GAM run 08-16

by Richard Smith, P.G.
Texas Water Development Board
Groundwater Availability Modeling Section
(512) 936-0877
July 31, 2008

EXECUTIVE SUMMARY:

Groundwater Management Area 1 requested a groundwater availability model run to determine if retaining three different volumes of groundwater after 50 fifty years of pumping in the Ogallala Aquifer in three predetermined geographical subdivisions in Groundwater Management Area 1 (Figure 1) was feasible. They requested 40 percent retention of the starting point volume in fifty years in subdivision 1, 60 percent retention in subdivision 2, and 50 percent retention in subdivision 3. We ran the northern segment of the Ogallala Aquifer groundwater availability model in order to evaluate the three different proposed desired future conditions for the Ogallala Aquifer within Groundwater Management Area 1. We are in the process of running the groundwater availability model for the southern segment of the Ogallala Aquifer and will supplement this report with the additional information for Oldham, Potter, Randall, and Armstrong counties. Future addendums will also include figures showing the water levels by decade and water budget information to show flow in and out of each county to assess flow across the state boundary. We applied annual pumping based on individual cell volumes for each grid cell. After calculating the total volume in each grid cell and adding the recharge, we calculated the pumping rate for each cell that would result in the retention of the desired percent of the volume at the end of fifty years as specified in the request. The results were used to generate a new well file for both models in Groundwater Management Area 1. Pumping rates varied according to aquifer thickness. By 2055, large parts of Dallam, Hartley, and Moore counties and smaller part Sherman County become “dry”. Carson, Gray, and Hutchinson counties also include dry cells by this time. However, the model simulation did achieve the desired future conditions as described in the request.

REQUESTOR:

Mr. Steve Walthour with the North Plains Groundwater Conservation District on behalf of Groundwater Management Area 1.

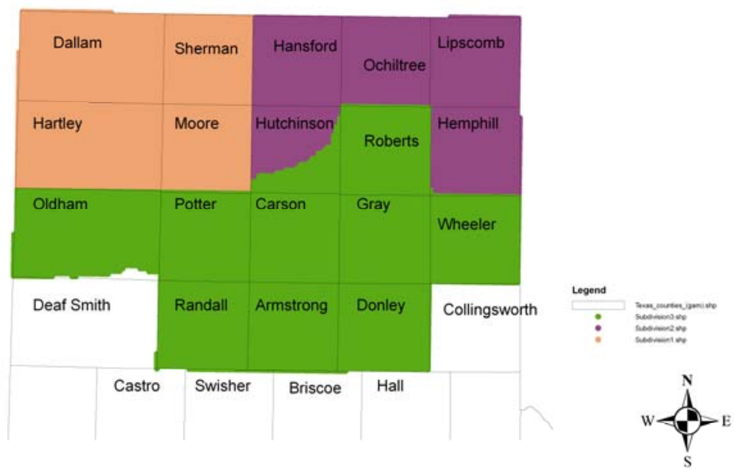


Figure 1. **Subdivisions requested by the groundwater conservation districts in Groundwater Management Area 1.**

DESCRIPTION OF REQUEST:

The groundwater conservation districts in Groundwater Management Area 1 requested a groundwater availability model run to determine if retaining different volumes of groundwater after fifty years of pumping in the Ogallala Aquifer in three subdivisions of the groundwater management area (Figure 1) was feasible. The three subdivisions are as follows:

- Subdivision 1 is comprised of Dallam, Hartley, Moore, and Sherman counties;
- Subdivision 2 is comprised of Hutchinson County north of the Canadian River and Hansford, Lipscomb, Ochiltree, and Hemphill counties; and
- Subdivision 3 is comprised of Hutchinson County south of the Canadian River and Armstrong, Carson, Donley, Gray, Oldham, Potter, Randall, Roberts, and Wheeler counties.

The districts requested that the Texas Water Development Board (TWDB) provide the draft managed available groundwater estimates in the management area based upon the draft desired future condition of the Ogallala Aquifer for each subdivision as follows:

- Subdivision 1 is to achieve at least 40 percent of the 2008 total aquifer storage remaining in 2058. The TWDB shall calculate the amount of managed available groundwater for the 50 year period with an initial amount of available groundwater set at 1,331,500 acre feet for the first year. This starting point will decrease at a fixed percent throughout the 50 years to achieve the desired future condition of the Ogallala Aquifer goal for the subdivision.
- Subdivision 2 is to have at least 60 percent of the total aquifer storage remaining in 2058. The TWDB shall estimate the managed available groundwater volume by reducing the baseline total aquifer storage in each district by no more than one percent. The initial available groundwater will be one percent of the 2005 volume as determined from the model.

- Subdivision 3 is to have at least 50 percent of the baseline total aquifer storage remaining in 2058. TWDB shall estimate the managed available groundwater volume by reducing the total aquifer storage by no more than 1.25 percent annually.

Based on the pumping rates established in GAM Run 07-31 (Smith, November 8, 2007) the districts requested that the area-wide pumping rates be applied to the northern and southern segments of the Ogallala Aquifer groundwater availability models for a fifty year period with 2005 as the baseline year.

METHODS:

To address the request, we did the following steps:

- We selected a stress period in the northern portion of the Ogallala Aquifer model which best approximated water level information and volume information supplied by the North Plains Groundwater Conservation District. The District's 2006 information corresponds to stress period 55 in the model which became the base year.
- Initial pumping rates were calculated on a cell-by-cell basis based on either the volume or maximum percent declines described in the request above plus the average recharge. We then annually decreased pumping by a set percent rate to achieve the desired final volumes of water as described in the request above.
- The pumping rates per grid cell were used to create a new well file which was then used as input to the model.
- The model was run to simulate projections for fifty years.
- Water levels for the base year and final year of the simulation, as well as the base of the aquifer and hydraulic properties, were exported from the model to ArcGIS© to compare and analyze the volume remaining in the aquifer.
- The model was then zoned by county, basin, region, and groundwater conservation district. Pumpage was extracted from the model to develop a table of the managed available groundwater the county, basin, region, and groundwater conservation district/non groundwater conservation district level.

PARAMETERS AND ASSUMPTIONS:

- We used version 2.01 of the groundwater availability model for the northern part of the Ogallala Aquifer (Dutton, 2004) and version 1.01 of the groundwater availability model for the southern part of the Ogallala Aquifer (Blandford and others, 2003),
- See Dutton and others (2001) and Dutton (2004) for assumptions and limitations of the model for the northern part of the Ogallala Aquifer. Root mean squared error for this model is 53 feet. This error has more of an effect on model results where the aquifer is thin.
- See Blandford and others (2003) for assumptions and limitations of the model for the southern part of the Ogallala Aquifer. Root mean squared error for this model

is 47 feet. This error will have more of an effect on model results where the aquifer is thin.

- Recharge was reappraised in the updated model of the northern part of the Ogallala Aquifer (Dutton, 2004).
- Average recharge used in both of the models was based on a percentage of precipitation for the 1950 through 1990 period of record. Since this includes the 1950s drought of record, the average recharge used for this analysis is considered a conservative estimate.
- For Oldham, Randall, Potter, and Armstrong counties, which are partially included in both the northern and southern parts of the Ogallala Aquifer groundwater availability models, we will combine the results of the volume calculation from each model to get full county totals. At this time this report only includes the results from the groundwater availability model for the northern portion of the Ogallala Aquifer. It should be noted that we will use the volume calculated from each model for that segment of the county covered as the starting point for the annual pumping rate calculation which would result in a fifty percent decline over a fifty year period.

RESULTS:

Table 1 gives the starting volumes and the final volumes as calculated from the model at the end of the 50 year simulation for each of the three subdivisions. The rates of decline, percentage decrease in pumping compared with the previous stress period, were adjusted to achieve the desired future condition of the Ogallala Aquifer requested for each subdivision. The starting pumpage was 1.98 percent of the initial volume in Subdivision 1, 1.0 percent in Subdivision 2 and 1.25 percent in Subdivision 3. It should be noted that recharge was added back into the initial value which accounts for a larger initial available groundwater value than a simple one percent or 1.25 percent of the starting volume.

Table 2 shows the different zones tabulated from the model runs. They are summed to achieve county values and, finally, subdivision totals. All numbers are in acre-feet per year. Tables 3, 4 and 5 show the tabulated results for Subdivisions 1, 2, and 3. Recharge was added back into each pumping value for each stress period. The declines are different since the starting volumes and the final requested volumes are different for each subdivision.

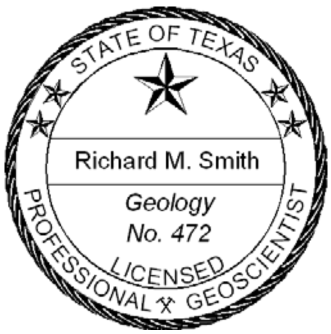
REFERENCES:

Dutton, A., 2004, Adjustments of parameters to improve the calibration of the Og-N model of the Ogallala aquifer, Panhandle Water Planning Area: Bureau of Economic Geology, The University of Texas at Austin, 9 p

Blandford, T.N., Blazer, D.J., Calhoun, K.C., Dutton, A.R., Naing, T., Reedy, R.C., and Scanlon, B.R., 2003, Groundwater availability of the southern Ogallala aquifer in Texas and New Mexico—Numerical Simulations Through 2050: Final Report prepared for the Texas Water Development Board by Daniel B. Stephens & Associates, Inc., 158 p.

Dutton, A., Reedy, R., and Mace, R., 2001, Saturated thickness of the Ogallala aquifer in the Panhandle Water Planning Area—Simulation of 2000 through 2050 Withdrawal Projections: prepared for the Panhandle Water Planning Group by the Bureau of Economic Geology, The University of Texas at Austin, 54 p.

Smith, R, 2007, GAM Run 07-31, Texas Water Development Board, 23 p.



The seal appearing on this document was authorized by Richard M. Smith, P.G., on July 31, 2008.

Table 1: Volumes within each Subdivision with decline rates and final percentages.

Subdivision	Initial volumes in acre-feet	Final volumes in acre-feet	Decline rate	Final percentage remaning
1	67,232,816	26,993,975	0.0124	0.401
2	81,943,828	49,092,547	0.0075	0.599
3	77,457,472	38,775,210	0.0039	0.501

Table 2: Zones used to tabulate the final results.

Zone	County	Groundwater Conservation District	River basin
2	Dallam	North Plains coverage	Canadian
3	Dallam	No North Plains - White areas	Canadian
4	Sherman	North Plains coverage	Canadian
5	Lipscomb	North Plains coverage	Canadian
6	Ochiltree	North Plains coverage	Canadian
7	Hansford	North Plains coverage	Canadian
8	Roberts	Panhandle coverage	Canadian
9	Roberts	Panhandle coverage	Red
10	Hartley	North Plains coverage	Canadian
11	Hartley	No North Plains - White areas	Canadian
12	Moore	North Plains coverage	Canadian
13	Moore	No North Plains - White areas	Canadian
14	Hutchinson	North Plains coverage	Canadian
15	Hutchinson	No North Plains - White areas	Canadian
16	Hutchinson	Panhandle coverage	Canadian
17	Hemphill	Hemphill	Canadian
18	Hemphill	Hemphill	Red
19	Carson	Panhandle coverage	Canadian
20	Carson	Panhandle coverage	Red
21	Gray	Panhandle coverage	Red
22	Gray	Panhandle coverage	Canadian
23	Potter	Panhandle coverage	Canadian
24	Potter	High Plains coverage	Canadian
25	Wheeler	Panhandle coverage	Red
26	Oldham	No coverage	Canadian
27	Potter	Panhandle coverage	Red
28	Potter	High Plains coverage	Red
29	Randall	High Plains coverage	Red
30	Donley	Panhandle coverage	Red
31	Armstrong	Panhandle coverage	Red
32	Armstrong	High Plains coverage	Red
33	Randall	No Coverage	Red
34	Hutchinson	No Coverage	Canadian - south
1	Outside the GMA		

Year	Dallam - North Plains	Dallam - White Areas	Dallam Total	Sherman	Sherman Total	Hartley-North Plains	Harley - White Areas	Hartley Total	Moore - North Plains	Moore-White Areas	Moore - Total	Subdivision I -Total Managed Available Groundwater
2009	338,740	82,680	421,420	266,624	266,624	365,974	57,860	423,835	216,865	35,710	252,575	1,364,454
2010	333,113	81,664	414,777	263,339	263,339	360,889	56,559	417,448	212,418	34,382	246,800	1,342,364
2011	325,797	80,662	406,459	260,093	260,093	355,584	55,572	411,156	208,929	32,788	241,717	1,319,426
2012	318,918	79,671	398,589	256,890	256,890	350,640	54,889	405,529	205,495	31,229	236,724	1,297,731
2013	312,984	78,692	391,676	253,723	253,723	345,474	54,213	399,687	201,266	30,274	231,540	1,276,626
2014	305,761	77,727	383,488	250,600	250,600	341,235	52,705	393,940	197,388	29,338	226,725	1,254,754
2015	298,061	76,771	374,832	247,512	247,512	336,203	51,780	387,983	193,298	28,141	221,439	1,231,766
2016	290,265	75,830	366,094	244,463	244,463	331,250	50,596	381,846	189,826	26,143	215,970	1,208,373
2017	281,772	74,899	356,671	241,453	241,453	326,914	49,974	376,888	186,679	24,190	210,869	1,185,881
2018	273,442	73,980	347,423	238,481	238,481	322,102	48,025	370,127	182,781	23,087	205,868	1,161,899
2019	265,292	72,809	338,101	235,544	235,544	317,096	46,644	363,740	178,698	22,539	201,237	1,138,622
2020	258,050	71,915	329,965	232,643	232,643	312,942	44,248	357,190	175,200	22,000	197,200	1,116,999
2021	250,201	70,777	320,978	229,781	229,781	309,108	43,447	352,555	169,727	21,471	191,198	1,094,512
2022	240,689	69,655	310,344	226,698	226,698	305,061	41,388	346,450	165,850	20,697	186,547	1,070,039
2023	233,171	68,801	301,972	223,908	223,908	300,548	39,875	340,423	161,824	19,433	181,256	1,047,559
2024	225,807	67,957	293,763	221,151	221,151	296,111	39,385	335,495	157,855	18,696	176,551	1,026,960
2025	218,823	67,124	285,947	217,941	217,941	292,480	38,166	330,646	153,968	17,481	171,450	1,005,984
2026	212,709	66,058	278,767	215,258	215,258	288,644	35,761	324,404	150,862	16,049	166,911	985,340
2027	207,199	64,771	271,970	212,609	212,609	284,632	33,887	318,519	147,339	14,891	162,230	965,328
2028	201,577	63,979	265,556	209,996	209,996	280,197	32,290	312,487	144,353	13,995	158,349	946,388
2029	194,140	63,194	257,334	207,410	207,410	276,527	30,728	307,255	141,416	13,354	154,770	926,769
2030	188,488	62,420	250,908	204,859	204,859	273,140	29,660	302,800	138,072	12,495	150,566	909,133
2031	182,949	61,655	244,604	202,340	202,340	269,569	28,386	297,955	136,150	11,427	147,577	892,477
2032	178,442	60,677	239,118	199,853	199,853	265,600	26,691	292,291	132,913	9,935	142,849	874,110
2033	171,524	59,478	231,002	197,395	197,395	262,345	24,815	287,159	130,400	9,368	139,768	855,324

Table 3: Subdivision 1 totals in acre-feet per year. Initial volume = 67,232,816, final volume =26,993,975, decline rate =1.24 percent per year. Because of cells that have become inactive the overall decline rate for the subdivision is not exactly 1.24 percent per year.

Year	Dallam - North Plains	Dallam - White Areas	Dallam Total	Sherman	Sherman Total	Hartley-North Plains	Harley - White Areas	Hartley Total	Moore - North Plains	Moore-White Areas	Moore - Total	Subdivision I -Total Managed Available Groundwater
2034	166,306	58,749	225,055	194,967	194,967	258,686	24,071	282,757	127,711	8,812	136,523	839,302
2035	161,203	57,808	219,012	192,353	192,353	255,307	22,702	278,009	125,709	8,486	134,195	823,568
2036	157,076	56,674	213,750	189,991	189,991	251,753	21,140	272,893	123,309	7,952	131,261	807,894
2037	151,322	55,119	206,441	187,446	187,446	248,461	20,669	269,130	120,960	7,429	128,389	791,407
2038	145,031	54,229	199,261	184,934	184,934	245,419	19,790	265,209	118,648	6,918	125,566	774,970
2039	137,586	53,354	190,940	182,458	182,458	242,203	18,933	261,136	115,967	6,216	122,183	756,718
2040	133,649	52,702	186,350	180,217	180,217	238,631	18,498	257,129	113,532	5,525	119,057	742,754
2041	128,972	51,645	180,617	177,805	177,805	235,312	17,472	252,783	111,736	5,457	117,193	728,399
2042	123,570	50,611	174,180	175,427	175,427	232,037	17,257	249,294	109,181	5,390	114,572	713,473
2043	119,856	49,594	169,450	173,074	173,074	228,609	15,877	244,486	107,055	5,127	112,183	699,192
2044	116,817	48,402	165,219	170,760	170,760	225,042	14,908	239,950	104,779	4,479	109,258	685,187
2045	112,852	47,232	160,084	168,663	168,663	221,909	14,534	236,443	103,492	4,042	107,534	672,725
2046	108,615	46,088	154,704	166,404	166,404	219,011	14,356	233,367	101,474	3,806	105,280	659,755
2047	104,629	44,768	149,397	164,361	164,361	215,962	13,807	229,769	99,665	3,384	103,049	646,577
2048	101,480	43,847	145,327	162,157	162,157	213,324	13,453	226,777	97,341	3,157	100,498	634,759
2049	98,202	42,573	140,775	159,987	159,987	210,172	12,743	222,914	93,793	3,118	96,912	620,588
2050	94,803	41,873	136,675	158,022	158,022	207,247	12,050	219,298	92,107	2,356	94,463	608,458
2051	91,484	41,002	132,486	155,907	155,907	204,365	11,193	215,558	90,272	2,327	92,599	596,550
2052	88,759	40,502	129,260	153,646	153,646	201,872	11,056	212,927	88,990	2,299	91,289	587,123
2053	85,733	39,651	125,384	151,762	151,762	198,719	10,227	208,947	87,037	1,747	88,784	574,876
2054	82,410	38,995	121,406	149,727	149,727	195,602	9,931	205,533	84,776	1,725	86,502	563,167
2055	80,199	38,007	118,206	147,556	147,556	192,873	9,640	202,513	83,399	1,704	85,103	553,379
2056	78,204	36,862	115,066	145,748	145,748	190,183	9,523	199,706	81,214	1,684	82,898	543,417
2057	74,882	36,247	111,129	143,633	143,633	187,365	9,076	196,441	79,403	1,663	81,066	532,270
2058	72,815	35,475	108,290	141,555	141,555	184,597	8,639	193,237	77,457	1,643	79,100	522,182

Table 3: Subdivision 1 totals in acre-feet per year. Initial volume = 67,232,816, final volume =26,993,975, decline rate =1.24 percent per year. Because of cells that have become inactive the overall decline rate for the subdivision is not exactly 1.24 percent per year.

Year	Hutchinson-North Plains	Hutchinson - White Areas	Hutchinson-Total	Hansford-Total	Lipscomb-Total	Ochiltree-Total	Hemphill-Canadian	Hemphill-Red	Hemphill - Total	Subdivision 2-Total
2009	45,155	38,048	83,204	218,076	180,453	189,843	86,154	77,377	163,531	835,106
2010	44,814	37,770	82,584	216,462	179,155	188,444	85,553	76,877	162,429	829,073
2011	44,475	37,493	81,969	214,860	177,866	187,055	84,957	76,380	161,336	823,086
2012	44,139	37,219	81,358	213,270	176,586	185,677	84,365	75,887	160,252	817,143
2013	43,806	36,947	80,753	211,692	175,316	184,309	83,777	75,398	159,175	811,245
2014	43,475	36,677	80,152	210,126	174,056	182,952	83,194	74,912	158,106	805,392
2015	43,147	36,409	79,556	208,572	172,805	181,604	82,615	74,429	157,045	799,581
2016	42,822	36,143	78,964	207,029	171,563	180,267	82,041	73,950	155,992	793,815
2017	42,499	35,879	78,377	205,498	170,331	178,940	81,471	73,475	154,946	788,093
2018	42,178	35,617	77,795	203,978	169,109	177,622	80,905	73,003	153,909	782,413
2019	41,860	35,357	77,217	202,470	167,895	176,315	80,344	72,535	152,879	776,775
2020	41,545	35,099	76,644	200,973	166,690	175,017	79,786	72,069	151,856	771,180
2021	41,232	34,842	76,075	199,488	165,494	173,729	79,234	71,608	150,841	765,627
2022	40,922	34,588	75,510	198,013	164,308	172,451	78,685	71,149	149,834	760,115
2023	40,614	34,336	74,950	196,549	163,130	171,182	78,140	70,694	148,834	754,645
2024	40,308	34,086	74,394	195,097	161,961	169,923	77,599	70,242	147,841	749,216
2025	40,005	33,837	73,842	193,656	160,801	168,673	77,062	69,794	146,856	743,828
2026	39,704	33,591	73,295	192,225	159,649	167,433	76,530	69,349	145,878	738,480
2027	39,169	33,346	72,515	190,805	158,507	166,202	76,001	68,906	144,907	732,936
2028	38,876	33,104	71,980	189,395	157,372	164,980	75,476	68,468	143,944	727,671
2029	38,585	32,863	71,448	187,996	156,247	163,767	74,955	68,032	142,988	722,445
2030	38,296	32,623	70,920	186,608	155,129	162,564	74,439	67,599	142,038	717,259
2031	38,010	32,386	70,396	185,230	154,021	161,369	73,925	67,170	141,095	712,111
2032	37,726	32,151	69,876	183,862	152,920	160,184	73,416	66,744	140,160	707,002
2033	37,444	31,917	69,361	182,505	151,827	159,007	72,911	66,321	139,232	701,932

Table 4: Subdivision 2 totals in acre-feet per year. Initial volume = 81,943,828, final volume = 49,092,547, decline rate = 0.75 percent per year. Because of cells that have become inactive the overall decline rate for the subdivision is not exactly 0.75 percent per year

Year	Hutchinson-North Plains	Hutchinson - White Areas	Hutchinson-Total	Hansford-Total	Lipscomb-Total	Ochiltree-Total	Hemphill-Canadian	Hemphill-Red	Hemphill - Total	Subdivision 2-Total
2034	37,164	31,685	68,849	181,158	150,743	157,839	72,410	65,900	138,310	696,899
2035	36,886	31,455	68,341	179,821	149,667	156,680	71,912	65,483	137,395	691,905
2036	36,611	31,226	67,837	178,494	148,599	155,530	71,418	65,069	136,487	686,947
2037	36,338	31,000	67,337	177,177	147,539	154,388	70,927	64,658	135,585	682,026
2038	36,066	30,775	66,841	175,869	146,487	153,255	70,441	64,250	134,691	677,143
2039	35,797	30,551	66,349	174,572	145,443	152,130	69,958	63,845	133,802	672,296
2040	35,329	30,330	65,659	173,285	144,407	151,014	69,478	63,443	132,921	667,285
2041	35,066	30,110	65,176	172,006	143,378	149,906	69,002	63,043	132,046	662,513
2042	34,806	29,892	64,698	170,738	142,358	148,806	68,530	62,647	131,177	657,777
2043	34,548	29,675	64,223	169,460	141,345	147,715	68,062	62,253	130,315	653,057
2044	34,291	29,460	63,751	168,211	140,339	146,632	67,596	61,862	129,459	648,392
2045	34,037	29,247	63,284	166,971	139,341	145,557	67,135	61,474	128,609	643,761
2046	33,784	29,035	62,819	165,740	138,351	144,490	66,677	61,089	127,766	639,166
2047	33,534	28,825	62,359	164,519	137,368	143,431	66,222	60,707	126,929	634,605
2048	33,285	28,617	61,902	163,306	136,392	142,380	65,770	60,327	126,098	630,077
2049	33,039	28,410	61,448	162,103	135,423	141,337	65,322	59,951	125,273	625,584
2050	32,767	28,204	60,971	160,909	134,462	140,301	64,878	59,576	124,454	621,098
2051	32,524	28,000	60,525	159,724	133,508	139,274	64,436	59,205	123,641	616,672
2052	32,283	27,798	60,082	158,548	132,562	138,254	63,998	58,836	122,835	612,279
2053	32,044	27,598	59,642	157,380	131,622	137,242	63,564	58,470	122,034	607,919
2054	31,807	27,398	59,206	156,221	130,689	136,237	63,132	58,107	121,239	603,592
2055	31,547	27,201	58,747	155,071	129,764	135,240	62,704	57,746	120,450	599,272
2056	31,282	27,004	58,287	153,930	128,845	134,250	62,279	57,388	119,667	594,978
2057	31,051	26,810	57,861	152,797	127,933	133,268	61,857	57,032	118,889	590,748
2058	30,801	26,616	57,418	151,672	127,028	132,293	61,439	56,679	118,118	586,529

Table 4: Subdivision 2 totals in acre-feet per year. Initial volume = 81,943,828, final volume = 49,092,547, decline rate = 0.75 percent per year. Because of cells that have become inactive the overall decline rate for the subdivision is not exactly 0.75 percent per year.

year	Hutchinson-South of Canadian	Armstrong-Pan H	Carson-Canadian	Carson-Red	Carson Total	Donley	Gray-Red	Gray - Canadian	Gray Total	Oldham
2009	26,077	46,070	76,225	101,547	177,772	71,096	126,362	38,721	165,083	12,620
2010	26,000	45,903	75,945	101,157	177,102	70,856	125,910	38,574	164,484	12,503
2011	25,922	45,737	75,666	100,769	176,435	70,617	125,460	38,428	163,887	12,387
2012	25,846	45,572	75,388	100,382	175,770	70,379	125,011	38,282	163,293	12,273
2013	25,769	45,407	75,111	99,996	175,107	70,141	124,564	38,138	162,701	12,159
2014	25,693	45,243	74,835	99,613	174,448	69,905	124,118	37,993	162,111	11,487
2015	25,617	45,080	74,560	99,230	173,790	69,669	123,675	37,849	161,524	11,383
2016	25,541	44,917	74,286	98,849	173,136	69,434	123,233	37,706	160,939	11,280
2017	25,465	44,755	74,013	98,470	172,483	69,201	122,793	37,564	160,356	10,909
2018	25,390	44,593	73,742	98,092	171,834	68,968	122,354	37,421	159,776	10,812
2019	25,315	44,432	73,471	97,716	171,187	68,736	121,918	37,280	159,198	10,716
2020	25,241	44,272	73,202	97,341	170,543	68,505	121,483	37,139	158,622	10,100
2021	25,167	44,112	72,933	96,967	169,900	68,275	121,049	36,998	158,048	10,013
2022	25,093	43,953	72,666	96,595	169,261	68,046	120,618	36,859	157,476	9,673
2023	25,019	43,795	72,399	96,225	168,624	67,817	120,188	36,719	156,907	9,339
2024	24,945	43,637	72,134	95,856	167,990	67,590	119,760	36,580	156,340	9,261
2025	24,872	43,480	71,870	95,488	167,358	67,363	119,333	36,442	155,775	8,694
2026	24,800	43,323	71,606	95,122	166,728	67,138	118,908	36,304	155,213	8,140
2027	24,727	43,167	71,344	94,757	166,101	66,913	118,485	36,167	154,652	7,837
2028	24,655	43,012	71,083	94,394	165,476	66,689	118,063	36,030	154,094	7,777
2029	24,583	42,857	70,823	94,031	164,854	66,466	117,643	35,894	153,538	7,717
2030	24,511	42,703	70,563	93,671	164,234	66,244	117,225	35,759	152,984	7,428
2031	24,440	42,550	70,305	93,312	163,617	66,023	116,809	35,624	152,432	7,372
2032	24,368	42,397	70,048	92,954	163,002	65,802	116,394	35,489	151,883	7,317
2033	24,298	42,244	69,792	92,598	162,389	65,583	115,980	35,355	151,335	7,263

Table 5: Subdivision 3 totals in acre-feet per year. Initial volume = 77,457,472 final volume =38,775,210 decline rate = 0.39 percent per year. Because of cells that have become inactive the overall decline rate for the subdivision is not exactly 0.39 percent per year. Armstrong, Randall and Potter counties have not been totally tabulated since the Southern Ogallala model run has not been completed.

year	Hutchinson-South of Canadian	Armstrong-Pan H	Carson-Canadian	Carson-Red	Carson Total	Donley	Gray-Red	Gray - Canadian	Gray Total	Oldham
2034	24,227	42,093	69,537	92,243	161,779	65,364	115,568	35,222	150,790	7,209
2035	24,157	41,942	69,282	91,889	161,172	65,146	115,158	35,089	150,247	7,156
2036	24,087	41,791	69,029	91,537	160,566	64,929	114,749	34,956	149,706	7,103
2037	24,017	41,641	68,777	91,186	159,963	64,713	114,342	34,824	149,167	6,416
2038	23,947	41,492	68,526	90,837	159,362	64,498	113,937	34,693	148,630	6,372
2039	23,878	41,343	68,275	90,488	158,764	64,283	113,533	34,562	148,095	6,329
2040	23,809	41,195	68,026	90,142	158,168	64,069	113,131	34,431	147,562	6,286
2041	23,740	41,047	67,778	89,796	157,574	63,857	112,730	34,302	147,032	5,841
2042	23,672	40,900	67,531	89,452	156,983	63,645	112,331	34,172	146,503	5,605
2043	23,604	40,753	67,284	89,110	156,394	63,433	111,933	34,043	145,977	5,571
2044	23,536	40,607	67,039	88,768	155,807	63,223	111,537	33,915	145,452	5,537
2045	23,468	40,462	66,794	88,428	155,222	63,014	111,143	33,787	144,930	5,503
2046	23,401	40,317	66,551	88,089	154,640	62,805	110,750	33,660	144,410	5,469
2047	23,334	40,173	66,308	87,752	154,060	62,597	110,358	33,533	143,891	5,436
2048	23,267	40,029	66,067	87,416	153,483	62,390	109,969	33,406	143,375	5,403
2049	23,200	39,886	65,826	87,081	152,907	62,184	109,580	33,281	142,861	5,188
2050	23,134	39,744	65,586	86,748	152,334	61,978	109,193	33,155	142,348	4,978
2051	23,068	39,602	65,347	86,416	151,763	61,774	108,808	33,030	141,838	4,950
2052	23,002	39,460	65,110	86,085	151,194	61,570	108,424	32,906	141,330	4,923
2053	22,937	39,319	64,873	85,755	150,628	61,367	108,042	32,723	140,764	4,723
2054	22,871	39,179	64,637	85,427	150,063	61,164	107,661	32,599	140,260	4,698
2055	22,806	39,039	64,402	85,100	149,501	60,963	107,282	32,477	139,758	4,673
2056	22,742	38,900	64,167	84,774	148,942	60,762	106,904	32,354	139,258	4,649
2057	22,677	38,761	63,934	84,450	148,384	60,562	106,527	32,232	138,760	4,625
2058	22,613	38,580	63,702	84,126	147,828	60,363	106,152	32,111	138,263	4,601

Table 5: Subdivision 3 totals in acre-feet per year. Initial volume = 77,457,472 final volume =38,775,210 decline rate = 0.39 percent per year. Because of cells that have become inactive the overall decline rate for the subdivision is not exactly 0.39 percent per year. Armstrong, Randall and Potter counties have not been totally tabulated since the Southern Ogallala model run has not been completed.

year	Potter - Pan H - red	Potter- High P- Red	Potter- Pan h Can	Potter - High p- Can	Potter Total	Randall High P - Red	Randall- No Coverage	Randall Total	Roberts Canadian	Roberts - Red	Roberts Total	Wheeler	Subdivision 3 total
2009	8,343	130	26,697	62	35,232	6,962	11,470	18,432	329,926	7,531	337,457	85,177	975,017
2010	8,311	130	26,579	61	35,082	6,936	11,427	18,362	328,705	7,502	336,207	84,909	971,409
2011	8,280	129	26,462	61	34,932	6,909	11,384	18,293	327,488	7,474	334,962	84,642	967,815
2012	8,249	129	26,345	61	34,784	6,883	11,341	18,224	326,276	7,445	333,721	84,376	964,237
2013	8,218	129	26,230	61	34,637	6,857	11,299	18,155	325,069	7,417	332,486	84,111	960,674
2014	8,187	128	26,115	60	34,490	6,831	11,256	18,087	323,866	7,389	331,255	83,847	956,565
2015	8,156	128	26,000	60	34,344	6,805	11,214	18,018	322,668	7,361	330,029	83,584	953,038
2016	8,125	127	25,887	60	34,199	6,779	11,172	17,950	321,475	7,333	328,808	83,323	949,527
2017	8,094	127	25,774	60	34,055	6,753	11,130	17,883	320,286	7,305	327,591	83,062	945,760
2018	8,064	126	25,661	60	33,911	6,727	11,088	17,815	319,103	7,277	326,379	82,802	942,281
2019	8,034	126	25,550	59	33,769	6,701	11,047	17,748	317,923	7,249	325,172	82,543	938,817
2020	8,003	125	25,439	59	33,627	6,676	11,005	17,681	316,748	7,222	323,970	82,285	934,846
2021	7,973	125	25,329	59	33,486	6,651	10,964	17,614	315,578	7,194	322,772	82,029	931,416
2022	7,943	124	25,219	59	33,346	6,625	10,923	17,548	314,413	7,167	321,580	81,773	927,748
2023	7,913	124	25,110	59	33,206	6,600	10,882	17,482	313,252	7,139	320,391	81,518	924,099
2024	7,883	123	25,002	59	33,068	6,575	10,841	17,416	312,095	7,112	319,208	81,264	920,719
2025	7,854	123	24,895	58	32,930	6,550	10,801	17,350	310,943	7,085	318,029	81,011	916,863
2026	7,824	123	24,545	58	32,550	6,525	10,760	17,285	309,796	7,058	316,854	80,760	912,789
2027	7,795	122	24,205	58	32,180	6,500	10,720	17,220	308,653	7,031	315,684	80,509	908,990
2028	7,765	122	23,868	58	31,813	6,475	10,680	17,155	307,514	7,005	314,519	80,259	905,449
2029	7,736	121	23,543	58	31,458	6,451	10,640	17,090	306,380	6,978	313,358	80,010	901,931
2030	7,707	121	23,450	57	31,335	6,426	10,600	17,026	305,250	6,951	312,202	79,762	898,429
2031	7,678	120	23,357	57	31,213	6,402	10,560	16,962	304,125	6,925	311,050	79,515	895,173
2032	7,649	120	23,265	57	31,092	6,377	10,521	16,898	303,004	6,899	309,903	79,269	891,931
2033	7,621	120	23,174	57	30,971	6,353	10,481	16,834	301,888	6,872	308,760	79,024	888,701

Table 5: Subdivision 3 totals in acre-feet per year. Initial volume = 77,457,472 final volume =38,775,210 decline rate = 0.39 percent per year. Because of cells that have become inactive the overall decline rate for the subdivision is not exactly 0.39 percent per year. Armstrong, Randall and Potter counties have not been totally tabulated since the Southern Ogallala model run has not been completed.

.

year	Potter - Pan H - red	Potter-high P-Red	Potter-Pan h Can	Potter - High p-Can	Potter Total	Randall High P - Red	Randall-No Coverage	Randall Total	Roberts Canadian	Roberts - Red	Roberts Total	Wheeler	Subdivision 3 total
2034	7,592	119	23,083	57	30,850	6,329	10,442	16,771	300,776	6,846	307,622	78,780	885,485
2035	7,563	119	22,992	56	30,731	6,305	10,403	16,708	299,668	6,820	306,488	78,537	882,281
2036	7,535	118	22,687	56	30,397	6,281	10,364	16,645	298,564	6,794	305,359	78,295	878,876
2037	7,507	118	22,600	56	30,281	6,257	10,325	16,582	297,465	6,769	304,233	78,053	875,066
2038	7,478	117	22,514	56	30,165	6,233	10,287	16,520	296,370	6,743	303,113	77,813	871,912
2039	7,450	117	22,428	56	30,051	6,210	10,248	16,458	295,279	6,717	301,997	77,574	868,770
2040	7,422	117	22,342	55	29,936	6,186	10,210	16,396	294,193	6,692	300,885	77,335	865,641
2041	7,394	116	22,055	55	29,620	6,162	10,172	16,334	293,111	6,666	299,777	77,098	861,921
2042	7,367	116	21,972	55	29,510	6,139	10,134	16,273	292,033	6,641	298,674	76,861	858,625
2043	7,339	115	21,890	55	29,399	6,116	10,096	16,212	290,959	6,616	297,575	76,626	855,543
2044	7,311	115	21,809	55	29,290	6,092	10,058	16,151	289,890	6,591	296,480	76,391	852,474
2045	7,284	114	21,727	55	29,180	6,069	10,021	16,090	288,824	6,566	295,390	76,157	849,417
2046	7,257	114	21,460	54	28,885	6,046	9,983	16,029	287,763	6,541	294,304	75,924	846,184
2047	7,229	114	21,382	54	28,779	6,023	9,946	15,969	286,706	6,516	293,222	75,692	843,154
2048	7,202	113	21,304	54	28,673	6,000	9,909	15,909	285,653	6,491	292,144	75,461	840,135
2049	7,175	113	21,226	54	28,568	5,978	9,872	15,849	284,604	6,466	291,070	75,231	836,946
2050	7,148	112	21,149	54	28,464	5,955	9,835	15,790	283,559	6,442	290,001	75,002	833,773
2051	7,122	112	21,072	54	28,359	5,932	9,798	15,731	282,519	6,417	288,936	74,774	830,795
2052	7,095	112	20,996	53	28,256	5,910	9,762	15,672	281,482	6,393	287,875	74,546	827,828
2053	7,068	111	20,920	53	28,152	5,887	9,725	15,613	280,449	6,369	286,818	74,319	824,640
2054	7,042	111	20,844	53	28,049	5,865	9,689	15,554	279,421	6,345	285,765	74,094	821,699
2055	7,015	110	20,768	53	27,947	5,843	9,653	15,496	278,396	6,321	284,717	73,869	818,770
2056	6,989	110	20,693	53	27,845	5,821	9,617	15,438	277,376	6,297	283,672	73,645	815,852
2057	6,963	110	20,587	52	27,712	5,799	9,581	15,380	276,359	6,273	282,632	73,422	812,915
2058	6,919	109	20,513	52	27,593	5,777	9,545	15,322	275,346	6,249	281,595	73,200	809,959

Table 5: Subdivision 3 totals in acre-feet per year. Initial volume = 77,457,472 final volume =38,775,210 decline rate = 0.39 percent per year. Because of cells that have become inactive the overall decline rate for the subdivision is not exactly 0.39 percent per year. Armstrong, Randall and Potter counties have not been totally tabulated since the Southern Ogallala model run has not been completed.