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United States Department of the Interior

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August 13, 2002

Mr. Morris Bell, Chairman
Imperial Valley Water Authority
P.O. Box 503
Havana, Illinois 62644-0503

Dear Mr. Bell:

This letter describes the results of the project conducted by the U.S. Geological Survey (USGS) in cooperation with the Imperial Valley Water Authority (IVWA) designed to improve the annual withdrawal estimates for irrigation water use made by the IVWA in Mason and Tazewell Counties, Illinois. These estimates are to be improved by using an updated conversion factor for transforming energy consumption by irrigation systems (well and pivot) to actual gallons pumped. The conversion factor was updated by the USGS by recording the instantaneous electrical demand and water discharge at a predetermined sampling of irrigation systems, calculating the conversion factor for each system, and determining the average value of the conversion factor for the sampled systems.

The permission forms received by our office from the Central Illinois Irrigated Growers Association enabled 79 irrigation systems to be located and accessed for this project. The necessary data could not be collected at 2 wells. One system, in the north half of sections 28 and 29 T20N R9W, owned by Dan Pfeiffer, could not be measured because of interference caused either by air bubbles or sediment in the water stream inside the pipe or by the pipe material. Another irrigation system in the ne1/4 sw1/4 sec 32 T20N R9W, owned by Jeff Clark, was powered through the same electric meter as an adjacent irrigation system, so the electrical demand and water discharge were combined for these two systems into one calculation. Thus, calculations for the conversion factor were made for 77 irrigation systems.

The enclosed data table provides results of the data collection. Irrigation-system size (in acres), electrical-meter number, and control-box number (for Menard Electric Cooperative meters) are listed in the table for identification purposes only. The acreage shown was not verified. The water-discharge measurements have been rounded to the nearest 5 gallons per minute (gpm) except for those values less than 300 gpm that have been rounded to the nearest 1 gallon (gal). The electrical demand was determined either by counting the number of revolutions of the rotating disc on the old-style analog meters for at least 1 minute or by reading voltage and current information accessed by interrogating the new-style digital meters. The applicable equations were used with this information to calculate the instantaneous electrical demand, in kilowatts-hours (Kwh), by the irrigation system.

The water-discharge measurement was made with a non-invasive flow meter usually placed on the horizontal pipe between the well and pivot point with 8 feet (ft) or more of straight unobstructed pipe upstream and about 3 ft downstream, where possible. Several measurements were made on the vertical pipe at the pivot point (if the power cord or other obstructions were not present) when the horizontal pipe was too short and/or obstructions were present inside the pipe that may have been disrupting the water flow. The error of the measurement is within 2 percent of the indicated flow when the setup is under optimum conditions. Several setups were made on shorter than optimum lengths along the horizontal pipe because the vertical pivot pipe contained obstructions. Also, less than optimum conditions inside the pipe may not always have been recognized from outward appearances. Various indicators are given by the flow meter that it is sensing a less than optimum situation. One indicator is a higher or lower value than normal for sonic velocity of the water as measured by the meter. Systems where outlier sonic-velocity values, which were arbitrarily determined to be one standard deviation greater or less than the mean sonic velocity, were measured are indicated in the table. The error of the water-discharge measurements obtained at these systems may be somewhat greater than 2 percent. The water-discharge measurements with outlier sonic-velocity values did not consistently result in conversion factors considered as outliers because only two systems had both values as an outlier.

It is not known whether the sampling of irrigation systems in this project is representative of all the irrigation systems in the area covered by the IVWA. The range in measured discharge was from 100 to 1,410 gpm. High-pressure impact sprinkler heads were used at ten of the measured irrigation systems. The size of the irrigation systems ranged from about 12 to 320 acres. Five of the irrigation systems had multiple pivots supplied from one well. Eleven irrigation systems did not swing through a full circle. The well pumps ranged from a 5 horsepower (hp) submersible pump to a 100 hp turbine pump.

The conversion factor (Q/Kwh) for each irrigation system was calculated with the following equation:

> Q(discharge in gallons per minute) x 60 (minutes per hour) / Kwh(electrical demand in Kilowatt-hours) = Q/Kwh (conversion factor in gallons per Kilowatt-hour).

The Q/Kwh values for the individual systems are listed in the data table. The average value for Q/Kwh from the 77 sampled irrigation systems is 1,259 gal per Kwh. This value is appreciably lower than the value of 1,505 gal per Kwh currently used by the IVWA. This updated value indicates that the estimated water withdrawn may have been over estimated by about 20 percent.

The large range in Q/Kwh values, from 767 to 1,762 gal per Kwh, obtained on the individual systems could be the result of many different conditions. The lowest Q/Kwh value was made on a system with high-pressure impact sprinkler heads, and the wellhead discharge appeared to have been valved back about one-half. Variations in the depth to water in the well, the efficiency of the well screen and the pump, and the friction losses because of the differing length of and number of bends in the pipe between the well and the pivot will result in a range of values for Q/Kwh.

Mr. Morris Bell

Hopefully, this update of the conversion factor will result in a more accurate accounting of the withdrawals for irrigation made in the area. Accurate figures of withdrawal amounts are needed when assessing the impact of withdrawals from wells on water levels in an aquifer and are a very critical input to any computerized simulation of ground-water flow that is made for a resource assessment of an aquifer.

If there are any questions about this project or if we can be of any more assistance, please contact Chuck Avery at (217) 344-0037, extension 3029, or email cfavery@usgs.gov. If the Central Illinois Irrigated Growers Association could use the data table in another format, such as an electronic spreadsheet file, to prepare the notification of the participants of the results, please let us know. It has been a pleasure dealing with you, the IVWA, the Central Illinois Irrigated Growers Association, and the individual farmers of the area.

Sincerely,

Richard D. Hayes

Richard D. Hayes
Acting District Chief
Illinois District

Enclosure

electronic copy
analysis by: size of system

- suggest database be built of systems
age of systems
rated pump rate

Owner	System location	System size, in acres	Electric meter number	Control number	Pump rating, in horsepower	Measured discharge (Q), in gpm	Sonic-velocity outliers	Type of pressure system	Electrical demand (Kwh), in kilowatt-hours	Calculated Q/Kwh, in gallons per kilowatt-hour	Comments
Jeff Clark	T19N R 9W- 4swse	40	63 321 799	2295	20	425		high	18.4	1383	
Jeff Clark	T19N R 9W- 5nwsw	40	75 774 242	1644	20	385		high	18.2	1270	
Jeff Clark	T19N R 9W- 6ne	160(3/4? swing)+40	49 175 910	1560	100	1190		low	91.3	782	
Jeff Clark	T19N R 9W- 6sene	40	84 473 830	1747	submersible	260	x	low	13.0	1196	Setup not optimum.
Jeff Clark	T19N R 9W- 6sesw	40	68 170 153	xx14	submersible	405		low	17.7	1371	385 gpm measured + (~20 gpm leakage).
Steve Turner	T19N R 9W- 7ne	68	13 873 932	1790	submersible	680	700	low	31.4	1299	
Jeff Clark	T19N R 9W- 8swne	40	49 397 021	1563	—	330	x	low	13.4	1475	
Jeff Clark	T19N R 9W- 9nesw	40	49 397 011	2114	20	360		low	17.7	1219	Setup not optimum.
Adkins Farm	T19N R 9W-10s	80	17 680 906	1703	—	650		low	27.0	1444	
Jeff Clark	T19N R 9W-10w	160	13 267 730	1791	submersible	865		low	45.3	1146	
Adkins Farm	T19N R 9W-17ne	160	64 493 556	1557	50	970		—	45.5	1280	
Steve Turner	T19N R 9W-17nwnw	120 (3/4 swing)	12 103 972	2168	submersible	780	x	low	39.0	1202	
Adkins Farm	T19N R 9W-17se	150	47 502 113	1558	50	1015		low	41.0	1487	
Morris Bell	T19N R 9W-19sw	110	13 873 922	273	50	745		low	30.4	1469	
Albert Hoesman	T19N R10W-12w	320	55 044 223	2246	100	1410		low	81.3	1040	
Albert Hoesman	T19N R10W-16nw	160	82 872 094	394	50	1000		low	45.5	1319	
Jeff Clark	T19N R10W-20nwne	40	17 002 063	1713	submersible	325		low	17.2	1136	
Morris Bell	T19N R10W-23sw	168	64 499 019	469	60	860	1100	low	54.0	956	
Richard Showalter	T20N R 7W- 3se	40	17 403 986	2163	submersible	276	x	high	13.3	1248	Valve at 3/4 open, end gun off.
Jeff Smith	T20N R 7W- 9se	160	11 781 584	1935	submersible	720		low	38.4	1125	
Jeff Smith	T20N R 7W-14w	160	64 499 015	1691	submersible	735		low	39.3	1123	
Tim Urish	T20N R 8W-15nene	40	19 313 382	2376	15	345		low	16.2	1280	
Steve Fornoff	T20N R 9W- 3ne	towable	17 403 995	1551	50	910		low	40.7	1341	Q on vertical pivot pipe.
Steve Fornoff	T20N R 9W- 3senw	40	14 533 082	2080	submersible	375		low	17.1	1314	
Richard Showalter	T20N R 9W-11nw	160	19 313 388	2329	50	895	x	low	56.8	946	
Steve Fornoff	T20N R 9W-12ne	160	55 044 228	557	40	820		low	38.8	1267	
Steve Fornoff	T20N R 9W-13nenw	40	82 072 085	2515	submersible	420		low	23.3	1082	
Jeff Clark	T20N R 9W-17s	160	10 810 644	1903	40	820		low	39.7	1239	
Marvin Lascelles	T20N R 9W-19ne	160	cips 92803950	---	60	1015		low	41.5	1468	
Dean Pfieffer	T20N R 9W-28ne	160	82 072 076	2248	40	885		low	33.9	1567	
Dean Pfieffer	T20N R 9W-28nw	12	86 405 075	1482	submersible	110		low	5.1	1289	Pvc pipe.
Dean Pfieffer	T20N R 9W-28nw	160	58 523 045	2238	50	895	x	low	37.2	1445	
Dean Pfieffer	T20N R 9W-28se	160	73 096 218	2392	50	880	x	low	45.5	1161	

Owner	System location	System size, in acres	Electric meter number	Control number	Pump rating, in horsepower	Measured discharge (Q), in gpm	Sonic-velocity outliers	Type of pressure system	Electrical demand (Kwh), in kilowatt-hours	Calculated Q/Kwh, in gallons per kilowatt-hour	Comments
Dean Pfieffer	T20N R 9W-28sw	160	13 873 925	1574	50	915	x	low	37.3	1471	
Dean Pfieffer	T20N R 9W-29se	160	79 892 539	2167	40	895		—	34.2	1569	
Dean Pfieffer	T20N R 9W-29swne	40	49 397 012	2245	submersible	315	x	low	14.1	1340	Setup not optimum.
Dean Pfieffer	T20N R 9W-29swnw	40	17 403 984	536	submersible	305	x	low	12.8	1434	Setup not optimum, Q on vertical pivot pipe.
Marvin Lascelles	T20N R 9W-30se	160	11 170 556	1838	50	940		low	42.1	1338	
Dean Pfieffer	T20N R 9W-31se	120 (3/4 swing)	13 393 125	1830	submersible	795		low	35.2	1356	
Jeff Clark	T20N R 9W-32swne	40	63 322 992	383	submersible	560		low	20.9	1604	Discharge 292 gpm + 268 gpm from 40-acre system in sec 32nesw.
Jeff Clark	T20N R 9W-32swnw	40	15 152 248	2209	submersible	360		low	17.0	1273	
Dean Pfieffer	T20N R 9W-33ne	160	82 072 073	1573	50	750		low	30.5	1476	
Lloyd Ingersoll	T21N R 6W- 5swnw	40	55 010 716	413	15	298		high	14.1	1268	
Lloyd Ingersoll	T21N R 6W- 5swse	40	84 010 187	2100	—	415		low	22.6	1093	Q on vertical pivot pipe.
Lloyd Ingersoll	T21N R 6W- 7e	160	84 855 771	1773	submersible	580		low	20.5	1695	
Lloyd Ingersoll	T21N R 6W- 8ne	160	13 267 712	1812	40	785		low	35.6	1322	
Steve Fornoff	T21N R 7W- 5ne	160	20 789 612	(missing)	50	985		low	42.3	1397	
Tim Urish	T21N R 7W-30nwse	40	84 588 975	1642	20	375		low	19.2	1172	Valve only 1/2 open.
Tim Urish	T21N R 7W-30nwsw	40+40	75 774 238	2389	50	580		low	36.8	947	South pivot running, setup not optimum.
Richard Showalter	T21N R 7W-30swne	40	47 553 573	2034	submersible	445		low	17.4	1532	
Richard Showalter	T21N R 7W-30swnw	40	82 034 335	546	submersible	450		low	22.3	1211	
Tim Urish	T21N R 7W-31/32	160	14 533 085	2049	40	940		low	40.7	1384	
Jay Frye	T21N R 8W-30nw	160+40	55 044 221	2289	75	1040		low	59.6	1047	Valve to 40-acre pivot shut off.
Steve Fornoff	T21N R 9W-24ne	160	97 169 508	1782	submersible	710		low	39.3	1085	
Doug Clark	T22N R 6W- 7sw	40	cips 82114443	—	submersible	445		low	19.9	1344	
Doug Clark	T22N R 6W-18nw	160	47 135 411	2538	50	915		low	41.1	1334	
Craig Gathmann	T22N R 6W-27nw	160 (3/4 swing)	84 010 186	1770	40	685		low	30.1	1368	
Ronald Armbrust	T22N R 7W- 8nw	240/2 pivots	55 044 216	1784	75	1100		low	56.7	1165	South pivot running.
Ronald Armbrust	T22N R 7W- 8sesw	80	82 072 097	127	30	825		high	28.1	1762	
Ronald Armbrust	T22N R 7W- 9sw	130	75 892 540	1785	75	895		low	44.3	1212	
Eric White	T22N R 7W-13ne	40	58 523 033	1783	50	735		high	40.7	1085	

Owner	System location	System size, in acres	Electric meter number	Control number	Pump rating, in horsepower	Measured discharge (Q), in gpm	Sonic-velocity outliers	Type of pressure system	Electrical demand (Kwh), in kilowatt-hours	Calculated Q/Kwh, in gallons per kilowatt-hour	Comments
Eric White	T22N R 7W-13se	160(1/2 swing)	82 072 088	1767	40	805	x	low	36.4	1328	Q on 1/2 swing, air in waterstream?
Doug Clark	T22N R 7W-15swsw	40	82 072 080	1509	submersible	385		low	19.2	1203	System run 1/2 hour before Q.
Ron Vance	T22N R 7W-22ne	40	84 855 770	1732	submersible	490		low	23.6	1248	
Ron Vance	T22N R 7W-22se	40	63 321 793	1641	submersible	460		low	28.8	958	Q on vertical pivot pipe.
Steve Fornoff	T22N R 7W-34nw	160	47 553 604	548	50	1275		low	52.4	1461	
Steve Fornoff	T22N R 8W-22swsw	40	47 553 579	2544	40	625	x	low	35.3	1063	
Doug Clark	T22N R 8W-27ne	160(3/4 swing)+20	cips 86436771	---	submersible	505	x	---	29.9	1013	Setup not optimum, only 20-acre pivot running.
Dan Duval	T23N R 5W- 8nwn	66 (1/2 swing)	cilco 6002399	---	submersible	575	x	low	19.6	1761	Setup not optimum.
Ronald Armbrust	T23N R 6W-17sw	160	47 135 406	168	75	1050		high	68.4	921	Valve at 1/2 open.
Ronald Armbrust	T23N R 6W-19nw	160	84 083 334	2231	75	850		high	66.5	767	
Ronald Armbrust	T23N R 6W-29ne	160(1/2 swing)	49 982 837	465	50	790		low	46.7	1015	
Ronald Armbrust	T23N R 6W-31nw	160 (3/4 swing)	49 265 488	227	60	830		high	54.0	922	
Ronald Armbrust	T23N R 6W-31sw	160 (3/4 swing)	18 547 185	2285	50	1000		low	45.3	1324	System run 1/2 hr before Q.
Kenneth Fornoff	T23N R 7W-12sw	160	47 511 850	2552	75	880		high	65.8	802	
Ronald Armbrust	T23N R 7W-24ne	160	58 523 044	1756	50	700	x	low	42.7	984	Setup not optimum.
Ronald Armbrust	T23N R 7W-24sw	160 (3/4swing)	13 393 141	2042	40	850		low	33.8	1507	