groundwater supplies due to variations in the local hydro-geology. The groundwater table rests between 250 and 650 feet underground with an average depth of approximately 300 feet. The quality of the groundwater is satisfactory for most District crops.

Producers in Central California ID also extract significant amounts of groundwater. Groundwater pumping is particularly important to vegetable growers in the northern part of the District who use it for double and triple-cropping regimes. Farm-level pumping estimates are not available. The District has a standing offer to purchase producer-pumped groundwater for $30 per AF. Even this relatively low price attracted 40 sellers in 1991. Groundwater quality is said to be deteriorating with the increased pumping.

Aside from a few domestic use wells, producers in El Dorado ID extract very little groundwater. For the most part, the local hydro-geology is not conducive to development of groundwater supplies.

Farm-level pumping estimates for Glenn-Colusa ID are currently not available. The District reported limited groundwater extraction by producers. Groundwater pumping from the gravel strata beneath the surface clays may become a viable option for producers given the recent success of a test well drilled by DWR and the District. As the CVP contract comes closer to re-negotiation in 2004, the District is investigating whether it would be feasible to replace the 105,000 AF of annual "contract water" with groundwater extractions (GCID, *Waterline*, October 1989).

Lost Hills WD reported very little groundwater extraction by producers. The District overlies a shallow aquifer with poor quality water and very low well yields. During the 1977 drought, some landowners drilled deep wells (800-1000 feet deep) to investigate the groundwater potential, but found only brackish water at 300 to 350 feet. There is some interest by District producers to augment total supply by blending the brackish groundwater with surface supplies as needed in the future.

In Westlands WD, approximately 300,000 AF of groundwater was pumped in 1990. In 1991, groundwater pumping by producers increased to 575,000 AF. This compares to an estimated "safe yield" of between 100,000 and 135,000 AF per year (see Figure 5.18). Overdraft has led to several problems in the past including reduced well yields, deteriorating water quality, land subsidence and increased pumping lifts and costs. The average pumping lift in the District is around 450 feet, though in some places it exceeds 800 feet.

Producers with excess pumping capacity may participate in the District's Groundwater Exchange Program. This program allows producers to pump water into the conveyance system and sell their surface allocations to other District producers. Westlands WD also has a Groundwater Integration Program to encourage producers to pump water into the conveyance system in exchange for future surface supplies. This program allows eligible producers to pump water during low demand months for storage in District canals in exchange for District supplies when demand is high. This alleviates inter-temporal distribution problems and augments surface water supply during peak demand when low rates of groundwater flow are insufficient to meet irrigation needs.

Wheeler Ridge-Maricopa WSD is comprised of both a "groundwater area" where producers rely exclusively on groundwater to meet their irrigation needs, and a "surface water service area" where producers receive SWP water. Average groundwater extractions throughout the District were estimated to be 53,600 AF per year between 1975 and 1989 (excluding 1977). In 1990 and 1991, groundwater pumping increased to an estimated 65,200 AF and 115,000 AF, respectively (See Figure 5.19). The District has not developed a "safe yield" figure to date.

Physical Constraints—As discussed above, groundwater is not available to all producers in the case study districts. Even where groundwater is available, its quality may be an important constraint. In Westlands WD, for example, some producers applied groundwater to their fields in 1991 despite total dissolved salt (TDS) levels as high as 2,500 parts per million (ppm). Well water in Central California ID is progressively deteriorating, particularly around the town of Mendota. Groundwater quality is poor in the western portion of Wheeler Ridge-Maricopa WSD as well.

Groundwater is not well-suited to meet peak water demands. Flow rates from producer wells are generally fixed, ranging in the case study districts from one to five cubic feet per

Figure 5.18: Estimated Producer Groundwater Extractions, Westlands WD

Source: Westlands Water District Facts and Figures (1989) and Communications with Shelley Vulcich and Steve Ottemoeller

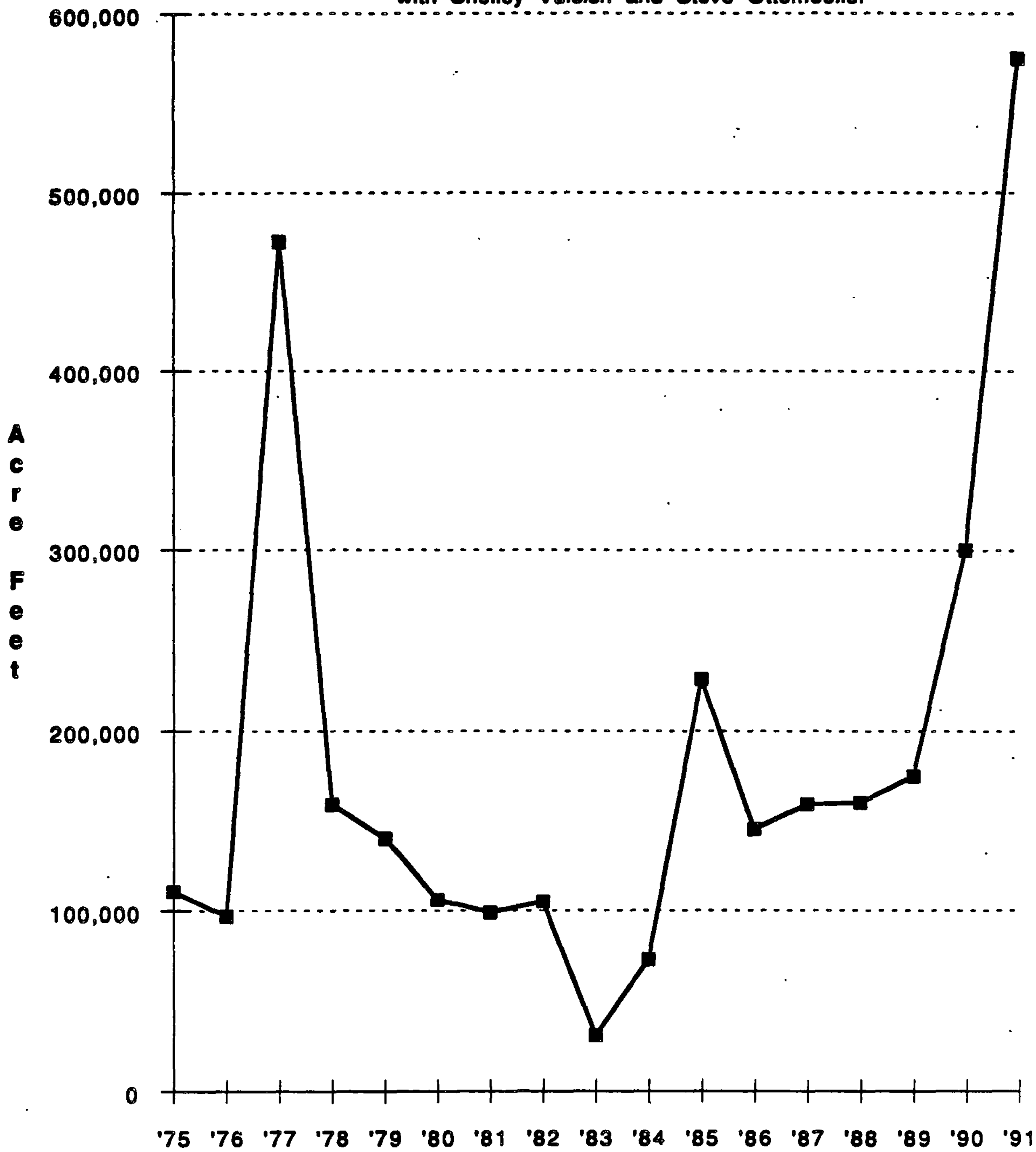
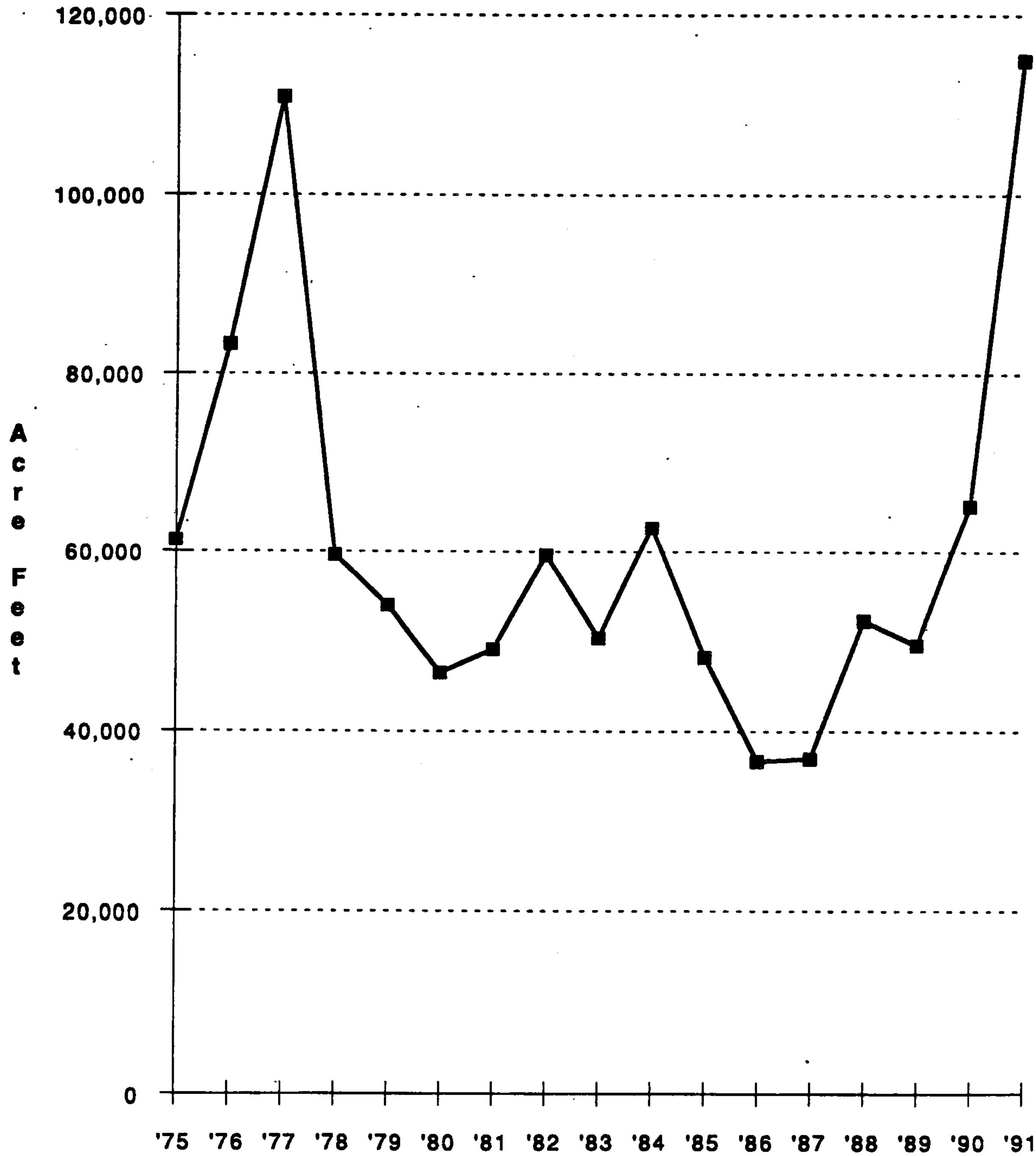


Figure 5.19: Estimated Producer Groundwater Extractions, Wheeler Ridge-Maricopa WSD
Source: Communications with William Taube, WRM WSD



minute (2 to 10 AF per day). Larger wells usually serve between 500 and 650 acres of cropland. As a consequence, many wells cannot meet the peak water requirements for the acreage of crops served. To spread out peak crop demands for water some growers have adopted new cropping patterns that incorporate a variety of different crops and planting dates. Nevertheless, meeting peak demand is still difficult for producers relying heavily on groundwater.

Legal Constraints—As discussed above, groundwater pumping by producers is today virtually unregulated in most of the Central Valley, although there have been some judicial adjudications and a few local agencies have obtained management authority (DWR, *California Water, Looking to the Future* 35, November 1987). If groundwater tables continue to fall, however, some legal constraints may come into play. First, local cities, water suppliers or even individual producers may decide to file for a judicial adjudication of threatened groundwater aquifers in an effort to limit withdrawals to safe yield. As noted, adjudications are extremely complex and costly. Because governmental records of groundwater users are incomplete at best, even determining the appropriate parties to an adjudication is difficult. Once the relevant parties have been determined, adjudications still often take years and consume millions of dollars in resolving such issues as the relevant boundaries of the basin, the safe yield of the basin and the appropriate apportionment of that safe yield among the various users. These drawbacks, combined with considerable uncertainty about California groundwater law and thus the likely results of an adjudication, have deterred groundwater users from seeking adjudications in the past. Continuing threats to a groundwater aquifer, nonetheless, may lead to adjudications in the future.

Currently, most irrigation, water and water storage districts in the Central Valley enjoy little if any power to regulate or charge for groundwater use where the district has not spread or otherwise increased the groundwater supply. Water storage districts have the authority to charge for the groundwater that the district supplies (which would arguably include water that the district spreads). The Kern County Water Agency (KCWA) has authority to levy groundwater charges in improvement districts where users will benefit from the Agency's recharge operations and voters have authorized such charges. To date, the KCWA has imposed a pump tax only on users within the Greater Bakersfield Area.

Some of the producers and district officials interviewed suggested that districts might need to seek greater legislative authority if groundwater problems continue. The most common powers granted to local institutions through previous special acts include the authority to require registration of groundwater wells, to meter groundwater extractions, to impose replenishment assessments on area users and to impose pump taxes. The level of pump taxes has generally been limited to either a small fixed sum or to the amount needed to cover district groundwater services. A few new districts have been given authority to directly restrict groundwater pumping. Such statutes generally provide that allocations of available groundwater among district users should be based on acres owned and farmed, taking into account crop type and reasonable need (see Cal. Water Code, App. sections 119-709.5, 128-709, 129-709, and 129-710).

Local districts, however, may find groundwater management difficult even if they have the necessary authority because current district borders will often not be coextensive with the borders of the relevant groundwater basin. As a result, it is also possible that Central Valley producers may form new local agencies in the future explicitly to manage local groundwater resources.

Impacts—The likely short and long-run impacts of increased groundwater pumping identified in Phase II of the study include:

Impacts of Substitution of Ground for Surface Water

- Higher variable water costs related to energy demand
- Increased expenses and long-term liabilities related to refurbishment or purchase of wells
- Increased opportunities for well drillers and other related industries
- Greater stability in local agricultural production
- Potential decline in water quality and subsequent reductions in crop yields and/or changes in cropping patterns
- Potential aquifer collapse and consequent losses in storage capacity and land subsidence
- Potential lower water quality or increased pumping lifts for surrounding farms and communities

5.4.2 Water Transfers by Producers

5.4.2.1 Introduction

One of the most frequently mentioned mechanisms for mediating surface water supply shortfalls is water transfers. In most contexts, water transfers are linked to the development of water "markets" wherein water flows to its most valuable uses. Economic theory suggests that water markets would minimize the economic losses associated with reduced water supplies. As will be discussed below, however, currently there are significant constraints which impede water transfers and limit their role in the adjustment process.

Water transfers fall into two categories: water transferred within a district (intra-district) and water transferred from outside a district (external). Recognition of this division is important because the two types of transfers face considerably different legal, institutional, physical and economic constraints. Generally speaking, intra-district transfers have occurred with some degree of regularity, even in years when full district allocations were available. External transfers, however, occur more frequently when surface water supplies have been reduced. In either case, California law requires that parties transferring water be granted the "use of a water conveyance facility which has unused capacity, for a period of time for which that capacity is available, if fair compensation is paid for that use" (Cal. Water Code section 1810).

Both the state and federal governments helped facilitate transfers in 1991. The California Department of Water Resources established a "State Water Bank" that provided water to urban agencies and growers at $175 per AF plus conveyance charges from the Delta. In addition, USBR "hardship water" was available to producers within CVP districts who required emergency supplies to maintain permanent plantings.

Observed Responses—In Arvin-Edison WSD there were few, if any, transfers of water from outside the District in response to drought-induced water scarcity. Within the District, however, transfers are allowed and there seems to have been a fair amount of activity in 1991. At the beginning of the season, the District purchased surplus allocations from producers for $100 per AF. The District then sold these supplies on a "first come, first serve" basis to producers for the same price. As of June 1991, "contributed" water exceeded "requested" water by approximately 1,900 AF.

In Central California ID there were also few, if any, transfers of water from outside the District in response to reductions in allocations to producers in 1991. In normal years, however, the "four entities" served by the USBR exchange contract (Central California ID, Columbia Canal Company, San Luis Canal Company and Firebaugh Canal WD) use an informal system of transfers to distribute surplus supplies when they were available. Intra-district transfers are also allowed, although CCID does not permit producers to sell their water at rates higher than what they paid.

Full water supplies have been available to producers in El Dorado ID throughout the study period. As a consequence, there has been little incentive for producers to transfer water within the District, or to arrange transfers from outside the District. If transfers became necessary, the relatively high elevation of the District would make it difficult to receive water from sources other than upstream users on the American River.

Given the reliability of Glenn-Colusa ID's water supplies and relatively low prices and high per-acre allocation levels in critical years, there is little incentive for District producers to arrange for private transfers from outside the District. Within the District, however, there is a significant number of transfers. While GCID does not keep track of prices, most believe that water was traded in 1991 at levels twice that of District rates.

In the 1980s, when the SWP entitlement for Lost Hills WD was increasing, many landowners engaged in intra-district transfers to reallocate supplies from one area to another. In recent years, some producers have leased land with the intention of leaving the land fallow and transferring the water allocations to their primary cropland. In 1990, this strategy paid off, as producers were able to consolidate per-acre allocations and have sufficient water to irrigate a portion of their acreage. However, in 1991, when SWP allocations were cut 100 percent, such transfers were no longer an option.

External transfers were a very important alternative supply for LHWD in 1991. Three transactions arranged by producers accounted for 10,200 AF of water entering the District. Two of these transfers originated from a private company that sold groundwater to District producers. The third was by a landowner who transferred water allocated to land owned in another district to his operation in Lost Hills. Producers in Lost Hills WD also purchased approximately 6,000 AF of water from the State Water Bank. The cost was $175 per AF at the Delta. After conveyance charges to the District were added, the cost to producers was approximately $200 per AF plus intra-district conveyance charges.

In Westlands WD, water transfers are very important because even normal year allocations to some parts of the District are insufficient for growing prevailing crops. Intra-district transfers are quite common. The situation is complicated, however, by the division of the District into three priority areas (PAs). Special rules govern where producers in each PA can transfer their water as stipulated in the 1986 Barcellos Judgment. In water short years, for example, transfers can occur within the three PAs, but in general not from PA #1 to PAs #2 and #3.

These rules do not apply to groundwater pumped by producers. Thus the Groundwater Exchange Program allows producers to pump groundwater and sell their surface water allocations to other producers located anywhere in the District. In water year 1990/91, more than 14,700 AF of water were transferred in this Program, and between March and July of 1991 another 9,025 AF of water were transferred. Approximately 4,500 intra-district transfers took place in water year 1990/91. A significant amount of water has been transferred from outside the District as well. In water year 1989/90, there were 26 District and privately negotiated water transfers from outside Westlands. In 1990/91, that number increased to 44. WWD does not keep track of the price growers pay for transferred water.

In April 1991, producers in Westlands WD requested approximately 6,000 AF of water from the State Water Bank. In June and July they requested another 1,810 AF and 1,200 AF, respectively. The cost on delivery was approximately $205 per AF. While initially only ordering water on the basis of producer requests, in July 1991, Westlands WD began to keep a buffer supply available for peak demand in order to reduce the processing and delivery time.

USBR "hardship" water (i.e., extra contract water provided but not "transfer" water as such) has been particularly beneficial to producers in PA #2. They were offered 1.2 AF per acre for their permanent plantings at the same cost as their normal allocation. In fact, the availability of hardship water raised their total 1991 water deliveries to a higher level (1.5 AF/acre) than in non-drought years (1.3 AF/acre).

Field interviews revealed that producers with permanent plantings purchased a bulk of the external water transfers. Keeping orchards and vineyards alive has financial benefits that extend beyond a single year. Many producers said they intended to apply enough water to obtain a normal yield. They pointed out that the marginal benefit of bearing a full crop was higher than the marginal cost of the additional water, even at $200 per AF. Producers growing annual crops utilized the high cost transfer water for critical irrigations near the end of the growing season. In a few cases, producers purchased water to keep important members of their farm organization (managers and foremen) employed.

Wheeler Ridge-Maricopa WSD allows intra-district transfers of surface water between lands with water service contracts and unrestricted groundwater transfers. In 1991, the District charged $5.00 per AF of transferred water plus power costs associated with wheeling. The District does not regulate prices negotiated in these transactions. As was the case for Lost Hills WD, producers also leased land to obtain water allocations in 1990.

Private transfers from outside the District were an important alternative supply in 1991, accounting for more than 8,000 AF of water. Two of these transfers involved exchanges from lands located adjacent to the Cross-Valley Canal. A third involved 2,000 AF of water transferred from land in the service area of the Antelope Valley-East Kern Water Agency by a landowner who also owns land in Wheeler Ridge-Maricopa WSD. The fourth transfer was from another member unit of the KCWA.

It is interesting to note that no WRM producers requested water from the State Water Bank. This water could have been purchased for between $210 and $255 per AF (depending on the Aqueduct Reach) plus intra-district conveyance charges. According to District personnel, producers simply could not justify purchasing State Bank Water at that price.

Constraints—Constraints vary considerably depending on whether a proposed transfer is intra-district or between producers in different districts. Physical constraints limit the extent to which external transfers can alleviate shortfalls. The state's conveyance facilities do not link all producers nor even all production areas. The most likely transfers—from the Sacramento Valley to the San Joaquin Valley—must pass through the Sacramento/San Joaquin River Delta. Insufficient capacity in the conveyance systems limits the ability to move water "on demand" since transferred water can only claim residual conveyance capacity. Water flow requirements for fish and wildlife protection constrain the availability of water for transfer. Future Bay-Delta water rights decisions by the SWRCB based on new water quality standards are likely to further restrict available supplies for transfer.

External transfers are also constrained by the lack of a functioning market. At present, it is difficult for buyers and sellers to find each other and negotiate a trade. In 1991, some districts went so far as to advertise in newspapers to find willing water sellers. The California legislature, however, has sought to improve communication between potential market participants, instructing DWR to maintain a "list of entities seeking to enter into water supply transfers. . . and a list of physical facilities available to transport the water" (Cal. Water Code section 481).

Legal, administrative and institutional requirements also limit external transfers as an option and increase the costs associated with such transfers. Chapter 4 discussed the principal legal and institutional constraints on external transfers in connection with transfers by districts. As noted, constraints include (1) judicial limitations on the transferability of some rights such as riparian surface rights; (2) the need to obtain the approval of the SWRCB for most transfers of appropriative rights; (3) statutory limitations on transfers of water that is currently held by local districts; and (4) restrictions on CVP water transfers imposed by federal law and the Bureau of Reclamation. Transfers directly to producers may also trigger additional requirements or restraints. Under state law, for example, a district cannot transfer water to a user within the boundaries of another district without the "prior consent" of the transferee's district (Cal. Water Code section 385).

Special problems are presented when a producer wishes to transfer its district water allotment to a producer within another district. Recent legislative enactments have recognized the value of permitting and even encouraging water users within a district to conserve or forego their water entitlement and to transfer that water to users outside the district, but only when the district itself is involved and approves of the transfer. Chapter 3.6 of the California Water Code, for example, authorizes water users and districts to agree "upon mutually satisfactory terms" that the district will transfer water that the user agrees to "forego use of for the duration of the transfer" (Cal. Water Code sections 382 and 383 (b)). As part of its emergency responses to the continuing drought, moreover, the legislature in 1991 provided that until the end of 1992, a water supplier could (1) contract with water users within its district "to reduce or eliminate their use of water" and (2) transfer that water to the State Water Bank or to another water supplier (Cal. Water Code section 1745, AB 9 sections 1-2).

No statute, however, has suggested that a water user within a district has any authority to transfer its water allocation directly to another user outside the district except through and with the approval of the district itself. Indeed, the emergency legislation just summarized explicitly notes that the legislation should not be construed to "imply that any person reducing water use has any interest in the water rights of the water supplier" or to give any person a right to require the district to transfer any water (Cal Water Code section 1745(c)).

Intra-district transfers do not generally face the same degree of constraints as external transfers. Because of the existence of district conveyance and storage facilities, intra-district transfers frequently do not present physical problems. Determination of potential buyers and sellers is far easier. As discussed already, in fact, some districts like Arvin-Edison WSD and Westlands WD actively promote such transfers by serving as a clearing house for buyers and sellers. Intra-district transfers, moreover, do not generally trigger any federal or state requirements or limitations. As discussed in "Observed Responses," however, local rules and regulations may still limit intra-district transfers or regulate the terms of such transfers.

Impacts of Water Transfers

- Increased unit water costs from the purchase of higher priced water and associated transactions costs
- Increased net revenue of transferring parties
- Maintained/increased/decreased net revenue of receiving producers and areas, depending upon crop yields and prices
- Some smoothing in variability of production
- Potential groundwater overdraft and related impacts where groundwater substituted for, or was pumped expressly for, surface water transferred to another location
- Potential reduction in economic activity in locations where transfers originate
- Potential disputed property rights of transferring parties
- Potential for overall net increase in California income and employment

5.5 Adjusting Water Demand to Meet Producer Objectives

Economic theory suggests that producers equate the marginal value product of water with its marginal cost. Accordingly, the responses and adjustments made by producers to reductions in water availability are explained by the relative increase in the marginal cost of water brought on by scarcity. This marginal increase explains producers' decisions to optimize water utilization, either through fallowing low value crops, reducing per-acre water applications or by improving irrigation efficiency. In this section changes in cropping patterns will be examined along with reductions in per-acre water application rates.

5.5.1 Changes in Cropping Patterns

5.5.1.1 Introduction

Drought-induced water scarcity may cause producers to take some cropland out of production or shift to different crops. Changes spurred exclusively by water scarcity, however, are difficult to differentiate from changes caused by other factors such as relative crop prices, federal commodity program rules, traditional rotation and pest control practices and coinciding weather patterns such as the 1990 freeze. In 1991, for example, the prices of many commodities produced primarily in California were expected to increase, encouraging producers to devote more land to production if water supplies were available. Figures 5.20, 5.21, and 5.22 illustrate the relationships between planted acreage and crop prices for cotton, rice and alfalfa, respectively. The expected lagged responses to increased prices are clear for cotton but diverge from expectations for alfalfa, and especially for rice.

5.5.1.2 Changes in Planted Acreage, 1989 and 1991

Changes in planted acreage between 1989 and 1991 (a critical water year) are presented aggregately and for each case study district in Table 5.11. The figures are based on district crop data. Total acreage figures are further disaggregated by annual and permanent crops and by commodity program crops, principally cotton and rice. Permanent crop acreage encompasses both bearing and non-bearing acreage since separate data were not available

Figure 5.20: Cotton Price and Acreage, Case Study Districts

Nominal prices deflated with USDA Producer Price Index.

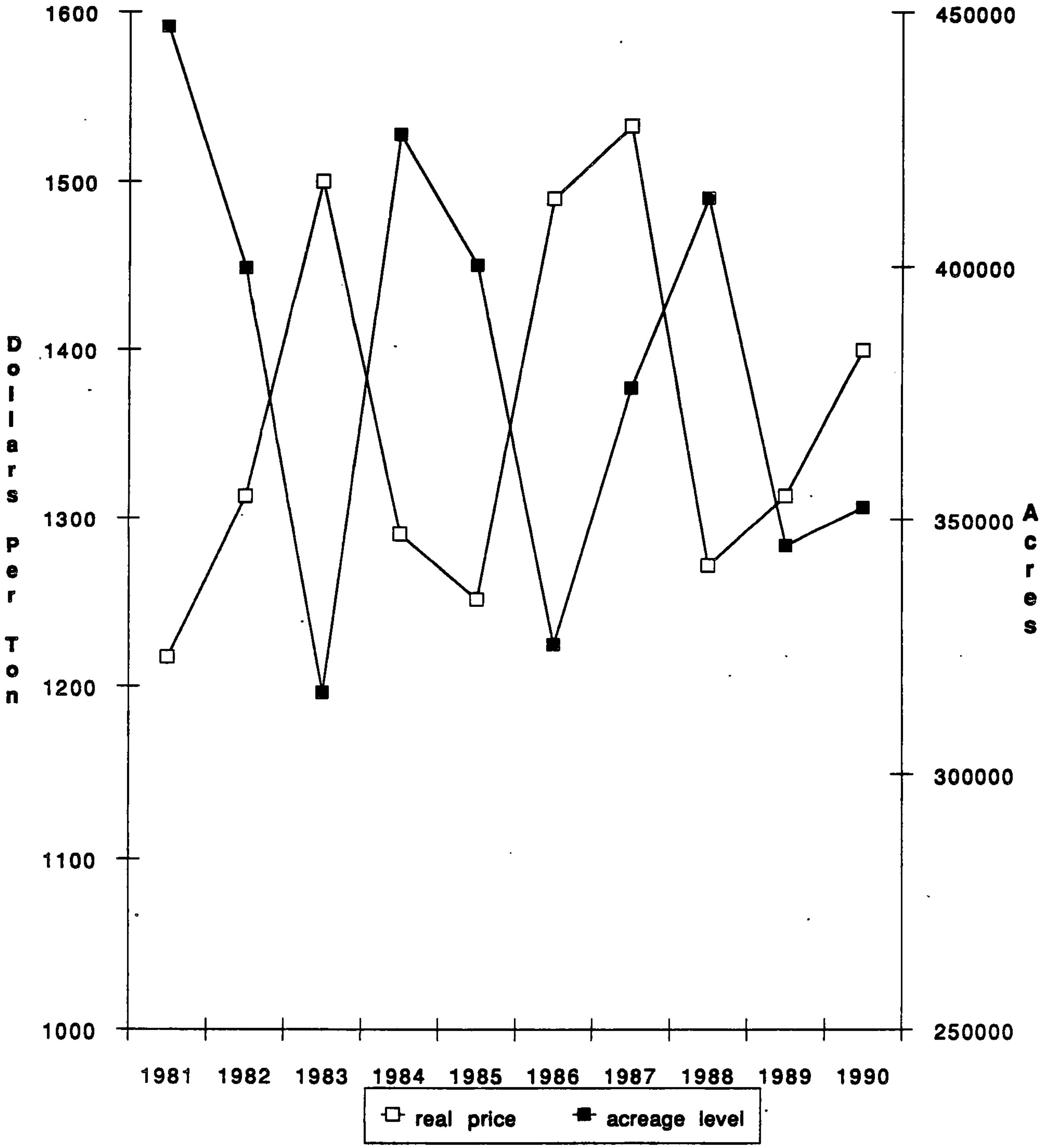


Figure 5.21: Rice Price and Acreage, Case Study Districts

Nominal prices deflated with USDA Producer Price Index

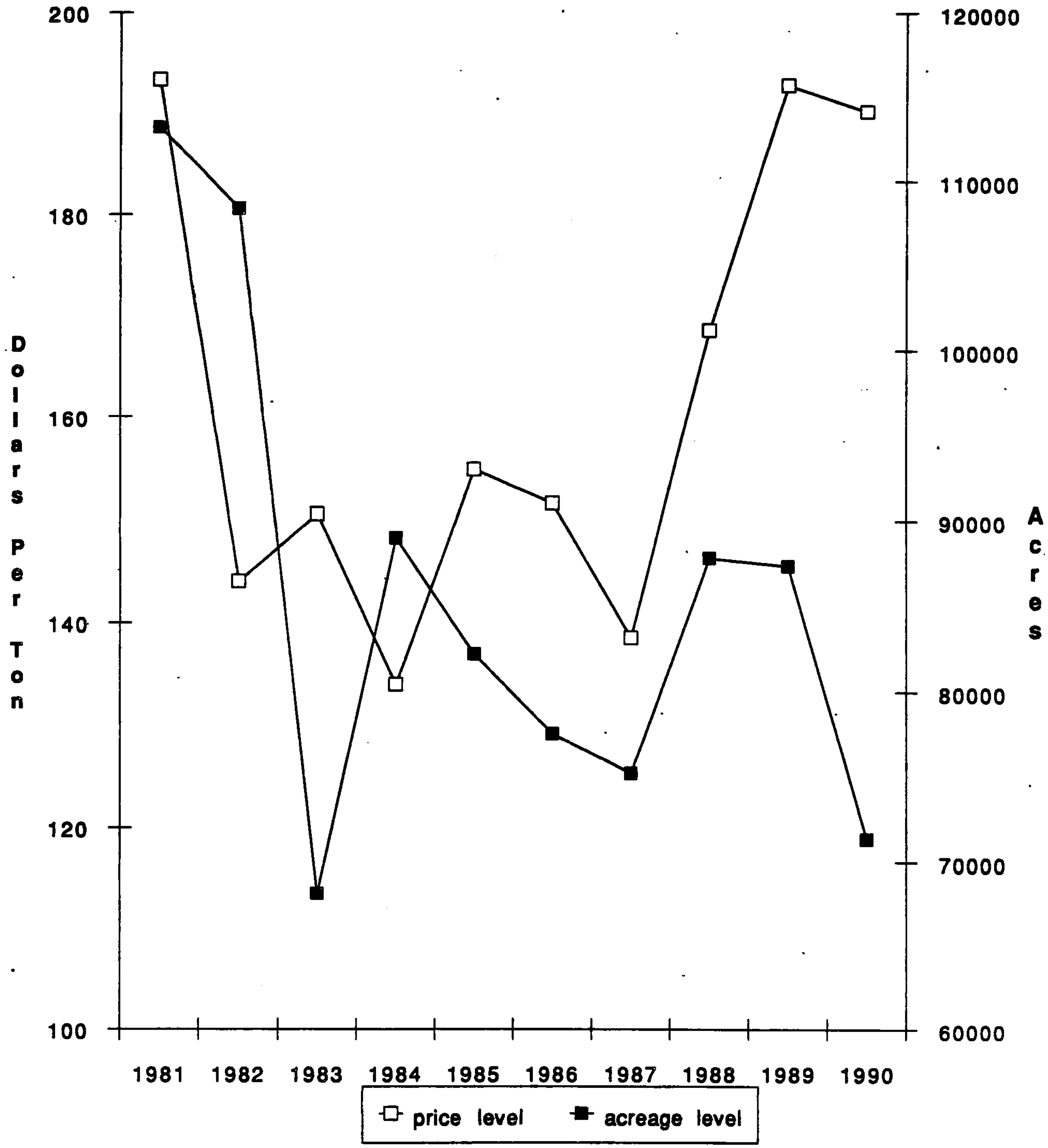


Figure 5.22: Alfalfa Price and Acreage, Case Study Districts
Nominal prices deflated with USDA Producer Price Index

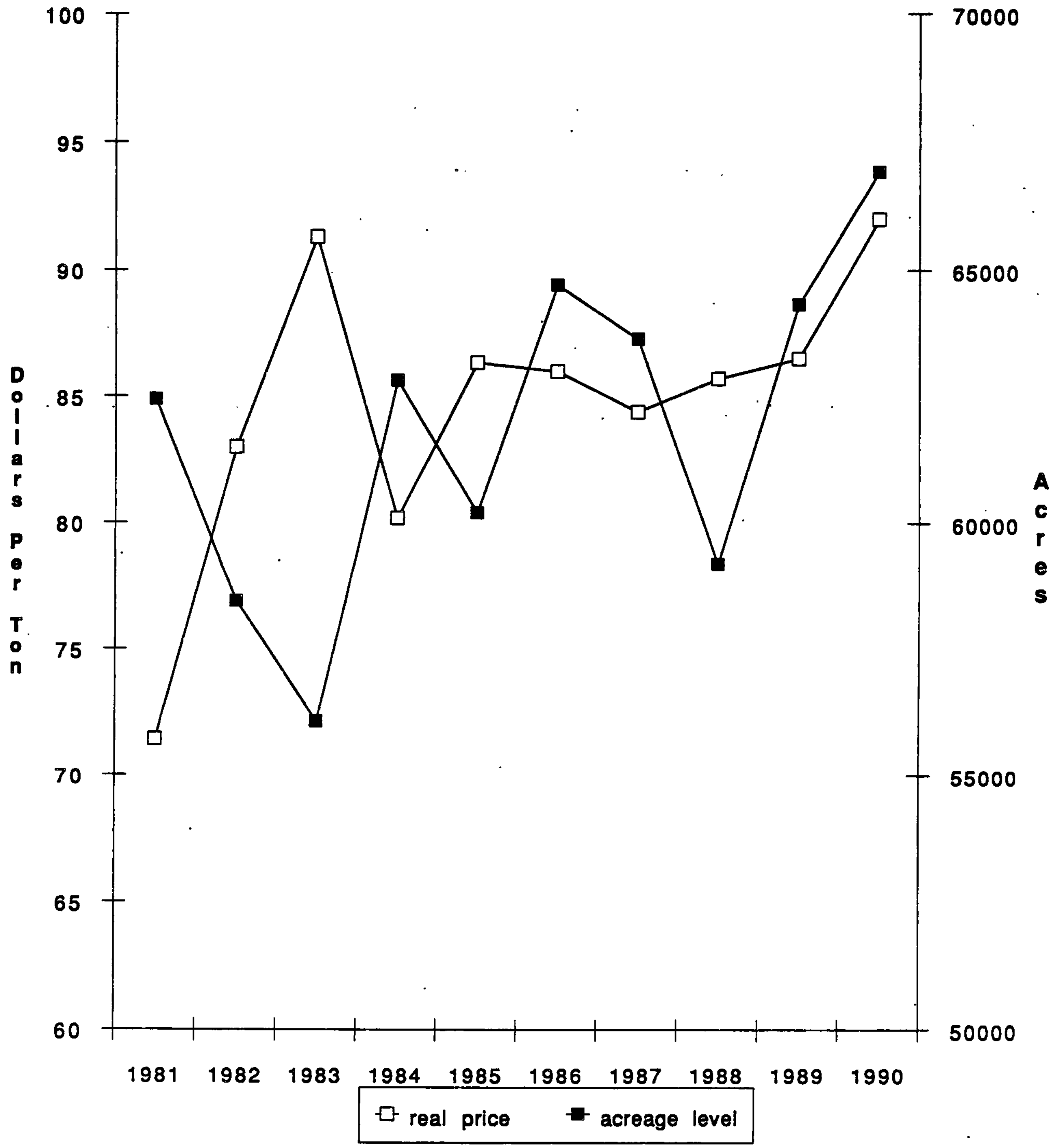


Table 5.11: Acreage Planted to Principle Crops, 1989 and 1991, Case Study Districts

Crop Category	AEWSD		CCID		EID		GCID		LHWD		WWD		WRM		TOTAL	
	1989	*1991*	*1989*	*1991*	*1989*	*1991*	*1989*	*1991*	*1989*	*1991*	*1989*	*1991*	*1989*	*1991*	*1989*	*1991*
Planted Acreage	92818	95371	149047	147719	7086	5506	111704	90702	44136	30964	515159	457139	88937	65883	1008887	893284
% of Total	9	11	15	17	1	1	11	10	4	3	51	51	9	7	100	100
% Change '89 to '91		3		-1		-22		-19		-30		-11		-26		-11
Annual Crops	50129	50641	135725	134710	650	400	110064	89243	31525	16197	488781	435146	64005	39402	880879	765739
% of Total	6	7	15	18	0	0	12	12	4	2	55	57	7	5	100	100
% of District	54	53	91	91	9	7	99	98	71	52	95	95	72	60	87	86
% Change '89 to '91		1		-1		-38		-19		-49		-11		-38		-13
Permanent Crops	42689	44730	13322	13009	6436	5106	1640	1459	12611	14767	26378	21993	24932	26481	128008	127545
% of Total	33	35	10	10	5	4	1	1	10	12	21	17	19	21	100	100
% of District	46	47	9	9	91	93	1	2	29	48	5	5	28	40	13	14
% Change '89 to '91		5		-2		-21		-11		17		-17		6		0
Com. Prgm. Crops	18438	13248	48335	50697	0	0	81746	62251	26332	8679	285177	228547	40840	19491	500868	382913
% of Total	4	3	10	13	0	0	16	16	5	2	57	60	8	5	100	100
% of District	20	14	32	34	0	0	73	69	60	28	55	50	46	30	50	43
% Change '89 to '91		-28		5		0		-24		-67		-20		-52		-24
Cotton Acreage	14828	11188	33308	43616	0	0	0	0	18787	3520	241995	209385	35809	16044	344727	283753
% of Total	4	4	10	15	0	0	0	0	5	1	70	74	10	6	100	100
% of District	16	12	22	30	0	0	0	0	43	11	47	46	40	24	34	32
% Change '89 to '91		-25		31		0		0		-81		-13		-55		-18
Rice Acreage	0	0	5582	3779	0	0	81746	62251	0	0	0	0	0	0	87328	66030
% of Total	0	0	6	6	0	0	94	94	0	0	0	0	0	0	100	100
% of District	0	0	4	3	0	0	73	69	0	0	0	0	0	0	9	7
% Change '89 to '91		0		-32		0		-24		0		0		0		-24
Alfalfa Acreage	2515	2969	29988	32940	0	0	2033	2495	2200	2067	24935	18293	2656	1827	64327	60591
% of Total	4	5	47	54	0	0	3	4	3	3	39	30	4	3	100	100
% of District	3	3	20	22	0	0	2	3	5	7	5	4	3	3	6	7
% Change '89 to '91		18		10		0		23		-6		-27		-31		-6

Table 5.11 (continued)																
Crop Category	**AEWSD**		**CCID**		**EID**		**GCID**		**LHWD**		**WWD**		**WRM**		**TOTAL**	
	1989	*1991*	*1989*	*1991*	*1989*	*1991*	*1989*	*1991*	*1989*	*1991*	*1989*	*1991*	*1989*	*1991*	*1989*	*1991*
Vegetable Acreage	12495	16972	7430	4256	0	0	0	0	0	0	73347	68596	20428	17329	113700	107153
% of Total	11	16	7	4	0	0	0	0	0	0	65	64	18	16	100	100
% of District	13	18	5	3	0	0	0	0	0	0	14	15	23	26	11	12
% Change '89 to '91		36		-43		0		0		0		-6		-15		-6
Tomato Acreage	0	0	5438	4227	0	0	4028	5370	0	0	80903	107156	0	0	90369	116753
% of Total	0	0	6	4	0	0	4	5	0	0	90	92	0	0	100	100
% of District	0	0	4	3	0	0	4	6	0	0	16	23	0	0	9	13
% Change '89 to '91		0		-22		0		33		0		32		0		29

Notes: Data for 1991 is preliminary and incomplete. Miscellaneous crops are listed as "annual." Commodity program crops (cotton, rice, corn, wheat, barley, oats and sorghum) are eligible to receive program benefits, though only a fraction of the acreage is actually enrolled. All acreage planted to "grain" was assumed to be eligible for the commodity programs. This may overstate total eligible acreage.

for most districts. Changes in acreage for specific key crops—cotton, rice, alfalfa, vegetables and tomatoes—are also presented.

As the last column indicates, total planted acreage declined 11 percent between 1989 and 1991, from over one million acres to less than 900,000 acres. In absolute terms, 50 percent of the acreage decline occurred in Westlands WD, but proportionally to total district acreage, the largest declines were in Lost Hills WD (30%), Wheeler Ridge-Maricopa WSD (26%), El Dorado ID (22%) and Glenn-Colusa ID (19%).

Over all districts, annual crops accounted for 87 and 86 percent of total acreage in 1989 and 1991, respectively, while permanent crops occupied the remaining 13 and 14 percent. As the last two columns in Table 5.11 indicate, on an aggregate level the change in acreage between 1989 and 1991 was entirely in annual crops (13 percent decline), while acreage in permanent crops, bearing and non-bearing taken together, remained stable overall. This is not unexpected given that USBR "hardship" water was supplied to CVP districts explicitly for permanent crops, and that DWR State Water Bank water was available for distribution at the rate of $175 per AF upon request. These emergency supplies were utilized widely by producers of permanent crops to protect their long-term investments.

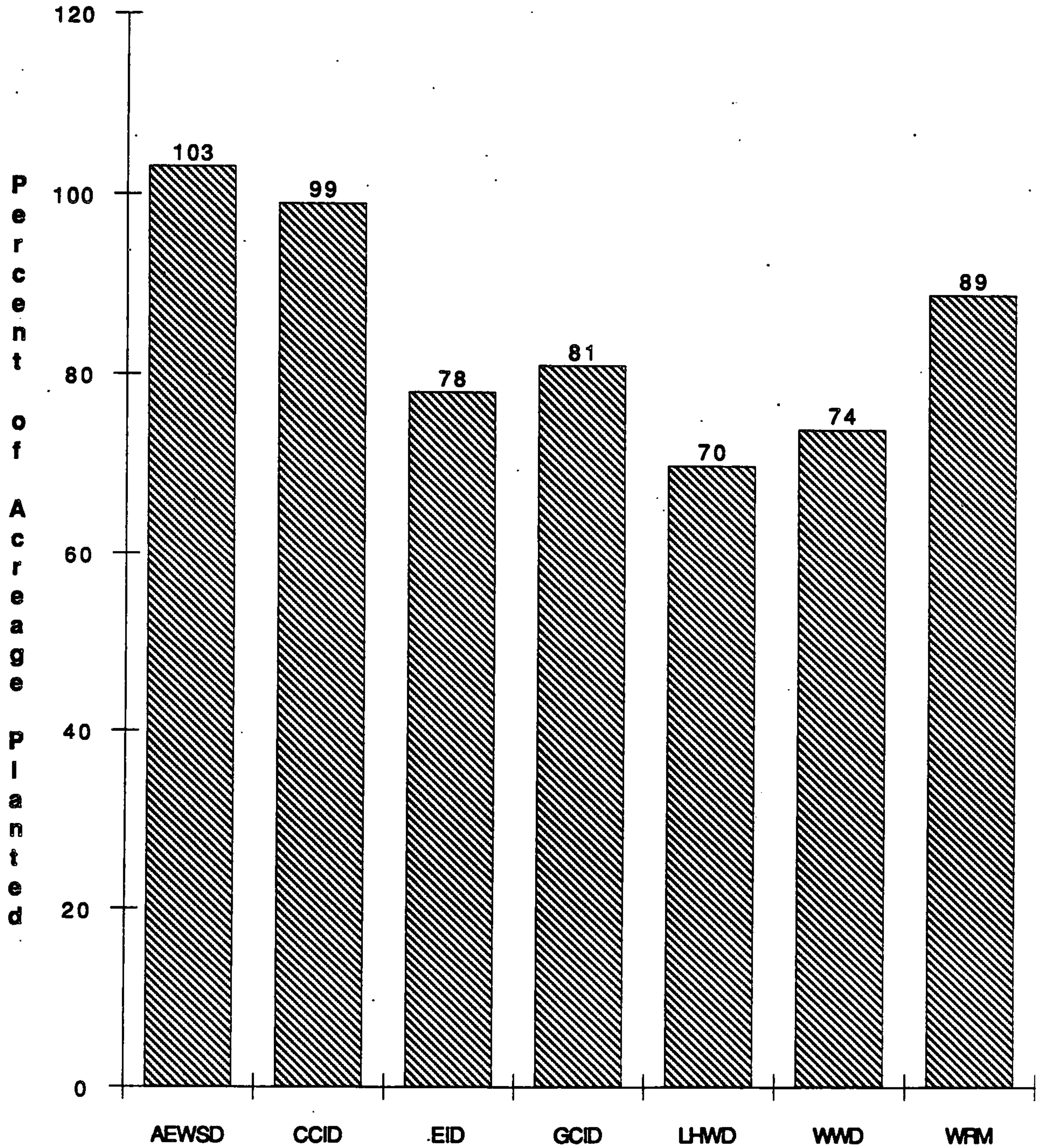
Cotton accounted for over half of the acreage decline (61,000 acres). Cotton tends to be the main "swing" crop during water short years, particularly in the southern San Joaquin Valley. Commodity program regulations also affect cotton acreage decisions as discussed in the next section. Rice, alfalfa and vegetable acreage for all districts, aggregately, declined by 24%, 6% and 6%, respectively. Other row crops not shown in Table 5.11 also experienced acreage reductions in 1991, including corn, wheat and barley. Acreage planted to processing tomatoes, however, increased by 26,384 acres or 29 percent between 1989 and 1991. Most of the increase occurred in Westlands WD where tomatoes partially substituted for reduced cotton acreage. Tomato acreage also increased in Glenn-Colusa ID.

Observed Responses—Changes in acreage planted between 1989 and 1991 for each case study district are portrayed in Figure 5.23. The changes range from a three percent increase in acreage in Arvin-Edison WSD to a 30 percent decline in Lost Hills WD and a 32 percent decline in the "surface water service area" of Wheeler Ridge-Maricopa WSD. More detailed descriptions of the cropping patterns follow below.

In Arvin-Edison WSD, total planted acreage in 1991 increased by about three percent as compared with 1989 (92,818 acres vs. 95,371 acres). Reduced water allocations to Arvin-

Figure 5.23: Percent of Acreage Planted in 1991 as Compared to 1989, Case Study Districts

Source: District Crop Surveys



Edison producers were supplemented in most cases by on-farm groundwater pumping. The two leading crops, grapes and potatoes, increased acreage by four and five percent, respectively, while the third crop, cotton, declined by 25 percent. Grain acreage also declined while vegetable and citrus acreage increased. Fallow acreage declined by nearly 70 percent or approximately 5,000 acres. Table 5.1 and Figure 5.24 provide more complete information.

Several factors unrelated to water supplies that have influenced planting decisions in Arvin-Edison include: 1) multi-year potato contracts with the nearby Frito-Lay processing plant; 2) an increased number of marketing opportunities for citrus through Sunkist; 3) increased demand for table grapes over varietal grapes; 4) a significant decline in cotton yields (partially due to deteriorating air quality); and 5) relatively cheaper land values in the southern San Joaquin Valley as compared with the Salinas Valley making the former more competitive for vegetable crop cultivation.

In Central California ID, total planted acreage remained nearly the same between 1989 and 1991, declining by only one percent. Reductions in water allocations to CCID producers, 15 percent on average, were partially offset by on-farm groundwater pumping. Cotton and alfalfa acreage in the District increased significantly, by 31 and 10 percent, respectively, while acreage in beans, grains, corn, rice and sugar beets declined. Table 5.2 and Figure 5.25 give more detailed information.

In El Dorado ID, total planted acreage in 1991 decreased by an estimated 22 percent as compared with 1989. While total planted acreage is declining in the District, the tendency is toward high production (plant density) per acre, increasing per acre water requirements. Water availability to EID producers has not changed in recent years, although conservation is actively encouraged through the IMS Program and many farmers have improved their irrigation efficiency. Between 1989 and 1991, acreage in irrigated pasture, hay and pears declined, while acreage in cherry trees and vineyards increased. See Table 5.3 and Figure 5.26 for more complete information.

The most important crop change in EID over the last few decades was the dramatic decline in pear production caused by the "pear blight" disease and changes in market conditions. Production fell from 52,000 tons in the 1960s to only 4000 tons in 1990. Irrigated pasture for cow/calf operations is also on the decline in the District and is reported to be the crop most likely to be affected by future water price increases. Demand for fruit from EID may

Figure 5.24: Cropping Pattern Changes, Arvin-Edison WSD

Source: District Crop Surveys

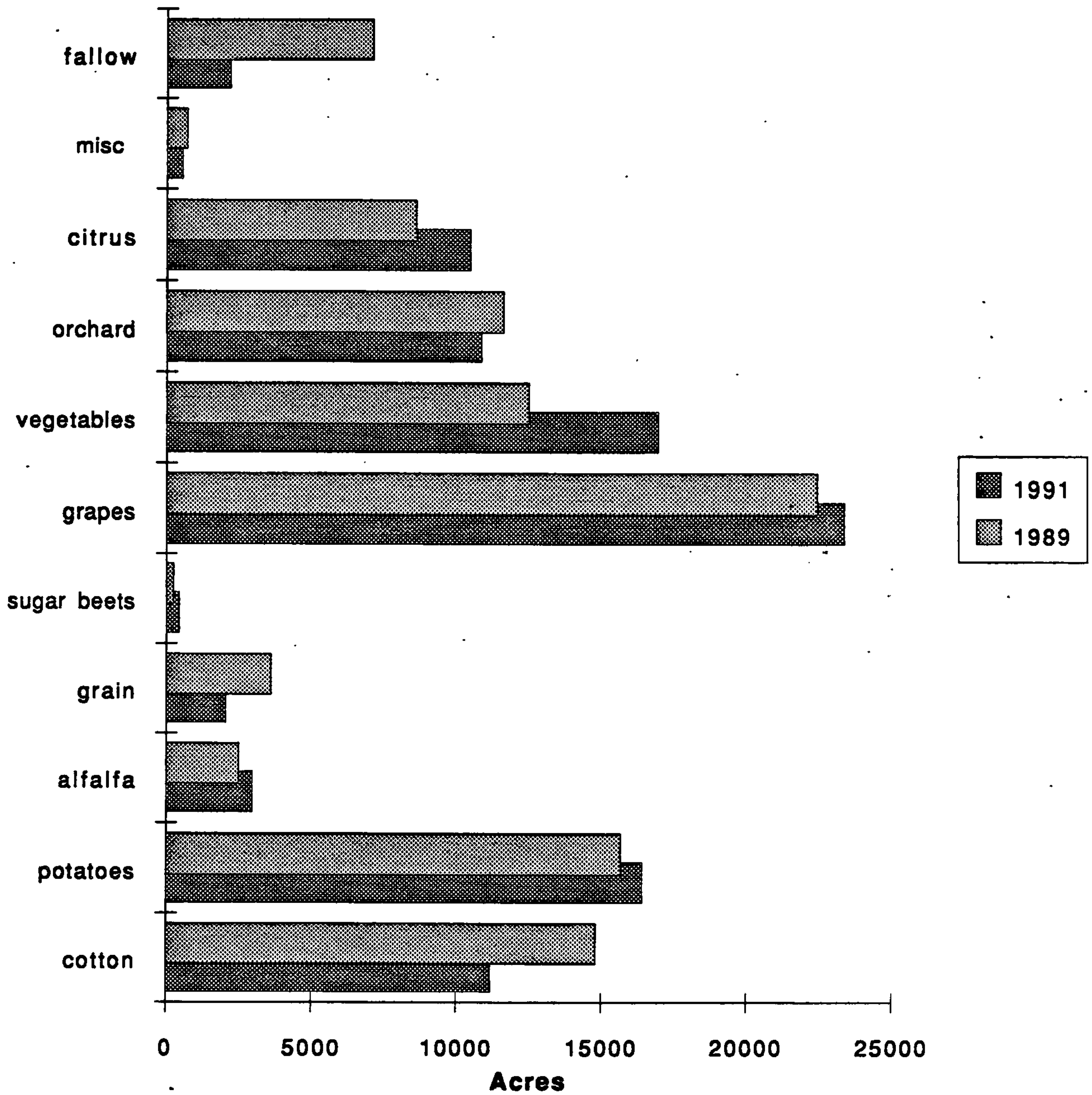


Figure 5.25: Cropping Pattern Changes, Central California ID

Source: District Crop Surveys

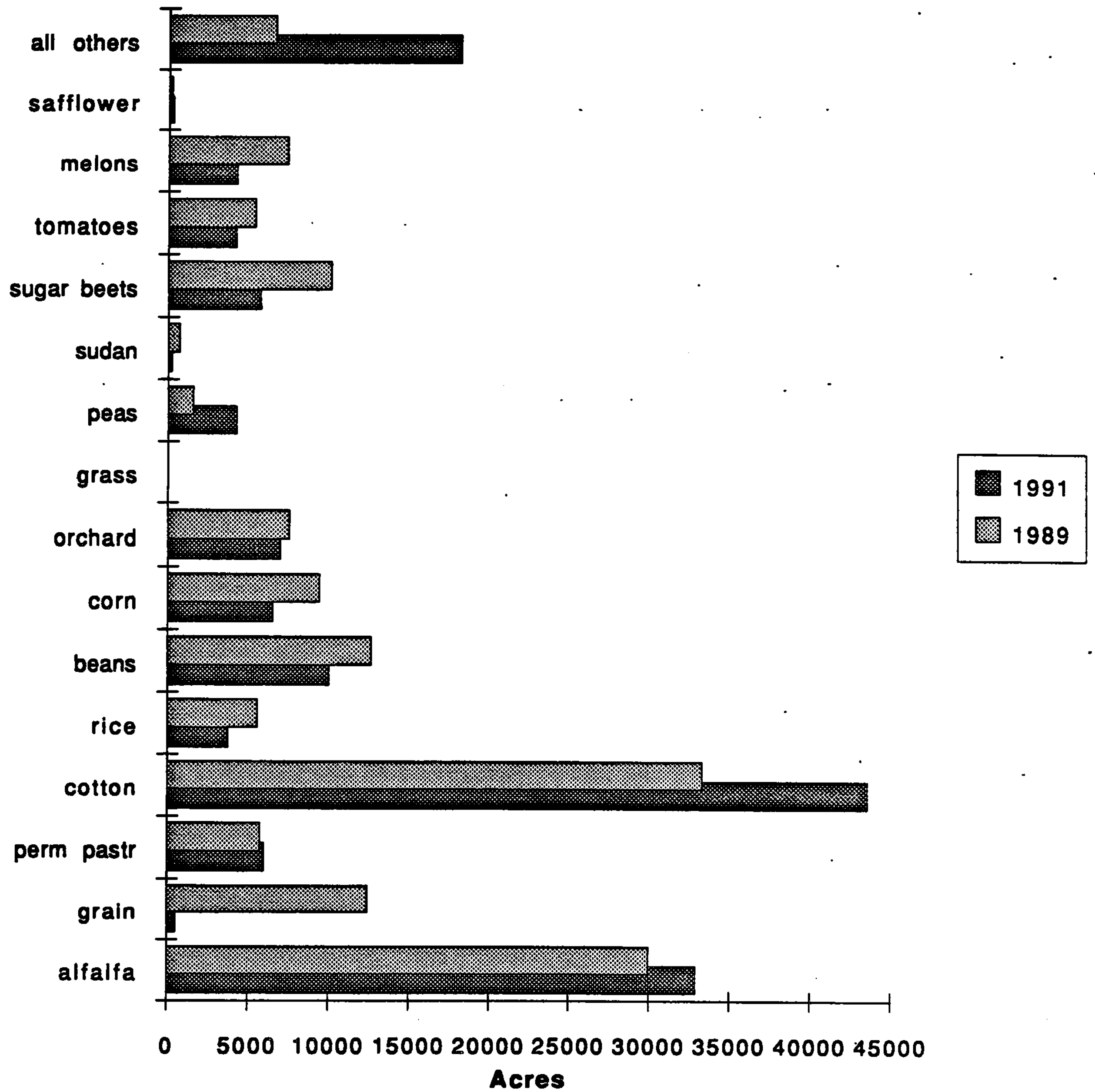
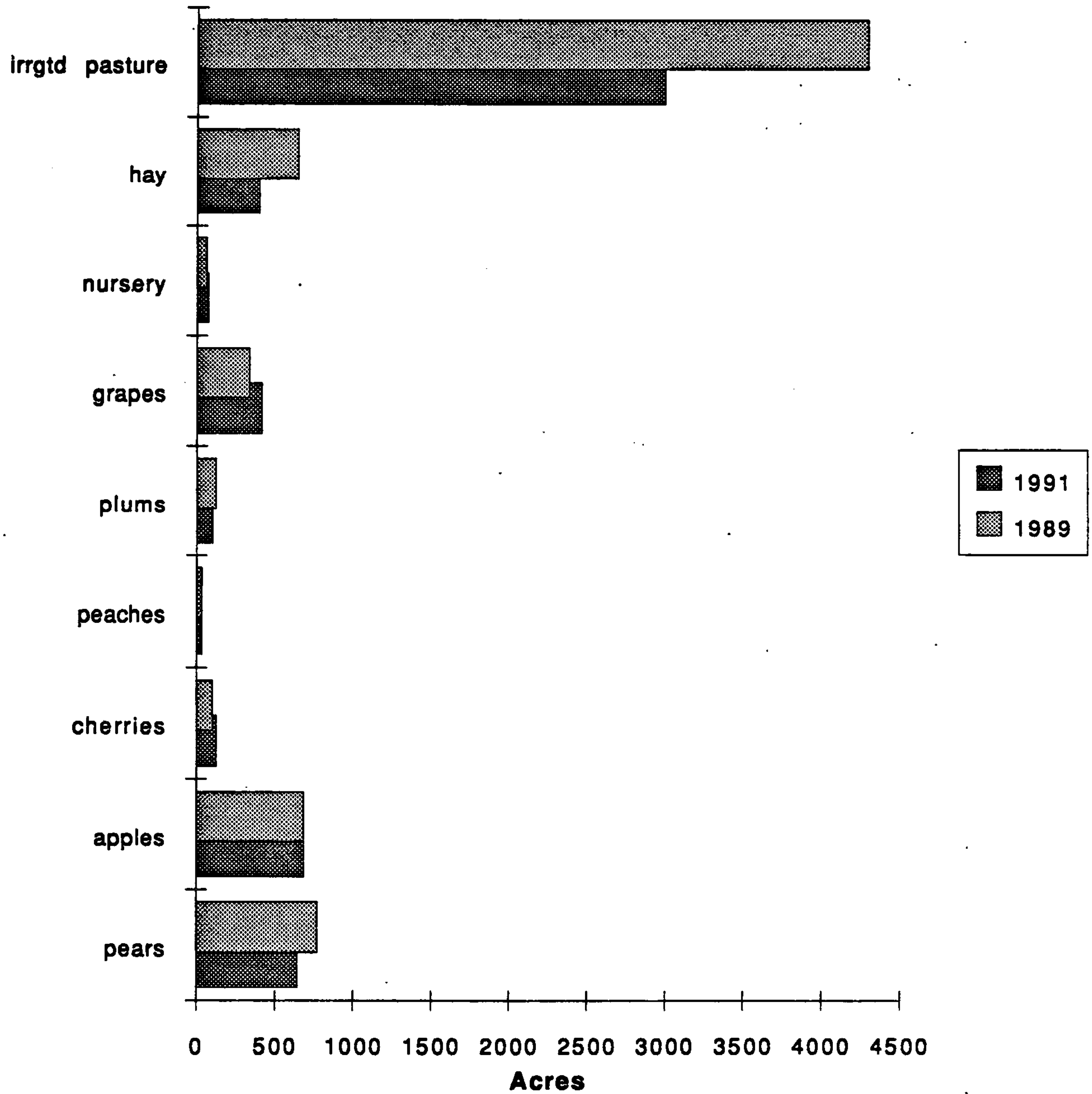


Figure 5.26: Cropping Pattern Changes, El Dorado ID

Source: District Crop Surveys



be more price inelastic than in other areas because of its premium export quality and direct marketing activities through the Ranch Marketing Program.

In Glenn-Colusa ID, total planted acreage decreased by 19 percent between 1989 and 1991, mainly in its principal crop, rice (19,500 acres). Tomato and alfalfa acreage increased, while acreage in clover, sugar beets and orchard crops declined. Table 5.4 and Figure 5.27 provide more information on GCID cropping patterns. GCID's reduction in total water availability of approximately 22 percent in 1991, compared to average levels, was passed on to District growers through a maximum allocation of 3.85 AF per acre of deeded land. On-farm groundwater pumping to supplement surface water shortages is a limited option in certain areas.

In Lost Hills WD, total planted acreage in 1991 decreased by about 30 percent as compared to 1989, or just over 13,000 acres. Cotton acreage declined dramatically, by 81 percent or more than 15,000 acres. In all, the number of acres planted to row crops in the District declined by 49 percent. Acreage in permanent plantings increased, however, principally in pistachios (by 33%). Table 5.5 and Figure 5.28 provide more complete information. Lost Hills ID producers received only 21 percent of their normal per acre water allocation in 1991. A few producers purchased additional water from outside the District, however, on-farm groundwater pumping was not a viable option.

Total planted acreage in Westlands WD decreased by approximately 11 percent between 1989 and 1991 (58,020 acres). Westlands producers received only 23 percent of their normal per acre water allocation in 1991, however, most producers were able to supplement reduced allocations with on-farm groundwater pumping and/or intra-district and external water transfers, including USBR "hardship" water for permanent plantings. Over 50 percent of the acreage decrease is accounted for by a 13 decline in cotton acreage; acreage also declined in alfalfa seed and hay, vegetables, barley and wheat. Acreage in processing tomatoes increased markedly over 1989, by 32 percent or 26,253 acres. Thus, there appears to be some substitution of tomato acreage for lost cotton acreage. Fallow acreage in Westlands increased by nearly 40,000 acres between 1989 and 1991, or 61 percent. See Table 5.6 and Figure 5.29 for more detailed information.

In Wheeler Ridge-Maricopa WSD, acreage in the "surface water service area" (SWSA) declined by 32 percent as compared with only a four percent decline in the "groundwater area" (GWA). In total, there was a reduction in planted acreage equal to about 25 percent, or just over 23,000 acres. Acreage in annual crops declined even further, by 38 percent,

Figure 5.27: Cropping Pattern Changes, Glenn-Colusa ID

Source: District Crop Surveys

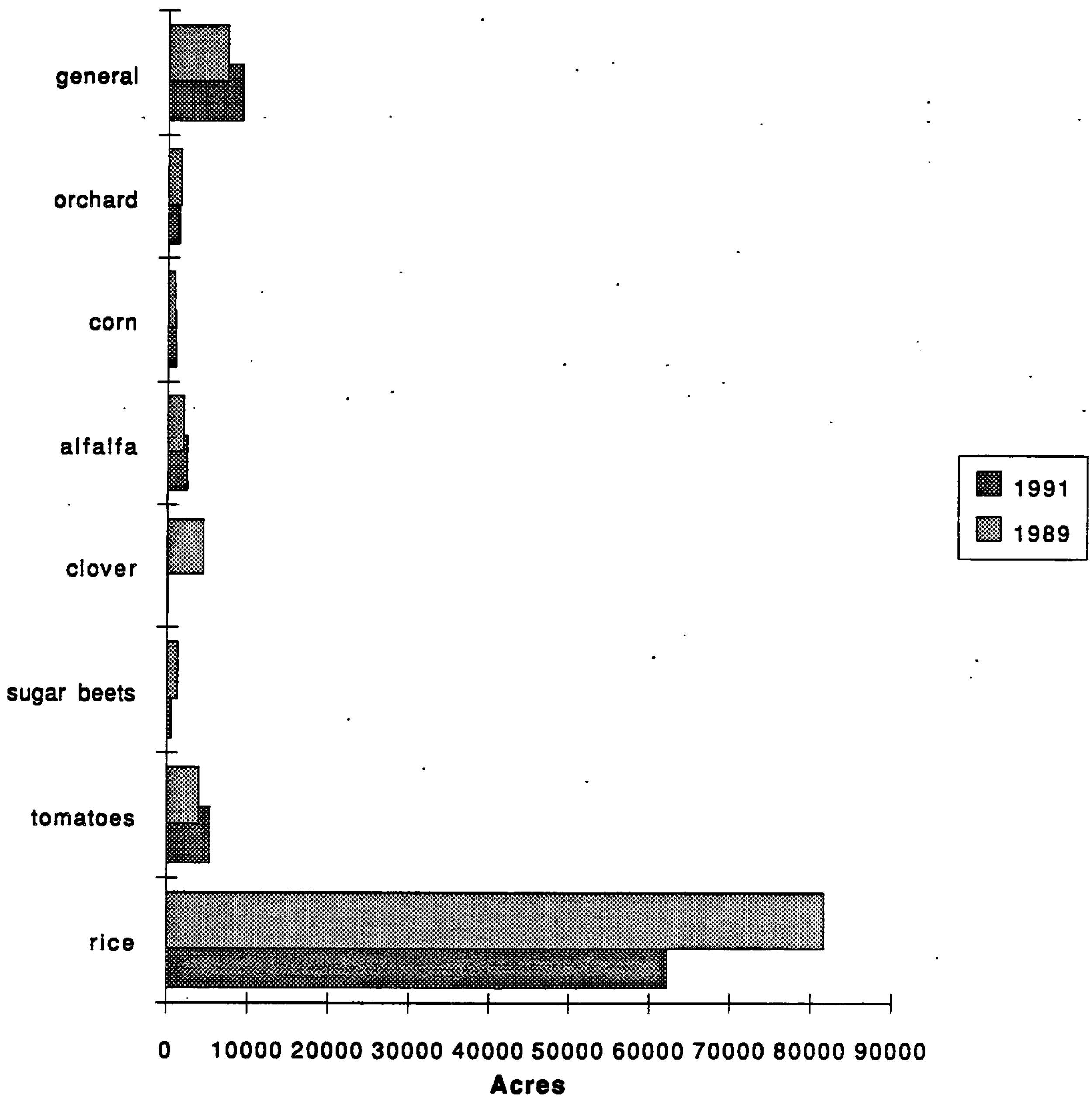


Figure 5.28: Cropping Pattern Changes, Lost Hills WD

Source: District Crop Surveys

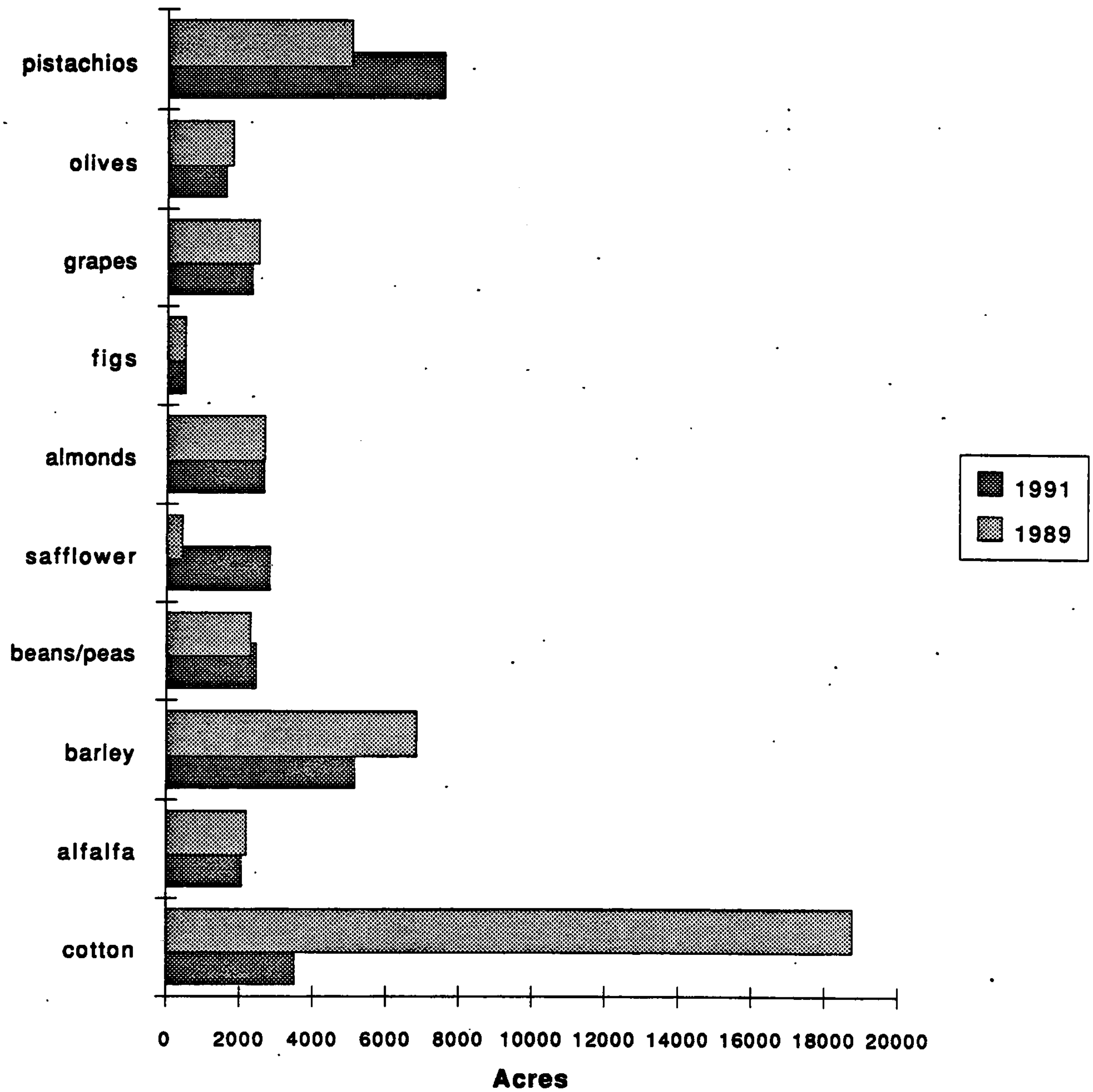
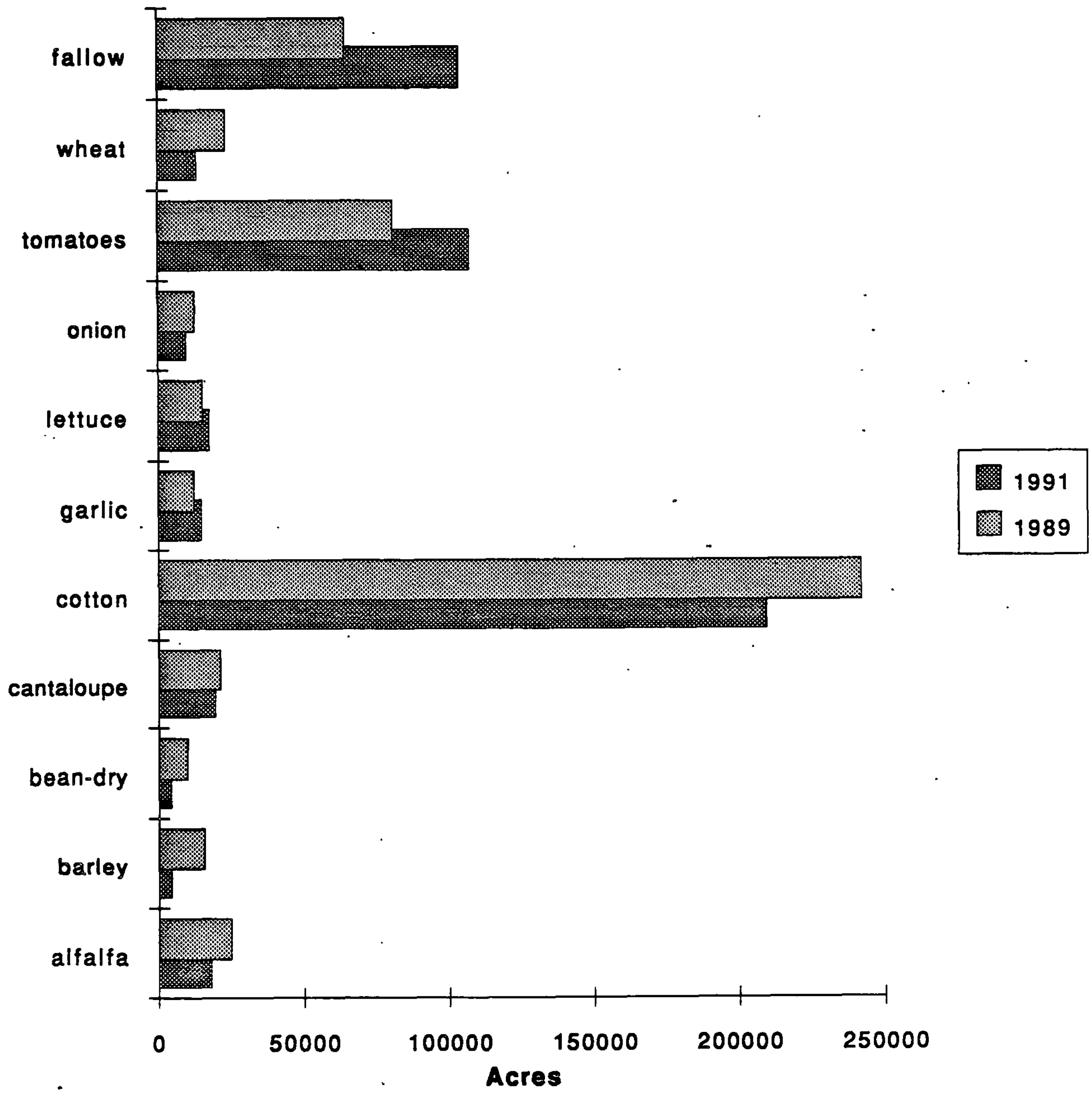


Figure 5.29: Cropping Pattern Changes, Westlands WD
Source: District Crop Surveys



while acreage in permanent crops (grapes, fruit and nut trees, citrus) increased. Planted acreage in cotton, the District's leading crop, decreased by 55 percent, and acreage in vegetables and alfalfa declined by 15 and 31 percent, respectively. Fallow acreage in the District almost doubled between 1989 and 1991, increasing by nearly 28,000 acres. Table 5.7 and Figure 5.30 provide more complete information on changes in WRM cropping patterns. District water allocations to producers in 1991 ranged from 13 to 26 percent of normal, depending upon base contracts. Producers in the GWA relied exclusively on on-farm pumping for irrigation. Producers in the SWSA supplemented reduced allocations with intra-district and external water transfers.

Constraints—Federal Commodity Programs: The federal commodity programs provide financial assistance for the production of seven basic row crops: corn, wheat, barley, cotton, rice, oats and sorghum. Program benefits are based on Congressionally-mandated "target prices" which most often exceed market prices. Participating producers are paid the difference between the target price and the market price for a set quantity of production that is determined by current and historical yields and acreage.

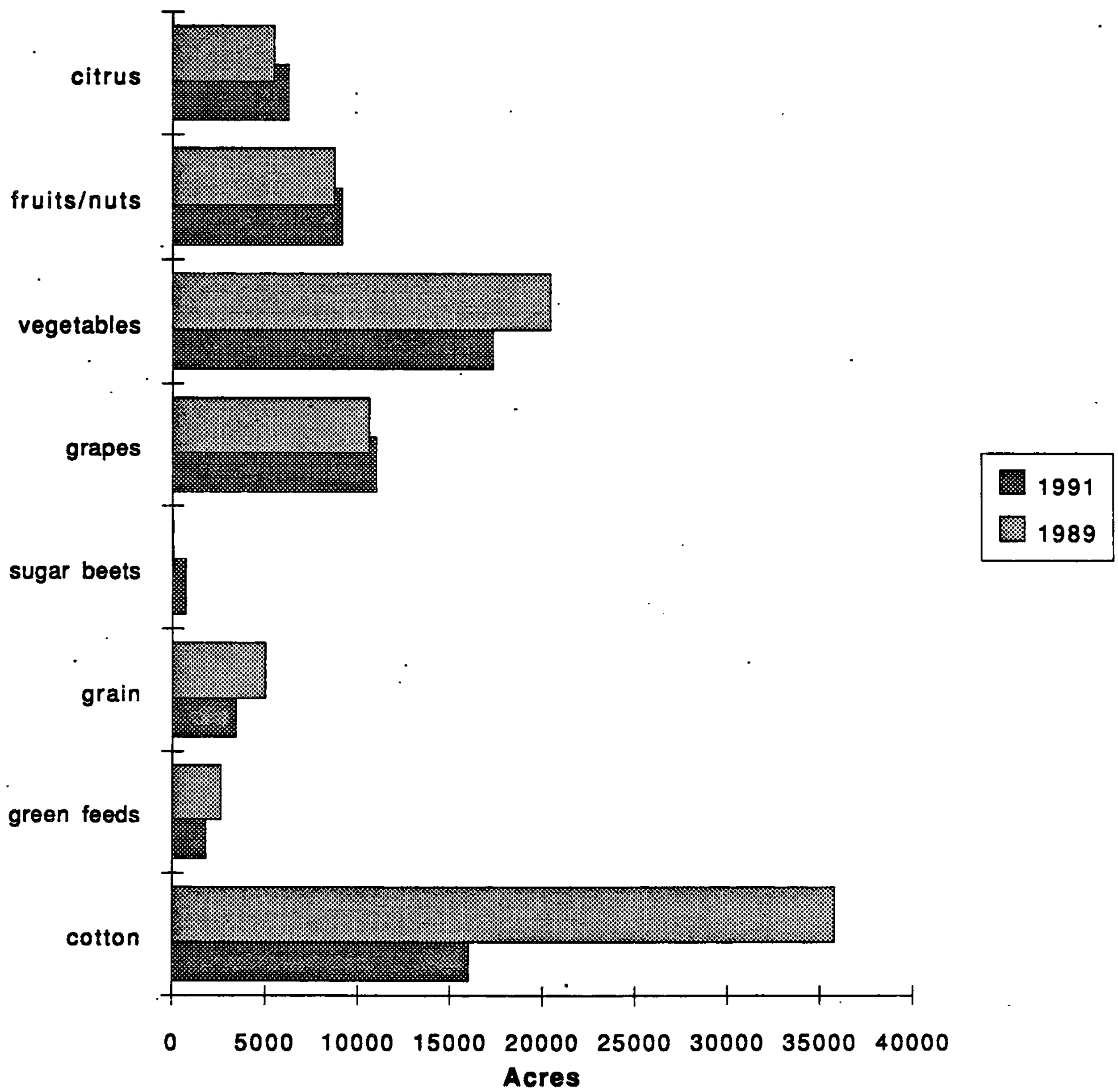
The federal commodity programs affect cropping decisions in two important ways. First, since payments are based on current and historical acreage planted to an eligible crop, producers may be reluctant to shift away from a commodity crop for a single year. Such a shift would affect not only the payments made in that year, but also payment levels in future years. This suggests that districts with significant acreage enrolled in the commodity programs may experience fewer crop shifts than otherwise expected, depending upon water availability and costs.

Second, aggregate drought-induced production shortages could well result in market prices that exceed program target prices for certain crops in certain years. This would provide an incentive for farmers with access to water to leave those programs which impose mandatory set-asides. However, the expected returns from this decision would have to be compared with the financial assistance provided by special program options (e.g. 0/92 and 50/92) for growers that agree to idle a significant portion of their eligible acreage for a given crop year.

Participation in the federal commodity programs is voluntary and varies by crop and location. The actual number of acres enrolled in the programs was not determined for the case study districts during Phase II. Information on commodity program participation rates will be collected and analyzed in Phase III of the study.

Figure 5.30: Cropping Pattern Changes, Wheeler Ridge-Maricopa WSD

Source: District Crop Surveys



The number of acres planted to crops *eligible* for the programs was tabulated (see Table 5.11). In 1989, almost 50 percent of the acreage in the case study districts, just over one-half million acres, was planted to eligible crops, mainly cotton and rice. With respect to individual districts, the proportion varied from zero percent in El Dorado ID to 55 percent in Westlands WD (cotton) and 73 percent in Glenn-Colusa ID (rice). In 1991, the number of acres planted to eligible crops in all districts as a percentage of total acreage dropped to 43 percent, or just over 380,000 acres.

Contracts with Processors: Many specialty crops (e.g. processing tomatoes, garlic and onions) are grown under contract for processors. These contracts specify, among other things, the day a crop will be delivered to the processor, the quality of the crop and the price. Average returns to producers are generally higher for these contracted crops than for crops sold on the open market. The stable profits that many contracts afford provide a strong incentive to meet contract obligations even when they require producing at a loss in the short-run.

As a result, producers with contracts will not switch their cropping patterns unless the benefits exceed the long-term profits from the contract. In rice production, multi-year contracts with rice drying and milling operations stabilize or increase profits, but they reduce flexibility with regard to cropping decisions.

Marketing Opportunities: Some marketing opportunities may take a long time to develop. Fluctuations in production levels may jeopardize certain markets not just in the current year, but also in years to come. Rice growers in Glenn-Colusa ID, for example, have worked hard to develop a domestic market for long and medium-grain rice varieties. They are not likely to switch to another crop in the face of short-run water scarcity because of potential negative effects on their domestic market share in the future.

Agronomic and Climate Constraints: Not all locations are suitable for all crops. In parts of Glenn-Colusa ID, for example, the high clay content in the soils makes it difficult to grow crops other than rice. Even within a district there are significant limitations that affect where crops can be grown. In the northern part of Central California ID, vegetables are double and even triple-cropped. In the southern part, however, it is too hot to grow vegetables.

Management Expertise: Not all producers know how to grow all crops. Even where equipment can be rented or leased and other conditions are right, it is difficult to profitably grow a crop with which a producer has little experience. Some producers may try to continue farming in the face of water scarcity to ensure key employees stay on the farm. In Lost Hills WD, for example, some growers maintained a base level of planted acreage to avoid laying-off farm managers and foremen.

Timing of Allocation Announcements: Producers cannot make instantaneous decisions about the crops they grow. Nevertheless, they are often informed of water supply allocations very close to, or after, their planting date. In Westlands WD, for example, allocations are announced in February, at the earliest, shortly before planting in March and April. This problem is particularly acute for growers who make large pre-planting investments. A producer in Glenn-Colusa ID reported that the expenses for crop specific soil preparation, chemical applications and pre-irrigation are incurred before water allocations are known, making it costly to switch crops or fallow land at a later date.

Direct Ownership of Processing and Marketing Infrastructure: Ownership interest in processing equipment and marketing cooperatives affect the production decisions of some producers. In Glenn-Colusa ID, for example, many rice growers have an ownership interest in rice drying and milling facilities. In Lost Hills WD, some producers are members of a growers' marketing cooperative. In Westlands WD, several cotton producers also own cotton gins and vegetable growers own cooling and packing plants. In all of these cases, profit-maximizing decisions extend beyond crop production and into processing and marketing. Producers with these other investments have an added incentive to maintain supply levels because their returns are linked to the volume of product that passes through the processing and marketing channels.

Impacts—The observed responses described above indicate that not all case study districts were affected by crop acreage reductions or significant crop shifts. Furthermore, not all acreage reductions or crop shifts can be attributed to water scarcity and/or higher water costs. To the degree that producers did respond by fallowing land and/or changing crop patterns the following impacts can be expected:

Impacts of Cropping Shifts

- Changes in input demand from "backward-linked" industries (e.g. machinery, fertilizers, pesticides, water, labor)
- Changes in composition of farm labor requirements
- Changes in farm output and input supplies and costs for "forward-linked" industries
- Potential changes in producer and consumer prices
- Potential changes in federal government outlays for commodity program payments

5.5.2 Lower Water Application Rates

Producers may respond to water supply reductions by altering per-acre water application rates. In theory, water application rates should be determined by bringing into equilibrium the marginal benefits and marginal costs of water. Lowering water application rates may "stress" plants, and reduce crop yields. The range of substitution possibilities of water for non-water inputs for maintaining yields is not expected to be very large. Reductions in water application rates should not be confused with efficiency improvements that allow the same level of plant growth (i.e. yields) with less water.

Observed Responses—Arvin-Edison WSD reported that some landowners in the "surface water service area" who did not have wells may have stressed their plants as a response to drought-induced water scarcity.

In Central California ID it was reported that the same amount of water was available to crops, although leaching rates declined. In the long term, yields will decline as the salts concentrate in the soil. The quantity of drainage effluent will decrease with reduced water application, however, the drain water quality is likely to deteriorate with inadequate leaching.

In El Dorado ID, water was available "on demand" for approximately the same price as previous years. As a consequence, there was no incentive to reduce per-acre application rates.

Likewise, in Glenn-Colusa ID there were no reports of any reduction in water application rates, explained in part by the District's "per-acre" method of charging for water.

Lost Hills WD reported that producers used scarce, expensive water to protect large investments in permanent crops. In general, water was applied at rates sufficient to produce normal crop yields. In most cases it appeared that the marginal cost of the additional water was less than the marginal benefits derived from normal yield output, as opposed to irrigations for plant survival alone.

According to Westlands WD personnel and producers, crops were supplied "with all of the water they needed" in 1991. According to one grower, there is "very little substitution possible" between water and nutrient applications. Permanent crop holdings in Priority Area II received USBR emergency water, eliminating the need to stress plants. There is also evidence of new plantings of vines and trees in the District.

Wheeler Ridge-Maricopa WSD reported that at the margin it made economic sense to provide adequate water for the permanent crops to produce high yields, rather than limit irrigations to merely keep the plants alive.

Constraints—Producers using flood and furrow systems have less control over flow to assure uniform distribution to their crops. This increases the risk of stressing plants with lower water application rates. Drip and sprinkler systems are able to apply more uniform amounts of water providing producers with better irrigation control and more flexibility for reducing water application rates.

Impacts—Determining optimal water application levels per crop under water scarce conditions requires a great deal of agronomic and economic information. Final crop prices, for example, bear heavily on the value of lost production when yields are affected. Nevertheless, opportunities for stressing plants occur throughout the growing season and decisions must be made when final prices are uncertain.

It is difficult to determine the extent to which a certain amount of water-stressing will affect yields both in the current year and in future years for permanent plantings. Site-specific factors such as soil type and the number of calorie-days in the growing season may affect final yields to a much greater extent than slight reductions in water applications. These confounding factors make it difficult for a producer to estimate the quantity of lost production associated with water scarcity.

Impacts of Reducing Applied Water

- Increased salt concentrations in the soil
- Reduced drainage effluent
- Variable yield effects with consequent effects on related industries
- Increased/decreased demand for irrigation labor

5.6 Mechanisms for Using Water More Efficiently

Irrigation efficiency is often defined as the ratio between the amount of water applied to a field and the water needs of the crop (plus leaching requirements and unavoidable losses minus effective precipitation). Improved efficiency entails producing the same amount of product with less water. Economic theory suggests that investments in irrigation efficiency improvement will take place if the marginal benefits of the water savings are larger than or equal to the marginal costs of achieving those savings. Marginal benefits are highly dependent on the price of water, but they also may include improved product quality, higher yields and reduced drainage effluent.

5.6.1 Irrigation Improvements

There are two categories of efficiency improvements: adoption of more efficient irrigation systems and employment of higher levels of management. Adoption of more efficient technologies depends upon favorable economic conditions, namely: economic incentives, that is, high water rates and/or technology subsidies; 2) high elasticities of marginal productivity with respect to water (i.e. crop output is elastic with respect to small changes in water application); and 3) sufficiently high crop returns to justify the incremental investment and variable costs associated with water-saving technologies. Furthermore, the effectiveness of low volume irrigation systems, such as sprinkler and drip, depend upon local topographical, soil, water quality and weather conditions.

Improved management can also increase irrigation efficiency. Management practices that can reduce water use without affecting crop yields include: 1) use of specialized equipment and computers to monitor soil moisture levels and weather conditions; 2) frequent monitoring of tailwater levels; 3) use of gated pipe to reduce furrow length, as well as other labor-intensive irrigation techniques; and 4) laser leveling.

Observed Responses—In Arvin-Edison WSD, vegetable crops are grown using sophisticated irrigation/nutrient technology to reduce risk and maximize yields. Both above-ground and bedded drip irrigation systems are used, often in conjunction with plastic mulches. Orchards and vines are irrigated almost exclusively with drip systems. For both fruits and vegetables chemigation is used to apply nutrients. A local irrigation consultant noted that the highest potential water savings from drip systems are for extreme conditions such as very sandy soils or rolling terrain. Otherwise, linear movement sprinklers are efficient for most row crops.

In 1989, the District reported that producers were using the following types of irrigation: cotton (sprinkler–100%), potatoes (sprinkler–100%), alfalfa (sprinkler–100%), vineyards (drip–50%, furrow–40%, sprinkler–10%), truck crops (sprinkler–70%, furrow–30%), grain (sprinkler–100%), deciduous orchards (drip or sprinklers–90%, furrow–10%), citrus (drip–100%). The District reports, "Almost all fields that are either sprinkler or row irrigated have tailwater sumps and tailwater recovery systems" (AEWSD, "Water Conservation Plan"). These systems are encouraged partly by District regulations governing tailwater returns.

Central California ID does not keep track of the irrigation systems used by its producers. It appears, however, that furrow and flood systems are most prevalent. Windy conditions in the District are an obstacle to the adoption of sprinkler systems. Drip systems would require constant maintenance because of high silt levels in District water supplies, although filtration devices are generally feasible. A local irrigation consultant said that many CCID producers are moving toward shorter furrow runs using gated pipe. Shorter runs allow more uniform water application, reducing seepage below the root zone near the water source and moisture deficiencies at the end of the run. Adoption of more efficient irrigation systems and other efficiency improvements are encouraged by the District's "Conservation Loan Program" (see Chapter 4).

In El Dorado ID irrigation efficiency has increased from below 50 percent to about 70 percent, on average, since the Irrigation Management Service began to serve producers in 1976. Most of the agricultural land is planted to permanent crops and the two most prevalent irrigation systems are micro drip and sprinkler.

About half the growers take part in the IMS. Participating growers rely on neutron probes and tensiometers placed in their fields to measure soil moisture at different depths. From the readings of these instruments (measuring soil moisture depletion) and data on daily weather conditions (CIMIS), elevation, slope, crop type, growth stage and cultivation practices, weekly field level crop water requirements are generated from a computer model. These computerized irrigation reports, containing specific timing and duration recommendations, are sent weekly to all IMS growers.

To qualify to participate in the IMS Program growers must have a commercial metered irrigation (CMI) account and own a minimum of five acres. Currently, there are 114 IMS participants out of a total of 228 active CMI accounts, covering 300 fields and about 3,000 acres (2/3 of all land farmed in the District). Non-participants include pasture/cattle operations (which are not eligible) and some CMI accounts that actually have less than five acres planted.

Glenn-Colusa ID does not keep track of irrigation systems used by producers. The District's "Water Conservation Incentive Plan" provides for an eight percent reduction in water rates for producers who take two of the following eight measures: minimize spills, install a recirculation system, install drip or sprinkler systems, reuse drain water, apply certain techniques approved by USDA's Agricultural Stabilization and Conservation Service or the Soil Conservation Service, maintain private laterals, laser level or apply any other conservation technique approved by the Board of Directors. Approximately 30 to 40 percent of the District's producers are participating in the program. Some producers are installing tailwater return systems.

Lost Hills WD has commissioned a water management plan that will determine relative adoption rates of different technologies. Preliminary results suggest that 60 percent of the cotton in the District is irrigated with sprinklers while 40 percent is grown with furrow systems. District personnel also report that increased management and some investment has taken place in 1991 to increase irrigation efficiency. Some producers, for example, irrigated their crops at night to reduce evaporative losses during 1991.

Irrigation efficiency improvements have been supported by LHWD's long-standing conservation program which encourages the following activities: (1) utilization of CIMIS and ET information for irrigation scheduling; (2) utilization of soil moisture sensing devices; (3) alternating furrow irrigation when water requirements are low; (4) shaping of furrows prior to irrigation so that water can advance faster to the end of the field; (5) installation of runoff return systems to allow application of heavy furrow flow rates and fast advance times, both of which lead to improved distribution uniformity; (6) replacement of earth ditches and siphon pipes with gated pipe; (7) conversion of furrow irrigation to sprinkler irrigation on annual crops; (8) conversion of furrow to drip irrigation on permanent crops; and (9) conversion to shorter furrows.

In Westlands WD there is little information about efficiency improvements that resulted directly from drought-induced water scarcity. The District's Water Conservation Program, however, continued to be heavily subscribed in 1991. Each week producers are mailed an irrigation guide with separate information tailored to the northern, central and southern areas of the District. The guide provides recommendations on the amount and timing of irrigations based on local weather monitoring. The District also assists growers with computer programs, technical advice and irrigation monitoring.

Past studies have investigated irrigation efficiency in Westlands WD. The 1986 Water Conservation Plan reported that 63 percent of District acreage was irrigated with furrow systems, 21 percent with sprinklers, 15 percent with "sprinkler-furrow" systems and one percent with drip systems. With regard to irrigation efficiency, a 1989 report had the following findings: (1) long-season, high water use, deep-rooted, salt-tolerant crops have higher irrigation efficiencies than short-season, less salt-tolerant, shallow-rooted crops; (2) producers apply excessive amounts of water to vegetables and other high value crops to guard against reductions in crop yield, quality or marketability; (3) furrow length did not show a consistent relationship with efficiency; and (4) flexibility in irrigation systems was important for enhancing efficiency (Jones and Stokes, 1989).

Producers in Westlands and other districts may be adopting drip irrigation for reasons other than reduced water costs. Drip can improve product yields and quality through micro-managing of nutrient and pesticide applications. Drip is said to be much more efficient for irrigating young trees than other systems, though with older trees furrow and sprinkler systems can be equally efficient.

Wheeler Ridge-Maricopa WSD does not collect data on irrigation technology. District staff stated that most permanent crops are irrigated with sprinkler or drip systems. Both sprinkler and furrow systems are used on annual crops. Producers using drip irrigation have purchased filtration systems to remove emitter-plugging silt.

The District does not have a formal conservation program. According to WRM personnel, "Price is the conservation program." Using a derived demand methodology, the District estimates average irrigation efficiency for the period 1977 through 1990 at 80 percent.

Constraints—The range of constraints facing adoption of irrigation system improvements is discussed below.

Lack of Information: Water savings from irrigation system improvements are highly dependent on site-specific conditions such as soil type, field slope and assorted climate conditions. The windy conditions around Central California ID, for example, may reduce or even eliminate the water savings from greater use of sprinklers. Variable water quality may also create uncertainty. For example, filtration devices of varying types and costs are required for drip systems supplied by water with high levels of suspended solids. Knowledge regarding future water availability and costs is also important, but is often untimely and unreliable. As a consequence of these uncertainties, it is very difficult for a producer contemplating irrigation improvements to be sure that a particular investment will produce financial benefits.

Crop Type: Different irrigation systems are appropriate for different kinds of crops. Drip systems have been successfully employed by vegetable growers and in orchards and vineyards. However, they are not economical for many crops such as cotton, grains and alfalfa. Sprinkler systems can be employed for nearly all crops, though the quality of some vegetables and grapes will be diminished if they are sprinkled close to harvest time.

Uncertainty: Producers may be unwilling to make long-run investments in irrigation systems in the face of infrequent shortages. An investment could "pencil out" in a critical year, but not in a normal year.

Water Rights: Some producers expressed concern over whether water that is saved from irrigation system improvements would lead to forfeiture of their water rights. In an attempt to eliminate such fears, the legislature has specifically provided that "any cessation or reduction" in water use due to conservation "shall be deemed equivalent to a reasonable beneficial use" of the water and, furthermore, that "[n]o forfeiture of the appropriative right to the water conserved shall occur" (Cal. Water Code sections 1011(a), 11961). The legislature has also provided that conserved water "may be sold, leased, exchanged, or otherwise transferred" (Cal. Water Code sections 1011(b) and 1244). Producer concerns, however, appear to persist even in the face of these statutory protections.

Ownership: Tenant farmers usually have little incentive (or authority) to install expensive irrigation systems. Cost-sharing arrangements between tenants and landowners may be difficult to arrange.

Impacts—The net financial impacts of irrigation system improvements depend upon the associated costs and affected crop yields and prices over time.

Impacts of Improvements in Irrigation Efficiency

- Reduced grower expenditures for water where water is charged on a per-unit basis
- Increased expenditures for the purchase, installation and maintenance of more efficient systems
- Potential increase in revenues from higher yields and improved product quality
- Potential decrease in drainage effluent and costs associated with drainage management
- Potential reductions in irrigation labor demand
- Potential changes in energy use
- Potential reductions in groundwater recharge from surface sources

6.0 RESEARCH FINDINGS ON RESPONSES AND ADJUSTMENTS TO WATER SCARCITY BY DISTRICTS AND PRODUCERS

There was wide variation in the kinds and levels of responses and adjustments adopted by the case study districts faced with water shortages. Opportunities for adjustment are determined by total water availability (rights, contracts, other sources of supply), on the one hand, and prevailing constraints (physical, legal, institutional, financial, environmental), on the other hand. The observed and potential impacts of these responses and adjustments were identified during Phase II and are reviewed in Chapter 7.

6.1 District Water Supplies

1. "Critical" year entitlement cuts, specified in Central Valley Project (CVP) and State Water Project (SWP) contracts, vary widely according to type and year of contract, priority status and source of water, among other factors. For example, exchange contractors (Central California ID - CCID) are subject to a maximum cut of 25 percent in any one year. SWP contractors (and Kern County Water Agency (KCWA) subcontractors) are subject to a fixed formula for allocating short supplies among agricultural and urban water users, such that agriculture cannot take more than a cumulative 100 percent cut over a seven year period.

2. Reductions in deliveries for the case study districts in 1990 and 1991 (as compared with 1989) were similar to those for the CVP and SWP as a whole, as shown in the table below. An exception was the substantially larger percentage cut for the CVP case studies in 1991 (51%)) as compared with all CVP contractors (32%), explained by the exceptionally large reduction in deliveries (67%) to Westlands WD (WWD).

Supplier	Ag.Deliveries in 1989 (MAF)	% Reduction in 1990	% Reduction in 1991
Entire CVP	5.58	15	32
Entire SWP	1.25	52	100
CVP Case Studies	1.80	19	51
SWP Case Studies	0.33	41	100

3. Critical year water entitlement announcements are usually made in mid-February, and may be revised anytime thereafter depending upon changes in precipitation and runoff conditions. This new element of uncertainty can have important financial implications. Several districts reported that late announcements and revisions impeded timely water and agricultural planning at both the district and farm-levels. This was a particularly serious problem for Glenn-Colusa ID (GCID) growers in 1990.

4. To significant and varying degrees, water suppliers are able to make up surface contract water shortages with alternative supplies, principally groundwater extractions and external transfers. The economic and social costs associated with these alternatives vary widely depending upon the location of the district and its hydrology, physical delivery system and institutional arrangements, among other factors.

5. Preliminary research indicates that those districts with access to multiple sources of water (Arvin-Edison WSD (AE), El Dorado ID (EID)) and those with contracts that specify relatively small reductions in critical years (CCID, GCID) have fared best during the on-going drought, whereas those districts highly dependent upon project water with little flexibility for augmenting supplies have fared worst (WWD, Lost Hills WD (LHWD), Wheeler Ridge-Maricopa WSD (WRM)).

6. When all sources of supply are included at the district-level, the data indicate the following ranges in *reductions in total water availability* for the case study districts as compared with "average" levels, where average levels are computed from annual water availability in 1975 through 1989, excluding 1977:

   CVP

   1977—21% (CCID) to 74% (WWD), average reduction = 47%
   1990—0-1% (AE, CCID) to 29% (WWD), average reduction = 15%
   1991—17 % (CCID) to 58% (WWD), average reduction = 37%

KCWA (SWP)

1977—33% (LHWD) to 61% (WRM), average reduction = 50%

1990—10% (WRM) to 17% (LHWD), average reduction = 12%

1991—67% (WRM) to 70% (LHWD), average reduction = 68%

On an aggregate level, the seven case study districts experienced reductions in total water availability, as compared with average levels, as follow:

Total Average Reductions

1977	47%
1990	15%
1991	40%

These figures do not include on-farm groundwater pumping. Estimates of on-farm pumping are available from WWD and WRM, but not from CCID or GCID. Adding estimated groundwater extractions to total water availability, the figures change as follow:

Total Average Reductions
(With Est. On-Farm Groundwater—WWD, WRM only)

1977	36%
1990	9%
1991	34%

6.2 District Responses and Adjustments

Water suppliers have three basic mechanisms for adjusting to surface water shortages caused by drought or longer-term changes in water quality standards and flow requirements: 1) maintain and/or enhance water supply through use of alternative sources; 2) change allocation of available supplies; and 3) improve efficiency in water delivery, monitoring and use. Districts that face severe constraints with respect to alternative supplies must rely on changes in allocation rules and improvements in efficiency to minimize the impacts of water shortages on their water users.

6.2.1 Mechanisms to Maintain Water Supply

A. District Groundwater Pumping and Integration

1. Prior to the CVP/SWP surface water deliveries there were serious overdraft problems in Arvin-Edison WSD, Westlands WD and Wheeler Ridge-Maricopa WSD (and generally throughout large areas of the S.J. Valley). Problems associated with overdraft include: longer pumping lifts and higher costs, deteriorating water quality and land subsidence. With the current on-going drought, these same overdraft conditions are surfacing again and will become progressively worse as the dry spell continues.

2. Advantages of groundwater pumping as a means to increase total water supply include: minimal legal and institutional constraints, availability of underground supplies in dry years and minimal conveyance requirements. Disadvantages and/or constraints include: hydrologic conditions and poor well yields (e.g., EID - 60 GPM), high fixed costs for well drilling and refurbishment and increasing variable costs with higher lifts and greater energy use. Also, high pumping rates, over and above estimated safe yields, can lead to deteriorating water quality with potential negative impacts on crop productivity.

3. Conjunctive water use management as practiced by Arvin-Edison WSD can mitigate to a large degree the economic and environmental costs associated with unmanaged groundwater pumping. Through concerted spreading and percolation operations during wet years, Arvin-Edison has been able to overcome earlier problems with overdraft and deteriorating water quality and accumulate adequate stored water for use during dry years.

   However, its success at maintaining groundwater stability over time (as with other districts) depends upon several factors: 1) the frequency with which surface water allocations reach normal to wet levels; 2) on-farm groundwater extractions and the district's ability to regulate this "common pool" problem; and 3) the financial resources available for investment in larger and more efficient spreading, percolation, pumping and monitoring operations. The proposed Water Storage and Exchange Agreement between Arvin-Edison WSD and Metropolitan Water District demonstrates one possible approach for easing the financial constraint.

4. Another mechanism to maintain water supplies was through district promotion of on-farm groundwater pumping *in exchange for* surface water allocations or for *integrating* groundwater with district supplies in exchange for future water credits. These groundwater exchange and integration programs allowed districts to better meet the inter-temporal irrigation needs of their users. Integrated or pooled water had to meet fairly stringent water quality standards.

B. External Water Transfers

1. On average, out-of-district water purchases represent a very small share of total water supplies for the case study districts - approximately one percent for the CVP contractors and zero percent for the KCWA subcontractors.

2. In 1991, the importance of external transfers rose slightly for the CVP districts - to nearly four percent of total supply. Most of the increase took place in Westlands, where transfers represented 12 percent of total supply. With the 100 percent cut in SWP allocations to agriculture in 1991, external transfers became an essential water source for these districts - 61% and 100% of total supply for WRM and LHWD, respectively.

3. Transfer water was available from counties, suppliers and individuals with surplus supplies, mainly north of the Delta, and from the DWR's State Water Bank. KCWA member units had access to water from the Agency's Emergency Groundwater Pool.

   In general, this water was purchased at high cost ($100-$200/AF plus conveyance charges) and was reserved for permanent crops and late season critical irrigations of annual crops. Wheeler Ridge WSD growers elected to fallow land rather than purchase State Water Bank water at over $200/AF, indicating the range at which the cost of water exceeds its marginal value for certain crops and regions.

4. The state legislature, USBR and DWR have relaxed certain constraints on water marketing since the late 1980s in order to encourage conservation and the sale of excess water in short years. However, certain legal, institutional and physical constraints remain including: 1) a 60 day waiting period for SWRCB approval of "temporary" transfers, and a much longer and more involved approval

process for transfers lasting longer than one year; 2) transfers of CVP contract water are bound by destination (other USBR contractors) and type of use provisions - otherwise contracts may be altered; 3) the timing and flow of transfers are limited by water quality standards in the Delta, Delta pumping capacity and the availability of conveyance facilities and facility capacity;[1] and 4) the lack of a functioning water market makes it difficult, time-consuming and often costly to "match" buyers and sellers. These constraints create high "transactions costs" and considerable uncertainty.

5. Preliminary research indicates that the case study most likely to be a candidate for selling water outside the district in some years - GCID - was in fact not eager to do so, even when the "price was right." GCID staff believe that unlimited water transfers would have negative effects on district water planning and on the local rice-dependent economy. GCID rice producers also cited long-term obligations to processors and protecting their market share as reasons for not engaging in short-term water transfers.

This finding suggests that the market price of water, while important, is only one factor that potential water sellers will consider as water marketing becomes a more common and flexible option.

C. New Water Supply Projects and Contracts

1. A long-term mechanism for maintaining or enhancing water supplies is for a district to pursue new water diversion or storage rights with the State Water Resources Control Board (SWRCB) or to renegotiate CVP/SWP contracts to include greater volume or more stable supply. These options are appealing in providing a long-term solution to future water shortages, but are severely constrained by various institutional, physical, financial and environmental factors.

   Both options are increasingly more limited by growth in urban water demand and flow restrictions required to meet Bay-Delta water quality standards. There is very little flexibility for augmenting long-term water supplies to agricultural regions south of the Delta unless new projects were developed to increase the Delta's pumping and

1 Insufficient capacity in the conveyance system limits the ability to move water "on demand" since transferred water can only claim residual conveyance capacity.

conveyance capacity and augment storage capacity in the San Joaquin Valley. Water development projects on both the state and district-levels must undergo very expensive and time-consuming environmental review processes and require strong financial backing. These and other political and institutional constraints have acted to deter such projects, a pattern that is expected by many to continue in the foreseeable future.

2. Only El Dorado ID among the case studies is actively pursuing acquisition of new water rights and approval for project development. The District enjoys favored status as a "watershed of origin" and "County of origin" and holds early priority appropriative rights to the American River. Furthermore, both the motivation and financial backing for water development are coming from growing urban demand in the area. The water generated from these projects, expected to be expensive as compared with current rates, will by and large be assessed to new urban occupants. This unique set of conditions places EID in a better position for obtaining approval from the SWRCB.

6.2.2 Mechanisms to Allocate Available Water Supplies

A. Water Allocations to Growers

1. While pursuing various mechanisms to maintain water supplies, most districts have also instituted changes to ensure the most equitable and efficient allocation (in terms of delivery and management) of reduced supplies in water short years. During 1991, districts "rationed" short supplies through "across the board" per acre allocation cuts, subject to seasonal restrictions. Only EID continued to supply its agricultural customers with water "on demand" (voluntarily controlled through widely used conservation practices).

2. The range in allocation cuts to district growers in 1991 was zero percent (EID) to 87 percent (WRM). Cuts were fifty percent or greater in four of the seven case studies (AE, WWD, LHWD, WRM). To varying degrees, growers were able to supplement district supplies with on-farm groundwater pumping, intra-district transfers and private external transfers. Emergency CVP water was made available to producers of permanent crops.

B. Timing of Deliveries

1. The timing of district deliveries in water short years is especially critical to ensure that peak irrigation demand is met to the fullest extent possible. Nevertheless, districts' flexibility for altering the timing of deliveries to growers is constrained by the timing and flow of imported supplies, which, in turn, are guided by run-off and storage levels, conveyance capacity and seasonal flow restrictions out of the Delta.

2. Most district contracts and permits for appropriate rights specify maximum monthly (or seasonal) diversions/entitlements and flow rates. Usually entitlement water not taken during one period cannot be "carried over" and used during a later period. This "use it or lose it" policy may discourage some districts from adopting conservation measures that could lead to permanent reductions in water deliveries.

3. In general, districts with the potential for conjunctive water use, either with district or on-farm groundwater pumping, were able to best meet irrigation demand by allocating scarce surface supplies during the peak season (with its maximum flow and frequency requirements), letting off-peak irrigation needs be satisfied with groundwater. Changes in Bay-Delta water quality standards and flow restrictions could reduce surface deliveries to agriculture during "peak" demand on a permanent basis. This would severely strain conjunctive water use as a partial solution to inter-temporal water planning.

4. The efficient and equitable allocation of water was facilitated through the use of intra-district transfers of surface water and groundwater among "surplus" and "deficit" growers. Although intra-district transfers occur in all years, the research findings indicate that such transfers increase in number and volume in water short years. All case study districts permitted such transfers, with the exception of WRM which allows transfer of groundwater only. Some districts allow "free market" intra-district transfers, while others regulate the prices charged. In all cases, growers were permitted to use district conveyance facilities for wheeling, at a minimum charge.

C. Water Rates and Revenues

1. There appear to be few legal limitations on districts' authority to set water rates for their customers. Districts may charge for water by acre, connection or metered use to reasonably cover their operating costs, and may assess additional fixed charges to cover special projects or investments.

2. Examination of the case study districts' statements of revenues and expenses indicates that water sales were the principal source of revenue for the five CVP contractors, and that fixed producer charges were the principal revenue source for the two KCWA subcontractors. Districts may raise their water rates to offset lost sales volume and greater expenses (e.g. higher energy costs) in water short years, or alternately, use district reserves and cost-cutting measures to make up the deficit.

3. Among the case study districts, only GCID raised its water rates for contract water in both 1990 and 1991 in response to drought conditions. Westlands WD raised rates continually from 1985 through 1990, but was able to lower rates in 1991 by temporarily eliminating certain grower charges. Both Westlands and Arvin-Edison dipped into reserves and adopted cost-cutting measures (e.g. deferral of maintenance and temporary lay-offs) to offset lower sales revenues. Water rates for growers in the two SWP districts increased dramatically as the districts and individual producers were forced to rely on high cost alternatives, principally external transfers. LHWD and WRM allowed these growers to defer their SWP fixed obligations to future years. CCID introduced an inclining tiered rate structure in 1989 to promote conservation and raise additional revenues. These responses are consistent with water suppliers' efforts to provide "stability" in prices during periods of shortage.

4. In 1991, and historically, the variation in water rates among the case studies was very wide, from a low of just under $10/AF (CCID, GCID) to over $200/AF in LHWD and WRM for non-contract water. El Dorado ID, Westlands WD and Arvin-Edison WSD water rates fell somewhere in between.

6.2.3 Efficiency Improvements in Water Delivery and Use

Faced with potential long-term surface water reductions, most districts have shown interest in finding ways to improve the efficiency of their delivery systems, primarily through reductions in seepage losses and improved water use accountability. The ability to achieve significant water savings from these measures depends upon current delivery efficiency rates and the level of "unrecoverable" losses, among other factors. Districts are also interested in promoting improved on-farm irrigation efficiency as a means to match demand with reduced supply.

A. Information Services and Conservation Measures

1. The case study districts, to varying degrees, encouraged improvements in on-farm irrigation efficiency by providing: 1) relevant information and technical services to growers, and 2) economic incentives for growers to adopt an array of conservation measures.

2. For example, EID, LHWD and WWD provide crop-specific irrigation recommendations to district growers based on local weather conditions and estimated ET rates. In the case of EID, its sophisticated Irrigation Management Service is responsible for saving approximately 2,000 AF of water per year, or 0.67 AF/acre.

3. CCID offers low interest loans to district growers for investments in a series of water-saving measures (e.g. ditch lining, installation of water recovery systems, adoption of sprinkler or drip irrigation, among others). Since 1991, GCID initiated a Conservation Plan that offers an 8 percent refund on water bills for growers that can demonstrate adoption of at least two recommended conservation measures. Both programs enjoy high participation rates, however, estimates of actual water savings are not available.

B. Physical Delivery System Improvements

1. The case study districts vary widely with respect to estimated delivery efficiency rates (water delivered at farm-gate/water conveyed). Variation in efficiency rates reflects

differences in conveyance facilities (pipeline, lined and unlined canals and ditches), tailwater and drain water recovery, meter accuracy, level of automation and weather conditions, among other factors.

2. Among the case study districts, CCID, EID and GCID reported fairly low delivery efficiency rates of approximately 70 percent. CCID estimates that 60,000 to 80,000 AF of water (13% of full entitlement) are lost annually from seepage through district canals, although a portion of this is recoverable. The other four case studies, Arvin-Edison WSD, Westlands WD, LHWD and WRM reported high delivery efficiency rates, at or exceeding 80 percent. Westlands WD estimates seepage losses from district ditches and reservoirs at about 27,000 AF per year or less than two percent of normal deliveries.

3. Of the seven cases, only El Dorado ID invested substantially in physical system improvements in the last two years. Other districts could not justify the long-run costs of such improvements (e.g. canal lining, replacement of leaky pipeline) given the value of expected water savings. Most districts continued to support routine maintenance of facilities and equipment, although certain maintenance projects were deferred because of insufficient funds. Deferred maintenance over time will likely have negative effects on finances and operations.

6.3 Producer Responses and Adjustments

As discussed earlier, district allocations to producers in 1991 were cut in all case study districts except El Dorado ID. The reductions varied from just 15 percent in CCID to over 70 percent in WWD, LHWD and WRM. However, in all case study districts at least some producers were able to supplement reduced allocations with alternative sources, bringing *total water availability* to a higher level. Data is not yet available on these other sources for all cases.

Preliminary research on producer responses and adjustments to on-farm water shortages indicates that producers have coped with reductions in district allocations in three basic ways: 1) reliance on alternative sources of supply; 2) changes in planted acreage and cropping patterns; and 3) irrigation efficiency improvements.

6.3.1 Case Study Farm-Level Characteristics

Primary data on basic farm-level characteristics in the case study districts reveal a heterogeneous sample with respect to farm size and operation, cropping patterns, value of production and land values. Producers' responses and adjustments to water shortages are affected, to varying degrees, by these farm characteristics.

1. In 1989, the percentage of total acreage in permanent crops ranged from less than 4 percent (GCID, WWD) to nearly 100 percent (EID), and exceeded 25 percent in Arvin-Edison, LHWD and WRM.

2. The estimated gross value of crop production in 1989 per acre was highest in Arvin-Edison WSD ($3,392) and lowest in CCID and GCID (about $800). These figures reflect the predominance of high value vegetable, fruit and nut crops in AE versus lower value annual crops (cotton, rice) in CCID and GCID.

3. Farm operation size among the case study districts ranges from a predominance of very small farms in EID to a majority of medium and large farms in Westlands WD and Lost Hills WD. In general, larger farms have greater flexibility for adjusting to water shortages as a result of the financial resources available to them for investing in wells and on-farm efficiency improvements and for purchasing high cost water from outside the district.

4. The availability and reliability of water supplies are reflected to some degree in agricultural land values. Among the case studies, land values in Westlands WD declined in recent years, in part because of uncertain water supplies, but remained stable or increased in districts with fairly secure water availability (CCID, EID, GCID and AE).

6.3.2 Alternative Sources of Supply

A. On-farm Groundwater Pumping

1. Groundwater is accessible to farmers in five of the case study districts (all except EID and LHWD). A significant portion of Wheeler Ridge WSD relies exclusively on groundwater for irrigation. Well depths, yields and water quality vary widely among

and within the district areas. For example, the groundwater table varies from about 250 to 600 feet in Arvin-Edison and from 150 to over 1,000 feet in Westlands.

2. On-farm groundwater pumping and intra-district groundwater transfers played a very major role in augmenting water supplies for producers in Arvin-Edison WSD, Westlands WD and WRM, and to a lesser extent in CCID. Groundwater has been used to a limited extent in certain areas of GCID.

3. The variable costs of groundwater pumping depend upon the depth of the lift and the capacity and efficiency of the pumping operation as well as prevailing energy rates and standby charges. Anecdotal information from case study producers indicate a range in cost of about $0.12 to $0.16 per foot of lift for lifts ranging from 150 to over 1,000 feet. This translates into a minimum cost of $18.00/AF of pumped water to a maximum of over $160.00/AF. The latter figure may no longer be economically efficient for most crops. If groundwater extractions continue to exceed replenishment, the associated energy costs will increase over time with the lowering of the water table.

4. Many producers had to invest in well drilling or refurbishment to utilize their groundwater resource. Anecdotal evidence from district producers suggests that a new well costs from $150 to $400 thousand, well refurbishment costs about $50,000, a test well costs about $10,000, and a diesel pump costs $35,000 or $2,000 per month on a rental basis. These large investments required producers to take on substantial long-term debt and defer other farm improvements or purchases for an indefinite period.

5. Although the use of groundwater has mitigated the negative effects of surface water shortages in many areas of the Central Valley, such heavy reliance on the groundwater resource is not sustainable in the long-run. Not only would unregulated pumping become uneconomical over time, but it would also create serious resource quality problems such as land subsidence, deteriorating water quality, aquifer depletion and salt water intrusion in certain areas. Therefore, if surface water reductions are to continue on a more permanent, if less drastic, basis, groundwater regulation might be appropriate as a means to avoid serious overdraft and maintain groundwater stability and quality.

B. Intra-district and External Water Transfers

1. Case study producers used both intra-district transfers of surface and groundwater and external (out-of-district) transfers to supplement reduced allocations. Intra-district transfers occurred in all cases except El Dorado ID; farmers purchased water from outside the district in three cases—WWD, LHWD and WRM. In addition, producers of permanent crops in CVP districts were eligible for USBR emergency or "hardship" water at the normal water rate.

2. Interviews with producers indicate that the high cost transfer water, especially external transfers, was used for permanent plantings and critical late summer irrigations of annual crops. In these cases, the expected marginal benefit of the water, in terms of permitting normal yield output, exceeded its marginal cost.

3. Privately arranged external water transfers are bound by the same constraints described under district responses, in addition to the need for district authorization of such transfers. As with districts, overcoming these constraints often involve high transactions costs.

C. Changes in Acreage and Cropping Patterns

For those producers that experienced a marginal increase in water costs brought on by water scarcity, economic theory would predict behavior that would either increase the marginal product of water or decrease its use and total cost. This could be accomplished in three basic ways: 1) fallowing low value crops; 2) reducing per acre water applications by shifting to less water intensive crops or by "stressing" crops; and 3) improving irrigation efficiency.

1. To varying degrees, producers in the case study districts fallowed cropland and shifted cropping patterns to match irrigation demand to available water supplies. In 1991, total planted acreage declined 11 percent as compared to 1989, and virtually all of the decrease was in annual crops, principally cotton. Westlands experienced the greatest absolute decline in acreage - over 58,000 acres.

2. The change in total planted acreage from 1989 to 1991 among the case study districts ranged from a three percent *increase* in Arvin-Edison to a 30 percent decrease in Lost

Hills WD. LHWD, as described above, is the case study with the least flexibility for supplementing surface water cuts with alternative supplies.

3. There were several significant changes in case study cropping patterns on an aggregate basis between 1989 and 1991: 1) cotton, rice, alfalfa and vegetable (excluding tomatoes) acreage fell by 18, 24, 6, and 6 percent, respectively; 2) tomato acreage increased by 29 percent; and 3) acreage in permanent crops remained stable overall. There appeared to be significant substitution of tomato acreage for lost cotton acreage in Westlands, and some substitution of cotton acreage in CCID (an increase of 31%) for lost acreage in WWD, LHWD, WRM and AE. When compared to other years these shifts exceed "normal" trends, although other data on possible confounding factors must be analyzed to determine the extent to which water supply reductions caused these shifts.

4. Research findings from the case study districts indicate a wide range of constraints that limit producers' abilities to shift cropping patterns in response to water shortages, especially in the short-run. These constraints include: 1) federal commodity program regulations that can encourage or discourage shifts away from program commodities such as cotton and rice; 2) multi-year supply obligations to processors of such crops as garlic, onions, processing tomatoes and rice; 3) concern about maintaining market share in a particular commodity (e.g. domestic long-grain rice among GCID producers); 4) producer ownership of processing operations that depend upon reliable supply levels for profitability; 5) various agroclimatic constraints, including soil type, temperature ranges and pest conditions; 6) farm management expertise and machinery and equipment complements required to grow a particular crop; and 7) the timing of water allocation announcements (e.g. reduction announcements made after crop specific pre-planting investments may come too late to trigger crop shifts).

5. With respect to changes in water application rates, research from the case study districts indicates that producers by and large applied the same amount of water to their crops in water short years. Producers chose to fallow land rather than risk lower yields from "stressing" their crops. In particular, lower value annual crops were fallowed to save reduced contract supplies and high cost transfer water for the high value crops, especially permanent plantings. Better information on water application rates will be available when 1991 crop yields are known and analyzed.

D. On-Farm Irrigation Efficiency Improvements

Irrigation efficiency is often defined as the ratio between the amount of water applied to a field and the water needs of the crop (plus leaching requirements and unavoidable losses minus effective precipitation). Improved efficiency entails producing the same amount of product with less water. There are two main categories of efficiency improvements available to producers: adoption of more efficient irrigation systems and improvement in irrigation management practices.

1. Anecdotal evidence suggests that few producers invested in more efficient irrigation technologies in 1990 and 1991. This may be explained by the competing financial demands of securing water supplies through well investment and transfers, and also by the lack of economic incentive in certain cases. Moreover, the effectiveness and efficiency of a particular irrigation system depends upon topography, soil type and the crop's particular water requirements. Adoption of low volume systems is not always feasible (e.g. rice). Furthermore, some districts reported high rates of low volume irrigation systems already in use (AE, EID, LHWD, WRM), diminishing their "room" for improving efficiency through technological change.

2. Improvements in irrigation management over the last few years are fairly widespread. Producers in Lost Hills WD, for example, irrigated at night during part of the 1991 season to reduce evapotranspiration losses. In CCID, producers have installed shorter furrow runs and gated pipe to obtain better water distribution uniformity. Laser leveling is also becoming more widespread. Irrigation Management Service (IMS) participants in EID monitor soil moisture conditions with the use of neutron probes and tensiometers. In general, there has been better utilization of crop and weather information through computerized water planning and irrigation programs, although the level of sophistication in irrigation scheduling varies widely.

The responses and adjustments to water shortages reviewed in this chapter have certain important economic and resource quality impacts that were identified during the course of Phase II research. A full inventory of these impacts, both observed and potential, is presented in the next chapter followed by a brief description of the economic analysis proposed for Phases III and IV of the study.

7.0 INVENTORY OF IMPACTS FOR FUTURE ANALYSIS

7.1 Introduction

Phase II of this study was designed to conduct preliminary case study analyses based on available data as a means of identifying the most salient impacts to be assessed and the additional data required for assessing them in Phases III and IV. Chapter 3 discussed the expected impacts of water shortages as predicted from economic theory and Chapters 4 and 5 reported the actual responses and adjustments to water supply reductions by case study suppliers and producers. Observed and potential impacts gleaned from field research were listed briefly.

The Phase II analysis has provided a great deal of insight into both the types of impacts resulting from water supply reductions and how they can be expected to vary with differences in water sources and rights as well as other institutional and physical factors which constrain adjustment decisions. It has also provided a sense of the economic and institutional complexities which must be reflected in the choice of methodology employed in Phases III and IV if we are to obtain an accurate assessment of economic impacts.

Information is not complete enough at this stage, however, to provide an analysis of the level or magnitude of expected impacts, nor would this be wise given that the reductions in water supply examined are a result of only one scenario regarding water supply levels (e.g. drought conditions). What is possible to do at this stage of the research is to identify the range of both observed and potential impacts that are likely if and when shortages are introduced on a more permanent basis. This "inventory" of impacts is provided in a series of tables that make up this chapter. Brief discussion of some of these impacts precedes the tables. The chapter concludes with a proposed plan of study for Phases III and IV that discusses what analyses and data are needed to further refine and measure a select subset of the impacts identified.

7.2 Defining Impacts

The scope of impacts to be considered in the economic analysis will be refined in Phase III of the study. As a working guideline for this Phase, *impacts have been broadly defined to include the full range of direct and indirect (both private and social), short-run and long-run changes that resulted or can be expected to result from reductions in water supplies to Central Valley agriculture.*

Portraying the full range of short-run and long-run impacts allows for maximum flexibility in determining the appropriate economic techniques for assessing impacts and will help to identify further data needs. Preliminarily, defining impacts in terms of "changes" that result from water shortages allows inclusion of both monetary and non-monetary effects. Were impacts to be defined solely in terms of "costs" or "benefits"—whether private or social—those not readily capable of being monetized might be excluded. Thus, the decision for this first step was to include all reported and potential changes. "Direct" impacts are defined as those associated with water suppliers and producers. "Indirect" impacts are defined to include changes affecting or likely to affect local economies and the quality of the agricultural resource base.

For this effort, the short-run is defined as the period of time absent capital investment with the long-run contingent upon capital investment. This "economic" definition differs from the "chronological" definition adopted by the SWRCB which encompasses a ten year planning horizon that may or may not include capital investment. It also differs within this study when reference is made occasionally to "long-run" resource impacts. In the Phase III analysis these various planning horizons will need to be clarified and defined in more detail.

This broad definition of impacts is intended to recognize that there are different perspectives with respect to which "changes" should be included in the economic analysis and how they should be measured and weighted in such analysis. This approach provides maximum flexibility for designing Phases III and IV of the study.

7.3 Identifying Impacts of Reductions in Surface Water Supplies

The first few tables present an inventory of the impacts or changes identified in Chapters 4 and 5 for water suppliers and producers, categorized by the different response and adjustment mechanisms. Table 7.1 is an inventory of observed and potential impacts for the case study water suppliers or districts. Table 7.2 presents the same information for case study producers. Impacts are further categorized by type as identified above: direct (district/producer) and indirect (local economy/resource quality). From these inventories, a subset of "priority" impacts can be selected for economic analysis in Phases III and IV.

For illustrative purposes, the impacts inventoried in Table 7.1 for water suppliers are mapped into an economic//financial analysis which is shown in Table 7.3. Observed and potential impacts of reduced water supplies on district income, operating expenses and capital investments are classified under financial and economic prices. Table 7.4 presents a similar economic framework for producers. Tables 7.5 and 7.6 inventory the local, state and national economy and resource quality impacts or "indicators of change" associated with reductions in surface water supplies. A subset of these indicators will be selected for qualitative and/or quantitative assessment, as needed.

7.4 Identifying Constraints on Adjustments

Table 7.7 provides a comprehensive list of the constraints identified during Phase II research on the abilities of districts and producers to adjust to changing water reliability and supply levels. These constraints are broadly categorized by: 1) level, timing and reliability of water supply; 2) management of available supplies, including institutional, legal and physical system constraints; and 3) financial and resource quality constraints. Table 7.8 presents a smaller inventory of similar constraints at the farm-level. The proposed plan of study for Phase III includes analysis of the expected mitigating effects of relaxing or changing some of the more important of these "binding" constraints.

Table 7.1: Inventory of Observed and Potential District Impacts Categorized by Response

	Direct		Indirect	
Responses and Associated Impacts	**District**	**Producer**	**Local Economy**	**Resources**
Impacts of Developing New Supply Sources				
Capital expenditures				
Legal and engineering costs for environmental assessments				
Deferral of other investments				
Higher per unit water costs				
Uncertain environmental impacts				
Reduce supplies for competing purposes				
Uncertain impacts on contracts (federal reclamation law)				
Impacts of Changing Allocation Rules				
Intra-district equity and efficiency issues				
Induce conjunctive water management				
Induce intra-district transfers				
Provide incentives to fallow land or shift crops				
Impacts of Changing Water Rates				
Increase or decrease sales revenues				
Provide incentives to reduce demand/increase irrigation efficiency				
Provide incentives to fallow land or shift crops				
Impacts of Improved District Water Management				
Higher operation and maintenance expenditures				
Higher monitoring expenses				

Table 7.1: Inventory of Observed and Potential District Impacts Categorized by Response (cont.)

	Direct		Indirect	
	District	Producer	Local Economy	Resource
Impacts of Incentives for Improved On-farm Water Management				
Increase operating expenditures (unless passed on to growers)				
Reduce per-acre demand for water/enhance supply				
Impacts of Physical System Improvements				
Increase long-term debt				
Water savings from reduced system losses				
Greater accountabiliy of water use				
Increase or decrease revenues (savings vs. expenses)				
Improve public image				

Table 7.2: Inventory of Observed and Potential Producer Impacts Categorized by Response

	Direct		Indirect	
	District	Producer	Local Economy	Resource
Responses and Associated Impacts				
Impacts of Reductions in Surface Water Supplies				
Reduce deliveries				
Reduce supply certainty				
Reduction in surface supplies for percolation				
Potential higher per unit water costs				
Potential increase/decrease in net farm revenues				
Potential reduction in drainage problems				
Impacts of Substituting Groundwater				
Higher energy demand and costs				
Investment in well development				
Well refurbishing and maintenance expenses				
Potential water quality deterioration				
Potential decline in crop yields				
Potential crop shifts				
Potential increase in pumping lifts				
Potential land subsidence				
Potential depletion of aquifer capacity				
Smoothing of supply fluctuations				

Table 7.2: Inventory of Observed and Potential Producer Impacts Categorized by Response (cont.)

	Direct		Indirect	
	District	Producer	Local Economy	Resource
Impacts of Water Transfers (for importers)				
Higher marginal water costs				
High transactions costs				
Smoothing of supply fluctuations				
Impacts of Water Transfers (for exporters)				
Maintain/enhance net returns in the short-run				
Increase fallowed acreage				
Wind erosion				
Continued need for weed control				
Increase uncertainty regarding future supplies				
Potential groundwater overdraft				
Potential reduction in local economic activity in related industries				
Potential for overall net increase in California income and employment				
Impacts of Crop Shifts				
Changes in seasonal water demand				
Changes in non-water input demand				
Changes in farm labor requirements				
Changes in composition of farm output				

Table 7.2: Inventory of Observed and Potential Producer Impacts Categorized by Response

	Direct		Indirect	
	District	Producer	Local Economy	Resource
Impacts of Crop Shifts (cont.)				
Potential changes in federal commodity program expenditures				
Potential changes in producer prices				
Potential changes in consumer prices				
Impacts of Lower Water Application Rates				
Increase in salt concentrations				
Uncertain yield impacts				
Decrease in drainage effluent				
Impacts of Adopting New Irrigation Technology				
Decrease in water demand and per acre costs				
Capital costs of irrigation systems and maintenance expenditures				
Increase/decrease in demand for irrigation labor				
Decrease in drainage effluent and groundwater recharge				
Potential yield and product quality improvements				

Table 7.3: District Economic Impacts of Reduced Water Supplies

		Financial Prices	Economic Prices
Income			
	Water Sales		
	Price		
	Quantity		
	Assessments		
	Interest		
	Other		
Operating Expenses	Salaries		
	Transmission/Distribution		
	Energy		
	Canal operation and maintenance		
	Well operation and maintenance		
	Conservation programs		
	Transactions costs		
	Water costs		
	Surface		
	Ground		
	Transfers		
	Legal, engineering, and environmental fees		
	Other		
Capital			
	Well development		
	System improvements		
	Long-term debt		
	Other		
Net Change			

Table 7.4: Producer Economic Impacts of Reduced Water Supplies

		Financial Prices	Economic Prices
Income			
	Production output		
	Acreage		
	Yields		
	Quality		
	Crop prices		
Variable Expenses	Water		
	Energy		
	Labor		
	Other inputs (fertilizers, pesticides, etc.)		
	Well maintenance and refurbishing		
	Irrigation management		
	Rent		
	Other		
Fixed Costs	Irrigation technology		
	Drainage and return flow systems		
	Well development		
	Land improvements		
	Machinery and equipment purchases		
	Other		

Table 7.5: Observed and Potential Impacts of Reduced Water Availability on Local, State and National Economies

		Indicators of Change: Qualitative	Indicators of Change: Quantitative
Local economy			
	Changes in level and composition of farm labor requirements		
	Changes in level and timing of energy demand		
	Changes in demand for other production inputs		
	Changes in supplies to "forward" linked industries (processing, transportation, marketing and trade, etc.)		
	Tax revenue changes (property, sales and income taxes from production and sales of agricultural commodities)		
	Changes in demand for social services (unemployment, health care, other)		
State	*Above changes at the State level*		
	Changes in consumer prices		
	Shifts in California's comparative advantage		

Table 7.5: Observed and Potential Impacts of Reduced Water Availability on Local, State and National Economies (cont.)

	Indicators of Change	
	Qualitative	**Quantitative**
National		
Changes in national income		
Changes in federal excise, transportation and other tax revenue derived from farm production		
Changes in export revenues		
Potential impacts on:		
• production stability		
•balance of trade and international competitiveness		
•federal program commodity costs		
•solvency of financial institutions		
•other		

Table 7.6: Observed and Potential Resource Impacts from Reductions in Water Supplies

	Indicators of Change	
	Qualitative	**Quantitative**
Drainage effluent		
Surface water and groundwater quality (TDS levels, heavy metals, salt balance, etc.)		
Water table levels		
Aquifer depletion		
Land subsidence		
Wind erosion		
Riparian habitat		

Table 7.7: Constraints on District Responses and Adjustments

Constraints on Level, Timing and Reliability of District Water Supply

Hydrological
- shallow or no aquifer
- poor groundwater yield/quality
- no local surface water sources
- intra-district hydrological heterogeneity

Physical System
- seasonal supply restrictions
- physical system bottlenecks
- overall pumping and conveyance capacity

Legal
- priority and type of water rights
- restrictions on rights ("beneficial use")

Resource
- existing overdraft situation
- quality deterioration

Policy
- regulation of water transfers
- contract conditions
- pricing policies
- water quality standards
- flow restrictions

Table 7.7: Constraints to District Responses and Adjustments (cont.)

Constraints on District Supply Management

Project Contracts
- variable water entitlements (Class II/surplus)
- critical year reductions
- maximum monthly entitlements and flow rates
- no profits allowed from transfers (CVP)
- limits on size of district service area
- compliance with Bay-Delta water quality standards
- land use restrictions
- fixed payment obligations

Federal Commodity Programs
- acreage restrictions (eligibility requirements for deficiency payments)
- farm size restrictions (CVP only)

Legal Decisions
- Racanelli (water quality)
- Barcellos (Westlands Priority 1,2,3 allocations)
- Reclamation Reform Act
- Bradley Bill (potential)
- Legal allocation requirements
- Continued legal challenges

Physical System Management
- hydraulic capacity/conveyance limits
- canal capacity (intra and inter-district)
- delivery efficiency rates (seepage losses)
- limits on storage capacity

Table 7.7: Constraints to District Responses and Adjustments (cont.)

Financial Constraints

- long-term debt
- limits on cash reserves
- limits on revenue-generating capacity
- fixed payment obligations (CVP/SWP)
- loan eligibility (credit risk increases with supply unreliability)
- escalating water costs (esp. SWP)
- rising operation and maintenance costs

Resource Constraints

- surface water and groundwater quality
- drainage management and disposal
- fish and wildlife habitat (required seasonal flows, water quality, dredging restrictions, riparian vegetation, endangered species scoping, etc.)
- urban/rural demographic pressures
- strict environmental review requirements for new projects/rights

Table 7.8: Constraints on Producer Responses and Adjustments

Constraints on Level, Timing and Reliability of Producer Water Supply

Hydrological
- access to groundwater
- well yields
- local surface water availability

System Constraints
- district capacity to provide timely surface water delivery

Water Rights
- priority status
- project participation and contract provisions (CVP, SWP)

Constraints on Management of Available Supplies

Agroclimatic
- weather (precipitation, wind, etc.)
- soils (permeability, salinity)
- topography

On-Farm Physical System
- on-farm storage
- drainage facilities
- water application efficiency
- water use measurement (surface and ground)

Irrigation Technology Information
- lack of technical assistance
- imperfect information
- computer literacy

Table 7.8: Constraints to Producer Responses and Adjustments (cont.)

Constraints on Management of Available Supplies

Institutional
- commodity program restrictions
- contract obligations with water districts
- water transfer policies
- district allocation policies
- flow and timing restrictions
- district groundwater programs
- drainage water quality/level standards

Financial
- cash reserves
- long-term debt
- loan eligibility

Market Conditions
- market share
- commodity prices
- profit margins
- long-term contracts (processors, marketing boards)

Farm Structure
- farm size
- ownership
- operator characteristics
- geographic distribution of farm operation

Resource Quality
- irrigation water quality (silt, salt concentrations)
- drainage management and disposal
- protection of endangered species

7.5 Proposed Plan of Study: Phases III and IV

The case study approach used in Phases I and II of the study will be continued in Phase III, building on the research base developed thus far for analysis of selected district, producer, local economy and resource quality impacts. These impacts will be modelled using surface and groundwater supply assumptions provided to the study team by the Technical Advisory Committee (TAC). Continuing with the case studies ensures that a wide range of observed and potential impacts will be assessed and that specific legal, institutional, physical and economic constraints will be incorporated into the analysis.

The economic impact analysis in Phase III will be guided by a "partial" net social welfare framework that considers both the private and social costs and benefits of adjustments to reduced surface water supplies. The direction and magnitude of a chosen subset of district, producer, local economy and resource quality impacts will be assessed. Quantitative analytical techniques will be used to estimate impacts where adequate data are available; detailed qualitative analysis will be used in other instances. The "state of the system" assumptions prevailing in Phase II of the study will remain valid in the Phase III analysis. As mentioned above, however, relaxation of some of the assumptions or constraints (institutional, physical, economic) will be explored for their potential mitigating effects on case study districts and producers and related local economy and resource quality issues.

7.6 Tasks for Completion in Phases III and IV

Task One: Obtain Water Supply Scenarios from the TAC

The study team will work with the TAC and the hydrology subcommittee to finalize a set of probable supply levels likely to result from different assumptions regarding water quality standards for the Bay-Delta. The supply levels will be expressed as "probabilities" of delivering given levels of supply for the Central Valley Project and the State Water Project. In other words, the scenarios will be expressed as the number of years in a given time period that water deliveries will approximate certain supply levels (e.g. wet, above average, normal, dry and critical). Water supply scenarios will also specify the amount of groundwater that can be pumped in any given year, expressed either as an acre-foot amount or as meeting certain criteria (for example, no net overdraft within any ten year period).

While no one expects the levels or standards selected for this analysis to be those that the SWRCB ultimately adopts, they will provide a mechanism by which longer-term responses can be solicited from districts and producers. Because shortages are likely to be sporadic and not as "deep" as those experienced during drought years, a more accurate assessment of the impacts can be determined with this method. Furthermore, by presenting water supply reductions as a year-to-year "probability," a more realistic set of investment patterns will be revealed by farmers than under "emergency" drought conditions. For example, farmers may invest in wells or more efficient technologies at different rates under a "random" path of water reductions (e.g. 20 percent chance of a "critical" year) than under a "flat reduction" scenario (e.g. 15 percent annual reduction).

Task Two: Collect Data Required for Economic Analysis of Impacts

As the framework for analyzing impacts has been developed, it has become clear what data remain to be collected in the case study districts. For example, only two of the five districts where producer groundwater pumping is important have developed estimates for producer groundwater use. Data for extractions in the other three districts will have to be developed to ensure consistent application of the TAC water supply scenarios. Other data that will be collected include final 1991 surface water deliveries, final 1991 cropping patterns, federal commodity program participation rates and the most recent financial statements for each district.

Task Three: Conduct Focus Groups with District Personnel and Producers

Analysis of financial statements for the last few years will serve to determine the financial impacts suffered by the case study districts from recent surface supply reductions. District responses to the TAC water supply scenarios will be modelled based on extensive consultation with "focus groups" comprised of district personnel. Expected adjustments under projected long-run changes in water availability will be elicited. The focus groups will be organized according to standard statistical procedures that should minimize any bias in their responses. Particular interest will be paid to expected behavior regarding water pricing, capital investments, groundwater extractions and future exchange and/or transfer arrangements with parties outside the district.

Focus groups will be used to elicit responses to the TAC water supply scenarios from producers as well. Comprised of producers representing the full range of major crops in each district, these focus groups will be presented with 1990 and 1991 data for district-level cropping patterns and land use changes, representative crop budgets, per acre water use, groundwater pumping levels and other important "decision" variables. Given this information, producers will be asked to predict their behavior (responses and adjustments) under the TAC water supply scenarios. These expectations will be used to determine a "range" of likely responses and adjustments by producers. Focus groups will also be asked how their responses and adjustments would differ given specific changes in prevailing constraints.

Task Four: Analyze Economic Impacts of Predicted District and Producer Responses

Expected responses and adjustments of participants in the district and producer focus groups will be compared to the empirical analyses of district-level data to determine if they are consistent with "rational" decision-making. Investigation of both the primary data and the predicted responses will occur where there are sizeable deviations. Selected impacts will then be quantified within the net social welfare framework discussed above.

Economic impacts at the district-level will be assessed by analyzing how changes in water supplies will affect individual items on the balance sheets. It is expected that districts will face reductions in water sale revenues and increased costs of obtaining non-contract supplies. The balance sheet analysis will determine the extent to which current "stop gap" measures (e.g. hiring freezes, maintenance deferral, etc.) can be used to balance the district budgets in the long-run. Other options for maintaining a balance between expenditures and revenues, such as changes in water price policies and/or assessments, will be analyzed using information obtained from the focus groups. The result will be a measure of district financial performance and the likely changes that will need to take place to ensure financial solvency in the long-run.

Changes in "net value of production" for the major crops will also be assessed by the study team. Using the cropping patterns and land use changes elicited in the focus groups as well as projected costs of production, net value of production will be calculated under each of the TAC water supply scenarios. Sensitively analysis will be conducted to test assumptions about water costs, commodity prices and other key variables.

Task Five: Assess Impacts on Local Economies and Resource Quality

Local economy impacts will be derived from the district and farm-level responses and adjustments to the TAC water supply scenarios. Local economy indicators are likely to include: 1) changes in the level and composition of on-farm employment; 2) growth and employment changes in agriculturally-related industries; and 3) changes in the county/city tax base (e.g. tax revenues from farm income and property and related industries). Sources of information on these indicators include the Census of Manufacturing and the California Economic Development Department. The social costs associated with changes in employment and local tax revenues will also be discussed.

Many observers expect new water quality standards to require more fresh water to be flushed into the Bay to serve environmental needs. This study does not assess the probable benefits of these additional flows to the Bay-Delta. Nevertheless, it will provide important information on changes in resource quality within each case study district from reductions in surface water deliveries. The most important resource impacts have been identified as: 1) increased groundwater pumping with associated changes in groundwater quality, aquifer storage capacity and pumping depths; and 2) changes in the quantity and management of drainage effluent. Existing data bases and research will be relied upon to assess the selected resource quality impacts.

Task Six: Assess the Potential for Mitigating Impacts by Changing Prevailing Constraints

Phase III will conclude with an analysis of the potential "mitigating" effects on the case study districts of changing or "relaxing" certain key physical and institutional constraints identified earlier in the study. Pending review by the TAC, the following changes appear to be likely candidates for more detailed examination: 1) development of Delta conveyance facilities; 2) improved management and regulation of groundwater pumping; and 3) increased flexibility in water transfers.

The first change addresses the physical system constraints that affect the quantity, quality, timing and reliability of water flowing through the Bay-Delta. Expanding and improving the Bay-Delta conveyance facilities would provide more flexibility for the delivery of water in wet and dry years, particularly the movement of transferred water from surplus to deficit areas. In Phase III, the analysis will focus on the potential benefits from such facilities above and beyond changes in surface water supplies that are captured by the TAC water supply scenarios. Environmental costs or benefits for the Bay-Delta would not, however, be considered in the analysis.

The potential mitigating effects from improved groundwater management and regulation will be discussed generally, and then applied to the case studies. Specifically, Phase III will explore the potential benefits and costs from institutional/ legal changes that would grant increased authority for regulating on-farm groundwater pumping (e.g. metering, pumping taxes, etc.). The question of "how much overdraft?" to allow will also be addressed.

Legal and institutional restrictions on water transfers have been relaxed in recent years motivated primarily by drought-induced water scarcity. As Phase II of the study describes, however, significant constraints on transfers remain. Phase III will examine the potential mitigating effects on the case study districts of easing current restrictions (federal, state, local) on: 1) inter-district transfers; 2) private water transfers among producers in different districts; and 3) water transfers from or to USBR districts, specifically.

Task Seven: Extend the Case Study Results to Regional and State Impacts

It is anticipated that Phase IV of the study will explore the extent to which the case study results presented in Phases II and III can be generalized at higher levels of aggregation—both regionally and statewide. Where feasible, the case study research base may be integrated into existing economic models to provide information about the aggregate economic impacts of actual and projected changes in water supply conditions. Such models will only be useful, however, if they can be modified to reflect the inherent complexities identified in Phases II and III and/or the results of the models can be properly qualified to account for these complexities.

Task Eight: Complete the Final Report

The final task will be completing a report describing the research findings of the study and the most important conclusions that the SWRCB should consider in developing water quality standards for the Bay-Delta. The study team will present preliminary drafts of the final report to the TAC for review and comment.

APPENDIX A: List of TAC Members

Name	Affiliation
Robert Alcott	El Dorado Irrigation District
Sandra Archibald	Food Research Institute, Stanford University
James Beard	Alameda County Water District
Gary Bedker	U.S. Bureau of Reclamation
Joe Callahan	Sierra Club
William DuBois	California Farm Bureau Federation
Sandra Dunn	DeCuir and Somach
Farhad Farnam	Department of Water Resources
John Farnkopf	Bay Area Water Users Association
Mike Farro	State Water Resources Control Board
David Fullerton	Committee for Water Policy Consensus
Ray Gaines	Central Valley Project Water Association
Howard Hirahara	U.S. Bureau of Reclamation
Lyle Hoag	California Urban Water Agencies
Ray Hoagland	Department of Water Resources
William Johnson	Modesto Irrigation District
Leroy Kennedy	Turlock Irrigation District
Bob McKusick	Northwest Economic Associates
Lloyd Mercer	Economics Dept., UC Santa Barbara
W.D. Morgan	Economics Dept., UC Santa Barbara
Tim Quinn	Metropolitan Water District of Southern Calif.
Thomas Rinn	Metropolitan Water District of Southern Calif.
Cliff Schulz	State Water Contractors

APPENDIX B: Field Interviews

June 27-28: Central California Irrigation District

Michael Porter, Manager
James O'Banion, President, Board of Directors
John Fawcett, Member, Board of Directors
Don Anderson, Irrigation Specialist

July 11-12: Glenn-Colusa Irrigation District

Bob Clark, Manager
Donald Cecil, Member, Board of Directors
Dennis Michum, Jr., District Accountant
Louis Hoskey, District Watermaster
S.W. Dunlap, District Controller
John Jaklitsch, USBR Repayment Specialist
Donald Perez, ASCS County Executive Director

July 15-16: Westlands Water District

Gerald Butchert, Manager
Bob Stanley, District Engineer
Jim Ganion, District Counsel
Dave Orth, District Financial Officer
Steve Ottomueller, District Operations
Shelly Vuicich, District Public Relations
Larry Turnquist, Farmer
Ross Borba, Farmer
Mark Borba, Farmer
Terry Amaro, Farmer
Paul Couture, Farmer
Gary Robinson, Farmer
Jim Dufer, Farm Machinery Dealer
Paul Wilson, Pesticide Dealer
David Berman, Wells Fargo
Ken McCorkle, Wells Fargo

July 17-18: Arvin-Edison Water Storage District

Cliff Trotter, Manager
District Watermaster
Gary Bucher, KCWA
Howard Frick, President, Board of Directors
Several Farmers

July 31, August 1: El Dorado Irrigation District

Robert Alcott, Manager
Fred McKain, District Engineer
Dorine Kelley, District Public Information
John McPherson, District Finance
Jim Kosta, Irrigation Consultant
Edio Delfino, County Agriculture Commissioner
Bob Reeb, General Manager, El Dorado County Water Agency

August 14, 21-22: Wheeler Ridge-Maricopa Water Storage District

Arnold Rummelsberg, Manager
William Taube, Assistant Manager/Engineer
Board of Directors (scheduled meeting)

July 18, August 22: Lost Hills Water District

Phillip Nixon, Manager
Joe Steele, Engineer

APPENDIX C: Self-Supplying Irrigators

Introduction

To ensure wide representation of agricultural producers throughout the Sacramento/San Joaquin River watershed, a sample of "self-supplying" irrigators was surveyed by the study team. William DuBois, a consultant to the California Farm Bureau Federation and a member of our study's Technical Advisory Committee, provided a list of names and addresses of producers in Plumas and Sierra counties. On August 19, 1991, 276 surveys were mailed to these producers. A follow-up letter was mailed to 217 producers on September 18, 1991 to remind them to return their completed surveys.

Of the 276 surveys that were initially mailed, 28 were returned by the U.S. Postal Service as undeliverable (change of address, unclaimed, no such street, etc.). An additional 34 were returned but not tabulated because the respondents were no longer involved in farming or did not irrigate their crops (e.g. tree farmers). The survey results presented in this appendix are based on 44 questionnaires that were completed by producers currently engaged in irrigated agriculture. This represents a net "yield" of approximately 18 percent.

Survey Results

The respondents were primarily livestock operators who use irrigation water for growing pasture and hay. Of the surveys analyzed, 39 reported having cattle in 1991. The remainder leased their pasture, produced fruit and vegetables or kept other kinds of animals (horses, poultry, sheep). Figure C.1 displays the distribution of the herd size in 1991 for those with cattle. Approximately 18 percent of the operators had less than 100 head of cattle in their herd in 1991, 62 percent had between 100 and 500 head and 21 percent had more than 500 head. When asked if the size of their herd had changed significantly over the past five years, 62 percent responded that there had been no change, 31 percent responded that the size of their herd had declined and 8 percent responded that the size of their herd had increased in size.

Operated acreage for the farming operations ranged from under 100 acres to over 10,000 acres. The distribution of the operation size in 1991 was fairly evenly distributed across the various size categories as displayed on Figure C.2. Approximately 44 percent of the operations were less than 500 acres in 1991, 19 percent were between 500 and 1000 acres and 37 percent were larger than 1000 acres. When asked if the size of their operation had changed significantly over the past five years, 80 percent responded that there had been no change, 10 percent responded that the size of their operation had decreased and 10 percent responded that the size of their operation had increased.

Most of the respondents owned the land they operated. Approximately 65 percent reported owning their operated acreage, 9 percent leased their operated acreage and 26 percent reported that they both owned and leased their operated acreage. By and large, the larger operations consisted of a greater proportion of leased land, while most of the smaller operations did not include any leased land. It is interesting to note that many respondents indicated that their land had been in the same family for more than fifty years.

Nearly all of the respondents grew pasture and hay. Half of the respondents grew pasture, 21 percent grew hay and 31 percent grew a combination of hay and pasture. Several operations also devoted a small portion of their acreage to fruit and vegetable crops. Figure C.3 displays the types of irrigation systems used for pasture and hay production. Approximately 79 percent of the pasture was irrigated using flood systems exclusively. The remaining irrigation systems for pasture included sprinkler (6 percent), flood and sprinkler (9 percent) and other (6 percent). For hay production, 55 percent used flood systems exclusively, while 23 percent used sprinkler systems and 23 percent used sprinkler and flood systems.

Water for irrigation purposes was generally obtained from local creeks. It is interesting to note that many of the creeks have been subject to court-supervised adjudications. Creeks listed by respondents as adjudicated include Indian Creek, Green Horn Creek, Chandler Creek, Wolf Creek, Long Valley Creek, Nichols Creek, Antelope Creek, West Hamlin Creek, Cooks Creek and Ward Creek. Several respondents attached copies of the adjudication of the Indian Creek Diversion. A significant number of "dates of first diversion" listed by the respondents date are from the mid- and late 1800s indicating early priority water rights.

Approximately 36 percent of the respondents indicated they rely, at least partially, on groundwater for their irrigation needs. In general, groundwater extractions represented a small share of total water supply. Of those using groundwater, more than 80 percent used electric powered pumps, while the remainder used other types of pumps.

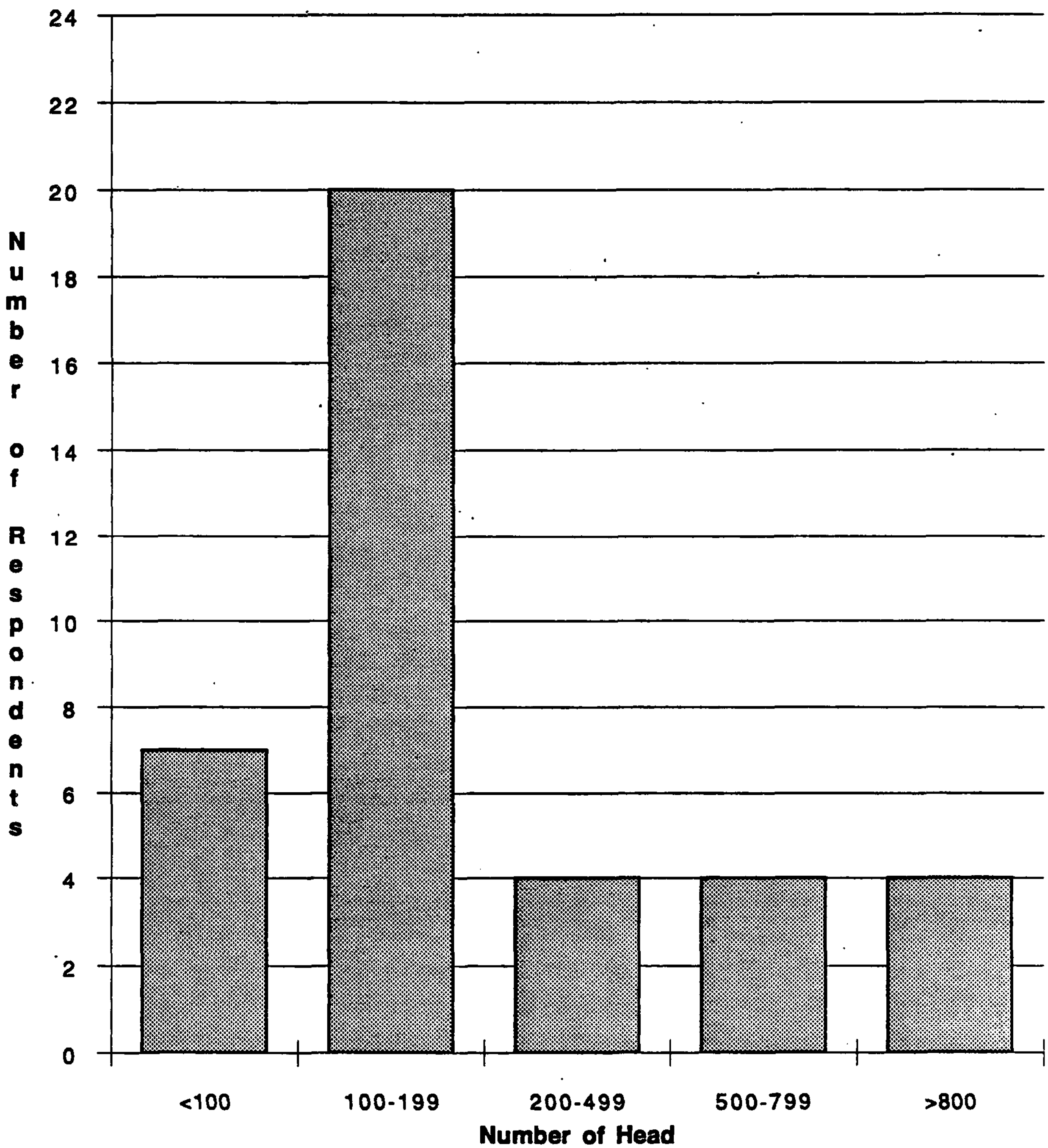
Finally, nearly all respondents listed several ways that they have improved water management efficiency in recent years. Some of the more frequently mentioned conservation measures included stream bank rehabilitation, improved grazing management, installation of underground pipelines and more frequent cleaning of irrigation ditches.

Conclusions

The survey of the self-supplying irrigators broadened the coverage of the study to include producers who do not receive water from water districts. The self-supplying irrigators appear to have few options for obtaining additional water supplies in times of shortage; most rely on a single source of water for irrigation. In most cases, the demarcation of water rights is very clear due to extensive adjudication in the study area. Groundwater supplies are limited, further constraining the responses and adjustments of these operators.

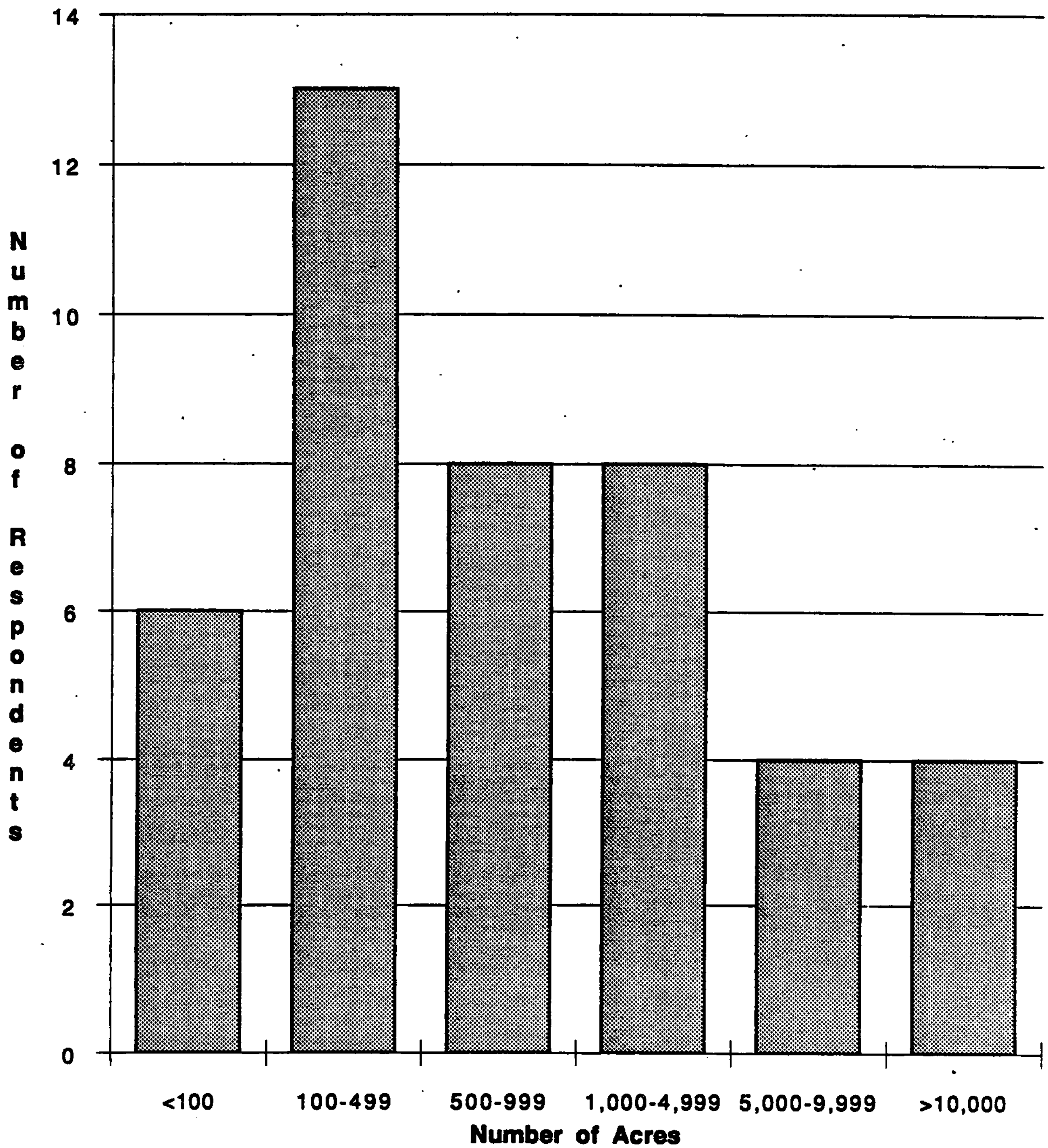
It appears that many of the self-supplying irrigators have "senior" appropriative water rights (and in several cases, riparian rights). Strong water rights coupled with the self-supplying producers' close proximity to the source of supply suggest that water supplies will generally be available except in the driest years. In any case, the impacts from reduced water supplies thus far in the drought do not appear to have been severe for the self-supplying irrigators surveyed, although further study is required to understand fully how changes in water supply conditions will affect these producers.

Figure C.1: Number of Cattle in 1991, Self-Supplying Irrigators



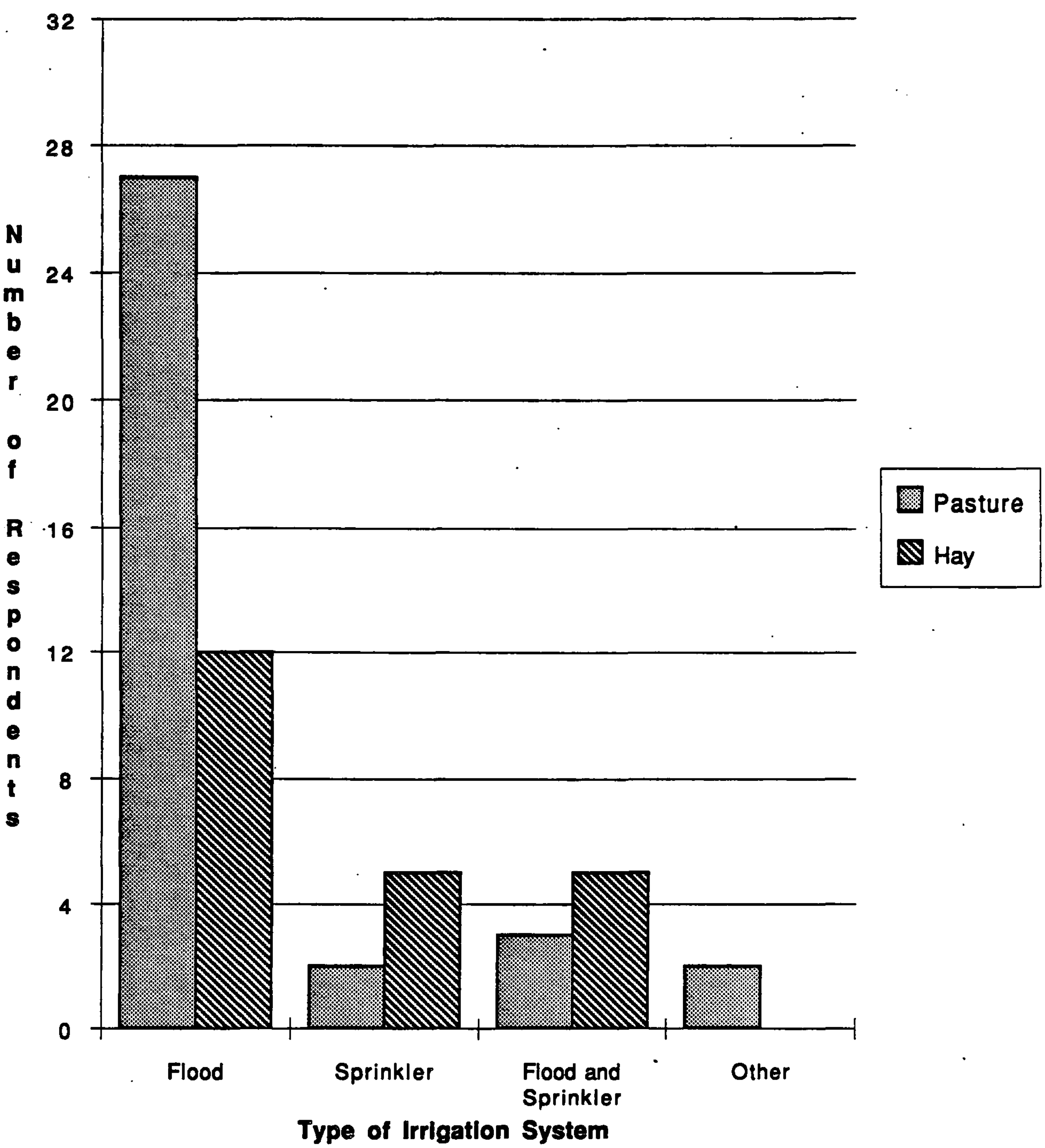
Source: Producer Surveys

Figure C.2: Size of Operation in 1991, Self-Supplying Irrigators



Source: Producer Surveys

Figure C.3: Irrigation Systems in 1991, Self-Supplying Irrigators



Source: Producer Surveys