SAND77-0968
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Irrigation Data Base for Arizona

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Prepared by Sandia Laboratories, Albuquerque, New Mexico 87115
and Livermore, California 94550 for the United States Department
of Energy under Contract AT(29-1)-789

January 1978

Sandia Laboratories

SF 2900 Q(7-73)

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Printed in the United States of America

Available from
National Technical Information Service
U. S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

Price: Printed Copy \$4.50 ; Microfiche \$3.00

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Abstract

Part of Sandia Labs responsibility as technical manager of DOE's solar irrigation project is to determine the locations in the U.S. where solar energy might be used for irrigation. One of the first steps in determining these locations is to establish a data base for the agricultural states that extensively use irrigation. The data base must include information on the crops grown, the irrigation wells, and the irrigation pumps. This document contains the results of an effort to establish such a data base for the state of Arizona.

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Introduction

This report contains data which describes irrigated agriculture in the State of Arizona. The data was compiled for use in the application analysis of solar irrigation systems. This effort had two purposes: to establish a format for data compilation for the states of interest while assessing the difficulty of obtaining the necessary data and to provide a data base for preliminary applications analysis and economic analysis for the solar irrigation program.

The time required to develop this preliminary data base makes it prohibitive to attempt to develop a similarly detailed data base for each area of concern. As a result, agricultural census data, although somewhat out-of-date, will be relied upon for the Western U. S. data still to be assembled. Other data bases will also be used where possible to reduce the time required to assemble a data base which characterizes western agriculture.

Methodology

The ultimate objective of the solar irrigation program data compilation is to provide sufficient information to determine regions where solar irrigation is most applicable. Arizona is the site of the 150 KWe solar irrigation experiment. Therefore the state was chosen for the preliminary data compilation and application analysis.

Table 1 shows the type of data which were required to meet the stated objective.

The data are grouped by groundwater well characteristics, crop characteristics, pump energy use, surface water pumping characteristics, and water storage data. The data were compiled from the most current documents available. Numerous telephone discussions were held with authorities in the various fields to clarify the data. In some cases, data are not available. The data were compiled for each county in which irrigated agriculture is significant. These include Cochise (118,000 acres), Graham (56,000 acres),

Maricopa (430,000 acres), Pima (50,000 acres), Pinal (210,700 acres), and Yuma (230,000 acres) based on 1970 data.

Results

Tables 2 through 8 contain the data. Each data group in Table 1 is presented with explanatory notes.

Table 1

	maximum	minimum	median	average	natural gas electricity	diesel	L.P. gas	crop type 1	crop type 2	...
A. Wells										
1. number (irrigation)										
2. flow rate (gpm)										
3. lift (feet)										
4. drawdown (feet)										
5. annual pumpage (ac. ft.)										
6. H ₂ O temperature										
7. operating hours total annual										
8. distance between wells (feet)										
9. water table depth										
10. acres per well										
B. Crops										
1. number groundwater irrigated acres										
2. number surface water irrigated acres										
3. system (acres) flood gravity										
4. system (acres) furrow flow										
5. system (acres) sprinkler										
6. inches/acre water applied *										
7. irrigated crop value per acre										
8. irrigated crop yield per acre										
C. Energy										
1. energy cost (\$/BTU)										
2. annual energy consumption (BTU)										
3. 1980 availability of energy										
D. Surface Water Pumped for Irrigation										
1. number pumps										
2. flow rate (gpm)										
3. lift (feet)										
4. annual pumpage										
5. operating hours total annual										
6. total annual (acre feet)										
7. distance between pumps										
8. water temperature (°C)										
E. Water Storage Data										
1. seepage rate										
2. cost of water storage										
3. evaporation rate										

* Item 6 is a matrix showing water demand for each 1/2 month for each crop considered.

A. Wells

1. Number of irrigation wells. Data unavailable on a county basis for this parameter. There are about 7,000 irrigation wells in the state.
2. Flow rate (gpm). See Table 2.
3. Lift (feet) See Table 2.
4. Drawdown (feet) this parameter was not estimated.
5. Annual pumpage (acre-feet) See Table 2.
6. Water Temperature. See Table 2.
7. Total Annual operating hours. See Table 2.
8. Distance between wells.

We were not able to get good information on this parameter. However from conversations with several agriculture-type people in Arizona, we estimated that the minimum number of acres per well is about 120 and the maximum is about 200. A rule of thumb that irrigation specialists often use is 10 gal/min/acre. Hence a 1200 g/min pump could irrigate about 120 acres.

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C. Energy

1. Energy cost (\$/BTU). We did not try to calculate values for this parameter. This data should be readily available from the power companies.
2. Annual Energy Consumption (BTU). See Table 1. We do not have complete data for this parameter. The table gives numbers for 1976 electric consumption based on information from Jim Carter, Arizona Cotton Growers Association.
3. 1980 Availability of Energy - we do not have much information on this parameter. From conversations with several knowledgeable people we have concluded that very little natural gas will be available in 1980. Most farmers are converting to electric power as quickly as possible.

D. Surface Water Pumped for Irrigation. We do not have specific information on surface water pumpage. Most of this type of pumping is done in Yuma county. According to Scot Hathorn, irrigation specialist at University of Arizona, the energy requirements for surface pumping are quite small.

E. Other Data

1. Water Storage Efficiency (seepage rate). No data.
2. Cost of Water Storage. No data.
3. Evaporation Rate (inches/year). See Table 8.

Table 2
Wells

Maricopa				Cochise				Pima				Pinal			
Area	Average Lift Ft.	Flow Rate Gal/min	Annual Pumpage Acre-ft	Area	Average Lift Ft.	Flow Rate Gal/min	Annual Pumpage Acre-ft	Area	Average Lift Ft.	Flow Rate Gal/min	Annual Pumpage Acre-ft	Area	Average Lift Ft.	Flow Rate Gal/min	Annual Pumpage Acre-ft
Gila Bend	300	3,000	2,005	Kansas Settlement	410	800	535	Avra Valley	358	1,400	936	Coolidge	395	1,200	802
Aguila	500	2,500	1,671	Stewart	305	800	535	Marana	305	1,000	568	Casa Grande	555	1,200	802
Rainbow Valley	475	1,900	1,270	Bowie	420	1,200	802					Eloy	605	800	535
Harquahala	575	1,900	1,270	Elfrida-McNeal	310	800	535					Stanfield	610	1,200	802
Queen Creek	575	1,100	737	San Simon	325	800	535					Maricopa	480	1,900	1,270
Overall Avg.	485	2,080	1,391		354	880	538		331	1,200	812		529	1,260	842
Water															
Temperature 98°F (1000 ft)				100°F (1000 ft)				75°F (100 ft) 85°F (200 ft)				75°F (270 ft) 95°F (450 ft)			
Yearly Operating Hours	Min	Av	Max	Min	Av	Max		Min	Av	Max		Min	Av	Max	
	3,500	3,600	3,700	3,500	3,600	3,700		3,500	3,600	3,700		3,500	3,600	3,700	

Table 2 (cont)

Notes:

1. No data available for Graham and Yuma counties - Pumpage for most of Yuma County and part of Graham County is for surface drainage.
2. Lift, Flow, Pumpage, and Total Operating Hours data is from "Arizona Pump Water Budgets 1976", References [2], [3], [4], [5].
3. Water Temperature estimates are from [8].

Table 3
Ground and Surface Water Irrigation Information

	Maricopa*	Cochise	Pima*	Pinal*	Graham	Yuma*
Irrigated Acreage, Acres	430,000	118,000	50,000	210,700	56,000	230,000
Surface water Diversion, Acre-ft	941,000	17,000	0	197,000	113,000	1,878,000
% of Total County Withdrawal	31%	3.0%	0%	15%	40%	78%
% of Total State Surface Water Diversion	28.6%	0.5%	0%	6.0%	3.4%	57.0%
Ground Water Pumpage, Acre-ft	2,049,000	505,000	412,000	1,115,000	168,000	180,000 (ground water) 361,000 (drainage only) 541,000
% of County Total	69%	97%	100%	85%	60%	22%
% of State Total	41.3%	10.2%	8.3%	22.4%	3.4%	3.6% 11.6%
Total Irrigation Water, Acre-ft.	2,990,000	536,000	412,000	1,312,000	281,000	2,419,000

1970 Conditions. Information is from "Inventory of Resources and Uses." Ref [8].

* Some double cropping in these counties

Table 4
System of Irrigation
Total Acres based on "1975 Arizona Ag. Statistics" Ref. [6]
Percents based on 1969 USDA Census Data*

Type	Total Ac.	Maricopa 471,740	Cochise 157,480	Pima 52,880	Pinal 280,300	Graham 72,860	Yuma 299,040
Furrow		70.8% 33,992 Acres	89.7% 141,259 Acres	92.8% 49,073 Acres	81.0% 229,473 Acres	92.8% 67,614 Acres	45.1% 134,867 Acres
Sprinkler		1.5% 7,376	3.1% 4,882	2.0% 1,057	5.3% 15,015	.4% 291	2.1% 6,280
Flooding		27.6% 130,200	7.3% 11,496	5.2% 2,750	13.7% 38,812	6.8% 4,954	52.6% 157,295
Sub-Irrigation		.1% 4,717	0%	0%	0%		.2% 598

* Overlap between systems of irrigation was neglected. For example, acreage that was both sprinkled and furrow irrigated was counted twice. This overlap acreage is judged to be small.

Table 5
Water Demand (Plant Consumptive Use)
Inches

Crop	Jan.	Feb.	Mar.	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total Con- sumptive Use (Applied)
Cotton				.15 .33	.63 1.28	1.95 3.30	4.65 5.84	5.70 5.60	4.35 3.30	2.25 1.25	.57		41.15 (55.88)
Wheat	.30 .48	.56 .70	1.35 3.52	5.25 5.85	4.20 .72								22.9 (36.2)
Alfalfa		1.81	2.75 3.22	3.54 4.02	4.61 5.36	5.34 5.48	5.48 5.30	4.55 4.43	4.38 4.29	3.18 2.48	1.85 1.65		74.3 (64.8)
Grain Sorghum							.60 3.20	5.25 6.72	4.30 2.85	1.50 .48			25.4 (39.85)
Grain Sorghum Double Crop				.08 .90	2.55 4.80	6.15 6.60	3.75 3.20	2.40 4.16	5.85 4.05	2.55 1.92	1.35 .90	.30	51.5
Barley	.45 .74	1.37 1.72	2.64 3.60	5.87 5.16	3.50							.23	25.3 (48.98)
Broccoli	1.61 2.13	2.06							.12 .87	1.70 2.40	2.76 2.15	1.89 1.70	19.7
Cabbage (early)	1.5 1.60								.26 .75	1.53 2.88	2.85 2.28	1.8 1.76	17.2
Cabbage (late)	1.80 1.86	1.55 1.58	1.50						.45 1.35	2.25 2.88	2.75 2.40	2.10 1.94	24.5
Carrots	1.50 1.46	1.26 1.23	.93						.15 .68	1.50	2.55 2.10	1.65 1.60	16.6
Cauliflower	1.8 1.65								.38 .99	1.40 2.30	2.75 2.69	2.46 2.13	18.6
Dry Onions	.51 .74	.88 1.20	2.07 3.79	4.94 5.55	2.87						.05 .09	.20 .37	23.3
Lettuce									.24 .77	1.18	1.31 1.49	1.76 1.71	8.5
Oranges	.60 .80	.80 1.0	1.0 1.2	1.3 1.5	1.7 1.9	2.2 2.4	2.6 2.7	2.7 2.6	2.3 2.3	2.0 1.6	1.3 1.2	.80 .60	39.1 (63.85)
Grapefruit	.08 1.0	.90 .90	1.2 1.4	1.5 1.6	2.0 2.5	2.7 3.0	3.4 3.4	3.3 3.3	2.9 2.7	2.4 2.0	1.6 1.2	1.1 1.1	47.9 (64.44)
Lemons													
Sugar Beets	1.16 1.22	1.03 1.06	1.41 2.50	3.14 3.73	4.14 4.65	4.36 4.17	3.05 1.76			.10 .51	1.06 1.28	1.25 1.25	42.8 (56.38)
Safflower	.12 .35	.43 .80	1.35 2.67	4.88 6.54	6.8 7.49	6.75 5.75	1.47						45.4

Consumptive use values are from "Consumptive Use by Crops in Arizona" Ref. [1]. Total Applied Values are from Ref. [7].

Table 6

Crop Information by County (1975 Data from Ref [6])

	Maricopa	Cochise	Pima	Pinal	Graham	Yuma
<u>Alfalfa</u>						
Acres	96,000 A	9,600 A	2,100 A	16,000 A	8,100 A	66,000 A
Yield	7.1 Tons/A	6.0	5.6	6.0	5.9	8.0
Production	681,600 Tons	57,600	11,800	96,700	47,800	528,000
Value	\$39,845,200	\$3,367,200	\$689,808	\$5,652,920	\$2,794,308	\$30,866,000
Value/Acre	\$415/acre	\$350.75	\$328.48	\$353.31	\$344.98	\$467.67
<u>Cotton</u>						
Acres	117,600	13,550	14,150	107,650	9,250	34,500
Yield	1,151 lbs/A	553	882	767	580	1230
Production	282,000 bales	15,600	26,000	172,000	11,170	88,400
Value	\$70,420,464	\$4,197,018	\$6,793,962	\$43,711,573	\$3,491,301	\$22,718,710
Value/acre	\$598.81/Acre	\$309.74	\$480.14	\$406.05	\$377.44	\$658.51
<u>Barley & Wheat</u>						
Acres	139,000 A	57,500	19,800	105,400	21,000	87,300
Yield	2.067 Tons/A	1.961	1.894	2.025	1.880	2.173
Production	287,310 Tons	112,780	37,500	213,480	39,480	190,750
Value	\$30,666,510	\$11,894,118	\$4,007,484	\$22,726,440	\$4,275,810	\$20,073,678
Value/Acre	\$220.62	\$206.85	\$202.40	\$215.62	\$203.61	\$228.63
<u>Sorghum</u>						
Acres	35,000 A	61,000	8,800	12,000	33,300	12,000
Yield	3580 lbs/A	4,200	2,800	3,700	3,920	3,420
Production	52,050 Tons	128,100	12,320	22,180	65,270	20,500
Value	\$6,577,300	\$13,578,600	\$1,305,920	\$2,351,080	\$6,918,620	\$2,173,000
Value/Acre	\$187.92	\$222.60	\$148.40	\$195.92	\$207.77	\$181.08

Table 6 (cont.)

	Maricopa	Cochise	Pima	Pinal	Graham	Yuma
<u>Fruits</u>						
Oranges, Tangerines, Grapefruit, Lemons						
Acres	25,480 A			1,000		41,110
Yield	411.38 Cartons/A			401.99		376.26
Production	10,482,006 Cartons			401,993		15,468,000
Value	\$14,133,836			\$491,902		\$23,207,460
Value/Acre	\$553.92			\$491.90		\$564.52
<u>Sugar Beets</u>						
Acres	4,370 A	4,330		4,890	360	3,050
Yield	24.56 Tons/A	18.53		19.65	16.61	25.04
Production	107,320 Tons	80,230		96,090	5,980	76,380
Value (Used 1973 Price)	\$1,867,368	\$1,396,002		\$1,671,966	\$104,052	\$1,329,012
Value/Acre	\$427.31	\$322.40		\$341.92	\$289.03	\$435.74
<u>Vegetables</u>						
Dry Onions, Broccoli, Cabbage, Carrots, Cauliflower						
Acres	4,400 A					800
Yield	179.93 Cwt/A					291.25
Production	791,680 Cwt					233,000
Value	\$8,480,100					\$2,406,410
Value/Acre	\$1,927.29					\$3,008.01
<u>Lettuce</u>						
Acres	6360*	900 A*	2,780*	4,160*		25,000
Yield	237.42 Cwt/A	210.00	197.84	197.12		198.20
Production	1,510,000 Cwt	189,000	550,000	820,000		4,955,000
Value	\$11,038,100	\$1,381,590	\$4,020,500	\$5,994,200		\$34,982,300
Value/Acre	\$1,735.55	\$1,535.10	\$1,446.22	\$1,440.91		\$1,399.29
<u>Safflower</u>						
Acres	14,800 A			24,700		5,000
Yield	2,400 lbs/A			2,490		3,390
Production	17,720 Tons			30,760		5,980
Value	\$5,061,600			\$8,766,600		\$1,704,300
Value/Acre	\$342.00			\$355.00		\$341.00

*spring &
fall acre-
age
\$7.31/Cwt

Table 6a
Crop Information for Upland and Am. Pima Cotton

	Maricopa	Cochise	Pima	Pinal	Graham	Yuma
<u>Cotton, Upland</u>						
Acres	112,300 A	70,750	11,500	99,200	3,450	29,500
Yield	1,178 lbs/A	561	947	732	644	1,312
Production	275,620 bales	12,560	22,700	151,520	4,630	80,640
Value	\$68,129 x 10 ³	\$3,105,836	\$5,608,607	\$39,950,816	\$1,144,227	\$19,932,560
<u>Cotton, Am. Pima</u>						
Acres	5,300 A	2,800	2,650	8,450	5,800	30,000
Yield	578 lbs/A	521	598	595	541	600
Production	6,380 bales	3,040	3,300	10,480	6,540	7,760
Value	\$2,291,423	\$1,091,182	\$1,185,355	\$3,760,757	\$2,347,074	\$2,786,150
<u>Total</u>						
Acres	117,600 A	13,550	14,150	107,650	9,250	34,500
Yield	1,151 lbs/A	553	882	767	580	1,230
Production	282,000 bales	15,600	26,000	172,000	11,170	88,400
Value	\$70,420,464	\$4,197,018	\$6,793,962	\$43,711,573	\$3,491,301	\$22,718,710

Table 6a (cont.)

Crop Information for Barley and Wheat

	Maricopa	Cochise	Pima	Pinal	Graham	Yuma
<u>Barley</u>						
Acres	50,000 A	6,200	7,400	32,000	13,600	4,500
Yield	3,700 lbs/A	3,120	3,500	3,600	3,550	3,700
Production	92,400 Tons	9,670	12,960	57,600	24,150	8,320
Value	\$15,200,960	\$1,067,568	\$1,430,784	\$6,359,040	\$2,666,160	\$918,528
<u>Wheat</u>						
Acres	89,000 A	51,300	12,400	73,400	7,400	83,300
Yield	4,380 lbs/A	4,020	3,960	4,250	4,150	4,380
Production	94,910 Tons	103,110	24,580	155,880	15,330	182,430
Value	\$20,465,550	\$10,826,550	\$2,576,700	\$16,367,400	\$1,609,650	\$19,155,150
<u>Total</u>						
Acres	139,000 A	57,500	19,800	105,400	21,000	87,800
Yield	2.067 Tons/A	1.961	1.894	2.025	1.880	2.173
Production	287,310 Tons	112,780	37,500	213,480	39,480	190,750
Value	\$30,666,510	\$11,894,118	\$4,007,484	\$22,726,440	\$4,275,810	\$20,073,678

Table 6a (cont.)
Crop Information for Oranges, Tangerines, Grapefruit, and Lemons

	<u>Central</u>			<u>Western</u>
	Maricopa	Pinal	Central Total	Yuma
<u>Oranges & Tangerines</u>				
Acres	15,500	570	16,070	15,750
Production (Cartons)	$\frac{15,500}{16,070} * 5,046,000 = 4,867,000$	$\frac{570}{16,070} * 5,046,000 = 179,000$	5,046,000	6,114,000
Value (Packing House Door Price (oranges \$1.34/Ct) (Tang. \$2.37/Ct)	$4,867,000 * 1.44 = \$7,008,480$ wt. AV.	\$257,760	\$7,266,240	\$8,804,160
<u>Grapefruit</u>				
Acres	6,940	430	7370	4,160
Production (Cartons)	$\frac{6,940}{7,370} * 3,822,000 = 3,599,006$	222,993	3,822,000	1,718,000
Value (Phoenix House Door Price)	$3,599,006 * 1.05 = \$3,778,956$	$222,993 * 1.05 = \$234,142$	\$4,013,098	\$1,803,900
<u>Lemons</u>				
Acres	3040			21,200
Production (Cartons)	2,016,000			7,636,000
Value (Packing House Door Price)	$2,016,000 * 1.65 = \$3,326,400$			\$12,599,400
<u>Total</u>				
Acres	25,480	1,000		41,110
Production (Cartons)	10,482,006	401,993		15,468,000
Value	\$14,113,836	\$491,902		\$23,207,460

Table 6a (cont.)
Crop Information for Vegetables

	Maricopa	Cochise	Pima	Pinal	Graham	Yuma
<u>Broccoli</u>						
Acres	600					
Production	34 Tons or 680 Cwt					
Value	\$585,000					
<u>Cabbage</u>						
Acres	600					100
Production	97,000 Cwt					20,000
Value	\$545,140					\$112,400
<u>Carrots</u>						
Acres	1,500					
Production	155,000 Cwt					
Value	\$1,718,950					
<u>Cauliflower</u>						
Acres	700					300
Production	44,000 Cwt					22,000
Value	\$1,562,160					\$531,080
<u>Dry Onions</u>						
Acres	1,000					400
Production	495,000 Cwt					191,000
Value	\$4,568,850					\$1,762,930
<u>Total</u>						
Acres	4,400					800
Production	791,680 Cwt					233,000
Value	\$8,480,100					\$2,406,410

Table 7

Pump Information

	Maricopa		Cochise		Pima		Pinal		Graham		Yuma	
	NG	Elec	NG	Elec	NG	Elec	NG	Elec	NG	Elec	NG	Elec
Energy Cost												
Annual Energy Consumption KWH		$2,049 \times 10^6$		328.9×10^6		247.2×10^6		$1,115 \times 10^6$				
1980 Availability												

Table 8
Other Data

	Maricopa	Cochise	Pima	Pinal	Graham	Yuma
Evaporation* Rate in 1 Yr	Min Max 72 75	64	66	68 71	62	76 78

* Based on map, p. 12 of Ref [3].

Appendix

This appendix contains two additional tables which may be of some interest. The information in the tables comes from [7]. Table A1 is a list of the water applied by crop. Table A2 gives energy information by crop. The crops are ordered by the amount of irrigation energy required. The notes on the bottom of the table are intended to clarify the numbers in the body of the table.

Table A1

Total Water Applied by Crop

USDA and FED Report - 1974 Data. See Ref. [7].

Cotton	55.88 inches/acre-year
Winter Wheat	36.17
Alfalfa	64.78
Grain Sorghum	39.85
Barley	48.98
Vegetables	31.87
Hay - other	31.97
Oranges	63.85
Sugar Beets	56.38
Lemons	63.71
Corn	47.60
Potatoes	48.41
Grapefruit	64.44
Corn Silage	47.77
Sorghum Silage	48.00
Seed Crops	63.20
Citrus - other	62.18
Grapes	48.92
Vegetables - Process	62.4

Table A2

Energy Information by Crop USDA & FEA Report. Ref. [7]
1974 Data

Crop	Irrigation Energy (Total Energy)	Irrigation BTU's (Total BTU's) $\times 10^9$	VOP Value of Production $\times 10^3$	VOP/ Million BTU of Irr. Energy (VOP/ Million BTU of Tot. Energy)	Irrigated Acres $\times 10^3$	Acre-Ft Applied $\times 10^3$
Cotton	34.90% ⁽ⁱ⁾ (36.6%)	7764 ⁽ⁱⁱ⁾ (12548)	\$251,000	32.33 ⁽ⁱⁱⁱ⁾ (20.0)	282.5	1315.6
Alfalfa	20.37 (14.76)	4533 (5063)	68,879	15.20 (13.60)	215	768.2
W. Wheat	13.26 (13.80)	2951 (4734)	48,800	16.54 (10.31)	165.9	500.0
Grain Sorghum	11.95 (11.01)	2659 (3778)	43,000	16.17 (11.38)	135.7	450.6
Barley	5.32 (4.96)	1183 (1702)	16,500	13.95 (19.69)	49.1	200.4
Vegetables	2.82 (4.08)	628 (1400)	84,700	134.87 (60.50)	40.1	106.5
Oranges	2.29 (4.09)	509 (1402)	10,026	19.70 (7.12)	16.2	86.2
Hay other	1.68 (1.19)	374 (409)	3,506	9.37 (8.57)	23.8	63.4
Lemons	.96 (1.73)	213 (593)	18,067	84.82 (30.47)	6.8	36.1
Sugar Beets	.91 (.80)	202 (274)	11,881	58.82 (43.36)	7.3	34.3
Grapefruit	.77 (1.42)	171 (487)	4,182	24.46 (8.59)	5.4	29.0
Corn	.63 (.62)	140 (213)	1,200	8.57 (5.63)	6.0	23.8
Potatoes	.63 (.96)	140 (331)	11,739	83.85 (35.47)	5.9	23.8

Notes: (i) Of the total irrigation energy used in Arizona, 34.90% was used for cotton irrigation. Of the total agriculture energy used in Arizona, 36.6% was used for cotton

(ii) BTU's used for irrigating cotton was 7764×10^9 . BTU's used for growing cotton was $12,548 \times 10^9$.

(iii) VOP per million BTU's of irrigation energy was \$32.33. VOP per million BTU's of agriculture energy was \$20.00.

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