
GENERAL EXPLANATION

PLANNING AND DEVELOPMENT

Planning for the survey started in 1997 with a review of the previous farm and ranch irrigation surveys. Letters were sent to more than 100 individuals in water-related government organizations, industry, and academic positions to solicit their comments on questionnaire content and format. Presentations were made to several associations seeking their comments. Forty-seven responses were received. All responses were reviewed and categorized to evaluate data collection feasibility and priority needs.

Methods used in conducting the 1998 Farm and Ranch Irrigation Survey were changed from previous surveys to utilize the resources of NASS and its 45 State Statistical Offices (SSO). Each SSO provided enumerators who assisted with data collection in areas of low response. State statisticians reviewed their State's final tabulated data. The 1998 sample size of 23,567 farms increased over the 1994 sample size, primarily due to expanding coverage to all 50 States.

METHOD OF ENUMERATION AND DATA COLLECTION

The 1998 Farm and Ranch Irrigation Survey was conducted primarily by mail and was supplemented by telephone calls and personal enumeration by NASS SSO staff. A sample of 23,567 irrigators was selected and mailed a questionnaire in February 1999. The initial mail packet included a report form and letter requesting a prompt response. The operators were asked to complete and return the report form to NASS. The initial mailing was followed by one follow-up mailing to everyone who had not responded in the first 4 weeks. The follow-up packet included a reminder letter and a report form. Six weeks after the initial mailing the SSOs were provided nonresponse lists. The offices made telephone calls and personal visits to maximize the response. For a description of the adjustment for nonresponse, see Statistical Methodology.

DATA PROCESSING

All report forms were clerically reviewed prior to data keying to identify inconsistencies and ensure that the data could be keyed. Major inconsistencies, respondent remarks, blank

forms, and large irrigation cases were reviewed by analysts and adjusted prior to data keying. Data from each report form were processed through a computer edit which flagged inconsistent entries. Each flagged report form was reviewed manually. An imputation program during the edit processing supplied missing data and made adjustments based on averages of similarly sized farms within the same geographic area. Data entries of large magnitude and data items that were changed significantly in the computer edit process were reviewed and verified by analysts.

Prior to publication, tabulated totals were reviewed by SSOs to identify and resolve remaining inconsistencies and potential coverage problems. Comparisons were made to 1997 census data and other available check data.

COMPARABILITY OF DATA

Differences exist between the expanded results of the 1998 Farm and Ranch Irrigation Survey and published data from the 1997 Census of Agriculture. Some of these are as follows:

1. The survey excludes horticultural speciality and abnormal farms. The effect of the excluded farms is listed below:

	Irrigated farms	Acres irrigated
1997 U.S. totals	279,442	55,058,128
Excluded from survey	59,452	3,856,435
Eligible for selection in survey	219,990	51,201,693

2. The survey includes data only for operators who irrigated in both 1997 and 1998. Operators in some areas, especially the Eastern States, irrigate intermittently according to moisture needs. Operators having irrigation capabilities may not irrigate depending on the amount of rainfall for a particular year or geographic area. The number of operators who irrigated in 1997 but discontinued irrigation in 1998 is tabulated in table 35 by reason of discontinuance.

3. Some operators reported that they had been misclassified as irrigators and did not irrigate in either 1997 or 1998. An estimated 18,187 operators with 1,214,013 acres irrigated in 1997 were misclassified as irrigators in the 1997 census. This is estimated by expanding reports in the survey where the respondents reported that they did not irrigate in 1998 nor in 1997. In addition to errors in processing data, some operators misreported or misinterpreted the questions. Most of the operators misreporting irrigation in the 1997 census reported irrigation of small acreages of vegetables, fruits and nuts, tobacco, potatoes, or berries. Small amounts of water were applied to these crops at the time of transplanting.

4. Some respondents indicated that they had quit farming, retired, moved, gone bankrupt, etc., since 1997. After analytical review of the 1998 receipts, an estimated 9,470 operators accounting for 2,301,484 acres irrigated in 1997, after expansion, were dropped from processing because they were no longer farming. Special care was taken with large operations to ensure that they were not erroneously dropped due to reorganization or name change rather than discontinuing agricultural operations. This included the use of field and telephone enumeration.

5. New irrigators in 1998 (not included in the 1997 census) did not have a chance of being selected in the sample and, therefore, were excluded from the survey. It is believed that the impact of new irrigators is probably minimal. This conclusion is supported by comparisons between the 1992 and 1997 censuses which show little change in acres of irrigated cropland harvested.

6. In the previous farm and ranch irrigation surveys, farms were classified by type of activity or activities according to the Standard Industrial Classification (SIC). For the 1997 census and the 1998 Farm and Ranch Irrigation Survey, a new classification system, the North American Industry Classification System (NAICS), replaced the SIC. Table 27 provides irrigation data for farms classified by NAICS.

When comparing the number of farms and irrigated acres between the 1998 survey and the 1997 census published U.S. totals, most of the differences are for operators reporting less than 100 acres irrigated. This is expected since the excluded horticultural farms average

about 40 acres irrigated per farm and the other categories of discontinued or excluded irrigators generally are smaller than average irrigators. Table A shows acres irrigated in the 1998 survey (expanded) compared with U.S. totals from the 1997 census. The expanded survey accounts for 90.9 percent of all land reported as irrigated in the 1997 census and all irrigation characteristics associated with that land.

Table A. Comparison of Irrigated Farms and Acres by Acres Irrigated: 1998 Survey With 1997 Census

Item	1998 survey (expanded)		1997 published U. S. totals
	Total	Percent of 1997 census totals	
Land irrigated			
farms..	182 101	65.2	279 442
acres..	50 028 439	90.9	55 058 128
1 to 9 acres			
farms..	38 255	43.9	87 238
acres..	159 239	53.8	295 717
10 to 49 acres			
farms..	44 846	65.5	68 451
acres..	1 133 713	70.1	1 616 361
50 to 99 acres			
farms..	17 950	63.2	28 412
acres..	1 257 718	63.5	1 979 440
100 to 199 acres			
farms..	24 314	81.6	29 812
acres..	3 353 676	81.4	4 121 593
200 to 499 acres			
farms..	27 492	77.8	35 314
acres..	8 757 757	78.7	11 126 404
500 to 999 acres			
farms..	17 246	91.4	18 866
acres..	11 973 745	92.0	13 010 164
1,000 acres or more			
farms..	11 998	105.7	11 349
acres..	23 392 591	102.1	22 908 449

DEFINITIONS AND EXPLANATIONS

This section provides definitions and explanations of selected items that are used on the report form or in the tables. A facsimile of the 1998 Farm and Ranch Irrigation Survey report form is found in the appendix.

Water Resources Areas (WRA)

Data from the 1998 Farm and Ranch Irrigation Survey were tabulated by WRA. Boundaries of these areas are shown on the map on page XIX. These boundaries are essentially the same as the water resources regions (WRR) as delineated and defined in the past by the U.S. Water Resources Council. The areas differ

somewhat from the regions because of the method used for boundary delineation. Region boundaries are delineated on the basis of topographic drainage characteristics, whereas areas are delineated on the basis of county boundaries which approximate actual drainage-basin boundaries. Geographic descriptions of each water resources region that can be used to approximate the area included in each water resources area are as follows:

01 New England Region- The drainage within the United States that ultimately discharges into the Bay of Fundy and the Atlantic Ocean. These points of discharge are located within and between Maine and Connecticut; Long Island Sound and the St. Francis River, a tributary of the St. Lawrence River.

02 Middle Atlantic Region- The drainage within the United States that ultimately discharges into the Atlantic Ocean, whose point of discharge is located within and between New York and Virginia, and the Richelieu River, a tributary of the St. Lawrence River.

03 South Atlantic-Gulf Region- The drainage that ultimately discharges into the Atlantic Ocean, whose point of discharge is located within and between North Carolina and Florida; and the Gulf of Mexico, whose point of discharge is located within and between Florida and Mississippi, including the Pearl River.

04 Great Lakes Region- The drainage within the United States that discharges into the Great Lakes system, including the Lakes' surfaces; and the St. Lawrence River as far east as, but excluding the Richelieu River.

05 Ohio Region- The drainage of the Ohio River, excluding that of the Tennessee River.

06 Tennessee Region- The drainage of the Tennessee River.

07 Upper Mississippi Region- The drainage of the Mississippi River above the mouth of the Ohio River, but excluding the drainage of the Missouri River above a point immediately below the mouth of the Gasconade River.

08 Lower Mississippi River- The drainage of the Mississippi River below the mouth of the Ohio River, but excluding the drainage of the Arkansas, White, and Red Rivers and above the points of highest backwater affects of the Mississippi River in those parts; and the coastal streams, other than the Mississippi

River, that discharge into the Gulf of Mexico from the boundaries of, but excluding the Pearl and Sabine Rivers.

09 Souris-Red-Rainy Region- The drainage within the United States of the Souris, Red, and Rainy Rivers.

10 Missouri Region- The drainage within the United States of the Missouri River above a point immediately below the mouth of the Gasconade River and the Saskatchewan River.

11 Arkansas-White-Red Region- The drainage of the Arkansas River above the point of highest backwater affect of the Mississippi River, the Red River above the point of highest backwater affect of the Mississippi River, and the White River above the point of highest backwater affect of the Mississippi River near Peach Orchard Bluff, AR.

12 Texas-Gulf Region- The drainage that discharges into the Gulf of Mexico from and including Sabine Pass to, but excluding the Rio Grande and the Lower Rio Grande Valley.

13 Rio Grande Region- The drainage within the United States of the Rio Grande; the San Luis Valley, North Plains, San Augustine Plains, Mimbres, Estancia Jonado del Muerto, Tularosa, Salt, and various smaller closed basins; and the Lower Rio Grande Valley.

14 Upper Colorado Region- The drainage of the Colorado River above the Lee Ferry Compact Point, which is about 1 mile below the mouth of the Paria River; and the Great Divide closed basin.

15 Lower Colorado Region- The drainage within the United States of the Colorado River below the Lee Ferry Compact Point, which is about 1 mile below the mouth of the Paria River; the Rios Yaqui, Magdalena, Sonoita, and other lesser streams that ultimately discharge into the Gulf of California; and the Animas Valley, Wilcox Playa, El Dorado Valley, and other smaller closed basins.

16 Great Basin Region- The drainage of the Great Basin that ultimately discharges into Utah and Nevada.

17 Pacific-Northwest Region- The drainage within the United States that ultimately discharges into the Straits of Georgia and Juan de Fuca and the Pacific Ocean. The point of discharge is within Washington and Oregon, including the Columbia River.

18 California Region- The drainage within the United States that ultimately discharges into

the Pacific Ocean, whose point of discharge is within California, which includes the Central Valley; and that portion of the Great Basin and other closed basins in California.

19 Alaska- entire State.

20 Hawaii- entire State.

Abnormal Farms

Abnormal farms were not included in the survey universe. These are institutional, experimental, and research farms. Indian reservations, not considered abnormal farms for the 1997 census, were included in the survey universe. They were not included in the 1994 survey. Institutional farms include those operated by hospitals, penitentiaries, churches, schools, grazing associations, etc.

Acre-Foot of Water

An acre-foot of water is the quantity of water required to cover 1 acre to a depth of 1 foot. This is equivalent to 43,560 cubic feet or 325,850 gallons.

Acres and Quantity Harvested

If two or more crops were harvested from the same land during the year, the acres were counted for each crop. Therefore, the total acres of all crops harvested generally exceeds the acres of harvested cropland. Exceptions to this procedure are hay crops. When more than one cutting of hay was taken from the same acres, the acres were counted only once, but the quantity harvested included hay from all cuttings.

For interpolated crops or "skip-row" crops, acres were to be reported according to the portion of the field occupied by each crop. If a crop was planted but not harvested, the acreage was not to be reported as harvested. These acres were to be reported in the "land use" section under the appropriate cropland items -- cropland used only for pasture or grazing or other cropland.

Acres of land in bearing and nonbearing orchards--citrus or other groves, vineyards, and nut trees--were to be reported as harvested cropland regardless of whether the crop was harvested or failed. However, abandoned orchards were to be reported as cropland idle, not as harvested cropland or for the individual crop acreage.

Acres Irrigated

Acres irrigated are the acres of agricultural land to which water was artificially applied by controlled means including preplanted, partial, supplemental, and semi-irrigation. Land flooded during high water periods was to be included as irrigation only if the water was

diverted to agricultural land by dams, canals, or other works.

Cropland Harvested

Cropland harvested is land from which crops were harvested or hay was cut; and land in orchards, citrus groves, Christmas trees, vineyards, nurseries, and greenhouses. Land from which two or more crops were harvested was counted only once.

Cropland Used Only for Pasture or Grazing

Cropland used only for pasture or grazing is land used only for pasture or grazing that could have been used for crops without additional improvement. Included also is all cropland used for rotation pasture. However, cropland that was pastured before or after crops were harvested was to be included as harvested cropland rather than cropland for pasture or grazing.

Crops Unit of Measurement

Respondents were instructed to report each crop in the same unit specified.

Flowing or Artesian Wells

Flowing or artesian wells are wells which flow freely and provide water used for irrigation without pumping. All flowing or artesian wells were excluded from pumping data on tables 12 and 13. This should be taken into consideration when using data from these two tables. The 1998 survey is the first time the question was a respondent-reported item. Past surveys subtracted the reported number of pumped wells from the reported total wells used to derive the number of artesian wells.

Irrigated Farms

Irrigated farms or ranches are those with any agricultural land irrigated in the specific calendar year. The acreage irrigated may vary from a very small portion of the total acreage in the farm or ranch to irrigation of all agricultural land in the farm or ranch.

Land in Farms

Acreage designated in the tables as "land in farms" consists primarily of agricultural land used for crops, pasture, or grazing. It also included woodland and wasteland not actually under cultivation or used for pasture or grazing, provided it was part of the farm operator's total operations. Large acreages of woodland and wasteland held for nonagricultural purposes were deleted from individual reports during the processing operations. Land in farms is an operating unit concept that includes land owned and operated as well as land rented from others. Land used rent free was to be reported as land rented from others. All grazing land, except

land used under government permits on a per-head basis, was included as "land in farms" provided it was part of a farm or ranch.

Market Value of Agricultural Products Sold

The market value of agricultural products sold represents the gross market value before taxes and production expenses of all agricultural products sold or removed from the place in 1997 regardless of who received the payment. It includes sales by the operator as well as the value of any shares received by partners, landlords, contractors, and others associated with the operation. The market value of agricultural products sold represents the sum of all crops, including nursery products, and livestock and poultry and their products. It does not include income from farm-related sources, such as custom work or agricultural services, or income from nonfarm sources.

These data were taken from the 1997 Census of Agriculture report forms of the irrigation survey respondents. The market value of agricultural products sold in 1997 does not necessarily represent the sales from crops harvested in 1997. Data include sales from crops produced in earlier years and exclude some crops produced in 1997 but held in storage and not sold in 1997. For crops sold through a co-op which made payments in several installments, only the total payments received in 1997 were to be reported.

North American Industry Classification

In the previous farm and ranch irrigation surveys, farms were classified by type of activity or activities according to the Standard Industrial Classification (SIC). For the 1997 census and the 1998 Farm and Ranch Irrigation Survey, a new classification system, the North American Industry Classification System (NAICS), replaced the SIC. An establishment primarily engaged in crop production (major group 01) or production of livestock and animal specialties (major group 02) is classified in the four-digit industry and three-digit industry group which accounts for 50 percent or more of the total value of sales of its agricultural products. If the total value of sales of agricultural products of an establishment is less than 50 percent from a single four-digit industry, but 50 percent or more from the products of two or more four-digit industries within the same three-digit industry group, the establishment is classified in the miscellaneous industry of that industry group. Otherwise, it is classified as a general crop farm in industry 0191 or a general livestock farm in industry 0291.

All farms in the 1997 census were classified

by NAICS. Classifications of irrigated farms by selected NAICS groupings are shown in table 27. The NAICS codes for survey respondents were obtained from their 1997 Census of Agriculture report form.

Off-Farm Water Supply

Off-farm water supply is water from off-farm water suppliers, such as the U.S. Bureau of Reclamation; irrigation districts; mutual, private, cooperative, or neighborhood ditches; commercial companies; or community water systems.

On-Farm Surface Supply

On-farm surface supply is water from a surface source not controlled by a water supply organization. It includes sources such as streams, drainage ditches, lakes, ponds, and reservoirs on or adjacent to the operated land.

Other Cropland

Other cropland includes cropland not harvested and not grazed which was used for cover crops or soil-improvement crops, land on which all crops failed, land in cultivated summer fallow, idle cropland, and land planted in crops that were to be harvested after the survey year.

Other Land

Other land includes land in house lots, barn lots, ponds, roads, ditches, wasteland, etc. It includes those acres in the farm operation not classified as cropland, pastureland, or woodland.

Sprinkler Irrigation

Sprinkler irrigation is divided into four areas to reflect current trends in irrigation. The center pivot and mechanical-move methods have, by definition, high-pressure delivery with water delivered at 60 psi or greater, medium pressure delivery with water delivered at 30 to 59 psi, and low pressure delivery with water delivered at less than 30 psi. The mechanical-move systems are classified as either linear move, side roll, wheel move, or big gun where the sprinkler device is moved across the field either by self-propelled methods or by tractor. Since all big guns operate at high pressure, there was no reason to ask for pressure.

Hand move systems include distribution systems laid out in the spring and removed at the end of the season, as well as other sprinkler systems which are moved without mechanical assistance.

Solid set and permanent systems are sprinklers placed in the ground permanently and used mostly for perennial crops.

Total Cropland

Total cropland includes land from which crops were harvested or hay was cut; land in orchards, citrus groves and vineyards; cropland used only for pasture and grazing; land in cover crops, legumes, and soil-improvement grasses; land on which all crops failed; land in cultivated summer fallow; and idle cropland.

Woodland

Woodland includes natural or planted woodlots or timber tracts, cutover and deforested land with young growth which has or will have value for wood products and woodland pastured. Land covered by sagebrush or mesquite was to be reported as other pastureland and rangeland or other land. Land planted for Christmas tree production was to be reported in cropland harvested.

Table B. Leading Irrigation States: Census Years 1997, 1992, and 1987

Geographic area	Acres irrigated			Rank			1997 cumulative percent of U.S. total
	1997	1992	1987	1997	1992	1987	
United States	55,058,128	49,404,030	46,386,201	(X)	(X)	(X)	100.0
20 leading States	51,159,744	45,703,882	42,936,801	(X)	(X)	(X)	92.9
California	8,712,893	7,571,313	7,546,091	1	1	1	15.8
Nebraska	6,939,036	6,311,633	5,681,835	2	2	2	28.4
Texas	5,484,663	4,912,308	4,271,043	3	3	3	38.4
Arkansas	3,717,217	2,701,651	2,406,338	4	6	7	45.2
Idaho	3,493,542	3,260,006	3,219,192	5	4	4	51.5
Colorado	3,430,129	3,169,839	3,013,773	6	5	5	57.7
Kansas	2,707,489	2,680,343	2,463,073	7	7	6	62.6
Montana	1,994,484	1,978,167	1,996,882	8	8	8	66.2
Oregon	1,948,739	1,622,235	1,648,205	9	11	9	69.7
Florida	1,862,404	1,782,680	1,622,750	10	9	10	73.1
Wyoming	1,719,463	1,464,585	1,517,891	11	12	12	76.2
Washington	1,705,025	1,641,437	1,518,684	12	10	11	79.3
Utah	1,212,201	1,142,514	1,161,207	13	13	13	81.5
Mississippi	1,076,231	882,976	636,842	14	16	19	83.5
Arizona	1,013,902	956,454	913,841	15	14	14	85.3
Louisiana	942,528	897,641	646,677	16	15	17	87.0
Missouri	881,924	708,864	534,795	17	19	20	88.6
New Mexico	804,616	738,272	718,449	18	17	16	90.1
Nevada	764,738	556,172	778,977	19	20	15	91.5
Georgia	748,520	724,792	640,256	20	18	18	92.9

STATISTICAL METHODOLOGY

Target Population

The target population for the survey was composed of all farms that irrigated in the reference year 1998, provided they were neither horticultural speciality farms nor abnormal farms with the exception of Indian reservations. To obtain measurement for this target population, the frame population was constructed to include all farms that reported irrigated acres in the 1997 Census of Agriculture except for specialized horticultural farms, farms that reported horticultural crop sales of at least \$10,000, or abnormal farms not on Indian reservations. The farms in these excluded categories represented 21.3 percent of the total number of irrigators and 7.0 percent of the irrigated land reported in the 1997 Census.

Undercoverage existed in the frame population to the extent that there were farms that either erroneously reported not irrigating in the 1997 census, started irrigating in 1998, or had succeeding irrigators in 1998 (i.e., an operator who, since 1997, took over control of an irrigating farm through sales, rental, or other arrangements). Overcoverage existed in the frame because some operations were misclassified as irrigators and did not irrigate in either 1997 or 1998, or had either stopped farming or irrigating in 1997. Farms in these

groups that were selected into the sample were identified during the survey and estimates of their number and acres irrigated are provided. Table C provides the farm count and acres irrigated by State for both the survey frame population and the 1997 census.

Sample Design

Sampling frames were created at the State level and consisted of the farm operations reported in that State in the 1997 census that satisfied the frame definition stated above. The survey estimates were based on a probability sample of farms from each State frame. The sample design consisted of a stratified systematic sample selected independently from each of the 50 State frames. All farms in a sampling frame were stratified on the basis of total irrigated acres reported in the 1997 census. The stratification boundaries varied among the States and were dependent on the distribution of

Table C. Irrigated Farms: 1998 Survey and 1997 Census

State	1998 survey						1997 census			
	Initial mailout counts		Final reports processed and tabulated				Published totals		Sample universe ¹	
			Unexpanded		Expanded					
	Farms (number)	1997 Acres irrigated	Farms ² (number)	Acres irrigated	Farms ³ (number)	Acres irrigated	Farms (number)	Acres irrigated	Farms (number)	Acres irrigated
United States	23 567	19 065 862	16 391	13 945 015	200 288	50 028 439	279 442	55 058 128	219 990	51 201 693
Alabama	510	51 172	278	32 967	505	46 811	1 301	76 871	743	55 095
Alaska	45	2 356	27	2 257	48	2 618	114	2 667	61	2 396
Arizona	504	708 977	296	410 661	2 698	873 589	3 426	1 013 902	2 871	964 869
Arkansas	695	1 012 231	385	688 006	5 384	4 043 382	6 593	3 717 217	6 008	3 640 281
California	869	2 228 334	593	1 572 303	44 210	8 139 834	55 920	8 712 893	46 204	8 153 353
Colorado	531	731 525	388	490 642	12 920	2 942 230	15 470	3 430 129	13 430	3 182 210
Connecticut	103	2 370	71	1 610	151	1 913	674	7 366	228	2 702
Delaware	206	66 942	137	49 488	279	77 382	415	72 635	307	69 357
Florida	593	1 205 100	393	912 039	7 053	1 613 719	12 673	1 862 404	7 484	1 652 405
Georgia	776	472 794	529	318 462	2 683	647 749	4 372	748 520	3 168	693 226
Hawaii	402	71 275	278	93 029	904	96 543	2 241	76 971	1 092	73 133
Idaho	706	1 040 193	406	702 238	12 615	3 188 406	15 191	3 493 542	13 394	3 270 810
Illinois	571	251 587	401	188 055	1 055	290 825	2 021	349 799	1 293	307 653
Indiana	580	205 561	412	154 001	989	217 197	1 753	250 050	1 212	234 310
Iowa	461	107 305	274	44 589	487	67 852	957	124 983	659	114 275
Kansas	533	779 278	381	576 393	5 032	2 650 486	6 135	2 707 489	5 530	2 632 827
Kentucky	646	24 591	529	13 946	2 680	25 454	4 104	58 490	3 286	52 172
Louisiana	922	647 872	544	433 758	2 251	920 823	3 400	942 528	2 811	910 556
Maine	105	17 965	76	16 638	249	18 324	671	21 791	336	19 550
Maryland	305	53 537	213	39 770	569	55 150	1 154	68 588	671	58 151
Massachusetts	125	8 701	102	7 025	816	16 367	1 630	24 564	884	18 698
Michigan	584	271 512	469	250 321	1 816	367 992	3 752	393 485	2 284	355 535
Minnesota	665	292 803	399	200 228	1 267	322 346	2 193	380 394	1 555	346 621
Mississippi	731	924 295	610	823 935	1 256	1 109 079	1 769	1 076 231	1 439	1 064 459
Missouri	787	673 097	585	536 522	1 833	832 591	2 891	881 924	2 291	855 546
Montana	589	582 592	441	410 672	7 248	1 740 873	9 059	1 994 484	7 899	1 860 349
Nebraska	496	554 730	399	428 735	14 013	5 692 215	18 804	6 939 036	15 354	6 116 080
Nevada	402	552 558	335	426 166	1 807	694 930	2 159	764 738	1 884	736 047
New Hampshire	99	720	71	507	129	718	429	2 691	180	941
New Jersey	384	59 678	317	50 661	761	63 508	2 089	92 965	927	67 528
New Mexico	580	437 627	441	341 440	6 203	720 319	7 444	804 616	6 397	759 203
New York	405	39 750	273	20 016	792	29 176	2 501	69 197	1 048	46 663
North Carolina	445	63 960	346	51 766	2 544	134 468	4 695	156 250	3 077	133 468
North Dakota	351	154 006	267	126 273	527	164 741	710	180 362	608	172 639
Ohio	314	18 336	196	9 307	460	12 037	1 778	33 997	619	19 200
Oklahoma	573	344 363	340	255 617	1 717	451 788	2 710	506 459	2 118	474 908
Oregon	697	785 134	559	593 717	10 367	1 534 961	15 348	1 948 739	11 979	1 706 105
Pennsylvania	466	21 106	269	11 036	917	17 916	2 814	36 150	1 257	25 586
Rhode Island	37	441	24	364	37	408	180	3 265	56	501
South Carolina	284	61 607	162	35 457	584	61 015	1 248	86 477	736	68 522
South Dakota	406	210 270	305	160 166	1 110	297 205	1 439	343 742	1 289	329 149
Tennessee	411	28 955	177	18 599	691	22 741	1 768	45 581	952	31 443
Texas	930	1 270 044	749	971 088	13 579	5 237 584	18 756	5 484 663	15 279	5 226 306
Utah	528	338 795	407	241 336	9 505	1 076 346	11 291	1 212 201	9 896	1 114 666
Vermont	97	1 401	64	543	85	579	333	2 570	137	1 513
Virginia	414	48 162	310	34 452	1 305	65 734	2 337	84 926	1 597	72 480
Washington	671	705 526	456	528 536	10 388	1 554 813	13 131	1 705 025	11 236	1 552 073
West Virginia	83	2 257	47	1 153	83	1 211	268	3 285	141	2 400
Wisconsin	513	282 078	349	238 970	1 190	351 023	2 025	341 813	1 347	325 379
Wyoming	437	650 393	311	429 555	4 496	1 533 468	5 306	1 719 463	4 736	1 628 354

¹Excludes abnormal and horticultural specialty farms.

²Includes 1,519 farms that discontinued irrigation since 1997.

³Includes 18,187 farms that discontinued irrigation since 1997.

total acres irrigated variable within the State. A certainty stratum, whose farms were selected with probability one, was included in each State so that the major irrigators in each State were included in the survey.

The State sample sizes necessary to obtain the desired level of precision were determined by analyzing the variation of the total acres irrigated variable in each State's sampling frame. These sample sizes were adjusted using historical nonresponse data to account for expected nonresponse to the survey. The total national sample size was 23,567 farms; 1,579 of these farms were selected from the certainty strata and the remaining 21,988 farms were systematically selected from the noncertainty strata. Table C provides the State sample sizes.

Estimation

Estimates were produced for the Nation as a whole, for each of the 50 States, and for the geographic domains known as Water Resources Areas (WRA). The estimation methodology accounted for both selection of the survey sample and survey nonresponse. The estimator for the State totals was a direct expansion reweighted estimator. The expansion factor was the inverse of the selection probability for the sample farms in a stratum. This expansion factor was reweighted at the stratum level to account for whole-farm nonresponse. The nonresponse adjustment factor used to reweight the expansion factor was the ratio of the number of sample farms in a stratum to the number of sample farms that responded to the survey in that stratum. The assumption underlying this weighting approach to survey nonresponse was that survey respondents and nonrespondents within a stratum constitute a homogeneous population, thus allowing respondents to represent nonrespondents. The reweighted expansion factor is the product of these two factors and is equal to the ratio of the total number of farms in the stratum to the total number of sample farms that responded to the survey in that stratum.

An expanded data value for a sample record was obtained by multiplying the data value by the reweighted expansion factor. State totals for a characteristic were estimated by summing the expanded data values from all responding sample records across all strata within the State. National estimates were obtained by summing across all States. The WRA

estimates were obtained by summing the expanded data values for the portion of the sample that happened to fall in the WRA.

Survey Error

The statistics in this report are estimates derived from a sample survey. There are two types of errors possible in an estimate-based sample survey: sampling and nonsampling. Sampling error is the error caused by observing only a sample instead of the entire population. The sampling error is subject to sample-to-sample variation. Nonsampling errors include all other errors and are classified into two main categories—errors due to nonobservation and errors in observation. Errors of nonobservation include errors due to undercoverage and nonresponse. Errors in observation occur due to measurement error and processing error. Sources of measurement error can include errors due to the interviewer, respondent, questionnaire design, and mode of interview. Processing error can include errors due to coding, transcription, imputation for missing data, editing, outlier treatment, and other types of pre-estimation data processing. The accuracy of a survey result is determined by the joint effects of sampling and nonsampling errors.

Measures of Precision

The survey sample was one of a large number of possible samples of the same size that could have been selected using the same sample design. Survey estimates derived from the different samples will differ from each other.

The relative standard error is used as an indicator of the precision in the survey estimates and is reported for major survey items in table D. The relative standard error expresses the standard error of an estimate as a percent of the estimated value. The standard error of a survey estimate is a measure of the variation among the estimates from all possible samples. It is a measure of the precision with which an estimate from a particular sample approximates the average result of all possible samples.

Table D. Relative Standard Error (percent) for Selected Irrigation Data: 1998

States and Water Resources Areas	Irrigated Farms	Acres in Farms	Acres Irrigated				Acre-Feet Of Water Applied, all Sources	Wells Used in 1998	Pumps all Types	Expenses for Irrigation		
			Total	Cropland Harvested	By Sprinkler Systems	By Gravity Flow				Energy Used For Pumping	For Wells, Pumps, Equipment, and Facilities	Maintenance and Repair
United States	1.8	3.4	1.3	1.9	1.7	2.4	2.1	2.0	1.9	3.9	12.4	3.4
Alabama	3.4	5.6	4.6	4.7	5.0	33.7	5.4	6.9	4.0	7.6	31.5	8.7
Alaska	10.4	33.6	4.4	39.7	5.0	36.9	26.2	10.4	22.3	14.9	44.6	24.9
Arizona	3.3	36.6	3.3	4.0	11.9	3.7	3.5	9.1	8.1	9.6	24.9	27.6
Arkansas	5.8	5.8	4.2	5.4	11.4	4.3	6.3	3.8	4.0	7.4	14.6	10.3
California	7.1	7.9	6.5	6.1	14.3	8.9	6.8	10.6	8.8	13.8	33.4	12.5
Colorado	4.3	23.6	3.7	7.6	6.2	6.6	5.1	7.4	7.8	6.5	19.6	10.5
Connecticut	8.5	6.5	4.4	6.0	4.7	83.9	8.1	22.4	9.5	7.7	16.8	14.2
Delaware	6.3	9.6	5.4	9.4	5.4	--	10.5	6.5	5.1	5.7	10.4	10.9
Florida	2.9	8.4	6.3	9.0	7.6	27.3	6.9	8.3	7.8	8.0	12.0	10.9
Georgia	3.9	4.4	2.5	3.6	2.7	74.2	3.1	4.2	3.5	3.1	9.7	4.7
Hawaii	3.2	0.6	0.4	0.8	4.8	1.5	0.3	15.1	5.7	1.0	2.6	1.9
Idaho	2.6	9.4	3.0	4.8	4.4	7.1	4.3	10.4	6.2	5.4	12.7	6.3
Illinois	3.6	4.1	2.2	3.9	2.3	53.3	2.8	3.0	2.7	2.9	12.8	6.9
Indiana	3.6	3.5	2.1	3.8	2.2	27.6	2.8	3.6	3.2	3.7	16.2	5.0
Iowa	4.4	5.5	4.4	3.7	4.5	17.8	5.7	5.6	5.3	5.6	15.2	9.7
Kansas	3.3	6.5	3.2	7.2	4.1	8.8	4.1	5.0	4.7	3.7	15.4	5.6
Kentucky	5.7	7.6	4.9	5.4	5.1	20.5	8.9	14.3	7.0	11.4	22.1	14.4
Louisiana	5.9	5.4	3.3	5.1	18.4	3.2	4.1	5.2	4.2	14.5	10.9	7.2
Maine	14.3	5.0	2.7	4.0	2.7	9.4	2.3	31.5	16.1	6.7	13.5	1.6
Maryland	5.7	4.3	2.7	4.2	2.8	36.3	5.0	6.3	4.8	4.3	8.4	6.4
Massachusetts	6.0	6.7	4.6	12.7	5.2	31.1	11.3	21.5	6.8	14.5	15.5	14.2
Michigan	3.9	3.8	2.7	3.9	2.8	63.1	2.7	7.0	5.2	4.7	9.7	5.5
Minnesota	3.6	5.1	2.5	4.7	2.6	10.8	3.0	3.2	3.3	3.3	12.7	6.1
Mississippi	4.2	1.9	1.6	1.9	2.9	2.0	2.9	2.3	2.2	2.3	5.4	3.3
Missouri	5.4	4.9	2.3	4.0	3.8	3.2	3.2	2.7	2.7	2.7	16.7	6.0
Montana	3.8	14.8	4.2	19.7	8.4	5.9	7.4	34.9	9.1	7.8	27.8	9.1
Nebraska	4.5	10.4	3.2	6.9	5.5	7.0	4.6	4.3	4.3	8.3	23.1	6.9
Nevada	2.5	11.4	3.6	5.3	12.3	3.9	4.7	9.9	7.8	11.1	27.8	9.8
New Hampshire	6.0	12.5	9.2	18.6	12.0	--	13.4	12.2	7.6	11.2	22.7	27.6
New Jersey	5.5	4.5	1.8	3.1	2.2	21.8	5.6	5.0	3.4	4.7	7.1	6.5
New Mexico	1.6	15.9	2.7	15.5	4.4	5.3	3.3	7.3	6.9	4.6	8.3	6.2
New York	6.3	6.8	3.8	6.6	4.3	22.3	7.7	9.7	9.1	5.4	14.8	8.6
North Carolina	4.7	9.0	5.7	8.4	5.8	52.9	8.7	21.3	5.8	13.8	14.2	12.4
North Dakota	3.7	5.5	2.4	5.0	3.1	6.0	2.5	3.8	3.7	2.8	11.0	4.1
Ohio	5.5	7.0	6.3	5.9	7.9	41.2	4.5	10.9	5.9	24.4	13.8	9.6
Oklahoma	6.3	5.9	2.8	5.1	3.9	6.6	4.0	5.7	5.0	6.5	9.4	6.2
Oregon	7.4	6.7	2.4	6.5	4.2	5.0	3.4	18.1	9.7	6.2	24.6	9.8
Pennsylvania	6.1	6.3	6.4	7.5	7.6	69.5	14.2	12.4	6.5	7.0	13.5	8.2
Rhode Island	12.1	34.6	19.9	17.2	19.8	27.1	50.8	26.2	20.3	45.4	51.5	19.7
South Carolina	6.7	8.8	4.2	9.1	5.4	50.5	13.8	10.3	5.7	7.7	33.0	9.4
South Dakota	4.2	11.2	3.6	8.5	4.9	8.6	6.8	7.8	5.4	5.1	26.8	7.2
Tennessee	10.8	16.1	5.1	7.7	5.2	34.2	18.3	12.7	10.3	20.0	10.6	14.6
Texas	4.6	6.6	3.1	5.4	4.4	6.3	4.0	4.5	4.4	3.5	9.1	7.5
Utah	1.8	10.6	2.5	7.4	6.0	4.9	3.6	18.8	10.6	9.5	22.2	8.0
Vermont	7.1	27.0	4.0	7.8	3.7	23.7	5.6	25.3	6.7	7.4	14.0	6.7
Virginia	5.0	5.0	3.6	5.1	3.8	37.9	7.9	36.7	8.9	6.0	11.5	8.5
Washington	8.9	14.8	3.8	8.5	5.0	9.3	3.9	12.0	7.2	4.6	8.3	5.4
West Virginia	13.3	13.2	2.0	20.1	1.8	16.8	3.1	30.9	15.7	6.0	8.6	18.3
Wisconsin	3.7	4.6	2.1	3.8	2.1	45.4	5.9	2.9	4.4	4.2	12.5	9.8
Wyoming	3.0	14.3	3.7	15.8	11.8	4.6	6.0	24.2	14.2	11.6	21.8	12.0
Water resources Areas												
WRA 01 New England	4.4	3.6	2.4	4.0	2.6	23.1	8.9	13.9	5.4	12.4	11.6	10.5
WRA 02 Mid-Atlantic	3.1	3.2	2.0	3.2	2.1	15.8	4.0	3.4	2.7	2.6	4.5	3.9
WRA 03 South Atl Gulf	2.0	4.5	4.1	4.4	2.5	27.2	5.5	6.3	4.8	4.4	6.7	8.2
WRA 04 Great Lakes	3.4	3.1	2.4	3.0	2.4	57.9	2.6	5.4	4.1	3.9	8.2	4.6
WRA 05 Ohio	4.0	4.2	3.5	3.7	3.5	21.3	4.2	4.8	4.0	6.0	16.3	6.1
WRA 06 Tennessee	15.9	11.0	22.8	10.2	24.1	54.1	24.1	21.5	14.0	29.2	43.5	22.3
WRA 07 Upper Mississippi	3.0	3.5	1.7	3.4	1.7	15.5	3.2	2.0	2.7	2.6	9.3	6.6
WRA 08 Lower Mississippi	3.9	3.5	2.8	3.3	5.5	3.1	4.3	2.7	2.9	5.3	10.0	7.1
WRA 09 Souris-Red-Rainy	8.6	8.0	4.8	6.8	5.1	12.8	4.9	5.9	6.2	6.1	11.8	8.6
WRA 10 Missouri	3.5	7.9	2.3	5.6	3.9	3.9	3.3	3.6	3.4	5.5	14.7	4.7
WRA 11 Arkansas-White-Red	6.6	5.8	3.3	5.7	3.7	6.1	4.0	4.4	4.2	3.7	10.8	7.8
WRA 12 Texas-Gulf	6.8	7.5	4.5	7.4	6.1	8.3	5.6	5.7	5.6	5.0	9.6	7.1
WRA 13 Rio Grande	9.3	16.0	6.8	8.4	11.7	7.7	7.7	10.1	10.0	8.5	13.1	10.5
WRA 14 Upper Colorado	11.5	25.5	6.8	17.0	10.3	8.3	7.8	29.0	18.0	13.9	22.3	9.2
WRA 15 Lower Colorado	8.3	30.7	3.3	10.6	10.8	3.7	3.5	10.0	10.1	9.1	24.5	26.7
WRA 16 Great Basin	3.9	9.7	3.7	6.7	8.4	3.9	3.7	11.1	8.4	8.3	19.8	7.3
WRA 17 Pacific Northwest	3.7	5.2	1.9	3.8	2.8	4.2	2.6	7.7	4.6	3.3	8.5	3.9
WRA 18 California	7.0	7.7	6.3	6.1	13.6	8.7	6.7	10.5	8.7	13.8	33.2	12.4
WRA 19 Alaska	10.4	33.6	4.4	39.7	5.0	36.9	26.2	10.4	22.3	14.9	44.6	24.9
WRA 20 Hawaii	3.2	0.6	0.4	0.8	4.8	1.5	0.3	15.1	5.7	1.0	2.6	1.9

The relative standard errors given in table D can be used to construct confidence intervals for the major survey items. Confidence intervals are another way to express the precision of an estimate by calculating the upper and lower bounds for a level of confidence. This confidence interval is designed to contain the true value being estimated. If all possible samples were selected, each of the samples were surveyed under essentially the same conditions, and an estimate and its standard error were calculated from each sample, then:

1. Approximately 67 percent of the intervals from one standard error below the estimate to one standard error above the estimate would include the average value of all possible samples.
2. Approximately 90 percent of the intervals from 1.65 standard errors below the estimate to 1.65 standard errors above the estimate would include the average value of all possible samples.

The computations necessary to construct the confidence intervals associated with these statements are illustrated in the following example: Assume that the estimated number of irrigated acres of a certain item is 669,813 and the relative standard error of the estimate is 1.6 percent (0.016). Multiplying 669,813 by 0.016 yields 10,717, the standard error. Therefore, a 67-percent confidence interval is 659,096 to 680,530 (i.e., $669,813 \pm 10,717$). If corresponding confidence intervals were constructed for all possible samples of the same size and design, approximately 2 out of 3 (67 percent) of these intervals would contain the figure obtained from a complete enumeration. Similarly, a 90-percent confidence interval is 652,130 to 687,496 (i.e., $669,813 \pm 1.65 \times 10,717$).

EDITING

Some data reported may be incorrect as a result of the misinterpretation of a question or because of the use of estimates in reporting. Respondents may have failed to provide all of the information requested. In

some cases, the respondent may have indicated the presence of an item but not the amount. Data were reviewed for inconsistencies. Changes were made to data items that appeared to be inconsistent with other items. Imputations were made for missing data on acres irrigated, quantity of water used, method of water distribution, quantities of crops harvested, maintenance and repair costs, cost of water received from off-farm water suppliers, and depths, capacities, and energy cost of well pumps. If a respondent discontinued irrigation, no imputations were made for expenditures on irrigation facilities, method of deciding when to apply water, and other irrigation uses on the place such as the application of fertilizer, chemicals, or water to prevent freeze damage.

QUALIFICATIONS OF THE DATA

Analysts reviewing the returned report forms and results of the computer edit detected a few inquiries that were not uniformly interpreted by all respondents. Data users should be aware that respondent interpretation of some inquiries may affect the final results in their use of these selected statistics. Clarification of data items with potential extortions and data impacted by unique problems or definitions are provided below.

Irrigated land - Irrigated land is defined as "all land watered by artificial or controlled means." No attempt has been made to define the degree or intensity of irrigation. Therefore, the figures for irrigated land include land with as little as one inch of water applied as well as land having several feet of water applied.

Nonirrigated crop yields - Data users are reminded that the nonirrigated crop yield averages in table 22 are for nonirrigated crops harvested from farms having land irrigated and may not be comparable with crop yield averages for total farms in the State.

Estimated quantity of water applied - Most water used for irrigation is not metered or measured accurately. Therefore, the quantity of water data are on the basis of best estimates provided by irrigators. Generally, in areas of water scarcity such as southern California and Arizona, irrigators are more likely to be able to provide quantities of water used than in Mountain States such as Montana,

Wyoming, and Idaho where scarcity of water is less of a problem. Furthermore, in the Mountain States where water from snow-melt is diverted for use in season, the amount of water used may be a rough estimate, seldom a measured figure.

Application of commercial fertilizers or pesticides in irrigation water - This inquiry was intended to measure the number of farms adding or mixing fertilizer and pesticides to irrigation water as it was being conveyed or distributed to the crop. The tabulated results may overstate this practice because some irrigators have misinterpreted the inquiry to include conventional application of fertilizer and pesticides to the irrigated crop as well as applying chemicals directly into the irrigation water, which carries them to the crop.

Cost of water received from off-farm water suppliers - Irrigators receiving water from off-farm water suppliers are generally required to pay for the water in charges, fees, or assessment. The computer edit procedures called for imputing an estimate for cost of water based on other reports from the same geographic area. If there were any indications written on the report form that the water was received free, no cost of water was imputed. The final tabulated results for this item may be overstated, because it was not possible to distinguish cases where the respondent received free water from cases where the cost amount was omitted in error, leading to imputation of a dollar amount. States with small sample sizes, mostly in the Northeast, reported a wide range for cost of water, usually on the high side. This is possibly due to the use of expensive municipal water on small acreages. Water costs for some of these States were omitted from the tables.

Irrigation wells - Some farm operators reported wells used only for domestic purposes or livestock as wells "not used" in 1998, meaning not used for irrigation. Where identified for domestic purposes or livestock use, the entry was deleted. Data users are reminded that additional wells were reported as not used in 1998, but

capable of being used, which may have been used for domestic purposes or livestock only.

Artesian wells - A specific entry space was provided for artesian wells. The data for well pumps exclude any pumps that may have actually been used to pump water from artesian wells.

Irrigation pumps - The inventory figures for number of irrigation pumps on farms reported in table 14 include reserve pumps not actually used in 1998, but exclude any pumps on wells not used in 1998. By definition, flowing or artesian wells do not have well pumps.

Expenditures for maintenance and repair and investment in irrigation facilities and equipment

- The expenditure data reported are expenditures that occurred only in 1998. Some respondents found it difficult to separate expenditures for maintenance and repairs from investment in irrigation facilities and equipment as defined on the report form. For example, replacement of wornout sprinkler nozzles, pumps, and motors could be considered as either repair cost or investment in new equipment. Therefore, data users are reminded that the distinction between the two expenditure categories is blurred for some respondents.

Government programs - This item shows the effect of government programs on irrigation practices. It was first asked in 1994 and was revised for 1998 to reflect changes in government programs.

Improvements to irrigation systems that reduce energy and/or conserve water used in irrigation

- This was first asked in 1994. It shows the benefits of new resource-conserving irrigation systems. Respondents were asked to respond for the period covering 1994 to 1998. The information was tabulated as reported. No imputation was made for a blank response.

Sources of irrigation information - This was first asked in 1994. This question identifies where farmers look for help in making irrigation decisions. The information for this item was tabulated as reported. No imputation was made for a blank response.

Reason for discontinuance of irrigation since 1997 - The data shown in table 35 reflect the expansion of reported entries. Some respondents reported multiple reasons, while others gave no specific reason.

SUMMARY AND CONCLUSIONS

Irrigated Crops

Based on the 1998 Farm and Ranch Irrigation Survey estimates for U.S. producers, corn continues to be the dominant irrigated crop accounting for nearly 21 percent of irrigated land. The top irrigated crops in the United States in 1998 were corn for grain or seed, alfalfa hay, cotton, soybeans, and orchard land (land in bearing or nonbearing fruit orchards, citrus or other groves, vineyards, and nut trees). These crops accounted for 57 percent of all irrigated land. While the number of irrigators fell to 182,101 in 1998, from 198,115 in 1994, the total land irrigated was up to 50.0 million acres from 46.4 million acres. The leading States in total acreage of irrigated land are California (16 percent of U.S. total), followed by Nebraska (11 percent) and Texas (10 percent).

Method of Irrigation

There were 50.0 million acres irrigated by different water distribution systems in 1998. Of the total acres irrigated by all types of distribution systems, 25.0 million acres were irrigated by gravity flow systems and 23.0 million acres by sprinkler systems. Comparisons with the past farm and ranch irrigation surveys show that sprinkler system usage, as a percent of acres irrigated, remained constant in 1998, while the use of gravity systems continued to decrease.

Sprinkler irrigation was used on 46 percent of the total land irrigated in 1998 compared with the same 46 percent in 1994, 40 percent in 1988, and 38 percent in 1984. Since total acres irrigated in 1998 were higher than previous years, the actual acres irrigated by sprinkler systems also continued to increase.

Gravity flow systems were used on 50 percent of the land in 1998, compared with 54 percent in 1994, 59 percent in 1988, 61 percent in 1984, and 63 percent in 1979.

Of the 23.0 acres irrigated by sprinkler systems, center-pivot-low pressure systems (under 30 psi) were used to irrigate 8.6 million. Next were center-pivot medium-pressure systems (30 to 59 psi) with 6.9 million acres. High-pressure center-pivot systems (60 psi or greater) were down to 1.8 million acres in 1998 from 3.2 million acres in 1994. All other mechanical move systems were reported on 2.8 million acres, and hand move systems on 1.7 million acres.

Drip or trickle systems were used on 2.1 million acres in 1998, a 20-percent increase over the 1.7 million acres in 1994.

Estimated Quantity of Water Applied

Quantity of water applied in 1998 was up from 1994, reversing a longstanding trend in the reduction of water usage. An above-average level of streamflow in the western Rockies allowed an increase in the amount of water used in gravity irrigation for alfalfa hay, other hay, and pasture. Irrigators estimated that a total of 90.6 million acre-feet of water was applied to the 50.0 million acres irrigated in 1998 in the United States for an average of 1.8 acre-feet per acre irrigated. Table E shows the average acre-feet of water applied per irrigated acre over the last 29 years. The average amount of water applied per acre in the States ranged from a high of 7.0 acre-feet in Hawaii, to a low of 0.3 acre-feet in Connecticut.

Table E. Average Acre-Feet of Water Applied Per Irrigated Acre

Year and source	Amount applied
1998 Farm and Ranch Irrigation Survey	1.81
1994 Farm and Ranch Irrigation Survey	1.72
1988 Farm and Ranch Irrigation Survey	1.82
1984 Farm and Ranch Irrigation Survey	1.80
1979 Farm and Ranch Irrigation Survey	1.86
1974 Census of Agriculture	2.09
1969 Census of Agriculture	2.11

Special tabulations of data for farms having only one of the four kinds of distribution systems-- sprinklers, gravity, drip, or subirrigation-- show noticeable differences in the amount of water applied per acre by each system. For example, farms using only sprinkler systems applied 1.3 acre-feet per acre irrigated, compared with 2.2 acre-feet for farms using only gravity flow systems (see table 7).

Source of Water

There was a total of 50.0 million acres irrigated by water from all sources in 1998. About 29.8 million acres (60 percent) were irrigated from farm irrigation wells, 6.8 million acres (14 percent) from on-farm surface sources, and 15.1 million acres (30 percent) from off-farm water suppliers. Of the 90.6 million acre-feet of water estimated to be used for irrigation in 1998, 40.9 million acre-feet (45 percent) were pumped from wells, 11.1 million acre-feet (12 percent) were provided by on-farm surface sources, and 38.5 million acre-feet (43 percent) came from off-farm water suppliers. Table F shows how these data correspond to previous farm and ranch irrigation surveys.

Table F. Irrigation Water Used by Source: 1998, 1994, 1988, and 1984

Farm	1998	1994	1988	1984
Total.....	90.6	79.6	84.1	82.7
Wells:				
Acre-feet (millions)...	40.9	39.4	40.5	36.2
Percent.....	45	49	48	44
On farm:				
Acre-feet (millions).	11.1	8.6	8.9	10.2
Percent.....	12	11	11	12
Off farm:				
Acre-feet (millions)...	38.5	31.6	34.9	36.2
Percent.....	43	40	41	44

The average amount of water applied per acre varies significantly by source. Land irrigated from wells averaged only 1.3 acre-feet applied per acre, while land irrigated from off-farm water suppliers

averaged 2.6 acre-feet applied. Sprinkler irrigation is more closely related to the distribution of well water, while gravity flow systems are generally used to distribute water from off-farm water suppliers. However, for purposes of water economy and efficiency of water use, the trend by irrigators has been toward greater use of sprinkler systems over the past decade.

Irrigation Wells

There were 374,072 irrigation wells capable of being used on 91,500 farms. Of these, 330,837 wells were pumped in 1998, while 5,203 were artesian or free flowing. All irrigation wells supplied 40,912,178 acre-feet of water to 29,790,719 acres of land, averaging 1.37 acre-feet of water and 88.6 acres irrigated per well. Farms with wells used in 1998 averaged 3.9 wells per farm. Over 60 percent of the farms using wells in 1998 used one or two wells, but the majority of wells used, 200,837, were on the 21,441 farms using more than five wells per farm, indicating the impact of the large irrigators on statistics. Pumped wells for the United States averaged 240 feet in well depth, 150 feet in pumping depth, and 866 gallons per minute in pumping capacity.

Irrigation Expenditures

Pumping costs - There were a total of 454,233 irrigation pumps of all kinds used on 117,611 farms in 1998 that irrigated 38.3 million acres of land. These pumps were powered by fuels and electricity costing irrigators a total of \$1,223 million or an average of \$10,400 per farm or \$32 per acre irrigated. The principal power source used was electricity, for which \$801 million was spent to power 273,077 pumps and irrigate 20.2 million acres at an average cost of \$40 per acre. Table 17 presents more information on the other fuels used to power irrigation pumps.

Cost of water from off-farm water suppliers - The 38.5 million acre-feet of water received from off-farm water suppliers to irrigate 15.1 million acres cost irrigators \$625 million, for an average cost of \$16 per acre-foot of water or \$41 per acre irrigated.

Maintenance and repair cost - Expenditures for maintenance and repairs totaled \$468 million on 115,549 farms, for an average of \$4,052 per farm.

Investment in irrigation equipment, facilities, and land improvement - Investment in irrigation equipment, facilities and land improvement in 1998 totaled \$1,062 million for an average of \$18,061 per farm. The principal investment was in the purchase of irrigation equipment and machinery which totaled \$643 million and represents 61 percent of total investment.

Discontinuance of Irrigation in 1998

An estimated 18,187 farmers who irrigated a total of 1.2 million acres in 1997, according to the census of agriculture, did not irrigate in 1998. The majority of these operators reported that their discontinuance was not permanent (83 percent).

Improvements to Irrigation Systems

Approximately 28.0 million acres irrigated were reported to have had improvements made on them to reduce energy use or conserve water. These improvements resulted in reduced water requirements on 19.2 million acres irrigated, improved crop yield on 17.8 million acres irrigated, and decreased energy costs on 16.7 million acres irrigated. Table 32 presents more information concerning the results of improvements made to irrigation systems in the last 4 years.