407

ECONOMIC IMPACTS OF THE 1991 CALIFORNIA DROUGHT ON SAN JOAQUIN VALLEY AGRICULTURE AND RELATED INDUSTRIES

Northwest Economic Associates

13101 N.E. Highway 99 - Suite 200
Vancouver, Washington 98686-2786
(206) 574-2554

WRINT SWC Exhibit 60

ECONOMIC IMPACTS OF THE 1991 CALIFORNIA DROUGHT ON SAN JOAQUIN VALLEY AGRICULTURE AND RELATED INDUSTRIES

Prepared For

The San Joaquin Valley
Agricultural Water Committee
c/o 1109 Whitley Avenue
Corcoran, California 93212

By
Northwest Economic Associates
13101 N.E. Highway 99, Suite 200
Vancouver, Washington 98686-2786
(206) 574-2554

555 Capitol Mall, Suite 260
Sacramento, CA 95814
(916) 444-9927

March 16, 1992

TABLE OF CONTENTS

TABLE OF CONTENTS
Continued

EXECUTIVE SUMMARY

Last year, the fifth consecutive year of drought in California, had profound effects on the state's agricultural sector, particular in the San Joaquin Valley. Not only have farms been affected, but the economy of the entire region has suffered.

This study uses a survey approach to analyze the economic effects of the drought on farmers, input suppliers, water districts, and lenders in the San Joaquin Valley. Highlights on the findings follow.

Previous estimates of drought impacts have relied heavily on computer models and anecdotal information. This study employed field surveys of growers and extensive surveys of local water agencies, who keep detailed records of actual conditions.

The study found that the impacts of the drought on San Joaquin Valley agriculture were much greater than previously thought. On-farm revenues fell $281 million and on-farm water costs rose $163 million, a reduction of $444 million in receipts to production agriculture. Other significant, documented impacts are listed below:

- 253,200 acres of cropland were idled (5% of total), with wide variations among the zones, and an additional 124,900 acres were characterized by reduced yields. The $281 million loss in farm revenues included a loss of $114 million in farm income.

- Accompanying the loss of farm revenues were reduced sales of farm machinery, fertilizer, and other inputs, causing an additional $264 million decline in SJV business activity. Lost wages and salaries in the related businesses totaled $85 million.

- Surface water deliveries declined 5.9 million acre feet (MAF), down 57% from normal year deliveries. As a result, farmers were required to use an additional 5.1 MAF of groundwater, an increase of 127% over normal usage. Total water usage by SJV agriculture declined 0.8 MAF.

- On-farm water costs rose a net $163 million.

- Farmers invested $124 million in new wells in 1991 with additional expenditures for reconditioning old wells (dollar estimate unavailable).

- Irrigation districts spent more than $25 million for new and rehabilitated existing wells.

- 5,000 jobs were lost at the farm level, representing nearly 3% of the farm labor force. An additional 4,050 jobs were lost in related support industries.

While certain areas of the Valley staved off disaster in 1991, they did so only at great financial stress and are now extremely vulnerable to the effects of continued drought. The most vulnerable areas are located where agriculture is the single or primary employer and where farmers have limited sources of water. In these areas, there is little opportunity to diversify, particularly in the short term.

Where lands have been idled, the entire revenue stream to agriculture and related industries has been lost. Farm machinery and fertilizer/chemical purchases have been cancelled. Farmer defaults on district bonds are likely to occur more frequently in 1992, potentially stressing some water districts whose financial reserves have already been stretched.

Where farmers have been able to use groundwater, they have kept land in production that would have otherwise lain fallow. However, by being forced to pump more groundwater, their cost of water has risen sharply. New wells have been drilled and older wells reconditioned. Thus, farmers' capital reserves have been seriously depleted because of lower revenues and increased costs.

While the economic data summarized above documents the direct, short-term impacts to the San Joaquin Valley economy, it does not reflect the long-term consequences of agricultural water shortages.

If these shortages continue, the agricultural industry, which provides 50% of the Valley's jobs, will slowly be crushed. Economists are already beginning to see the symptoms of an economic "death spiral" in which the number of farmers remaining in business decreases as water supplies dry up.

Those farmers who survive will face substantially higher water costs, further depleting cash reserves and threatening the small businesses that rely on farmers as their customer base.

A spin-off effect will be lower property values and a resulting reduction in tax base for farm counties that are already financially strapped.

If these shortages become chronic, the signs of this downward spiral are expected to become broader and deeper.

Ultimately, if agriculture loses its economic niche in the multi-billion dollar global agricultural market, it will be difficult and costly to recover, as competitors move to displace California producers.

ECONOMIC IMPACTS
OF THE 1991 CALIFORNIA DROUGHT ON
SAN JOAQUIN VALLEY AGRICULTURE AND RELATED INDUSTRIES

INTRODUCTION

Last year marked the fifth consecutive year of one of the most severe droughts in California's history. Statewide, precipitation was only 76% of normal and runoff was 43%. Reservoir storage was 61% of normal and 13 million acre-feet below 1986 levels. Virtually every resident, business, and industry in the state has been impacted. Drought and conservation are now prominent in our vocabularies, and we routinely check current precipitation levels versus normal and last season, assess the water content of fresh snowfall, and attempt to reduce water usage below last year's levels. In short, our awareness of the vital importance of water in our lives has never been greater.

This study focuses on the impacts of the 1991 drought on San Joaquin Valley (SJV) agriculture. This region was chosen for several reasons:

- SJV agriculture is a vital, basic component of the state, national, and international economy, yet its importance is not fully appreciated.
- There is a perception, commonly-held and incorrect, that the effects of the drought on agriculture have been minimal.
- Droughts, both naturally-occurring and man-made, are becoming more the norm than the exception in agriculture.
- Water shortages have impacts, not only on the agricultural production sector, but on many related industries and levels of government.
- Agriculture is one of the major sectors being impacted by both short- and long-term water supply considerations throughout California.

As will be discussed in subsequent sections of this report, while many parts of the SJV agricultural sector have survived this drought, it has been with significant adjustment and expense. Production levels in some areas have been maintained with alternative sources of water, but at much higher costs to farmers. In other areas, lands have been idled because alternative water supplies simply have not been available. In those cases, the entire revenue stream has been lost, yet farmers have continued to incur the fixed costs of their operations.

APPROACH OF STUDY

This study examines the effects of the drought not only on farmers in the SJV, but also on farm machinery, chemical and other input suppliers, lenders, and local water districts. Our approach, therefore, differs from several other recent drought studies summarized in Appendix B.

The analysis which follows relies heavily on surveys of water districts and of farmers, farm machinery and chemical dealers and lenders in the SJV. Background on survey design and content and the survey document itself are in Appendix A.

The survey was administered for the 110 irrigation, water, water conservation, and water storage districts comprising the San Joaquin Valley Agricultural Water Committee (AWC). The AWC is divided into 5 zones, 4 of which cross county lines. Those zones, the acreages of irrigated cropland in each, and the allocation across counties are shown in Table 1.

The survey approach was used to attempt to measure the varying impacts of the drought on different subregions in the SJV. Data at the zone level were obtained on acreage grown, water application rates, acreage fallowed or abandoned due to the drought, ground and surface water supplies, pumping costs, well costs, and related information. Results of the surveys are presented throughout the report.

TABLE 1

ZONES, ACREAGES, AND COUNTIES COVERED BY SAN JOAQUIN VALLEY AGRICULTURAL WATER COMMITTEE

	Zone[a]	Acres of Irrigated Cropland	% of Irrigated Land in Counties[b]							
			PSG	ST	ME	MA	FR	KI	TU	KE
A:	Kern	842,384								100
B:	Fresno/Kings	1,108,737					61	33	6	
C:	Kaweah/Tule	716,009						7	93	
D:	West Side	1,267,491	3	14	28		46	9		
E:	East Side	898,615	17	18	25	40				
	TOTAL	4,779,236[c]								

a Refer to Figure A-1, Appendix A, for a map showing zone boundaries.

b SJ = San Joaquin; ST = Stanislaus; ME = Merced; MA = Madera; FR = Fresno; KI = Kings; TU = Tulare; KE = Kern.

c Compares with 5,200,189 acres reported in 1990 Agricultural Commissioners' reports for the 8 counties. The zones of the SJVAWC include only portions of the 8 counties.

ORGANIZATION OF REPORT

The report begins with a general discussion of *Agriculture and Water in the SJV*. The second section, *Adjusting to Water Shortages*, includes comments on the adjustments and impacts to water shortages at the farm level, including higher water prices, reduced net income, increased well drilling and reconditioning activities, shifts in cropping patterns, conservation, and changes in financing. Adjustments at the irrigation district and the farm supplier levels are discussed in the third section, *Economic Impacts in Farm Communities*, along with estimates of economic impacts in the SJV due to the drought's impact on agriculture. The fourth section discusses *Implications – Short-Term and Long-Term.* Subjects covered include groundwater overdraft, salt buildup, and the likelihood of additional cropping pattern shifts or permanently fallowed lands. Final comments in this section address the implications for groundwater use, cropping patterns, and irrigation districts.

PRIMARY CROPS, MARKETS AND TRENDS

The eight-county SJV is one of the most prolific, productive farming areas in the world. It contains more than thirty thousand farms and 5.2 million acres of cropland.[1] Cotton historically is grown on more than one million acres (96% of the state's total acreage for that crop), orchard crops on 1.4 million acres (64% of the total), and vegetable crops on 0.3 million acres (35% of the total). The area is also a major livestock producer, with nearly two million dairy and range cattle and calves, about 43% of the state's total.

Over the last two decades, there have been important changes in cropping patterns in the SJV. Acreages of feed and food grains have declined, while those of vegetables, orchards, and other higher-value crops have increased. These trends derive from many factors, including crop prices, water availability and costs, land values and rents, and labor costs.

SJV agriculture serves three markets – the California population, the rest of the U.S., and the rest of the world [Cook]. In doing so, the sector spends more than $5 billion annually on machinery, chemicals, labor, and other inputs to produce more than $6 billion of goods, many of which are produced in few or no other locations in the U.S. For example, the SJV accounts for over 90% of U.S. production of raisins, almonds, walnuts, nectarines, and pistachios.

SJV agriculture is a basic industry, with linkages to many other service and support industries in the local economy. Besides the direct value of goods it produces, agriculture is linked to suppliers of farm machinery, chemicals, and other inputs, to food processors, truckers, and other distribution businesses.

1/ See Table 1 for a reconciliation of acreages by county with acreages by zones within the San Joaquin Valley Agricultural Water Committee.

Over time, SJV agriculture has attained an important role in the national and international economies. Through its productivity and efficiency, it makes available an abundant, diverse supply of food that helps keep "food scarcity" out of our domestic vocabulary. It also enables the American consumer to enjoy a healthy diet for a much lower share of his income, more so than in any other nation. Moreover, as the domestic population has changed -- growing more slowly and placing greater emphasis on a wider variety of healthier foods -- SJV agriculture has utilized its productive resource base and comparative advantage to grow and market the many products demanded.

In addition, SJV and California agriculture play a significant role in the U.S. balance of trade. In 1990, the state's exports of food and agricultural products rose to $4.5 billion, representing 25% of total California agricultural production for the year. Cotton, almonds, grapes, and oranges, all of which the SJV dominates in state production, accounted for 47% of total state exports [California Department of Food and Agriculture]. While total irrigated agricultural acreage in California has fallen about 5% since 1980, that devoted to the production of crops for export has increased significantly.

While expanding and adapting to important changes in the domestic and international economies, SJV agriculture has faced many other pressures, both short and long term. In the short term, farmers have been forced annually to adjust to 5 years of drought conditions in a variety of ways -- idling lands, changing crop patterns, applying minimum quantities of water in some instances to sustain trees and vines, etc. Farm machinery, chemical, seed, and other input suppliers and processors have also had to adjust to the drought conditions.

Among longer-term issues, the SJV is undergoing tremendous urbanization pressures, as populations from the coastal urban areas spill into once rural areas. The resultant dynamics add a critical element to the demands on all the SJV's resources, including housing, land, and <u>water</u>.

WATER USE IN THE SAN JOAQUIN VALLEY

The SJV produces a diversity of crops unmatched in other parts of the world. Since rainfall in the SJV is inadequate to produce acceptable crop yields, irrigation has been critical in making SJV agriculture productive. The region is served by two major surface water projects, the Federal Central Valley Project (CVP) and the State Water Project (SWP). In addition, many water districts have developed or have rights to local surface water supplies.[1] CVP water is dedicated primarily to agriculture, with small amounts contracted for municipal and industrial purposes. In contrast, SWP water is used primarily for municipal customers, with only about 30% to agriculture in the SJV. Both projects have been severely impacted by the 1987-1991 drought. In 1991, agriculture received only 25% of its normal CVP supplies and 0% of its SWP supplies. Farmers in some irrigation districts were forced to rely solely on groundwater. Some farmers with no groundwater for a backup supply utilized water purchased from the State Water Bank. Hence, while surface water normally accounts for about 60% of agricultural water supplies and groundwater for 40%, figures for 1991 indicate this relationship was reversed. Further, while groundwater use in the SJV typically exceeds replenishment by an average overdraft of 1.5 million acre feet (MAF) per year, the overdraft has exceeded 2.5 MAF for the last two years.

The shift in surface and groundwater supplies has been dramatic. Last year, surface water supplies were down 5.9 MAF from normal, a reduction of 57%. At the same time, groundwater usage was up 5.1 MAF or 127%. Total usage (groundwater and surface water) for 1991 was approximately 13.5 MAF. This was about 6% below normal water year usage of 14.3 MAF (see Table 2). The net change in the use of surface and groundwater and surface water supplies is presented by zones in Figures 1 and 2. Note that the groundwater supply number includes an estimate of both groundwater pumping from private farm wells, as well as irrigation district wells. Among zones, the largest declines in surface water supplies were in Kern, down 1.50 MAF, and the West Side, down 1.70 MAF. The data in Table 2 shows how extensively SJV irrigation districts and farmers turned to groundwater to substitute for lost surface water during the drought.

1/ See Appendix C for a discussion of local surface water supplies available in the SJV.

TABLE 2

ESTIMATED GROUND AND SURFACE WATER USAGE IN SAN JOAQUIN VALLEY, DROUGHT AND NORMAL YEARS*

Zone		Water Usage Normal Water Year in Acre Feet	Water Usage Drought Water Year in Acre Feet	Change in Supply in Acre Feet	Percentage Change, Drought Compared to Normal
A -	Kern				
	Groundwater	785,000	1,915,000	+1,130,000	+144
	Surface Water	1,743,000	246,000	-1,497,000	- 86
	Total	2,528,000	2,161,000	-367,000	- 15
B -	Fresno				
	Groundwater	1,904,000	2,672,000	+768,000	+ 40
	Surface Water	1,422,000	602,000	-820,000	- 58
	Total	3,326,000	3,274,000	-52,000	- 2
C -	Kaweah/Tule				
	Groundwater	806,000	1,558,000	+752,000	+ 94
	Surface Water	1,342,000	496,000	-846,000	- 63
	Total	2,148,000	2,054,000	-94,000	- 4
D -	West Side				
	Groundwater	46,000	1,474,000	+1,428,000	+3200
	Surface Water	3,757,000	2,052,000	-1,705,000	- 45
	Total	3,803,000	3,526,000	-277,000	- 7
E -	East Side				
	Groundwater	486,000	1,522,000	+1,036,000	+213
	Surface Water	2,048,000	1,008,000	-1,040,000	- 51
	Total	2,534,000	2,530,000	-4,000	< 1
All Zones					
	Groundwater	4,027,000	9,141,000	+5,114,000	+127
	Surface Water	10,312,000	4,404,000	-5,908,000	- 57
	Total	14,339,000	13,545,000	-794,000	- 6

* Estimated total groundwater usage was calculated from data provided by San Joaquin Valley Irrigation Districts. Estimates for non-respondent districts were included by proportionately adjusting the respondents data using percentages for the number of respondents compared to total number of districts. "Normal" water conditions were the prerogative of Irrigation Districts to decide. Generally this was the 1983-85 time period. Drought conditions were represented by the 1990, or 1991 drought situation in the SJV. Total water use is acreage times 3 acre feet/acre. Drought water use is based on an adjustment for idled land due to the 1991 drought. On-farm water use (i.e., private well pumping and riparian water) is calculated by subtracting estimated Irrigation District deliveries from the total crop requirement.

Source: Northwest Economic Associates, Inc., based on San Joaquin Valley Irrigation District data, January 1992.

Figure 1

**SURFACE WATER USE BY ZONE
NORMAL AND DROUGHT WATER CONDITIONS**

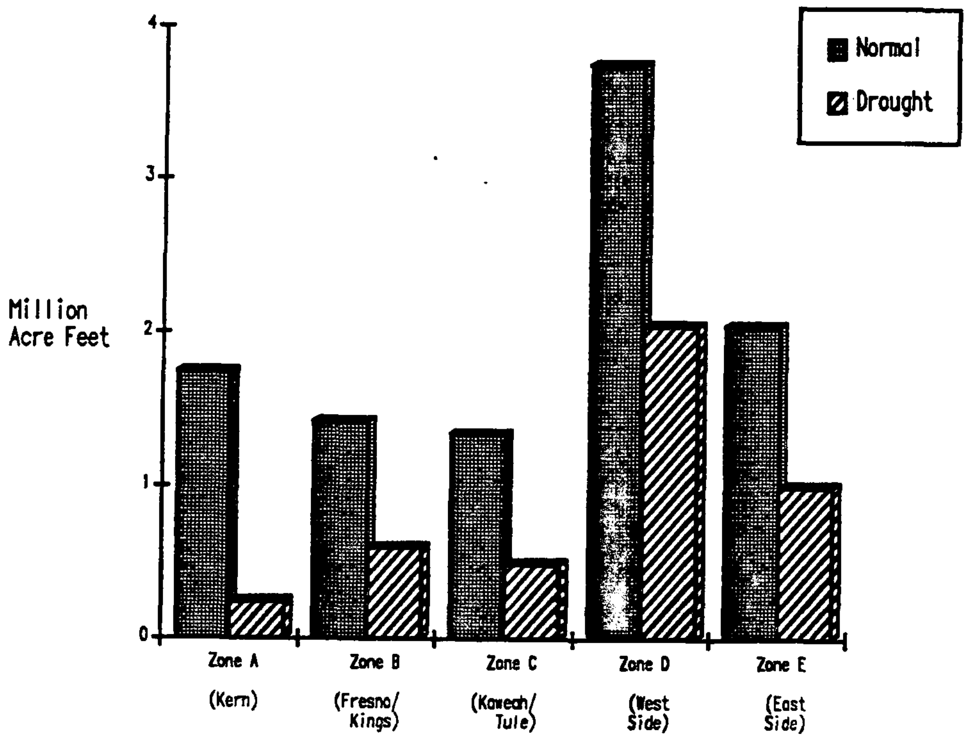
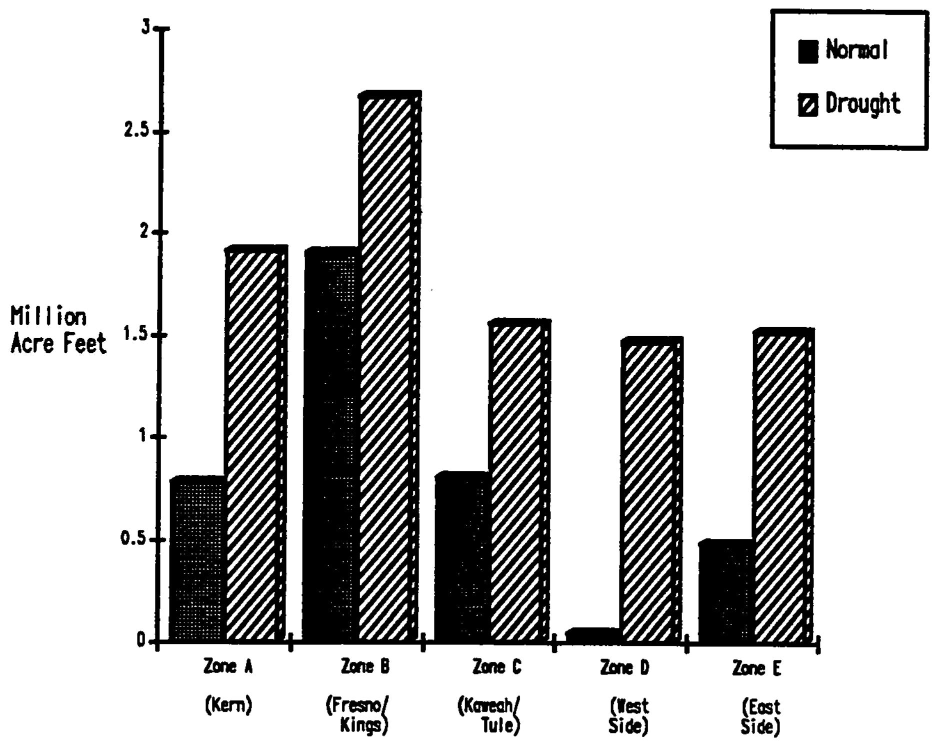


Figure 2

GROUNDWATER USE BY ZONE
NORMAL AND DROUGHT WATER CONDITIONS



WATER COSTS

Higher water costs over the past 5 years have had a severe impact on SJV farmers' net income and financial reserves. Many farmers' water costs have more than doubled since 1987 due to price increases for both surface and groundwater. Increased charges for surface water have resulted from fixed charges for water not delivered and higher cost supplemental surface supplies. Increased charges for groundwater, as discussed below, have related directly to falling groundwater levels and to higher energy costs for pumping.

Farm-level water costs depend on the relative quantities used and costs of ground and surface water. Surface water prices vary significantly throughout the SJV in normal as well as drought years. Variability depends on the source of water, the type of transportation and distribution system, and the operational policies of the water district. In general, farm-level delivered water costs must cover the fixed operating, maintenance and investment costs of the district. These costs typically include an acreage charge covering all the lands of the district, a demand charge for delivery of water to those lands, and a water toll for the service area of the district. Among districts, these elements may vary depending on debt service, depth to groundwater, source of surface water, and type of transportation and distribution system.

District costs per acre-foot have risen throughout the SJV and in 1991 were up 51% from normal (see Table 3). Groundwater costs were up 88%, while surface water charges were up 25%. The largest reported increase in total water costs was in the Kern Zone, where costs increased over $31/AF. The smallest increase was in the West Side, where per AF costs increased just over $5. These figures, however, understate the actual costs incurred by water districts. Even though operation and maintenance expenses rose for many districts, some districts left these charges unchanged from the previous year utilizing reserves to mitigate the increased burden on farmers. These deferred charges, however, will have to be paid at a later date.

TABLE 3

GROUND AND SURFACE WATER COSTS PAID BY IRRIGATION DISTRICTS DROUGHT AND NORMAL YEARS

Zone	Average Cost Per Acre Foot Normal Water Year	Average Cost Per Acre Foot Drought Water Year	Percentage Change
A– Kern			
Groundwater	47.97	78.54	+ 64
Surface Water	34.66	75.10	+117
Weighted Average	**$35.72**	**$77.37**	**+117**
B– Fresno/Kings			
Groundwater	32.00	32.00	0
Surface Water	16.20	25.21	+ 56
Weighted Average	**16.68**	**25.58**	**+ 53**
C– Kaweah/Tule[a]			
Groundwater	25.00	27.00	+ 8
Surface Water	18.01	24.54	+ 36
Weighted Average	**18.01**	**24.54**	**+ 36**
D– West Side			
Groundwater	16.56	34.73	+110
Surface Water	26.40	31.40	+ 19
Weighted Average	**26.28**	**31.62**	**+ 20**
E– East Side			
Groundwater	11.55	26.73	+131
Surface Water	4.51 [b]	4.43 [b]	- 2
Weighted Average	**5.25**	**11.88**	**+126**
All Zones			
Groundwater	**29.31**	**55.08**	**+ 88**
Surface Water	**22.52**	**28.15**	**+ 25**
Weighted Average	**$22.83**	**$34.44**	**+51**

Source: San Joaquin Valley Irrigation Districts, January 1992.

a Total water costs for surface water and for all water are the same because groundwater makes up only a marginal share of water deliveries by Zone C irrigation districts.

b For those Zone E districts providing information, surface water costs either remained the same or went up in 1991. However, the lower cost water districts in the zone made up a much larger share of the weighted average in 1991, causing the value to decrease relative to the normal.

As discussed previously, most farmers with access to groundwater have increased their use as surface water supplies have declined. That substitution has been at a high cost as the depth to groundwater has increased. The impacts on farmers have been significant, since more energy is required to pump from greater depths and the per-unit agricultural energy costs have risen sharply. It is estimated by the Agricultural Energy Consumers Association (AECA) that agricultural energy costs rose from $198 million in 1978 to $562 million in 1990 and now account for 15% - 40% of agricultural production costs, depending on the crop grown, depth to water, etc.

The combination of increased pumping lifts and greater use of groundwater increased SJV farmers' pumping costs by $219 million in 1991. As shown in Table 4, the average depth to water in the SJV has increased 54 feet compared to a normal year. That resulted in 1991 in a $31.2 million increase in pumping costs for the 3.5 MAF of groundwater normally pumped. Furthermore, SJV farmers last year pumped an additional estimated 4.4 MAF of groundwater in place of surface water at an average cost of $42.43 per acre foot (based on an average depth to water of 259 feet). The resultant charge was $187.8 million, assuming application of 3 acre feet per acre. Hence, overall pumping costs rose $219 million.

Total water costs to SJV farmers last year increased an estimated $163 million, reflecting the $219 million increase in pumping costs and an estimated $56 million decline in payments to water districts (see Table 5). The $56 million decline was a result of the drought-reduced supply which more than offset the higher per acre foot rates for district water. The $163 million was financed primarily by tapping existing farm-level reserves. If those reserves are depleted further, it is unlikely that growers will be able to maintain existing levels of production.

TABLE 4

INCREASES IN ON-FARM PUMPING COSTS

I. INCREASE IN WATER BILL RELATED TO INCREASED DEPTH TO WATER

Zone	Change in Depth to Water (Feet)	Energy Cost ($/AF)	Groundwater Affected (AF)	Increased Pumping Costs
A - Kern	+57	$ 9.39	633,475	$ 5,948,000
B - Fresno/Kings	+51	$ 8.33	1,860,077	$15,494,000
C - Kaweah/Tule	+59	$ 9.65	805,364	$ 7,772,000
D - West Side	+115	$18.90	1,594	$ 30,000
E - East Side	+49	$ 7.99	244,490	$ 1,954,000
TOTAL	**+54[a]**	**$ 8.85[a]**	**3,545,000**	**$31,198,000**

NOTE: Change in depth to water measures the increase in pumping lifts from 1985 to 1991. Groundwater affected is assumed to be the Total AF that would have been pumped in a normal year.

II. INCREASE IN WATER BILL RELATED TO INCREASED VOLUME OF GROUNDWATER PUMPING

Zone	1991 Pump Lift (Feet)	Energy Cost ($/AF)	Groundwater Affected (AF)	Increased Pumping Costs
A - Kern	398	$65.15	804,986	$56,445,000
B - Fresno/Kings	150	$24.57	777,082	$19,093,000
C - Kaweah/Tule	174	$28.47	751,012	$21,381,000
D - West Side	366	$59.97	1,321,517	$79,251,000
E - East Side	123	$20.18	772,192	$15,583,000
TOTAL	**259[a]**	**$42.43**	**4,426,789**	**$187,753,000**

NOTE: Groundwater affected is assumed to be the additional water pumped, beyond normal requirements, as a result of the drought.

Source: San Joaquin Valley Irrigation Districts, with energy costs computed by Northwest Economic Associates, Inc., January 1992.

a Weighted average.

TABLE 5

INCREASED WATER COST TO FARMERS FROM THE SHIFT TO GROUNDWATER SOURCES

In Million Dollars

Zone	Water Payments to Irrigation Districts: Normal Water Year	Water Payments to Irrigation Districts: 1991 Drought Year	Water Payments to Irrigation Districts: Net Change	Increased On-Farm Cost from Deeper Pumping	Increased On-Farm Cost from Additional Groundwater Pumping	Total Increase in On-Farm Water Costs
	(1)	(2)	(3)	(4)	(5)	(6)=(3)+(4)+(5)
A - Kern	$67.6	$55.9	($11.7)	$5.9	$52.4	$46.7
B - Fresno/Kings	24.5	16.3	(8.2)	15.5	19.1	26.4
C - Kaweah/Tule	24.2	12.2	(12.0)	7.8	21.4	17.2
D - West Side	99.9	69.6	(30.3)	0.03	79.3	49.0
E - East Side	12.0	18.0	6.0	2.0	15.6	23.5
TOTAL	**$228.2**	**$172.0**	**($56.2)**	**$31.2**	**$187.8**	**$162.8**

Source: San Joaquin Valley Irrigation Districts, January 1992.

ADJUSTMENTS AT THE FARM LEVEL

California agriculture is so large and diverse that any one factor – including a prolonged drought – does not impact all farmers in the state or in the SJV in the same way. This section describes in general terms the adjustments that SJV farmers made to the drought in 1991. We note at the outset that responses have varied widely, as certain regions have been much more severely impacted than others.

Reduction in Crop Acreage

In some areas of the SJV, groundwater was not fully substituted for the diminished surface water supplies. With less water available, many growers found it necessary to remove acreage from production. Alternatively, with less water available, some growers experienced reduced yields on crop acreages that were planted. Information from the districts' survey was used to quantify these acreage reductions and yield losses, both by crop type and valley location. Crop acreages affected by the drought are presented in Table 6.

For those districts that responded to the survey it was found that 253,200 acres were either not planted or were abandoned after planting as a result of the drought (Figure 3). Of these, 4,300 acres were identified as permanent cropland and the remainder was annual cropland. An additional 124,900 acres were identified as having reduced yields, with estimates of the yield loss varying by crop type and water district (Figure 4). Permanent crops, at 79,400 acres, comprised the largest share of acreage with reduced yields.

TABLE 6
CROP ACREAGE AFFECTED BY THE DROUGHT

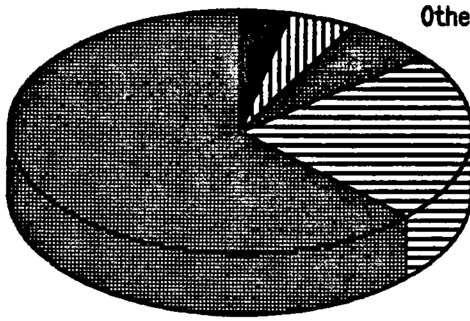
Crop Type	A Kern	B Fresno/ Kings	C Kaweah/ Tule	D West Side	E East Side	Total
TREE NUTS						
Not Planted					38	38
Abandoned	1,000			962		1,962
Reduced Yields	39,524			4,256	1,337	45,117
TREE FRUITS						
Not Planted						
Abandoned	200					200
Reduced Yields	13,450			296		13,746
GRAPES						
Not Planted					245	245
Abandoned	1,860					1,860
Reduced Yields	16,700				3,796	20,496
COTTON						
Not Planted	73,107	6,000	11,000	66,800	737	157,644
Abandoned	1,066					1,066
Reduced Yields	19,583				865	20,448
GRAINS						
Not Planted	22,371	8,000	16,100	11,067	80	57,618
Abandoned			200			200
Reduced Yields						
ALFALFA						
Not Planted		1,000	4,000	755		5,755
Abandoned	1,314	2,000	40			3,354
Reduced Yields	11,410	2,600				14,010
FRESH VEGETABLES						
Not Planted	5,879			1,606		7,485
Abandoned	4,304					4,304
Reduced Yields	10,000					10,000
PROCESSED VEGETABLES						
Not Planted				1,920		1,920
Abandoned				160		160
Reduced Yields				900		900
OTHER						
Not Planted		400		5,916		6,316
Abandoned				3,080		3,080
Reduced Yields				160		160
TOTAL						
Not Planted	**101,357**	**15,400**	**31,100**	**88,064**	**1,100**	**237,021**
Abandoned	**9,744**	**2,000**	**240**	**4,202**		**16,186**
Reduced Yields	**110,667**	**2,600**		**5,612**	**5,998**	**124,877**
IRRIGATED ACREAGE	**842,384**	**1,108,737**	**716,009**	**1,231,491**	**898,615**	**4,779,236**

Source: San Joaquin Valley Irrigation Districts, January 1992.

Figure 3

CROPLAND IN SAN JOAQUIN VALLEY NOT PLANTED OR ABANDONED IN 1991 DUE TO DROUGHT

Total Acres: 253,207

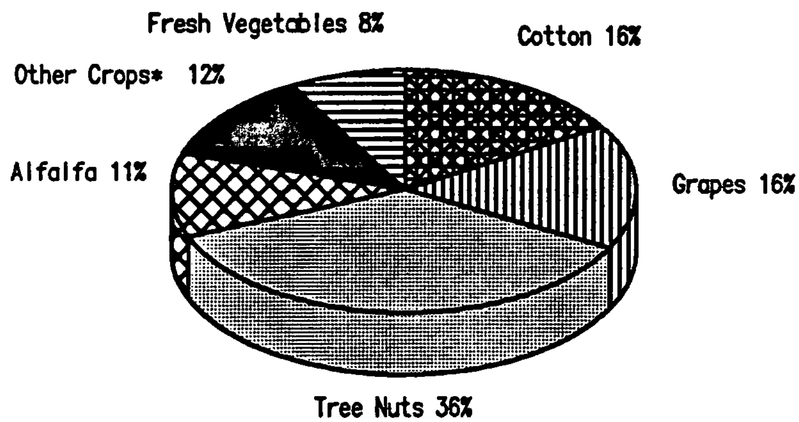


* Other Crops Include: 15,781 acres of tree nuts, tree fruits, grapes, processed vegetables and other miscellaneous crops.

Figure 4

CROPLAND IN SAN JOAQUIN VALLEY WITH REDUCED YIELDS IN 1991 DUE TO DROUGHT

Total Acres: 124,877



* Other Crops Include: Grains, Tree Fruits, Processed Vegetables, and Other Miscellaneous Crops

Cotton was the single crop most affected by acreage reductions. Over 157,700 acres were identified as not planted with a small number of acres abandoned after planting. Grains were also significantly affected with 57,600 acres not planted.

The largest acreage reductions were in the surface water areas of Zone A (Kern) and in Zone D (West Side). Districts in other areas of the SJV reported little or no acreage effects that could be linked to the 1991 drought conditions.

Well Drilling & Reconditioning Costs

One of the major costs to farmers and irrigation districts in the SJV in recent years has been that of drilling new wells and reconditioning existing wells, a direct result of reduced supplies of surface water and lower groundwater levels. These wells are generally large and high yielding. Consequently they are often very costly to establish or rehabilitate.

Data on the number of new or reconditioned agricultural wells drilled by farmers is not precise. The Department of Water Resources (DWR) keeps well driller logs, but this data is not complete since it is widely believed that some well drillers do not file the forms. Unfortunately, the extent of under-reporting is not estimable.

Table 7 presents the annual data from DWR on irrigation wells drilled in the SJV by farmers from 1984 through 1991 (projected). Even considering the significant under-reporting of the actual number of wells, the trend is unmistakable. New irrigation well drilling is occurring at a rapidly accelerated pace, with 1991 showing a dramatic jump to a new and much higher level.

TABLE 7
NUMBER OF IRRIGATION WELLS DRILLED IN SAN JOAQUIN VALLEY

Year	New Wells
1984	250
1985	233
1986	119
1987	242
1988	374
1989	485
1990	655
1991 (projected)	1,306 *

* Extrapolated for entire year based on data from January through August.

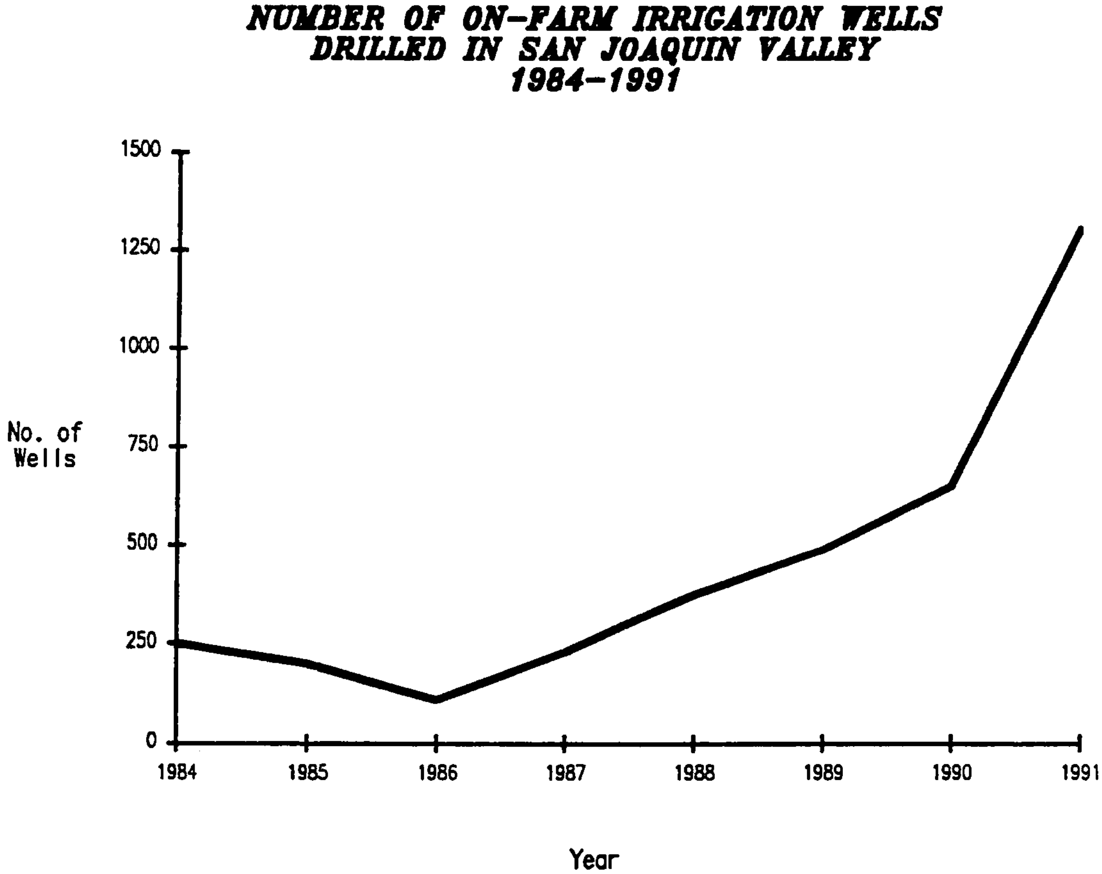
Source: Well Drillers Logs Received by Department of Water Resources, San Joaquin District. Data for 1991 through August.

There is also significant rehabilitation of wells in the SJV, as the depth to groundwater increases due to overdrafting. Previously operational wells have been deepened or reconditioned to remove sand obstructions and correct other problems. In some cases, wells cannot be renovated economically and must be abandoned.

DWR data on reconditioning of wells by farmers is not presented here, as very little of this type of well improvement activity is reported to the agency. Our contact with growers, however, revealed significant activity to improve existing wells. As a result, it is nearly certain that farmers in the SJV are expending significant funds to improve their wells, even though costs are unavailable.

SJV farmers that were surveyed for this study reported new well capital investment costs ranging from $30,000 to $400,000 per well, with an average cost of $95,000 per well. Applying this average to the 1,306 new irrigation wells projected to have been drilled on SJV farms in 1991 gives an estimated expenditure by farmers for new on-farm wells of $124 million.

Figure 5


NUMBER OF ON-FARM IRRIGATION WELLS
DRILLED IN SAN JOAQUIN VALLEY
1984-1991
1500
1250
1000
750
500
250
0
No. of Wells
1984
1985
1986
1987
1988
1989
1990
1991
Year

Many irrigation districts have also found it necessary to drill wells to supplement their water supply as surface water allocations have been decreasing. In our survey of SJV irrigation districts, respondents reported that 150 new wells were drilled between 1989-91. New well drilling occurred throughout the Valley with the exception of the East Side Zone where notably fewer new district wells were reported. The expenditure for the new irrigation district wells was $20.5 million. Additionally, the districts reported that 250 existing wells were rehabilitated, either by deepening or repairs or modifications to increase their pumping capacity. The costs were placed at $5.2 million to up-grade these wells, resulting in total irrigation district expenditures of about $24.3 million between 1989-91. Table 8 presents this well cost information for the irrigation districts.

TABLE 8

IRRIGATION WELL DRILLING & REHABILITATION BY SAN JOAQUIN VALLEY IRRIGATION DISTRICTS FROM 1989-91

	New Wells		Rehabilitated Wells	
Zone	Number	Total Cost	Number	Total Cost
A - Kern	40	$9,240,000	18	$400,000
B - Fresno/Kings	32	4,130,000	58	871,000
C - Kaweah/Tule	38	2,160,000	116	1,390,000
D - West Side	32	2,490,000	41	1,586,000
E - East Side	8	2,440,000	19	941,000
TOTAL	**150**	**$20,460,000**	**252**	**$5,188,000**

Source: Survey of San Joaquin Valley Irrigation Districts, January, 1992.

The water districts anticipate that an additional 50 wells will be required over the next 2 years at a cost of over $6 million. Well rehabilitations required in the next 2 to 3 years are expected to cost nearly $2.3 million.

Cropping Pattern Shifts

The types and acreages of crops grown in particular areas reflect the decisions of many farmers responding independently to short- and long-term factors. The drought appears to have had an influence on cropping decisions in some areas of the SJV, but not in others.

Cropping patterns change very slowly in regions dominated by permanent tree or vine crops that are not normally replaced until plant vigor decreases. Nut crops such as almonds, walnuts and pistachios, tree fruits such as peaches, pears and plums, citrus fruits, and vine crops such as varietal grapes have a long initial development before productive life. These permanent plantings represent a large, long term investment with prospects for extended income in future years. Hence, farmers give very high priority to applying sufficient water to keep the trees and vines alive and producing crops for their entire productive life. Where traditional surface water supplies in these areas have been reduced by the drought, farmers have maintained cropping patterns by increased groundwater pumping, transfers, etc.

It appears that the drought has had a role in cropping pattern shifts in areas where annual or row crops are dominant. In those regions, farmers may, within limits, vary their crop mix annually based on their expectations for crop prices, expected costs and availability of water and other inputs, debt repayment requirements, etc. Water availability and cost issues appear to have contributed to a significant decline in double cropping and some acreage shifts, including reduced cotton and grains and increased vegetables. However, even in these areas, year-to-year acreage adjustments are more dependent on micro-climate and soil characteristics as well as such institutional considerations as processing contracts than the drought.

Conservation/Efficiency Enhancing Technology

As the statewide drought has moved into the sixth year, the pressures to conserve water have been felt by virtually every sector of the economy. Residential users have been encouraged to install water-saving shower heads and toilets, minimize outdoor landscape watering, and eliminate washing down driveways and sidewalks, and have been penalized monetarily for exceeding conservation targets. Businesses of all types have instituted strict programs ranging from planting drought-tolerant plants through researching more efficient production processes, etc.

Farmers have also adopted water management strategies, reflecting the economic importance of water in the overall farm operation. Farmers apply only the water necessary to attain optimum crop yields and quality. Water management and conservation continue to be ongoing activities, whether or not there is a drought. Over the past 2 decades, farmers have adopted a host of techniques designed to use water more efficiently, including tailwater recovery systems, reduced tillage, laser land leveling, rescheduled applications, etc. Conservation efforts are maintained and increased even in times of plentiful water supplies.

ON-FARM VERSUS SYSTEMWIDE WATER SAVINGS

Conservation at the farm level, however, may not have a significant effect on total water usage for the SJV. Water delivered to, but not consumptively used on a farm is most frequently used productively elsewhere within the area -- by downstream users, for groundwater recharge, etc. While there are direct monetary costs to individual farmers for such inefficiencies, the "excess" water in those cases is not lost to the system. In contrast, some losses are unrecoverable, especially evapotranspiration, deep percolation, and runoff to saline sinks. Evapotranspiration is the largest such usage and relates directly to the type of crop grown, soil, and climate. As a result, short-run opportunities to reduce those losses are limited.

CHANGING IRRIGATION SYSTEMS

Irrigation system choice is one of the most important long-term decisions made by farmers. There is no type of system best for all circumstances. The selection depends not only on the capital investment required versus the anticipated cost savings, but also on the specifics of the farm. For example, sprinkler systems are feasible on sandy light soils where rapid percolation occurs. However, some systems will not work if the slope of the land exceeds 5%-10%. In other situations, the slope may be satisfactory for a sprinkler system, but the system may be incapable of delivering the volume required to leach the salts from a saline soil. Conversely, a drip system may be justified economically for a given farm, but due to variations in the flow rate of water supplied to the farm or soil type, may not be able to deliver the water in the quantities and at the times needed. Moreover, up to 75% or more of all water applied to California crops is used to satisfy the basic water requirements of those plants, including the leaching fraction, regardless of application method. And since cropping patterns change slowly, the potential for systemwide savings from changing irrigation systems is limited in the short run.

Although converting to an irrigation system with the potential for greater water savings may be appealing, good management can produce high efficiencies with almost any system. For example, farmers have shown in some cases that with proper management, flood or furrow irrigation is more efficient than drip or sprinkler, though at first glance flood or furrow application might appear wasteful. In other cases, farmers have adapted drip systems to fields and crops where previously such techniques seemed infeasible. As stated earlier, farmers as businessmen constantly review their operations and look for ways to operate more productively. Conservation and efficient water management are important components of that process and are impacted by many factors, not only drought cycles.

AGRICULTURAL FINANCE

Commercial lending involves sophisticated risk assessment, which influences both the availability and pricing of loans. Lenders must assess risk thoroughly, because the loss from writing off one "bad" loan can eliminate the profit made on many "good" loans, each of the same dollar amount. Consequently, risk assessment is a continual process among sound lenders. The more uncertain conditions are in a given sector or industry, the more time is spent measuring those risks.

Agriculture is a capital-intensive industry. Farmers use large amounts of debt and equity capital for short-term production expenses, machinery, and land purchases. Lenders look upon the farming enterprise in terms of what is produced and at what price and cost to determine their "primary source of repayment". As such, lenders are cash-flow oriented, in contrast to the late 1970s and early 1980s, when many lenders viewed rising farmland values as their primary repayment source, with cash flow secondary.

Interviews with several SJV lenders confirm that since water shortages and subsequent higher costs have had a major impact on net farm income, the risks associated with agricultural lending have increased. However, lending policy itself has not changed materially. Lenders indicate that they have not pulled out of the agricultural market due only to the drought. They still want to do business with profitable, well-capitalized clients that exhibit the ability to manage in a complex, uncertain environment. Increased risks, however, have caused lenders to deny credit to certain borrowers who previously might have been granted credit, but who currently are not able to meet certain financial ratios or guidelines.

Many lenders have imposed more stringent conditions on their agricultural borrowers than in the past to try to assure repayment of their loans. For example, virtually all lenders now require that farmers have explicit, developed water plans that identify water sources, prices, flow rates, and contingency plans.

Most lenders also now require that farmers prepare "downside" as well as "normal" scenarios as part of their credit requests. The intent is to focus more acutely on risk elements in farming operations – yields, costs, prices, water availability, etc. Farmers who do not go through this planning exercise are less likely to be able to borrow as much or as easily as they might have 4-5 years ago.

Lenders noted that they have been asked more frequently since 1988 to finance expenditures for irrigation wells (new, reconditioning, etc.) as well as new application systems. They said that they do finance those expenditures, assuming the borrower meets normal credit, cash flow, and risk criteria.

REAL ESTATE FINANCE AND LAND VALUES

Agricultural real estate financing has been impacted directly by the drought, as lenders have become more conservative on the types of properties they will finance and at what loan-to-value ratios. Water availability and costs are normally capitalized into property values, as the assurance or reasonable probability of continued water supplies at low cost tends to increase land values.

As costs have increased and/or water supplies have shrunk, lenders have tightened their real estate lending criteria accordingly.

Land values and lending ratios have also been impacted by the fixed capital and operating and maintenance costs of irrigation districts. As water and other production costs have increased since 1987, in many cases dramatically, the returns to some farm enterprises have declined sharply. Further, irrigation district fixed costs must be paid. As a result, in some areas, total revenues have been insufficient to cover all costs. When these properties are sold, their lower "income" potential as farmland is reflected in lower values per acre. There is a lag in that process, however, since only a few properties in any area are sold in any period of time. In times of stress, the number of buyers typically declines while the number of forced sellers increases. Several lenders hence estimated that land values would decline through much of 1992 in continued response to the drought. They judged that recent appraisals have not yet adequately reflected water uncertainties, and stated that in some cases lenders were adjusting reported appraised values downward to reflect these uncertainties.

ADJUSTMENTS AT THE IRRIGATION DISTRICT LEVEL

Farmers in the SJV receive surface water from more than 100 public and private irrigation entities. Most of the districts receive their water from either or both the CVP or SWP; others obtain their water from local sources only. Among districts, costs vary widely, depending in part on the quantity of water delivered in any year. Regardless of that quantity, however, fixed charges must ultimately be paid by the farmer -- even when, as in 1991, the amount of water delivered was severely restricted or curtailed altogether. In those situations, the fixed costs of irrigation districts must be spread over fewer units of water delivered, meaning that every water user's fixed costs increase. If these costs are not covered by farmers, then the irrigation district must cover them to the extent it can with reserves or risk defaulting on its bonded indebtedness and/or on its obligations to the state or federal government. In either case, the district's borrowing costs may increase and, in some cases, if the district has insufficient financial reserves to cover the shortfall, property tax assessments may be increased throughout the county – for all property owners.

To date in the 1987-1991 drought, no district level defaults have been documented. However, it is commonly acknowledged that farmers in some parts of the SJV are under extreme financial stress due to escalating water and pumping costs and/or lost crop revenues and depleted financial reserves. It is quite likely that some irrigation districts are vulnerable to financial setbacks due to the possibility of farmer defaults and minimal remaining reserves, and that defaults will occur if the drought continues unabated through 1992. This follows the many major adjustments that districts have already made in response to reduced water revenues, including deferred maintenance of existing systems, cancellation of planned capital investments in new facilities, personnel layoffs, etc. In addition, many districts are finding it increasingly difficult to locate financing for needed capital improvements.

The drought has not been equal in its treatment of farmers, nor the local communities or regional economies of the state. In this section of the report, the analysis links the various business sectors to the economic impacts that are initiated at the agricultural production level.

DROUGHT IMPACTS ON THE FARM MACHINERY INDUSTRY

In 1991, farm machinery dealers in the SJV began to experience reduced sales that they attribute directly to the drought. The sub-areas where land has been idled have experienced the greatest declines. One dealer estimated that 1991 sales and profits were down 10% compared to 1990 due to the drought. Other dealers reported approximately the same decline in business, or less.

Some equipment dealers report that customer spending patterns have changed. For example, some dealers reported higher used equipment sales, while new equipment sales have dropped off. Some dealers also reported more purchases of basic, less costly equipment models. More farmers are leasing tractors, harvesters, and other high cost equipment in order to reduce upfront capital outlays, preferring to "pay as they go". Again, drought-induced capital outlays, as well as less certainty over future water availability, are bringing a new sense of financial conservatism to farmers, and equipment dealer business has declined as a result. The impacts on total equipment sales, including heavy construction, industrial, pickup trucks, etc., are even larger, since water districts have reduced or eliminated many of those purchases.

Farmers have financed their increased water costs primarily from financial reserves. The loss of $163 million in reserves in 1991 to pay for additional water costs reduced their ability to purchase equipment. It is not likely that the entire $163 million would have been invested in 1991, because a portion would have continued in reserve for future investments. If it is assumed that growers use a 5 year capital build up for machinery purchases, then 20%, or $33 million, would have been spent on equipment in 1991.

This estimated $33 million decline in SJV machinery sales includes a loss of $11 million in employee income and a loss of 449 jobs. After taking into account the linkages between the farm equipment dealers and the local community, it is estimated that an additional $16 million in regional business activity has been lost. This $15 million includes a loss of $3 million in employee income and an additional 158 jobs.

DROUGHT IMPACTS ON OTHER RELATED INDUSTRIES

When crop acreage is pulled out of production, purchases of seed, fertilizers, chemicals, and farm labor are not made. As part of this study, interviews were conducted with a sample of farm suppliers in the SJV. The farm suppliers acknowledged that the drought has had an impact on their business, but impacts varied among geographical areas.

Insecticide sales decreased significantly in the Southern SJV area in 1991 compared to previous years because of the winter freeze, which greatly reduced the over-wintering insect population. Cotton had a lower-than-normal incidence of insect infestation in 1991. The March rains and late plantings prevented some emerging insects from moving into the cotton crop. The Spring aphid count was high in the SJV, but in areas where beneficial insect populations were not reduced, overall aphid control was good. Late-season aphid infestations in cotton were lighter than expected.

Fertilizer sales in 1991 were steady to lower in most areas, compared to the previous non-drought period of the early 1980's. Farmers generally apply sufficient fertilizer to achieve high yields, but the drought has made farmers more attentive to water and fertilizer applications. Less fertilizer can be applied when "precision" irrigation is used. For example, low pressure or drip systems in permanent crops such as tree fruits and tree nuts allow for the application of water in only the root zone of each tree and at metered rates for defined periods of time. Less fertilizer is applied, because leaching is minimized. Overall, however, while the drought has been one of several important factors affecting water, energy, fertilizer, and chemical use by SJV farmers, it would be difficult to ascribe the impact of a single year to the adoption of fertilizer saving technologies.

Chemical and fertilizer sales losses can be estimated using data on the amount of land that was idled in 1991 due to the lack of water availability. Based on the estimate that 253,000 acres in the SJV were fallowed in 1991 due to the drought and using an average expenditure of $77 per acre for chemicals and fertilizer, the loss in sales in 1991 is $19.5 million.

The reduction in these and other farm input purchases affects the agricultural service business in the local community. As these businesses experience lower sales volumes, so do the other agriculture and non-agriculture related businesses with which they trade. These linkages among the various businesses within the community virtually guarantee that losses suffered by agriculture are felt throughout the economy.

REVENUE LOSSES

As indicated previously, over 253,000 acres of cropland were either not planted or were abandoned after planting as a result of the drought. An additional 124,900 acres were identified as having a drought-related reduction in yields. These drought related acreage impacts are estimated to have resulted in a $287 million decline in the value of agricultural production in the SJV. As shown in Table 9, nearly $171 million of this loss occurred in Zone A. A significant loss, $76 million, also occurred in Zone D. The distribution of these losses is consistent with the distribution of the impacted acres. Over eighty percent of the losses were related to annual crop reductions, with the remainder estimated for permanent crops.

Sales losses by other related businesses in the local community are measured at an additional $264.3 million for a total loss of SJV business activity of $545.8 million. The total revenue losses shown in Table 9 are distributed over a wide range of businesses, including farm service and support sectors.

TABLE 9

FARM REVENUE LOSSES RELATED TO ACREAGE REDUCTIONS

I. LOSSES RELATED TO ACREAGE REDUCTIONS

Zone	Acreage	Farm-Level Revenue Loss ($ million)	Total Revenue Loss ($ million)
A - Kern	111,101	$117.6	$227.6
B - Fresno/Kings	17,400	11.0	20.9
C - Kaweah/Tule	31,340	16.5	31.2
D - West Side	92,266	74.7	144.1
E - East Side	1,100	1.5	3.0
TOTAL	**253,207**	**$221.3**	**$426.8**
Tree Crops	**4,305**	**$12.5**	**$25.6**
Annual Crops	**248,902**	**$208.8**	**$401.2**

II. LOSSES RELATED TO YIELD DECLINES

Zone	Acreage	Farm-Level Revenue Loss ($ million)	Total Revenue Loss ($ million)
A - Kern	110,667	$53.1	$105.0
B - Fresno/Kings	2,600	0.8	1.5
C - Kaweah/Tule	0	0	0
D - West Side	5,612	1.4	3.0
E - East Side	5,998	4.7	9.5
TOTAL	**124,877**	**$60.1**	**$119.0**
Tree Crops	**79,359**	**$36.9**	**$76.1**
Annual Crops	**45,518**	**$23.2**	**$42.9**

III. COMBINED LOSSES I AND II

Zone	Acreage	Farm-Level Revenue Loss ($ million)	Total Revenue Loss ($ million)
A - Kern	221,768	$170.8	$332.6
B - Fresno/Kings	20,000	11.8	22.3
C - Kaweah/Tule	31,340	16.5	31.2
D - West Side	97,878	76.1	147.1
E - East Side	7,098	6.3	12.6
TOTAL	**378,084**	**$281.5**	**$545.8**
Tree Crops	**83,664**	**$49.5**	**$101.7**
Annual Crops	**294,420**	**$232.0**	**$444.1**

INCOME LOSSES

The losses in wages and salaries for farm laborers and in returns to land and management for farm owners as a result of idled acreage or reduced yields are estimated to be over $113.5 million (Table 10). Zone A had the largest share of this loss with nearly $75 million, while growers in Zone D experienced an income loss of $25.5 million. The distribution of income loss between annual and permanent crops is somewhat different than that for farm revenue. Over 25% of the income loss is accounted for by permanent crops whereas they accounted for only 17% of revenue loss. This is because the permanent crops are generally more labor-intensive and yield higher net returns.

Income losses accruing to other businesses throughout the community as a result of the linkages to agriculture are measured at an additional $85 million. These bring total wage and salary losses along with losses in net returns to farm owners, to $198.5 million.

59339

TABLE 10

FARM INCOME LOSSES RELATED TO ACREAGE REDUCTIONS

I. LOSSES RELATED TO ACREAGE REDUCTIONS

Zone	Acreage	Farm-Level Income Loss ($ million)	Total Income Loss ($ million)
A - Kern	111,101	$36.6	$65.1
B - Fresno/Kings	17,400	3.9	7.7
C - Kaweah/Tule	31,340	4.1	8.4
D - West Side	92,266	24.5	46.8
E - East Side	1,100	0.6	1.0
TOTAL	**253,207**	**$69.7**	**$129.0**
Tree Crops	**4,305**	**$3.1**	**$4.2**
Annual Crops	**248,902**	**$66.1**	**$124.8**

II. LOSSES RELATED TO YIELD DECLINES

Zone	Acreage	Farm-Level Income Loss ($ million)	Total Income Loss ($ million)
A - Kern	110,667	$38.3	$61.1
B - Fresno/Kings	2,600	0.7	1.4
C - Kaweah/Tule	0	0	0
D - West Side	5,612	1.0	1.7
E - East Side	5,998	3.8	5.3
TOTAL	**124,877**	**$43.8**	**$69.5**
Tree Crops	**79,359**	**$25.3**	**$37.8**
Annual Crops	**45,518**	**$18.5**	**$31.7**

III. COMBINED LOSSES I AND II

Zone	Acreage	Farm-Level Income Loss ($ million)	Total Income Loss ($ million)
A - Kern	221,768	$74.9	$126.2
B - Fresno/Kings	20,000	4.5	9.1
C - Kaweah/Tule	31,340	4.2	8.4
D - West Side	97,878	25.5	48.5
E - East Side	7,098	4.4	6.3
TOTAL	**378,084**	**$113.5**	**$198.5**
Tree Crops	**83,664**	**$28.4**	**$42.0**
Annual Crops	**294,420**	**$85.1**	**$156.5**

JOB LOSSES

When crop acreage is idled, there is an associated reduction in farm labor requirements. It is difficult to make a precise estimate of these impacts because farm employment is not reported by crop type. This in turn makes it difficult to estimate per acre farm labor requirements for different crop groups from published data. For example, average farm employment per 1,000 acres in the SJV for 1991 was 34 workers. This estimate is probably high for most field and row crops, but low for the more labor-intensive fruits and vegetables. Alternatively, specialized studies are available which provide estimates of per acre hourly labor requirements for selected crop groups. However, it is difficult to translate hours required to the actual number of farm workers employed.

NEA estimates that 5,000 jobs were lost in the San Joaquin Valley as a result of the drought. This represents NEA's best estimate based on conversations with regional water managers, farmers, and employment economists. This is somewhat less than the approximately 6,000 job reduction in June to November agricultural employment from 1990 to 1991 reported by the California Employment Development Department. However, it is somewhat greater than estimates of 3,600 jobs lost based on employment ratios developed for California from U.S. Department of Agriculture information.[1]

In addition to the 5,000 direct jobs lost in agriculture, it is estimated that an additional 4,050 jobs were lost in related agricultural support industries. The largest share of these job losses occurred within Zone A.

1/ Farm Employment to Farm Output ratios are taken from the IMPLAN input-output modelling database developed by the University of Minnesota.

GROUNDWATER OVERDRAFTING

As discussed previously, groundwater overdrafting has increased the cost of pumping for SJV farmers. DWR estimates (12/91) that groundwater storage in the SJV has been depleted by 11 MAF in the current drought. It reports that 1991 groundwater levels were as low as or lower than post-1977 drought levels in 5 of the 8 SJV counties. This is a very significant economic impact of the drought, at least in the short run until several above-normal water years return and groundwater tables rise.

Other impacts that will be felt in the short run, and in the long run in the SJV, are land subsidence and increasing salt concentrations in certain areas. The lowering or settling of the land surface in the SJV is a result of many geologic or hydrologic processes. However, one of the primary causes is groundwater extraction. Subsidence occurs when fine-grained beds of clay and silt, called aquitards, compress as water is extracted, principally from pumping the groundwater. Once the aquitards are compacted, they can never hold as much water again, resulting in a permanent loss of aquifer water storage capacity. The U.S. Geological Service (USGS) reports that prior to 1977, 5,200 square miles of the SJV floor area subsided by at least one foot, and in some areas, subsidence has been as much as 30 feet. No recent land subsidence surveys have been made, but the DWR reports that subsidence has started again in Western Fresno County and may be occurring elsewhere in the SJV, even in areas where groundwater levels have not declined to 1977 levels [Brickson].

The economic impact of land subsidence from the extensive groundwater pumping in 1991 is not measurable because data is not available to compute groundwater storage losses. The potential impacts, however, on roads, municipal water and sewer lines, utility lines, etc., may be extensive. The permanent loss of groundwater storage is an important loss to all groundwater pumpers, whether they are irrigated crop farmers or other water users. Further deepening of wells, and a permanent reduction of available groundwater supply are two serious consequences of land subsidence.

SOIL SALINITY INCREASES

Continuation of the drought in the SJV in 1991 has contributed to problems of salt buildup in agricultural soils, particularly sodium chloride and boron. Sources for salts are local surface waters as well as water imported from the Sacramento-San Joaquin Delta, groundwater aquifers, saline native soils, man-made sources, including urban water run-off where salts have accumulated from water softeners and food residues, and industrial water discharges.

Salts accumulate in soil as irrigation water is applied to crops. Some of the saline water returns to the water supply, but most of the irrigation water evaporates from the soil or transpires into the air from growing plants. During this process, salts carried by the water remain in the soil.

The 1991 drought has contributed to greater salt buildup because farmers have not had sufficient water available to leach salts out of the top soil layer. (Leaching is the application of extra irrigation water to carry much of the salt below the root zone.) Groundwater is more commonly a source of salt than surface water. Greater groundwater pumping in 1991 is therefore contributing to the salt buildup.

Excess salinity in the plant root zone negatively affects crop plants through a reduction in the growth rate, hence production. Scientists generally believe that plant growth is inhibited as plants expend more energy under high salt conditions to acquire water from the soil and to make biochemical adjustments that are necessary to survive. The threshold level of salt tolerance varies among different crops. External environmental factors such as temperature, relative humidity, and wind speed are also factors.

Maas and Hoffman (1977) have grouped California crops in categories ranging from salt-sensitive to salt-tolerant, and these are listed in Table 11.

TABLE 11

A RANKING OF CALIFORNIA CROPS ACCORDING TO SALT SENSITIVITY

Sensitive Crops

Bean	Boysenberry
Carrot	Plum/prune
Strawberry	Apricot
Onion	Orange
Almond	Peach
Blackberry	Grapefruit

Moderately Sensitive Crops

Turnip	Potato
Radish	Sugarcane
Lettuce	Cabbage
Clover, berseem	Celery
Clover, strawberry	Corn (forage)
Clover, red	Alfalfa
Clover, alsike	Spinach
Clover, ladino	Trefoil, big
Foxtail, meadow	Cowpea (forage)
Grape	Cucumber
Orchardgrass	Tomato
Pepper	Broccoli
Sweet potato	Vetch, common
Broadbean	Rice, paddy
Corn	Squash, scallop
Flax	

Moderately Tolerant Crops

Wildrye, beardless	Soybean
Sudangrass	Trefoil, birdsfoot
Wheatgrass, std. crested	Ryegrass, perennial
Fescue, tall	Wheat, durum
Beet, red	Barley (forage)
Hardingrass	Wheat
Squash, zucchini	Sorghum
Cowpea	

Tolerant Crops

Date palm	Wheatgrass, tall
Bermudagrass	Cotton
Sugarbeet	Barley
Wheatgrass, Fairway crested	

Source: E.V. Maas and G.J. Hoffman, "Crop Salt Tolerance - Current Assessment", Journal of Irrigation and Drainage Division, ASCE 103 (IR2), 1977, pp. 115-134.

The SJV in 1990 included 577,000 acres (13% of total) in the salt-sensitive category. An additional 1.35 million acres, or 30% of the total cropland area grew crops of the moderately sensitive category.

It is clear that additional yield-reducing salt buildup has occurred in areas of the SJV. However, reliable data do not exist to make precise estimates of how much additional cropland was affected by salt buildup in 1991. Hence, our analysis has not explicitly added any yield losses to the drought impact estimates.

FURTHER CROP ACREAGE ADJUSTMENTS ?

Over time, there has been a noticeable shift in cropping activity in the SJV from lower-value to higher-value crops. Rising water costs have accounted for part of this trend, since a crop which provides a satisfactory return with water costing $25 per acre foot may be totally unsatisfactory with water at $50 or more per acre foot. The shifts from grains to cotton, vegetables, and permanent crops and more recent shifts from grain and cotton to vegetables and permanent crops reflect these price trends.

However, such conversions depend on market conditions and farmers' individual perceptions and expectations of those conditions (see previous discussion of cropping pattern shifts). Given the competitive nature of agriculture and the relative abundance of economic information to all who want it, there is a tendency within the sector to overadjust to economic phenomena. A case in point, processing tomatoes saw rapid increases in crop acreage and processing capacity over the last 3 years which outstripped demand growth. Similar situations could occur in any other crop.

Soil and other agronomic conditions also limit the acreage adjustments possible. Within parts of the SJV, for example, trees and vines will not grow satisfactorily. In other cases, the revenues from alternative crops will not cover the variable costs of growing those crops, and as water costs rise further, some land will simply be removed from production.

SOME AREAS/CROPS TO GO OUT OF PRODUCTION ?

The SJV is not a homogeneous area, but rather is comprised of many different soil and climate types, water availabilities, and other conditions. Over time, cropping patterns have changed within some regions of the Valley in response to crop prices, land prices, water costs and proximity to processors, among other factors. Ongoing urbanization pressures represent the dominant "non-farm" influences, while water costs and crop and land prices (the latter impacted in part by urbanization) are the primary forces causing land substitution among crops.

The drought has had a direct effect on the continued feasibility of farming in certain parts of the SJV, particularly since 1989. Surface water supplies have been severely limited or cut off, and many farmers have been forced to rely primarily or solely on groundwater to sustain their operations. Pumping lifts and costs have increased sharply in many areas, and those higher costs have reduced grower returns for some traditional crops. Both the quantity and quality of groundwater have become important issues, as increased pumping has aggravated the normal overdraft situation and has resulted in pumping low-quality water in some areas.

Those farmers without groundwater or alternative surface water supplies have been forced to idle their lands, with the most severe examples in Kern County. Some of that land will be recultivated after the drought ends. However, until that time or until water costs stabilize or decline, some lands will remain fallowed, since returns to the land will not justify the expense of farming.

Although there are exceptions, typically few alternative uses exist for idled land. As a result, there is a direct effect on the local economy in the short run, beginning with lower income for the farm manager and fewer farm laborers, continuing with local machinery, chemical, feed, and seed suppliers, custom service suppliers, and flowing through to lower sales for retailers, lower revenues for water districts, reduced sales tax collections, etc. To the extent that the properties involved are converted to non-farm uses, such as houses and commercial properties, these effects are mitigated. However, such conversions are limited by market conditions, foregoing any return to agricultural production. Significantly, much of the idled land is located in areas where municipal and industrial growth is not anticipated in the future.

REFERENCES

1. Sandra Archibald, et.al., "The Economics of Water Availability in California Agriculture," (forthcoming), Center for Economic Policy Research, Stanford University.

2. B. Brickson, "California's Groundwater Resources After Five Years of Drought" in Western Water, November/December, 1991, Water Education Foundation, Sacramento.

3. California Department of Food and Agriculture (CDFA), "California Agricultural Exports Surge 14 % in 1990," Release #91-171, November 14, 1991.

4. California Department of Food and Agriculture (CDFA), "Drought and Freeze Have Major Impact on California Agricultural Production and Value in 1991," Release #92-24, January 30, 1992.

5. Frederick Cannon, "Outlook for California Agriculture," Bank of America, San Francisco, July, 1991.

6. Central Valley Water Use Study Committee (CVWUSC), "Irrigation Water Use in the Central Valley of California," Division of Agriculture and Natural Resources, University of California, and Department of Water Resources, State of California, 1986.

7. R. Cook, C.F. Nuckton, and A.F. McCalla, "Perspective on Marketing and Trade of California Agricultural Products," in Agriculture in California: On the Brink of a New Millennium,(H.O. Carter and C.F. Nuckton, eds.), A Series of Issues Papers sponsored by the UC Agricultural Issues Center, Davis, 1990.

8. Department of Water Resources (DWR), "California's Continuing Drought, 1987-1991" Sacramento, December, 1991.

9. Department of Water Resources (DWR), "Crop Water Use in California," Bulletin 113-4, April 1986, Sacramento.

10. B.D. Gardner, R. H. Coppock, C.D. Lynn, D.W. Rains, R.S. Loomis, and J.H. Snyder, "Agriculture," Chapter II in Competition for California Water: Alternative Resolutions. (E.A. Englebert and A.F. Scheuring, eds.), UC Press, Berkeley, 1982.

11. Peter Gleick and Linda Nash, "The Societal and Environmental Costs of the Continuing California Drought," Pacific Institute, Berkeley, California, July, 1991.

12. Noel Gollehon and Marcel Aillery, "Drought Reduces Western Surface Water Supplies," Farmline, October, 1991.

13. Richard Howitt, "Water in California: A Resilient System Under Pressure," University of California, Agricultural Issues Center Position Paper 91-1, Davis, April, 1991.

14. E.V. Maas and G.J. Hoffman, "Crop Salt Tolerance - Current Assessment" in Journal of Irrigation and Drainage Division, ASCE 103 (IR2), 1977, pp. 115-134.

15. University of California Cooperative Extension Service (UC), "Does Drip (and other Low-Flow) Irrigation Save Water?," Leaflet 21380, 1984.

16. University of California Cooperative Extension Service (UC), "How Farmers Irrigate in California," Leaflet 21414, 1986.

17. W.D. Watson, C.F. Nuckton, and R.E. Howitt, "Crop Production and Water Supply Characteristics of Kern County," Giannini Foundation Information Series No. 80-1, Division of Agricultural Sciences Bulletin No. 1895 (University of California: Giannini Foundation, April 1980).

APPENDIX A
SURVEY OF SAN JOAQUIN VALLEY WATER DISTRICTS

In order to better understand the impacts of the 1991 drought on San Joaquin Valley crop acreages, pumping lifts, water supplies, and water costs, a survey of irrigation districts, water districts, water storage districts and private water companies was conducted. The survey was designed to determine how acreage and water supplies under the drought had deviated from what could have been expected with normal water supplies. A copy of the survey is attached at the end of this section.

The survey instrument was first reviewed by members of the SJV AWC Subcommittee overseeing the study, after which it was mailed to the membership of over 100 water districts. Where possible, personal contact was made with the water district managers and farmers to further clarify the content of the survey.

Results of the survey were aggregated to the 5 membership zones of the SJV AWC. These zones are shown in Figure A-1. Based on estimated crop acreages for the SJV, approximately 64% of production in the region was represented by districts responding to the survey. Response rates, based on acres surveyed, for the individual zones are shown below.

Zone	Total Acreage	Survey Acreage	Percent Surveyed
A - Kern	842,384	842,384	100%
B - Fresno/Kings	1,108,737	740,615	67%
C - Kaweah/Tule	716,009	293,089	41%
D - West Side	1,213,491	775,932	64%
E - East Side	898,615	426,655	47%
TOTAL	**4,779,236**	**3,078,675**	**64%**

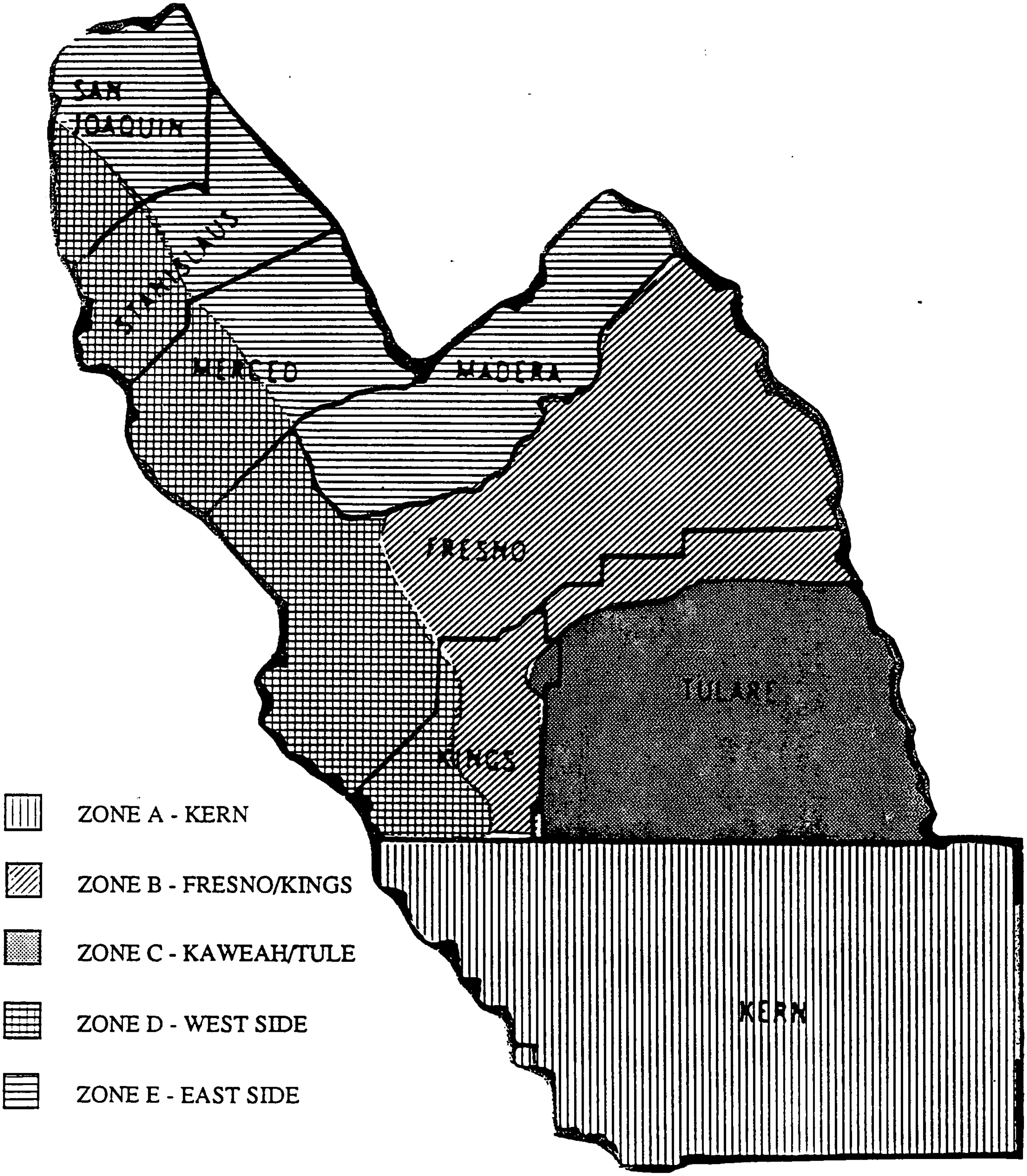
Information from the survey was used to quantify the following district-related characteristics:

- 1985 and 1991 crop acreages, including cropping patterns, fallowed acreage and nonirrigated lands. The year 1985 was selected as "normal" by being between drought cycles and beyond the wet 1982-83 season.
- Applied water coefficients under two scenarios: 1) normal water supplies and 2) drought water conditions as experienced in 1991.
- Crop acreage that was either not planted or removed from production as a result of limited water supplies or high water costs.
- Quantity of district supplied surface water and groundwater under normal water supplies and in the 1991 drought period.
- Average costs for district supplied water under normal water conditions and under the drought.
- Average pumping lifts in 1985 and 1991.
- Expected change in pumping lifts for alternative water supply scenarios.
- District expenditures for new and rehabilitated wells.

Results from the survey are presented in various sections throughout the report.

FIGURE A-1

SAN JOAQUIN VALLEY AGRICULTURAL WATER COMMITTEE MEMBERSHIP ZONES



SAN JOAQUIN VALLEY AGRICULTURAL WATER COMMITTEE
WATER DISTRICT SURVEY TO STUDY THE ECONOMIC IMPACT OF THE 1991 CALIFORNIA DROUGHT

Water District : ______________________________

Contact Person : ______________________________

NOTE: Please follow the instructions given below each item for assistance in completing the survey form.

A.

CROP ACREAGE 1985 and 1991			
	1985	1991	Comments
Tree Nuts			
Citrus			
Tree Fruits			
Grapes			
Cotton			
Grains			
Alfalfa			
Vegetables: Fresh			
Veg's: Processed			
Other			
Fallow			
Total Irrigable [1]			
Non Irrigable [2]			
TOTAL ACRES			

1/ Adjusted for Double Cropping. 2/ Farmstead, residential, roads, etc.

* Please indicate 1985 and 1991 district irrigated acres in each of the crop groups identified.
* When completed, acreage should sum to total irrigated acreage in 1985 and 1991.
* Provide comments as necessary.
* **If you would prefer, attach district acreage summaries for 1985 and 1991 if available.**

B. **CROP WATER USE**

	AF/Ac: Normal	AF/Ac: 1991	Comments
Tree Nuts			
Citrus			
Tree Fruits			
Grapes			
Cotton			
Grains			
Alfalfa			
Vegetables: Fresh			
Veg's: Processed			
Other			

* In the first column indicate total AF applied per acre under normal water supplies.
* In the second column indicate total AF applied per acre under the current conditions of limited water supply if this differs from normal.
* Provide comments as necessary. Identify both drought and non-drought factors that might impact water use, ie frost damage.

C. **CROP ACREAGE IMPACTED BY THE 1991 DROUGHT**

	Not Planted	Abandoned in 1991 1991	 Forever	Reduced Yields	Yield Loss (%)
Tree Nuts					
Citrus					
Tree Fruits					
Grapes					
Cotton					
Grains					
Alfalfa					
Vegetables: Fresh					
Veg's: Processed					
Other					
TOTAL					

* In the first column indicate the number of acres not planted this year as a result of the drought and limited, more expensive, or poor quality water supplies.
* In the second and third columns indicate the number of acres abandoned (planting begun but not continued) as a result of the drought. Indicate if abandoned forever or for 1991 only.
* In the fourth column indicate the number of acres on which yields have been reduced.
* In the fifth column indicate the average percentage reduction in yields for the acreages characterized by reduced yields.

D.

DISTRICT WATER SUPPLIES 1991				
	AF: Normal	Avg $/AF: Normal	AF: Drought	Avg $/AF: Drought
Groundwater				
Surface Water				
Total				

* In the first two columns indicate water supplies and average price per AF under normal water conditions.
* In the third and fourth columns indicate water supplies and average price per AF under the current drought conditions.

E.

INCREASED PUMPING COSTS 1991				
	Pump Lift: 1985	Pump Lift: 1991	$Energy/AF	Acreage Affected
Groundwater				

* In the first two columns indicate average groundwater pumping lifts in 1985 and 1991. Provide your best estimates for 1991. We will revise these figures as more information becomes available.
* In the third column indicate current farm level average energy costs per AF of pumped water.
* In the fourth column indicate the total number of acres affected by these increased pumping costs.

F.

INCREASED PUMPING COSTS 1992–1994				
	Continue Drought	Normal Conditions	Wet Years	Acreage Affected
Groundwater				

* In this section indicate your best estimate of pumping lift for the next 2–4 years based on: continued drought, normal water conditions, and wet years.

G.

INCREASED WELL COSTS				
	# New Wells	Cost/Well	# Rehabilitated	Cost/Well
1989–1991				
1992–1994				

* In this section estimate the number of new wells and the number of wells that have been rehabilitated as a result of the drought. Please provide estimates for the 1989–1991 period and your best estimate for future 1992–1994 well costs related to the 1989–1991 drought.
* The costs per well should be representative capital costs based on pumping lifts and well capacities for the district.

Thank you for your cooperation. Please return the survey form using the enclosed envelope.

San Joaquin Valley Agricultural Water Committee

APPENDIX B
RECENT DROUGHT STUDIES

Several government agencies, profit- and non-profit organizations, and individual authors have analyzed the effects of California's recent drought on sectors of or the entire state economy. The California Department of Food and Agriculture (1992) estimates that the state's gross cash receipts fell $1 billion last year due to the combined effects of the drought and the December 1990 freeze. Total crop production was down 6%. Field crop production fell 6% due to reduced planting and harvesting, and the value of production fell more than $500 million. The value of fruit and nut production fell about $350 million, while that of vegetables and melons fell $72 million.

The California Department of Water Resources (12/91) reports that the state overall suffered minimal economic impacts through 1990, but substantially more severe effects in 1991. In 1991, DWR estimates losses to agriculture of $500 million and another $500 million in increased consumer energy costs due to the loss of hydroelectric power generation. Drought-idled cropland statewide was estimated to be 455,000 acres in 1991.

Cannon (7/91) estimated that total California cash receipts from farming in 1991 would decline $600 million relative to 1990, a combined result of the effects of the freeze, the drought, and lower dairy prices. He noted that in general the prices for drought-related commodities are less sensitive to changes in output than freeze-damaged crops (citrus in particular) and consequently that gross incomes for drought-reduced crops would fall.

Howitt (4/91) utilized the California Agriculture and Resources Model and several assumptions regarding surface water supplies and groundwater pumping by agriculture, water costs paid by farmers, and availability of water for perennial crops in forecasting that statewide acreage in 1991 would be 14% below a normal year. He forecasted that the largest reduction in acreage would be in pasture, alfalfa, and cotton. Those reductions translated into an estimated loss of $304 million in net farm income in the 8-county SJV; the largest percentage loss in return to land and management was predicted for the Southern SJV, namely Kern County. It was also predicted that consumers' food bills at the farm gate last year would be $220 million higher, a number that would be considerably higher after retail distribution and margins were considered.

Gleich and Nash (8/91) stated that the California economy overall withstood five years of drought without major dislocations. They also asserted that the overall economic impacts on agriculture have been relatively small though unequally distributed across regions. They claimed that agriculture has escaped major impacts to date due to reservoir storage and groundwater reserves, which they acknowledged, however, have been largely depleted. Like the 12/91 DWR study, Gleich and Nash referenced the higher consumer energy costs due to the loss of hydroelectric power, although they estimate a $3 billion impact versus DWR's $0.5 billion estimate.

Gollehon and Aillery (10/91) offered a drought review of the entire Western region of the nation. They showed that the drought in California has unfortunate parallels in several other states, pointing out that while the size of the nation's drought-stricken areas has declined since 1990, drought conditions remain severe in several regions. They reported on California's reservoir levels and referred generally to the crops and sectors on which the drought has had its greatest overall impacts (based in part on DWR information). Specific economic loss impacts were not included.

Archibald, et.al., are preparing an in-depth analysis of the short- and long-term effects of water shortages on California agriculture as input into the proposed water quality standards for the San Francisco Bay-Sacramento-San Joaquin Delta. They are utilizing a case-study approach, surveying several irrigation/water/water storage districts throughout California as well as growers and representatives from related industries to assess the overall economic and financial effects of water shortages on agriculture.

APPENDIX C
LOCAL WATER SUPPLIES IN THE SJV

The impacts of the drought on water districts have varied, depending in part on the districts' source(s) of water. Besides contracts with the Central Valley Project or the State Water Project, many water districts have rights to water from rivers and streams flowing through their areas. Other districts pump ground water from their own wells or from wells on leased lands in their districts. The cost impacts to farmers can be significant, as discussed in "Water Prices." In some cases, farmers' costs are also significantly impacted by the effects of reduced water flows on districts' electrical generating capacity. Where electrical output has been reduced, districts have had to supplement their own output with purchased electricity, often at substantially higher costs which are passed on to customers.

While all water districts with surface water rights have been adversely affected by lower natural flows over the last 5 years, some have fared better than others. As shown in Table C-1 (next page), natural runoff from SJV rivers and streams in 1991 averaged 58% of normal, but ranged form 0% to 64%. Generally surface water offers the low-cost irrigation water source. However, these flows have been supplemented with higher-cost emergency supplies through privately-arranged transfers or the State Water Bank or through increased ground water pumping.

TABLE C-1

SUMMARY OF NATURAL RUNOFF FROM RIVERS AND CREEKS IN THE SAN JOAQUIN VALLEY

River/Creek	Water Year Runoff 1,000 Acre-Feet Average	1991	1991 as % of Average
Chowchilla River (80 Years)	69.1	22.1	32
Fresno River (80 Years)	79.2	32.8	41
San Joaquin River (86 Years)	1,777.8	1,027.2	58
CVP Class I	(800)	(742)	
CVP Class II	(700)	(-0-)	
Kings River (96 Years)	1,685.9	1,075.7	64
Kaweah River (88 Years)	422.7	252.3	60
Tule River (88 Years)	140.4	60.3	43
Kern River (88 Years)	692.9	383.6	55
Mill Creek	30.6	13.1	42
Hughes Creek	4.9	1.6	33
Cottonwood Creek near Elderwood	9.0	3.0	33
Dry Creek near Lemon Cove	15.9	4.7	30
Yokohl Creek	5.2	-0-	0
Deer Creek near Fountain Springs	24.0	3.7	15
White River near Ducor	7.1	2.0 *	28
Poso Creek near Oildale	23.0	7.8 *	34
TOTALS	**4,987.7**	**2,889.9**	**58**

( ) Not included in total
* Preliminary Data