DETERMINATION OF TRANSMISSIVITY VALUES IN THE SALT RIVER VALLEY USING RECOVERY TESTS, SPECIFIC CAPACITY DATA AND DWR DRILLER LOG PROGRAM

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Introduction

The purpose of this report is to make available the results of a study of transmissivity in the Salt River Valley. The objective of the study was to obtain transmissivity data for an ongoing digital modeling effort of the Salt River Valley and the study's primary focus was a field program in which transmissivity values were determined from aquifer tests. Transmissivity values from the field program were supplemented with values estimated using specific capacity or driller log data in order to produce a map of transmissivity in the Salt River Valley.

In the summer of 1979, the Arizona Department of Water Resources (DWR, then the Arizona Water Commission) and the Salt River Project (SRP) initiated a cooperative aquifer testing program in conjunction with the annual SRP well maintenance schedule. This field program was initiated after an extensive data search revealed few reliable estimates of transmissivity in the Salt River Valley (SRV).

Between May and September 1979, well recovery tests were performed on 172 large capacity irrigation wells during the SRP annual maintenance program using standard testing procedures and consistent methods of analysis. Due to the excess surface water available from the previous spring runoff, groundwater pumpage was below normal during this period. Therefore, the SRV aquifer system was not being heavily stressed and interference from pumping wells was mimimal. These factors enhanced the reliability of the test results.

The cooperative efforts of SRP are recognized, and appreciated, especially their assistance in formulating the program and furnishing field equipment and personnel.

The results from the field program provided the base for a transmissivity (T) map of the Salt River Valley model area. Within the SRP boundaries, transmissivity values determined from the 1979 well tests were used in preparing model input, however, outside these boundaries transmissivity data remained very scarce. Additional methods of estimating transmissivity were employed in order to construct a T map for the model area.

In addition to transmissivity values calculated from the aquifer tests, specific capacity values were also determined. A relationship between transmissivity and specific capacity was established from which transmissivities were predicted for areas which had sufficient specific capacity data.

Both transmissivity and specific capacity values were unavailable for some areas of the valley. Therefore, values generated from the DWR Driller Log Program were used to supplement field data, as further explained in the Analysis and Results section of this paper.

Previous Studies and Data Collection Efforts

Previous modeling studies of the Salt River Valley include Anderson, 1968, Turner, 1978. However, these studies were of a general nature and utilized regional transmissivity values.

Available aquifer tests and well data were collected from numerous irrigation districts, private water companies, cities, towns, U. S. Geological Survey files and DWR records.

Field Procedures

The basic field procedures for the aquifer testing program were as follows:

1. Static water levels were measured prior to the start of the pumping period.

2. Wells were pumped for 24 consecutive hours; this allowed sufficient time for the drawdowns to stablize in most instances.

3. Pumping water levels were measured immediately prior to shutting off the pump.

4. Discharges were measured using a Cox flow meter at both the beginning and end of the pumping period. In a few instances, only ending measurements were obtained due to the limited number of field personnel.

5. Although not part of the aquifer testing per se, water samples were obtained from selected wells for water quality analyses. The samples were collected by the U. S. Geological Survey for use in their SWAB/RASA program, a study of alluvial basins in central and southern Arizona.

6. After the pumps were shut off, water level recovery measurements were taken until field plots indicated the well had recovered sufficiently to obtain reliable data. This usually occurred within a two to six hour period from the time when pumping stopped.

Figure 1 indicates the location of the 172 irrigation wells that were tested in the Salt River Valley and also delineates the boundary of the model study.

Analysis and Results

Aquifer Tests

Transmissivity values were calculated from recovery test data by a modified non-equilibrium approach utilizing either direct recovery or residual drawdown (Johnson, 1975).

A comparison of transmissivity values estimated by direct recovery to those estimated by residual drawdown indicated that the two techniques yielded similar results.

Table 1 displays pertinent data and calculated transmissivity values for each recovery test. Although 172 wells were tested, transmissivity values were considered reliable for only 152 tests. The remaining 20 tests produced questionable results primarily due to mechanical problems with the pump, or difficulties with water level measurements.

Specific Capacity Data

Specific capacity data (SC) were available for numerous wells located in areas where aquifer tests were not performed. An analysis was performed to determine the relationship between specific capacity and transmissivity using the 1979 well tests. This analysis was based on the fact that transmissivity and specific capacity are related since both are functions of the permeability of the aquifer - transmissivity is directly related and specific capacity indirectly. Transmissivity versus specific capacity data when plotted on log-log paper yielded a straight-line trend suggesting that the parameters are related exponentially. The data were analyzed with a standard statistics package on a programable calculator, (Hewlett Packard, 1976). These analyses indicate that the relationship between the two parameters is best described by the equation $y=ax^b$ where y=transmissivity; x=specific capacity; and the terms a and b are constants. Solving for the constants in the equation yields a=1,972 and b=1.085 or approximately T=1,972 x SC. The results of the analyses are statistically reliable with a coefficient of determination of .8070 and a coefficient of correlation of .8983.

In addition, these analyses conform to the mathematics of a previous study in the SRV that indicated T=2,000 x SC (Anderson, 1968).

DWR Driller Log Program

The DWR Driller Log Program assigns permeability values to each material type referenced in a driller log, (for a detailed description of the DWR program, see Long and Erb, 1980 and Kisser and Haimson, 1981). Transmissivity is calculated for each

Table 1. Pertinent Data and Calculated Transmissivity Values from 1979 Salt River Valley Cooperative Well Testing Program. [1]

Well Location	Well Discharge (gpm)	Static Water Level (feet)	Pumping Water Level (feet)	Transmissivity (gpd/ft)
A-01-01 02ccc	3172	89	172	113,000
A-01-01 03abb2	3003	145	180	127,000
A-01-01 09bbb2	3332	102	144	105,000
A-01-01 10ccc2	3615	65	93	273,000
A-01-01 11add	2335	96	174	57,000
A-01-01 11cbc	2160	167	255	39,000
A-01-01 19abb	2282	47	62	450,000
A-01-01 21ddd	2688	47	72	131,000
A-01-01 24aac	3696	64	75	707,000
A-01-01 28cbd	4178	21	44	1,137,000
A-01-02 18ddd2	4074	67	115	179,000
A-01-03 02aaa	2860	56	101	58,000*
A-01-04 01aba	1063	198	299	38,000
A-01-04 01dbc	1929	225	283	121,000
A-01-04 02dbb	1586	214	256	42,000
A-01-04 19acc	903	41	80	63,000
A-01-04 24bbb2	3685	118	147	162,000
A-01-05 01add	2782	324	368	306,000
A-01-05 01bda	2096	287	297	294,000
A-01-05 02aaa2	2654	257	270	494,000*
A-01-05 02bbb2	2847	228	251	396,000
A-01-05 02cbb2	2491	231	248	518,000
A-01-05 02cdd2	3916	251	275	345,000
A-01-05 02dbb	3019	252	270	347,000
A-01-05 02ddc	3895	285	309	297,000
A-01-05 03ddc	2841	232	268	203,000
A-01-05 04ddd2	3675	217	251	347,000
A-01-05 09dcb	3702	221	260	166,000
A-01-05 10ccd	2231	266	294	109,000
A-01-05 13bbc	2723	290	318	300,000
A-01-05 13caa	2254	293	314	532,000
A-01-05 14baa	2793	292	340	*
A-01-05 16ccd	3055	250	295	129,000
A-01-05 17aaa	2264	194	230	107,000
A-01-05 17caa	3703	199	243	128,000
A-01-05 18cdc	2345	131	228	80,000
A-01-05 18ddd2	2303	161	223	75,000
A-01-05 19acc2	2731	125	186	76,000
A-01-05 21abb	1225	244	271	82,000
A-01-05 24aad	2870	295	318	316,000
A-01-05 26ddd	1167	219	259	32,000
A-01-05 27dcc	2679	226	272	104,000
A-01-05 30bba	2789	159	233	97,000
A-01-05 30cdd	3199	172	211	188,000
A-01-05 30bdd	1284	154	209	28,000
A-01-05 32cdd	2824	178	240	108,000
A-01-05 33cdd	2275	185	306	50,000
A-01-05 34ddd	4137	166	206	174,000
A-01-05 35baa	2238	242	309	39,000
A-01-06 06bba	2861	291	315	252,000
A-01-06 07cbc	2192	316	335	227,000
A-01-06 17acc	2564	362	386	212,000
A-01-06 21bcb2	2578	363	389	349,000
A-01-06 21cdc	2027	313	397	*
A-01-06 28dcd2	1906	383	424	245,000
A-01-06 30aba2	1127	290	322	149,000

Well Location	Well Discharge (gpm)	Static Water Level (feet)	Pumping Water Level (feet)	Transmissivity (gpd/ft)
A-01-06 32cbd	2024	246	292	53,000*
A-01-06 33cdd	2034	355	409	111,000
A-01-06 34ccc2	2423	377	407	286,000
A-02-01 01dad	2154	212	281	78,000
A-02-01 08ddd	2195	167	272	46,000
A-02-01 09ddd2	2592	158	236	41,000
A-02-01 12dda2	820	212	244	31,000
A-02-01 13ccc	2201	198	258	53,000
A-02-01 14bbb2	2372	174	243	50,000
A-02-01 14bdd	2264	180	278	44,000
A-02-01 14ccc	1224	176	194	61,000
A-02-01 15abb	1972	164	228	37,000
A-02-01 15cbb	1827	158	205	71,000
A-02-01 17ddd2	1247	158	202	40,000
A-02-01 20daa	2079	155	208	41,000
A-02-01 20ddd	2020	154	207	45,000
A-02-01 23ccc	2020	169	236	58,000
A-02-01 23dda	2403	193	231	89,000
A-02-01 24dbc	2483	200	272	53,000
A-02-01 26daa	2661	176	215	112,000
A-02-01 28aaa	781	159	175	64,000
A-02-01 29ddd2	2053	144	192	47,000
A-02-01 35ddd	3165	141	171	118,000
A-02-01 36dad	3902	143	194	165,000
A-02-02 03aad	789	254	346	7,000
A-02-02 04cba	1320	255	384	22,000
A-02-02 14cbc	773	175	284	14,000
A-02-02 17ada2	958	230	263	24,000*
A-02-02 18ddd2	853	218	281	27,000
A-02-02 19ccb	1208	200	263	40,000
A-02-02 25bca	1441	128	170	33,000
A-02-02 26dbb	3199	126	212	60,000
A-02-02 27dbb	2455	157	211	62,000
A-02-02 28caa	1640	172	205	59,000
A-02-02 29bcb	2489	210	268	48,000
A-02-02 29dbb2	2137	181	232	39,000
A-02-02 31aad	2806	162	193	153,000
A-02-02 32daa	3153	145	238	59,000
A-02-03 07dcc2	452	115	282	5,000*
A-02-03 08bcc2	1836	207	283	99,000
A-02-03 20add2	837	83	223	12,000
A-02-03 20bcc2	778	75	264	9,000
A-02-03 24aad	1300	35	103	93,000
A-02-03 25bbb2	1223	51	99	165,000
A-02-03 25cbb2	930	51	140	60,000
A-02-03 35bbc	1218	67	179	40,000
A-02-04 11adc2	1538	299	403	20,000
A-02-04 11dcc2	2379	382	428	314,000
A-02-04 12daa2	1487	149	407	39,000*
A-02-04 19ddd	853	7	136	41,000*
A-02-04 22dcc	769	347	369	92,000
A-02-04 35bba	589	139	157	96,000
A-02-06 27cbc	3048	391	439	156,000
A-02-06 28ddb	3133	385	419	369,000
A-02-06 31dcc	2912	334	363	112,000
A-02-06 32acb	2330	358	402	107,000
A-02-06 33bab	2899	350	421	383,000
A-03-01 01cdc	1467	365	441	40,000
A-03-01 21ada	2042	245	333	37,000
A-03-01 26add	1861	241	365	15,000
A-03-01 26ddd2	1127	257	404	17,000
A-03-01 27ccc	845	180	236	38,000
A-03-01 33ddd2	1300	169	242	26,000

Well Location	Well Discharge (gpm)	Static Water Level (feet)	Pumping Water Level (feet)	Transmissivity (gpd/ft)
A-03-01 35abb	2693	223	313	56,000
A-03-02 17dcb	1548	305	411	24,000
A-03-02 19ada	900	276	403	22,000
A-03-02 21caa	1216	302	422	31,000
A-03-02 25cad	1030	291	439	20,000
A-03-02 27bbb	684	303	360	17,000
A-03-02 27dbb	720	313	438	17,000
A-03-02 29dda2	1425	271	376	52,000
A-03-02 30ccc2	1860	235	272	41,000
A-03-02 33daa	684	271	376	12,000
A-03-03 30cbc	2758	339	414	324,000
A-03-03 30dcc		333	415	*
D-01-02 03cdd	1242	38	166	28,000
D-01-03 06aaa	2944	134	156	561,000*
D-01-03 06dbb	1167	102	233	171,000*
D-01-04 03bbb2	1041	122	194	36,000
D-01-04 09bdc	1298	193	235	43,000
D-01-04 11add	2518	146	181	88,000
D-01-04 11bcc	2506	133	194	74,000
D-01-04 12acc	2087	146	177	88,000
D-01-04 14ccc2	2503	136	171	131,000
D-01-04 22bcc	2855	134	186	120,000
D-01-04 24aaa	2965	139	201	142,000
D-01-04 36bba	1617	132	147	267,000*
D-01-05 01bab	2303	252	319	82,000
D-01-05 03ccc3	2264	206	299	35,000*
D-01-05 03ddd	3344	206		*
D-01-05 04ccc2	1931	185	261	55,000
D-01-05 07add	2310	140	221	110,000
D-01-05 07acc2	2730	144	181	140,000
D-01-05 08bdd	2206	169	246	120,000*
D-01005 09dbb	2350	188	280	48,000
D-01-05 10ddd2	3061	173	207	115,000
D-01-05 11aaa2	2477	202	282	56,000
D-01-05 12cbb	2062	205	286	42,000
D-01-05 12ccc	3247	174	216	500,000*
D-01-05 15bba	1831	181	271	36,000
D-01-05 19ccc	1575	124	141	290,000*
D-01-05 23bda	2823	235	380	35,000
D-01-05 32cab	2620	188	268	143,000*
D-01-06 03caa	2292	392	440	83,000
D-01-06 05baa	1190	205	239	130,000*
D-01-06 05cab	2693	200	230	384,000
D-01-06 07ddc2	1413	195	214	455,000
D-01-06 07add	2013	208	284	33,000
D-01-06 08ddd	2402	212	301	47,000
D-01-06 17dcc2	2206	227	326	42,000
D-01-06 18ccc2	1723	90	107	492,000
D-01-06 21dbb	2171	276	334	55,000
D-02-05 02bdd	3054	189	211	265,000
D-02-05 04add	2972	166	180	413,000
D-02-05 04dda	2212	203	357	22,000
D-02-05 11ccc	2044	259	312	50,000

1 Well locations are cadastral, by quadrant, township, range, section and ¼ ¼ ¼ section. For further explanation of cadastral location, see Laney, 1978

Water level measurements are expressed in feet below land surface.

* Denotes questionable test results due to mechanical problema with pump, or difficulties with water level measurements.

material type by multiplying the permeability of each unit by its thickness. The transmissivity values obtained for each material type are then summed from the static water level to the total well depth or a specified depth to yield a transmissivity value for the aquifer material represented in the driller log.

Results

Figure 2 illustrates zoned transmissivity values determined from the well testing program combined with those calculated from specific capacity values and from the DWR Driller Log Program. The distribution of high and low transmissivity values reflects, in part, the abrupt facies changes which occur over small distances in alluvial basins. Due to the extreme variation in values obtained from aquifer tests of wells within a few hundred feet of one another, the data points were not contoured. Instead, for the basic data report of the SRV model study, the values were zoned according to ranges of transmissivity in gallons per day foot of aquifer, as follows: low=0 to 25,000; medium=25,000; high=greater than 100,000.

For input to the SRV model, a node grid was placed over the transmissivity zone map and average values over each node were estimated. In a few areas of the model study, particularly the extreme eastern and southern areas, development of the groundwater resource has been minimal and data is insufficient to estimate transmissivity. For modeling purposes, the limited geologic and hydrologic data available in these areas was compared to that of surrounding areas and transmissivity values were approximated accordingly.

Summary

A transmissivity zone map of the Salt River Valley was produced by combining the transmissivity values from the 1979 aquifer testing program with estimated values from specific capacity data and from the DWR Driller Log Program.

In the summer of 1979, aquifer tests were performed on 172 large capacity irrigation wells located within the boundaries of the Salt River Project. Transmissivities were calculated from these tests utilizing direct recovery or residual drawdown methods. Data from the field tests were used to establish a statistical relationship between specific capacity and transmissivity which allowed transmissivity values to be estimated in areas where aquifer tests were not performed but specific capacity information was available. In areas where both transmissivity and specific capacity data were unavailable transmissivity values were estimated from driller log information using the DWR Driller Log Program.

The transmissivity zone map provides a better understanding of the relative values and areal distribution of transmissivity throughout the Salt River Valley and also demonstrates the substantial variations in the Salt River Valley alluvial aquifer which occur over small distances. Increased knowledge of the alluvial aquifer is essential to the further development and management of the groundwater resources in the Salt River Valley.

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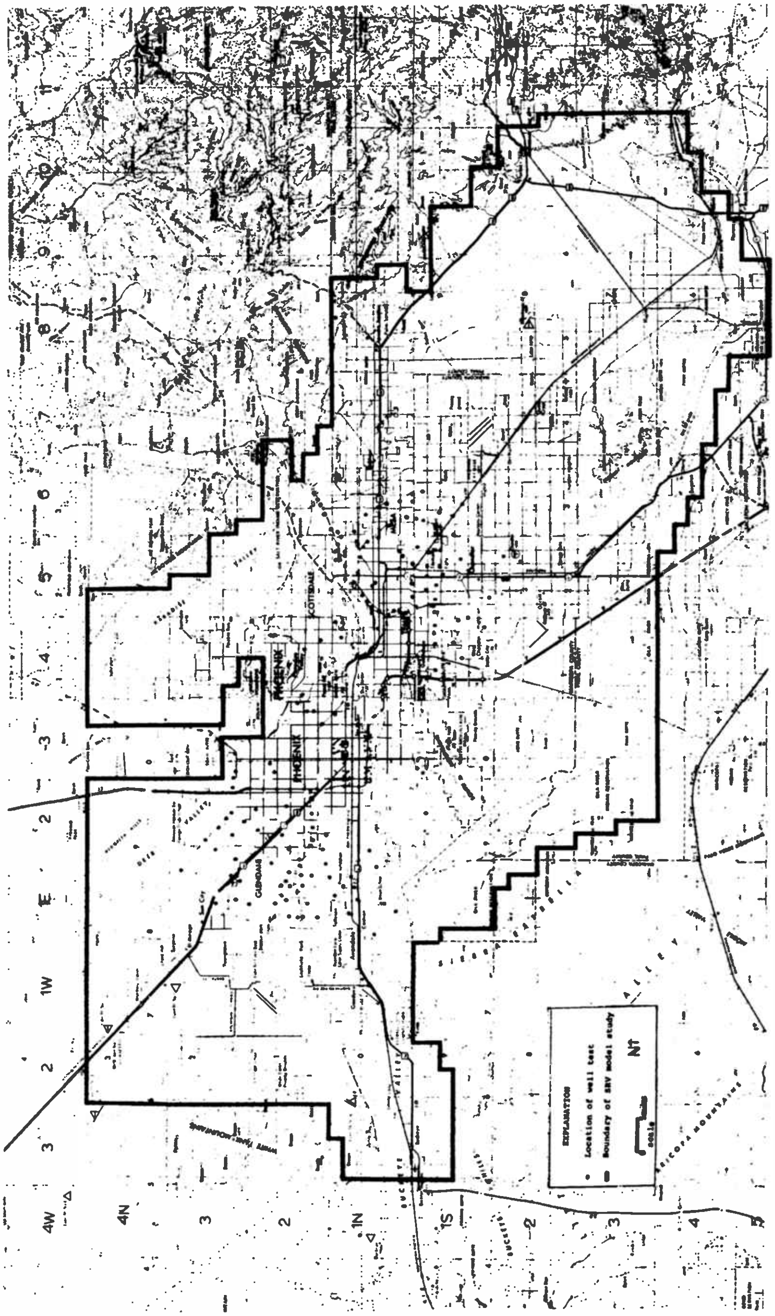

Figure 1. Salt River Valley Model Study Area and Distribution of 1979 Well Recovery Tests

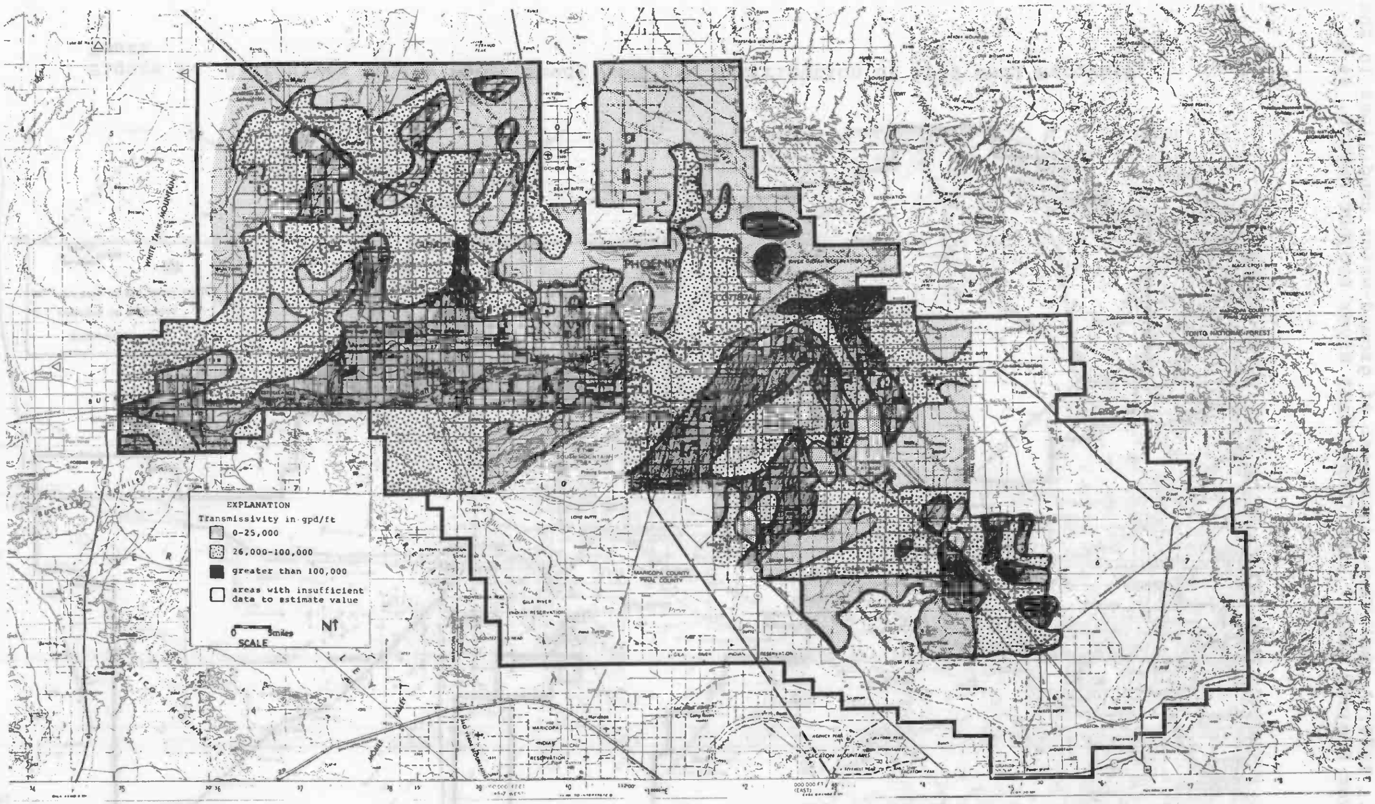

Figure 2. Variations of Transmissivity in the Salt River Valley