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Table 3A: Colorado's Five-Year Average Allocation and CBCU

Year	Allocation	Computed Beneficial Consumptive Use	Imported Water Supply Credit	Allocation - (CBCU - IWS Credit)
2003	21,420	33,470	NA	(12,050)
2004	21,540	33,670	NA	(12,130)
2005	21,430	31,550	NA	(10,120)
2006			NA	
2007			NA	
Average	21,460	32,900		(11,430)
Sum				(34,300)

Table 3B: Kansas's Five-Year Average Allocation and CBCU

Year	Allocation	Computed Beneficial Consumptive Use	Imported Water Supply Credit	Allocation - (CBCU - IWS Credit)
2003	167,780	48,910	NA	118,870
2004	137,450	38,120	NA	99,330
2005	117,670	50,820	NA	66,850
2006			NA	
2007			NA	
Average	140,970	45,950		95,020
Sum				285,050

Table 3C: Nebraska's Five-Year Average Allocation and CBCU

Year	Allocation	Computed Beneficial Consumptive Use	Imported Water Supply Credit	Allocation - (CBCU - IWS Credit)
2003	227,580	262,780	9,780	(25,420)
2004	205,630	252,650	10,380	(36,640)
2005	198,940	252,690	11,965	(41,785)
2006	182,820	226,680	11,486	(32,374)
2007				
Average	203,740	248,700	10,900	(34,050)
Sum				(136,219)

p10

Table 3A: Colorado's Five-Year Average Allocation and CBCU

Year	Allocation	Computed Beneficial Consumptive Use	Imported Water Supply Credit	Allocation - (CBCU - IWS Credit)
2003	21,410	33,470	NA	(12,060)
2004	21,590	33,670	NA	(12,130)
2005	21,430	31,550	NA	(10,120)
2006			NA	
2007			NA	
Average	21,480	32,900		(11,440)
Sum				(34,310)

Table 3B: Kansas's Five-Year Average Allocation and CBCU

Year	Allocation	Computed Beneficial Consumptive Use	Imported Water Supply Credit	Allocation - (CBCU - IWS Credit)
2003	158,630	48,910	NA	109,720
2004	128,710	38,120	NA	99,330
2005	109,510	50,820	NA	58,690
2006			NA	
2007			NA	
Average	132,280	45,950		89,250
Sum				267,740

Table 3C: Nebraska's Five-Year Average Allocation and CBCU

Year	Allocation	Computed Beneficial Consumptive Use	Imported Water Supply Credit	Allocation - (CBCU - IWS Credit)
2003	218,750	244,790	9,780	(16,260)
2004	197,230	235,560	10,380	(27,950)
2005	191,160	236,930	11,965	(33,805)
2006	174,980	210,680	11,486	(24,214)
2007				
Average	195,530	231,990	10,900	(25,560)
Sum				(102,229)

New

9160
8690
8519
8160
8630

$\bar{x}$ 8789

78,015

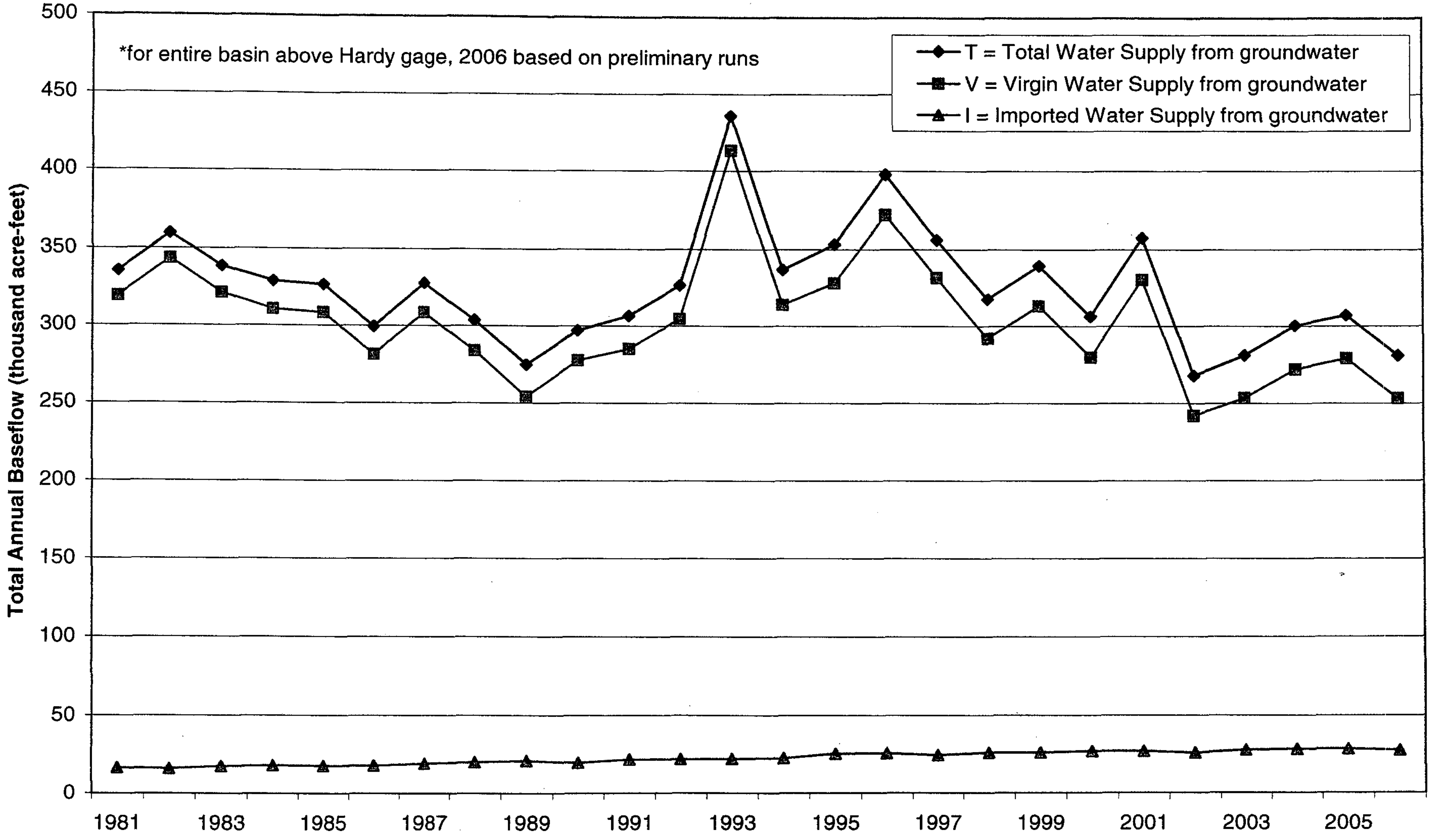
D 35,830

* This is a study of the methodology used to calculate the mound credit and the impact to baseflows due
* It was found that there are two different ways of getting to the right answer for the virgin water supply, v
  Care must be taken to assure the affects of pumping or the mound are not double-counted when calcul
  therefore, there are two distinct ways of calculating the impact and imported water credit:

1) MOUND: (NE Pumping on, Mound on) minus (NE Pumping on, Mound off)
   NE IMP: (NE Pumping off, Mound on) minus (NE Pumping off, Mound on)
2) MOUND: (NE Pumping off, Mound on) minus (NE pumping off, Mound off)
   NE IMP: (NE Pumping On, Mound on) minus (NE Pumping on, Mound off)

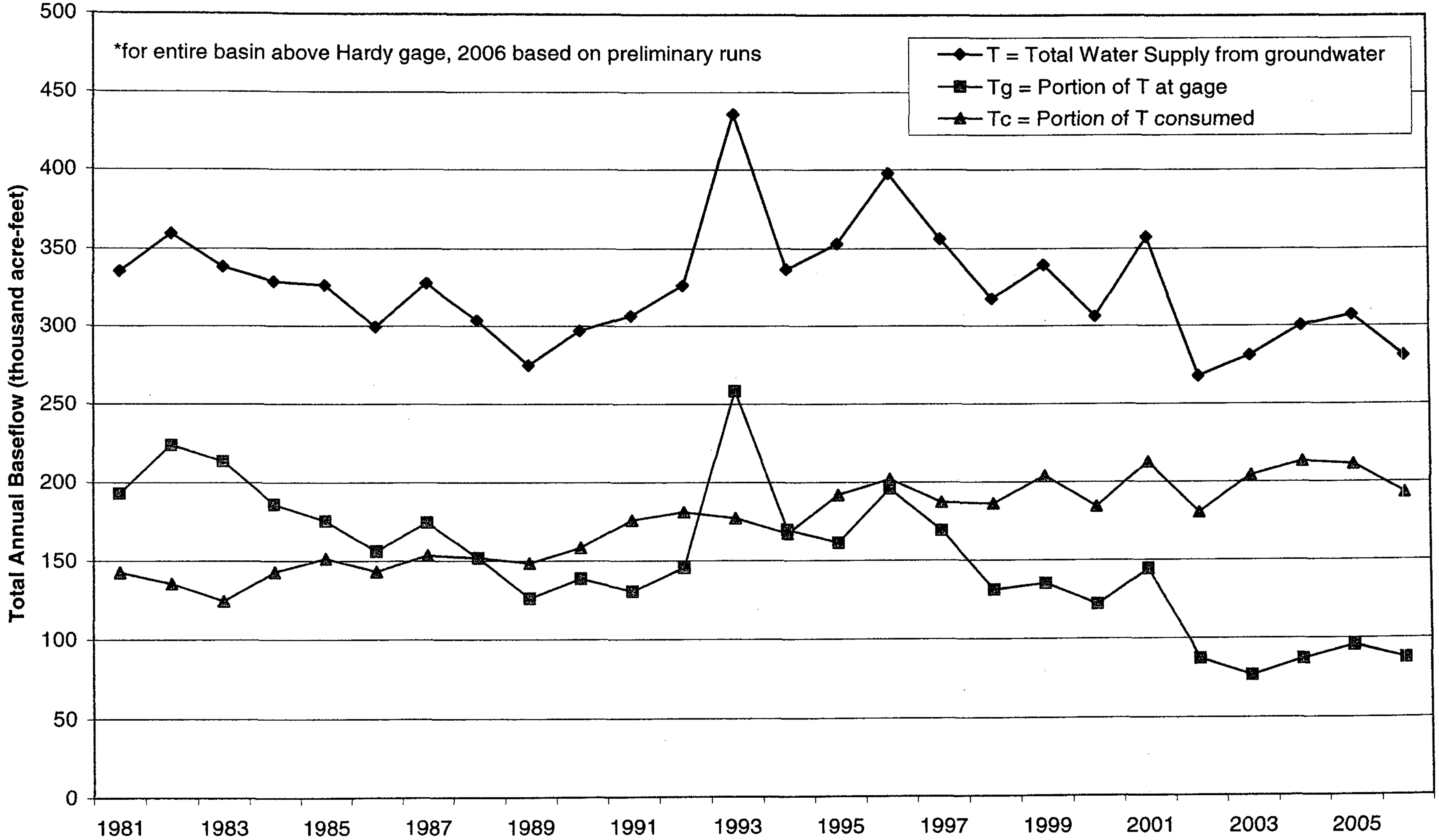
* Either of the two listed methods, when summed, will give the net NE consumptive use, which is the sar
  (NE Pumping on, Mound on) minus (NE Pumping off, Mound off)

Components of total groundwater supply in Republican River Basin



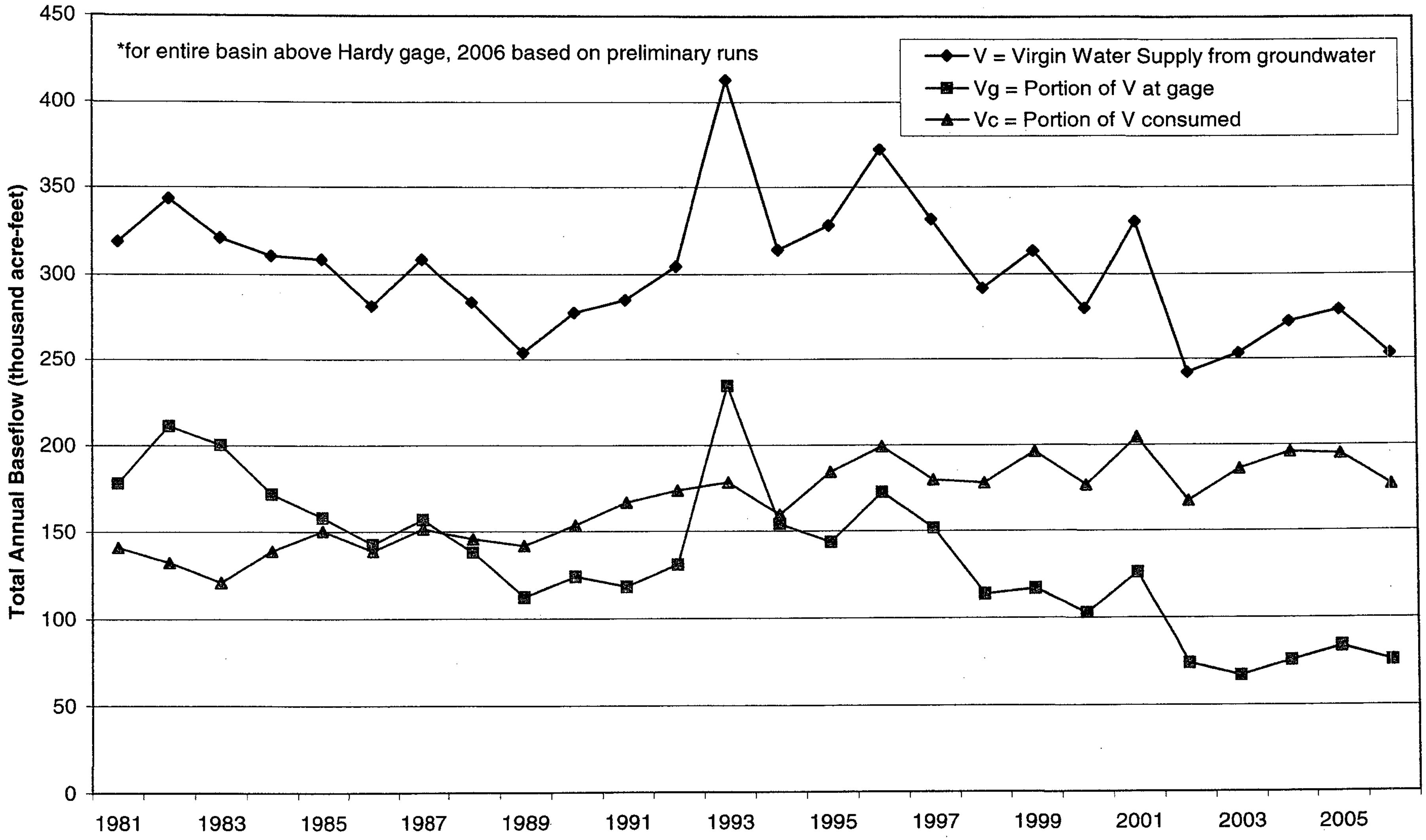
Baseflow and Pumping Components.xls

Components of total groundwater supply in the Republican River Basin



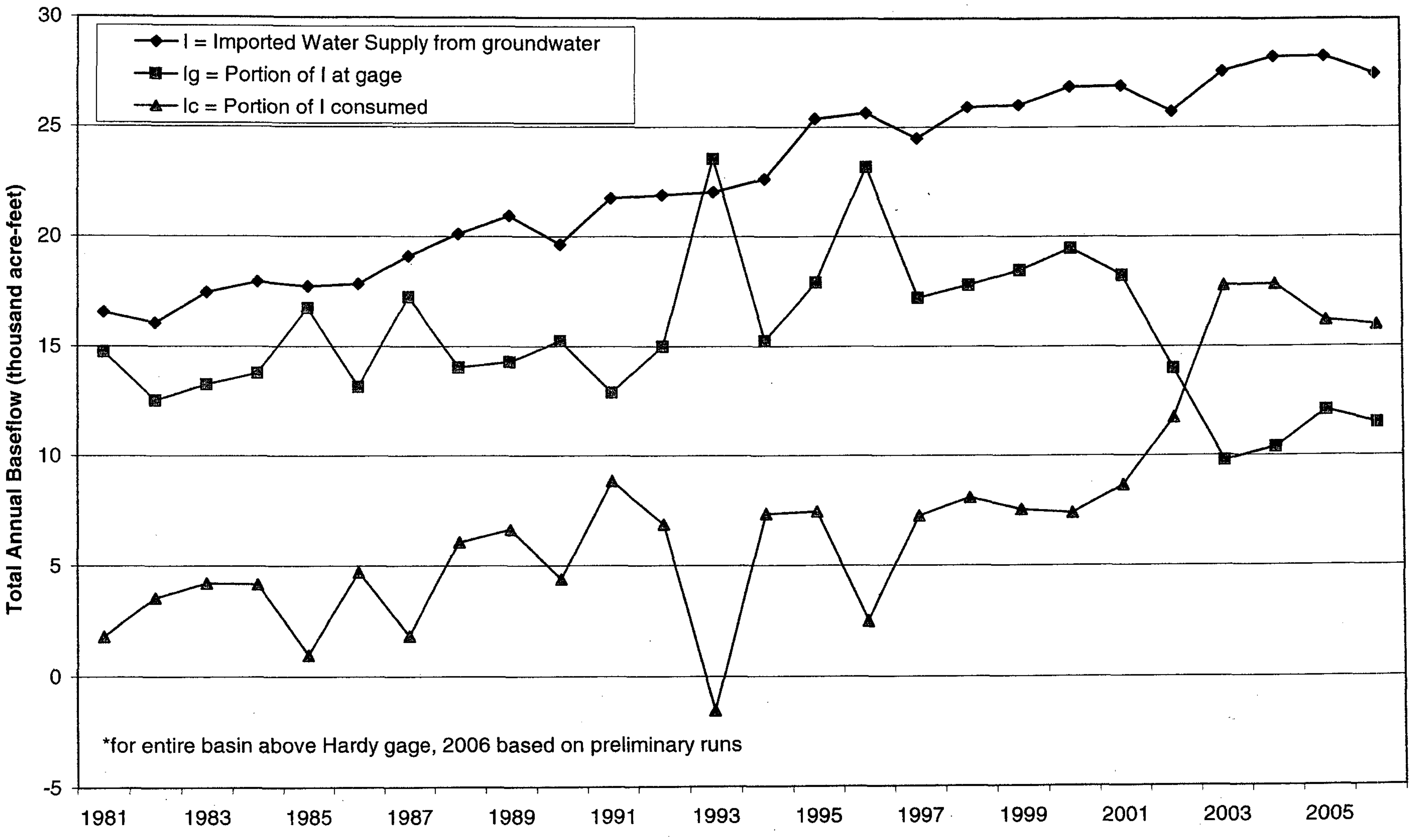
Baseflow and Pumping Components.xls

Components of virgin groundwater supply in the Republican River Basin



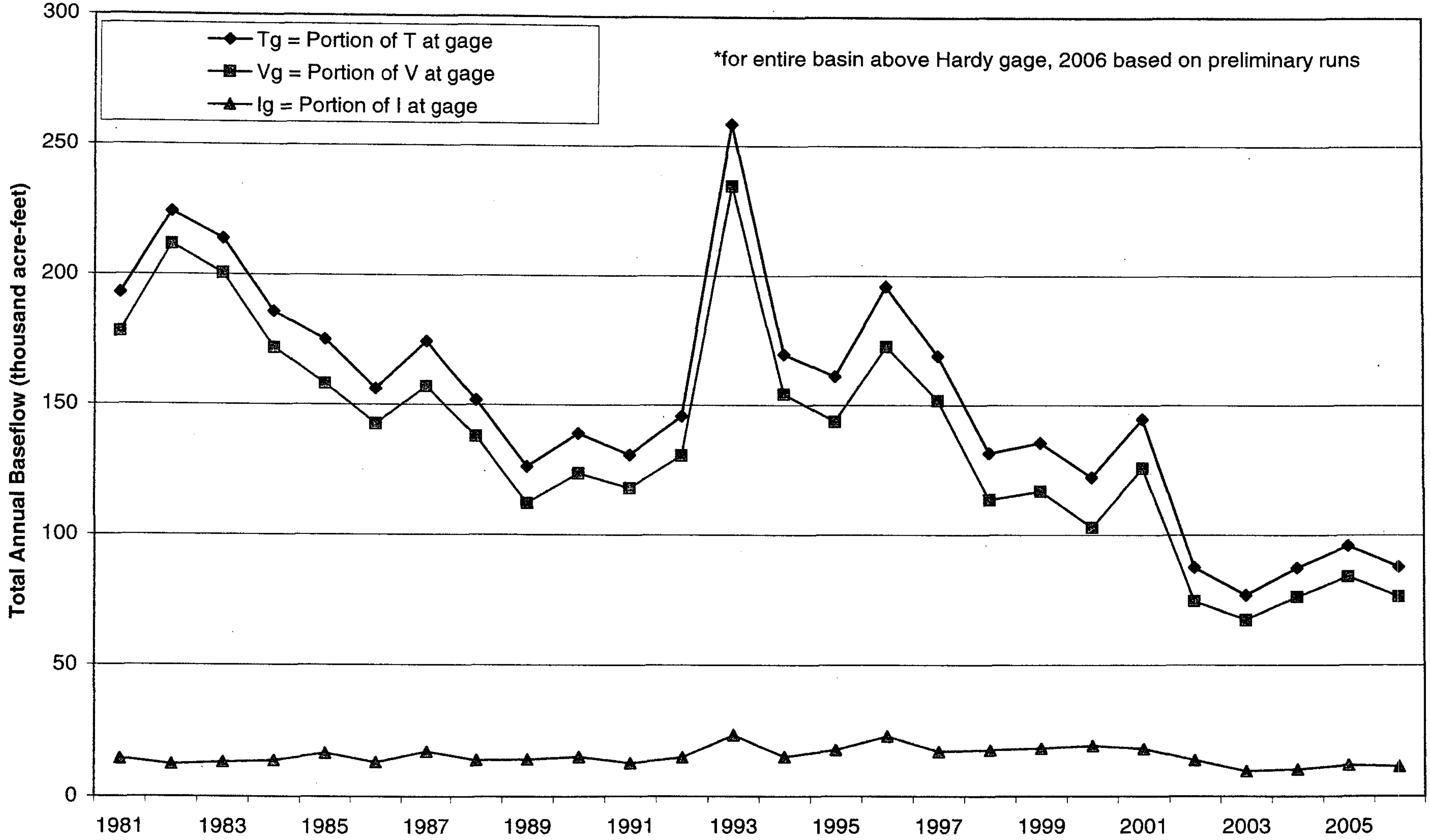
Baseflow and Pumping Components.xls

Components of imported groundwater supply in the Republican River Basin



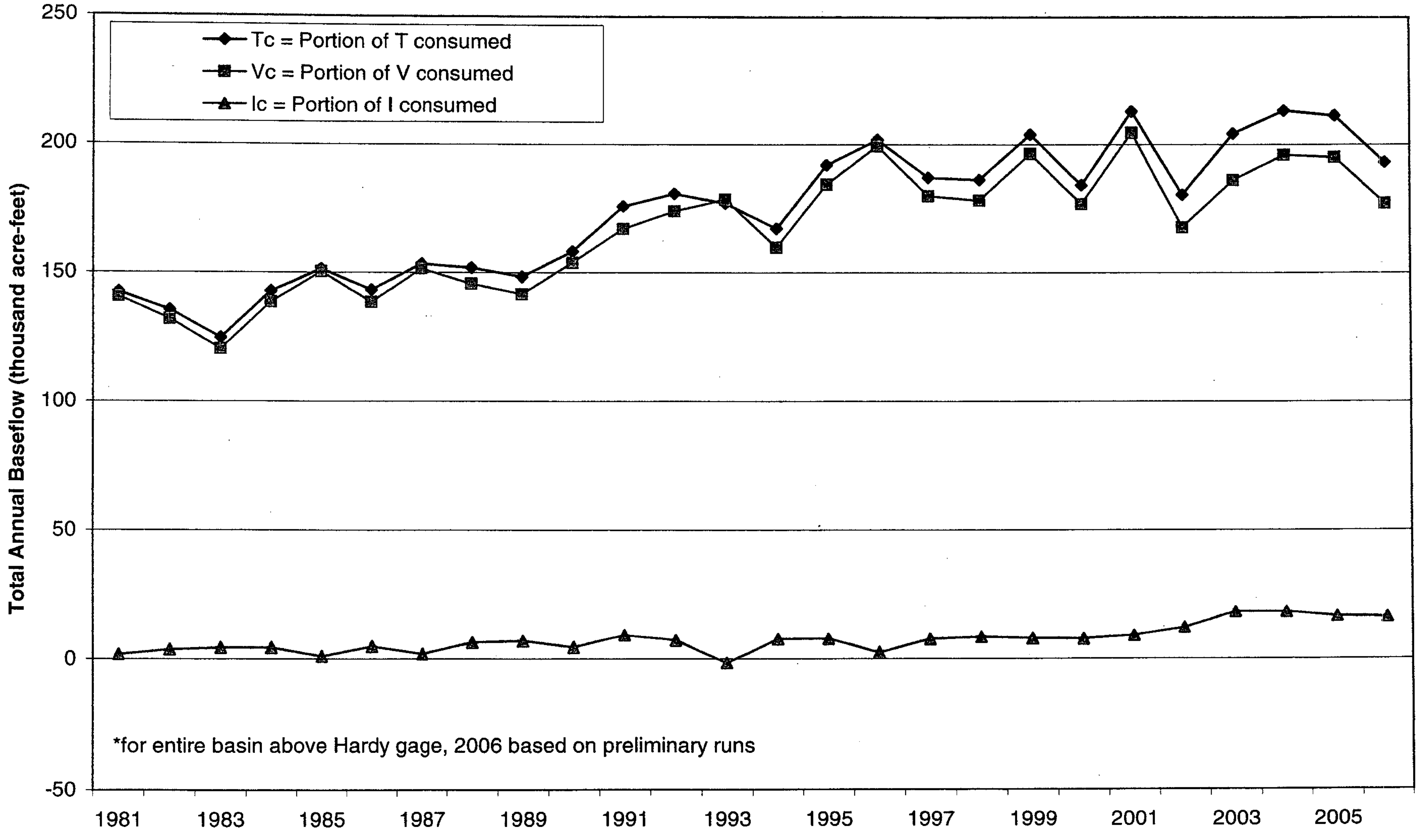
Baseflow and Pumping Components.xls

Components of gaged baseflow in the Republican River Basin, as simulated by the model



Baseflow and Pumping Components.xls

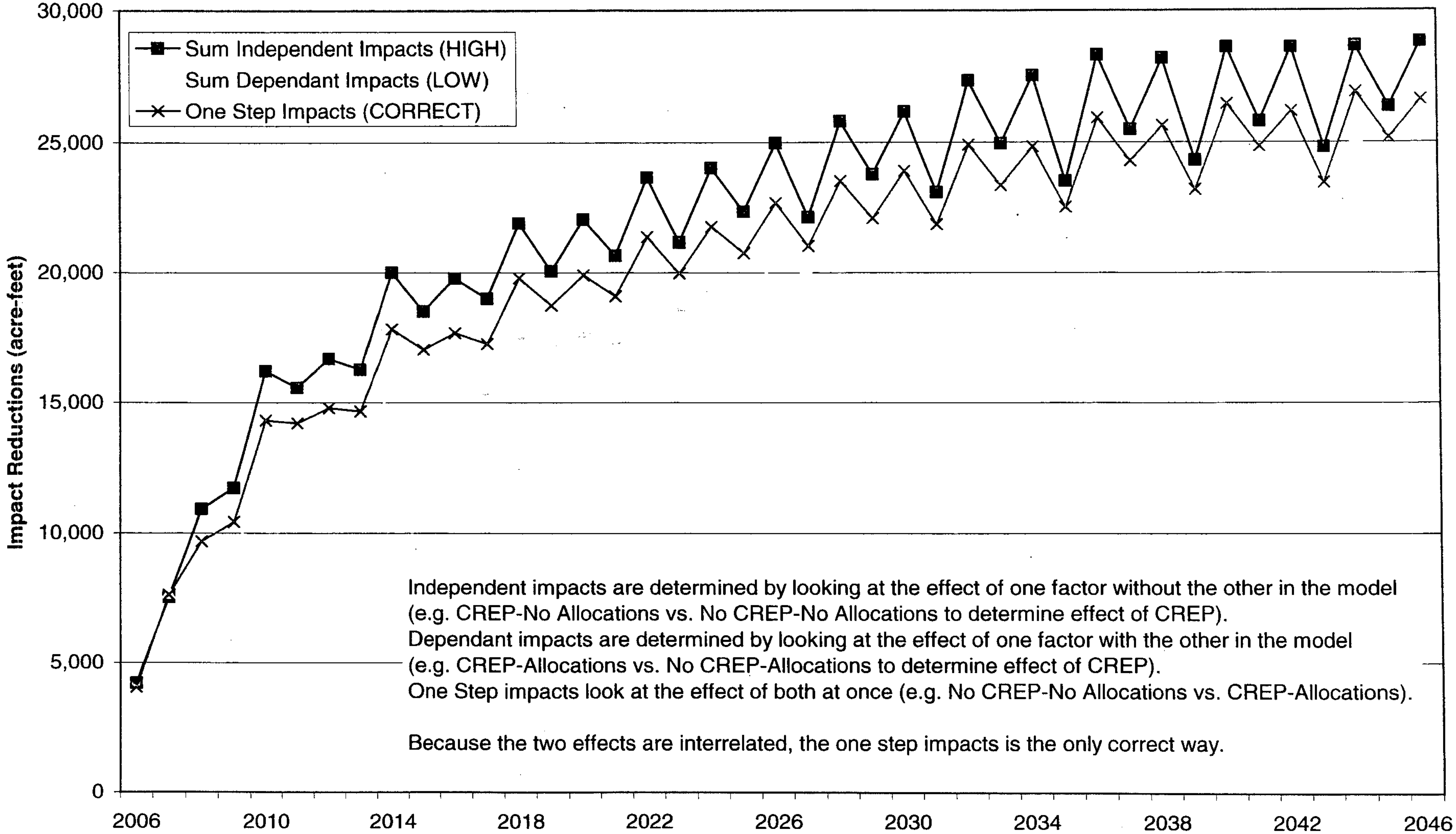
Components of groundwater consumption in the Republican River Basin



Baseflow and Pumping Components.xls

	T = Total V	V = Virgin \	I = Importe	Tg = Portic	Vg = Portic	Tc = Portion c	Vc = Portion of	Ig = Portion o	Ic = Portion of I consu	T-V-I	T-Tg-Tc	V-Vg-Vc
1981	335,631	319,061	16,577	192,967	178,216	142,664	140,845	14,758	1,819	-8	0	0
1982	359,666	343,543	16,065	223,925	211,350	135,741	132,193	12,517	3,548	58	0	0
1983	338,464	321,176	17,477	213,553	200,488	124,911	120,688	13,253	4,224	-189	0	0
1984	328,875	310,754	17,966	185,898	171,960	142,977	138,794	13,783	4,183	155	0	0
1985	326,694	308,526	17,744	175,313	158,128	151,381	150,398	16,761	983	424	0	0
1986	299,501	281,299	17,869	156,112	142,626	143,389	138,673	13,152	4,717	334	0	0
1987	327,899	308,590	19,121	174,529	157,068	153,370	151,522	17,274	1,847	189	0	0
1988	303,700	283,740	20,114	151,819	137,934	151,881	145,806	14,039	6,075	-154	0	0
1989	274,751	253,991	20,922	126,294	112,175	148,457	141,816	14,282	6,640	-161	0	0
1990	297,142	277,553	19,645	138,969	123,766	158,173	153,787	15,260	4,385	-55	0	0
1991	306,651	285,080	21,732	130,795	118,076	175,856	167,004	12,881	8,851	-161	0	0
1992	326,512	304,566	21,879	145,645	130,575	180,867	173,991	15,003	6,876	67	0	0
1993	435,550	413,140	22,026	258,441	234,494	177,109	178,646	23,563	-1,537	385	0	0
1994	336,818	313,980	22,614	169,709	154,224	167,109	159,756	15,262	7,352	223	0	0
1995	353,165	328,139	25,391	161,164	143,602	192,001	184,537	17,927	7,464	-366	0	0
1996	397,744	372,155	25,653	195,875	172,770	201,869	199,385	23,169	2,484	-64	0	0
1997	356,258	331,606	24,505	169,092	151,709	187,166	179,897	17,236	7,269	148	0	0
1998	317,732	291,830	25,914	131,491	113,685	186,241	178,145	17,819	8,095	-12	0	0
1999	339,454	313,337	26,020	135,468	116,905	203,986	196,432	18,466	7,554	96	0	0
2000	306,416	279,735	26,876	122,244	102,972	184,172	176,763	19,467	7,409	-194	0	0
2001	357,485	330,368	26,910	144,616	125,778	212,869	204,590	18,245	8,665	207	0	0
2002	267,816	241,954	25,722	87,378	74,400	180,438	167,554	13,996	11,726	140	0	0
2003	280,990	253,354	27,584	76,723	67,181	204,267	186,173	9,782	17,802	52	0	0
2004	300,402	272,044	28,240	87,287	76,026	213,115	196,018	10,386	17,854	118	0	0
2005	307,252	279,080	28,271	95,931	83,959	211,321	195,121	12,071	16,200	-99	0	0
2006	280,858	253,300	27,472	87,786	76,213	193,072	177,087	11,486	15,986	87	0	0

Comparison of methods for determining impacts of CREP and allocations



On the Occurrence of Negative Values in the Impact Tables

Willem A. Schreüder

August 7, 2006

In the tables that present the impacts of groundwater wells on streams, negative numbers occur in some basins for some years. Consider, for example, the following impact table:

Table 1: Impacts 2005 (acre-feet)

Location	*Colorado Pumping*	*Kansas Pumping*	*Nebraska Pumping*	*Nebraska Mound*
Arikaree	811	122	250	0
Beaver	0	1519	2684	0
Buffalo	306	0	3357	0
Driftwood	0	0	1481	0
Frenchman	42	0	78069	0
North Fork	14359	17	1443	0
Above Swanson	-1967	103	10992	0
Swanson - Harlan	0	70	39772	2061
Harlan - Guide Rock	0	0	29058	219
Guide Rock - Hardy	0	64	2956	0
Medicine	0	0	20414	9633
Prairie Dog	0	5265	0	0
Red Willow	0	0	6596	35
Rock	61	0	3744	0
Sappa	0	-1462	702	0
South Fork	13679	7227	1372	0
Hugh Butler	0	0	1709	0
Bonny	1273	0	0	0
Keith Sebelius	0	510	0	0
Enders	0	0	4650	0
Harlan	0	34	857	17
Harry Strunk	0	0	352	0
Swanson	13	0	421	0
Mainstem	*-1975*	*242*	*82778*	*2274*
Total	*28571*	*13483*	*210881*	*11966*

Two negative numbers occur in this table, namely -1,967 acre-feet for Colorado Pumping impacts in the Above Swanson reach, and -1,462 acre-feet for Kansas Pumping in the Sappa reach. These negative quantities cause credits to the States of Colorado and Kansas, respectively. The reason for these credits is not because pumping increases the stream flow, but rather because the impacts are assessed in other sub-basins and the credits are needed as offsets in order to obtain the correct basin-wide impact.

The negatives are caused by artificial boundaries in the accounting such as the State Line. By subdividing the basin along political rather than hydrologic boundaries, the accounting introduces artificial subdivisions which may cause some values to be negative. or subdivision along a sw boundary, which is different from the boundary along the gw divide.

Kansas Impacts on Sappa

The outflow of Sappa Creek is measured in model simulations at the SI201006AcctSappa gage, which is at the confluence of Sappa Creek with the mainstem of the Republican River. The outflow of Beaver Creek is measured in model simulations at the SI195030AcctBeaver gage, which is at the confluence of Beaver Creek with Sappa Creek.

Since the accounting requires a separate accounting of Beaver and Sappa Creeks, the Beaver Creek reach is defined as SI195030AcctBeaver, while Sappa Creek is defined as SI201006AcctSappa-SI195030AcctBeaver. Simple algebra shows that

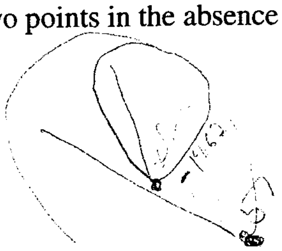
1519 57

Beaver+Sappa = SI195030AcctBeaver + (SI201006AcctSappa - SI195030AcctBeaver) = SI201006AcctSappa.

Table 2: Modeled Annual Flows (acre-feet)

Description	*Gage*	*No Kansas Pumping*	*With Kansas Pumping*	*Kansas Pumping Impact*
Beaver Creek at confluence with Sappa Creek	SI195030AcctBeaver	1519	0	1519
Sappa Creek at confluence with Mainstem	SI201006AcctSappa	57	0	57
Sappa Creek Alone	SI201006AcctSappa - SI195030AcctBeaver	-1462	0	-1462

Table 2 shows that without Kansas Pumping, Beaver Creek would have flowed 1,519 acre-feet at the confluence with Sappa Creek, but that Sappa Creek would have flowed only 57 acre-feet at the confluence with the Republican River. Therefore Sappa Creek lost 1,462 acre-feet plus any upstream flow in Sappa Creek between these two points in the absence of Kansas pumping.



With Kansas pumping, there is no outflow from Beaver Creek, and Kansas is charged with 1,519 acre-feet of depletions on Beaver Creek. However, in the absence of Kansas pumping, only 57 acre-feet of that 1,519 acre-feet would have reached the accounting point at the confluence with the mainstem of the Republican River. Therefore, Kansas is **credited** with 1,462 acre-feet on Sappa Creek, because in the absence of Kansas pumping, Sappa Creek lost 1,462 acre-feet, while with Kansas pumping it the net loss is zero.

Note that pumping never causes flows to increase, but rather it always causes the flows to decrease. In the case of Beaver and Sappa Creek, the flow at the confluence with the main stem decreases from 57 acre-feet to 0 acre-feet. However, as a result of separately accounting for Beaver and Sappa Creek, with a decrease of 1,519 acre-feet on Beaver Creek, the decrease on Sappa Creek must be -1,462 acre-feet in order to get the net effect of 57 acre-feet.

This is not an increase in flow. It is simply the result of a dry stream bed with zero losses, where before there had been 1,462 acre-feet of losses.

This is fair because Kansas is charged with 1,519 acre-feet of depletions on Beaver Creek even though only 57 acre-feet would have reached the mainstem of the Republican River in the absence of Kansas pumping.

Colorado Impacts Above Swanson

The impacts of Colorado well pumping on the North and South Forks of the Republican River and Arikaree culminate with the inflow to Swanson Reservoir. The net impact for all of Colorado pumping on all of the Republican River above Swanson Reservoir can be defined as the impact to the inflow at the Above Swanson gage (SI202005RRAbvSwanson) plus the impact to the inflow to Bonny Reservoir as measured by the South Fork above Bonny (SI0970326825000) and the Landsman Above Bonny (SI141004LandsmanabvB) gages.

Table 3: Impacts 2005 (acre-feet)

Location	*Colorado Pumping*	*Kansas Pumping*	*Nebraska Pumping*	*Nebraska Mound*
Republican Above Swanson	27249	7470	21158	0

Comparison of Table 3 with Table 1 shows that the Colorado Pumping Impacts to the Republican River above Swanson shown in Table 3 (27,249 acre-feet) is equal to the sum of North Fork (14,359 acre-feet), South Fork (13,679 acre-feet), Arikaree (811 acre-feet), Buffalo (306 acre-feet), Rock (61 acre-feet) and Above Swanson (-1,967 acre-feet). It is a mathematical necessity because these terms are defined in terms of gage flows as follows:

North Fork = SI153012AcctNFRepubl

South Fork = SI185007AcctSFRepubl + SI0970326825000 + SI141004LandsmanabvB

Arikaree = SI139003AcctArikaree

Buffalo = SI133001AcctBuffalo

Rock = SI131002AcctRock

Above Swanson = SI202005RRAbvSwanson - SI153012AcctNFRepubl – SI185007AcctSFRepubl - SI139003AcctArikaree - SI133001AcctBuffalo - SI131002AcctRock

Adding these terms together algebraically simplifies to

Republican Abv Swanson = SI202005RRAbvSwanson + SI0970326825000 + SI141004LandsmanabvB

Table 4: Modeled Annual Gage Flows (acre-feet)

Gage	*No Colorado Pumping*	*With Colorado Pumping*	*Colorado Pumping Impact*
SI153012AcctNFRepubl	47604	33245	14359
SI185007AcctSFRepubl	4264	2630	1635
SI0970326825000	12035	0	12035
SI141004LandsmanabvB	10	0	10
SI139003AcctArikaree	1589	778	811
SI133001AcctBuffalo	2341	2035	306
SI131002AcctRock	5069	5008	61
SI202005RRAbvSwanson	39652	24448	15204

Table 4 shows the modeled annual total flows past the various gages, and the resulting impacts. Note that with Colorado pumping, the inflow to Swanson Reservoir is reduced by 15,204 acre-feet as reflected by the reduction of the SI202005RRAbvSwanson gage flow from 39,652 acre-feet to 24,448 acre-feet. The remainder of the Colorado impact consists of the 10 acre-feet reduction in the Landsman Creek inflow (SI141004LandsmanabvB) and 12,035 acre-feet reduction in South Fork flow into Bonny (SI0970326825000), for a total of 27,249 acre-feet, which matches the value established above.

Note, however, that the inflow into the Above Swanson reach consists of the inflow from the North Fork at the State Line (SI153012AcctNFRepubl), South Fork at Benkleman (SI185007AcctSFRepubl), Arikaree (SI139003AcctArikaree), Buffalo (SI133001AcctBuffalo) and Rock (SI131002AcctRock). Adding these five terms results in Above Swanson Inflow, which results in the following values.

Table 5: Modeled Annual Flows Above Swanson Reach (acre-feet)

Description	*Gage*	*No Colorado Pumping*	*With Colorado Pumping*	*Colorado Pumping Impact*
Above Swanson	SI202005RRAbvSwanson	39652	24448	15204

Reach Outflow				
Above Swanson Reach Inflow	SI153012AcctNFRepubl+SI185007AcctSFRepubl+SI139003AcctArikaree+ SI133001AcctBuffalo+SI131002AcctRock	60866	43695	17171
Above Swanson Reach Gain	***Outflow-Inflow***	***-21214***	***-19247***	***-1967***

In Table 5, the reach gain for the Above Swanson reach is -21,214 acre-feet with No Colorado Pumping, that is a loss of 21,214 acre-feet. With Colorado pumping, the reach gain is -19,247 acre-feet, that is a loss of 19,247 acre feet. Although both the reach inflow and outflow decreases as a result of Colorado pumping, the decrease in the inflow is 17,171 acre-feet, while the decrease in the outflow is 15,204 acre-feet.

Therefore, the loss in this reach **decreases** by 1,967 acre-feet, and hence Colorado is **credited** with causing the loss along this reach of the river to decrease.

Note, however, that the pumping **does not** cause flows to increase. Pumping always causes the flows to decrease. The negative value results from the fact that the inflow decreases more than the outflow decreases.

Colorado is therefore credited with 1,967 acre-feet along for the Above Swanson reach. This is fair because Colorado is charged with 17,717 acre-feet of depletions for upstream reaches even though in the absence of any Colorado pumping, only 15,204 acre-feet would have reached Swanson Reservoir.

Conclusions

The subdivision of the Republican River basin into numerous sub-basins and river reaches results in the occasional negative number in the impact tables. The negative values naturally result from the algebra that calculates impacts as the difference between gages.

These negative values do not imply that pumping causes the flows to increase. Instead, the negatives simply mean that the groundwater model calculates impacts across artificial boundaries imposed by compact accounting in order to obtain the correct basin-wide total, also known as conservation of mass.

The physical meaning of these negatives is that in the absence of pumping, greater losses would have occurred in the reach or sub-basin when the negative occurs. As a result of the pumping, those losses now occur in other sub-basins.

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August 8, 2006

MEMORANDUM

TO: Ken Knox – Colorado Division of Water Resources

FROM: Jim Slattery and Randy Hendrix - Helton & Williamsen, P.C.
Dr. Willem A. Schreuder - Principia Mathematica

SUBJECT: 2005 Irrigated Acreage Analysis – Republican River Basin in Colorado

This memorandum documents the procedure to refine the pumping estimates in Colorado by identifying the specific location of the irrigated fields for the 2005 irrigation season using aerial photography. For the 1940 through 2004 period Colorado calculated the irrigation pumping in Colorado utilizing the information from the county's assessor records for irrigated acreage. The county assessors identified the irrigated acreage by county wide totals for sprinkler and flood irrigation. Using these county wide totals and county crop statistics total pumping was estimated for each county. Pumping was then distributed to each grid cell in the MODFLOW model based on the well locations and permitted acreage associated with each well.

Colorado developed a more refined procedure for estimating the well pumping for 2005 by using 2005 aerial photography to identify the location of the irrigated fields. Pumping was estimated for each field based on the county crop statistics, county climate data, and the type of pumping associated with the parcel (flood or sprinkler). The pumping was then assigned to the irrigation well located closest to the irrigated parcel.

Aerial photography for 2005 was obtained from the United States Department of Agriculture's Aerial Photography Field Office (APFO) as part of its National Agricultural Imagery Program (NAIP). Utilizing the 2005 NAIP photographs within a Geographic Information System (GIS) program, individual irrigated parcels were identified. The aerial photography analysis resulted in approximately 1% more irrigated acreage than the 2005 county assessor information for the basin as a whole.

METHODOLOGY

In analyzing the irrigated acreage using the 2005 NAIP aerial photographs several other sources of information were used to determine whether a field should be classified as irrigated in 2005. These sources included the 2004 NAIP aerial photographs, county assessor information, well commissioner field visits, and a tasseled cap analysis of 2001 satellite images. In performing the tasseled cap analysis of the 2001 satellite images, a supervised classification of irrigated versus non-irrigated on a composite of three 2001 satellite images taken during the irrigation season was performed using ERDAS Imagine software. Training and testing sets were developed from approximately 450 fields that were ground truthed in 2001. The overall accuracy assessment of the supervised classification was 76.6 percent.

The county assessor records indicate that center pivot sprinkler irrigation account for approximately 95 percent of all irrigation within the basin. Therefore, the vast majority of the irrigable fields are easily identified from the circular pattern seen in the NAIP aerial photographs.

As shown in Figure 1, the following steps were utilized in this analysis:

1. If a parcel was identified as being part of the Environmental Quality Incentives Program (EQIP) or Conservation Reserve Program (CRP) in 2005 by the Republican River Water Conservation District then the parcel was identified as not irrigated.
2. All surface water irrigated acreage was identified based on field visits and water commissioner information.
3. An inspection of the 2005 NAIP photograph was utilized to determine if the field was irrigated by a center pivot. If the field was not irrigated by a center pivot then the following steps were used to check if the field was flood irrigated.
    a. The 2005 aerial photograph was visually inspected to determine if the parcel was green with an irrigation well located near the parcel. If neither of these conditions were true then the parcel was identified as not irrigated.
    b. If the parameters from the previous step were true, information from the county assessor for that parcel was used to confirm that the field was flood irrigated.

4. If the parcel was determined to be irrigated by a center pivot then the following steps were utilized to determine if the parcel was irrigated in 2005:

    a. Visual inspection of the 2005 aerial photograph to determine if the parcel was green in 2005. If this condition was true then the field was identified as sprinkler irrigated in 2005.

    b. Visual inspection of the 2004 aerial photograph to determine if the parcel was green in 2004 to account for possible crop rotation practices. If this condition was true then the parcel was identified as sprinkler irrigated in 2005.

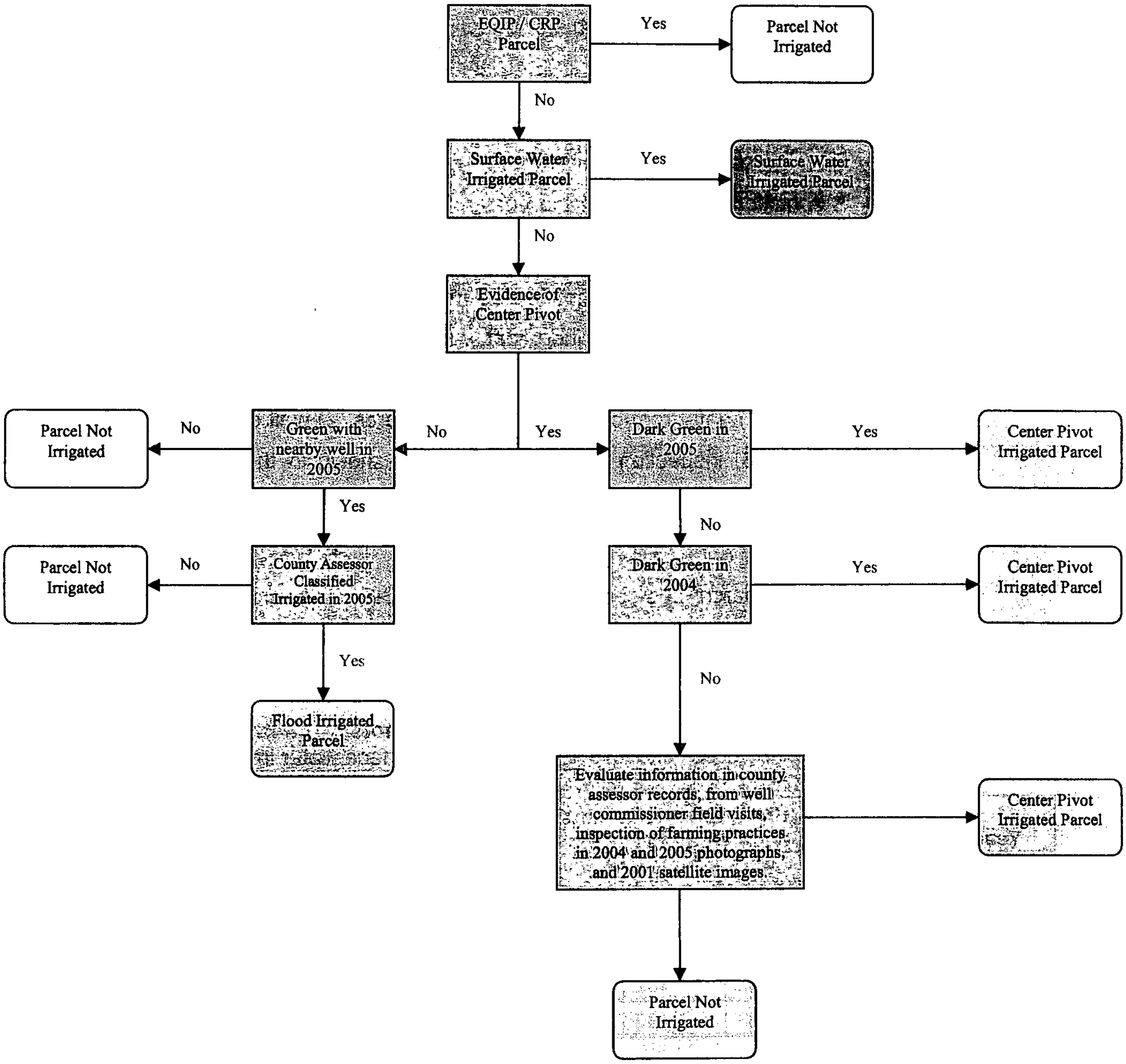
    c. If a parcel was not identified as irrigated in either of the previous two steps then engineering judgment was used to determine if the parcel was irrigated in 2005. In evaluating the parcel the following information was used: 1) data from county assessor's records, 2) well commissioner field visits, 3) inspection of farming practices shown in the 2004 and 2005 aerial photographs, and 4) indication of irrigation utilizing a tasseled cap analysis of satellite imagery during the 2001 irrigation season.

The acreage of each parcel was determined utilizing ArcGIS. The acreage was summed for each county and compared to the 2005 county assessor information. The following table is the results of that comparison.

Table 1 – Comparison of 2005 Assessor and Aerial Photograph Irrigated Acreage
(both figures reduced for estimated EQIP, CREP, and surface water irrigated acres)

	County (or portion of County in the Republican River Basin study area)								
Year	Cheyenne	Kit Carson	Lincoln	Logan	Phillips	Sedgwick	Washington	Yuma	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
2005 Assessor Data									
Sprinkler	10,354	149,546	1,080	5,002	62,155	22,463	31,253	257,182	539,035
Flood	1,024	11,256	402	102	5,331	458	5,258	8,228	32,059
Total	11,378	160,803	1,482	5,104	67,486	22,921	36,511	265,409	571,094
2005 Aerial Photography Estimated from GIS Coverage									
Sprinkler	10,242	155,163	2,367	5,841	68,670	23,282	37,310	268,982	571,858
Flood	102	1,893	0	0	2,262	584	0	1,254	6,095
Total	10,344	157,057	2,367	5,841	70,932	23,866	37,310	270,236	577,953

Figure 1
Republican River Basin Irrigated Acreage in 2005



As Table 1 indicates the overall difference between the irrigated acreage summarized by the county assessors and the evaluation using 2005 aerial photography is approximately 1 percent.

ASSIGN IRRIGATED ACREAGE TO WELL

A GIS layer of irrigated acreage and irrigation well location were spatially joined to assign each irrigated parcel to a well. A tool within ArcGIS will spatially join attributes from one layer to the information from a second layer. The option of using the attributes from the closest well to the parcel was used with this spatial joining tool. If a well was within a parcel it was considered the closest to that irrigated parcel.

The amount of sprinkler and flood irrigated acreage was summarized for each well within the model. This information was used to determine the location of pumping in the MODFLOW model.

IRRIGATION PUMPING WITHIN GROUND WATER MODEL

Once the amount of flood irrigated acres and the amount of center pivot irrigated acreage was determined for each well, the amount of pumping and associated groundwater recharge was estimated for each well. This was estimated using the following formulas to estimate the pumping and recharge rates (units of acre-ft/acre):

Pumping Sprinkler = Deficit * NetCIR / SprinklerFarmEfficiency
Pumping Flood = Deficit * NetCIR / FloodFarmEfficiency

ReturnSprinkler = DeepPercPercentSprinkler*PumpingSprinkler
ReturnFlood = DeepPercPercentFlood*PumpingFlood

Where:

DEFICIT = The amount of pumping as a percentage of the theoretical Net CIR amount. This value is used to adjust the Net CIR to represent the deficit irrigation employed based on the 150 change cases in the basin (75%).

SprinklerFarmEfficiency = Irrigation efficiency for sprinkler irrigation (80%)
FloodFarmEfficiency = Irrigation efficiency for flood irrigation (65%)

NETCIR = Net crop irrigation requirement by County after accounting for effective precipitation and gain in soil moisture from winter and spring precipitation estimated using the same procedure previously utilized by Colorado.

DeepPercPercentSprinkler = Percent of applied sprinkler irrigation that returns to the groundwater system by deep percolation (17%).

DeepPercPercentFlood = Percent of applied flood irrigation that returns to the groundwater system by deep percolation of the applied water (30%).

For each individual irrigation well in the well database, the calculation is then (units of ac-ft):

Pumping = PumpingSprinkler * AcresSprinkler + PumpingFlood * AcresFlood

Returns = ReturnSprinkler * AcresSprinkler + ReturnFlood * AcresFlood

Acres = AcresSprinkler + AcresFlood

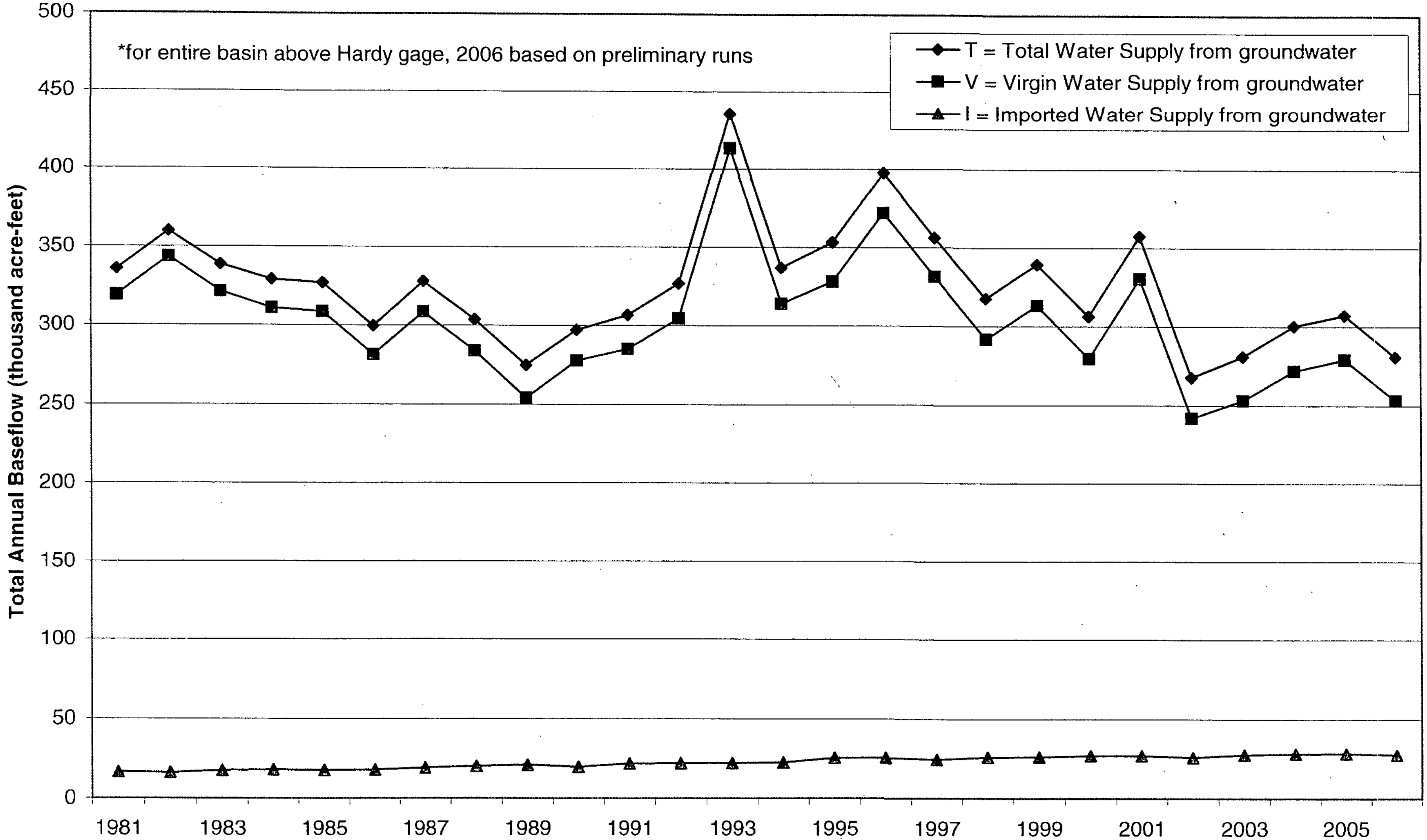
The Pumping, Returns and Acres are assigned to model cells corresponding to the location of the well. Note that for most wells, either AcresSprinkler or AcresFlood is zero. In isolated cases, some wells irrigate both flood and sprinkler acres.

SUMMARY

The irrigated acreage in the Colorado portion of the Republican River basin was determined to be 577,953 acres using 2005 aerial photograph and other supplementary sources of data. The aerial photography analysis resulted in approximately 1% more irrigated acreage than the 2005 county assessor information for the basin as a whole. The location of the irrigated parcels determined from the aerial photography was used to refine the location of the pumping within the basin.

County	P-3-5	S-1-3-3+	Assessed Acres	Permit	40	160	Sec	Twp	N-S	Rng	Last Name	2006 IRR
Kit Carson	P	<1	200.00	18094-FP	NW	NW	6	7	S	46	Liming	YES
Kit Carson	P	<1	236.00	20352-FP	NW	NW	8	7	S	46	Pautler	YES
Yuma	3	<1	127.50	28811-FP	NW	NW	14	5	S	44	Boden	NO
Yuma	3	<1	81.50	R-20457-FP	SE	NW	14	5	S	44	Boden	NO
Yuma	5	<1	92.10	30169-FP	NE	SE	20	5	S	44	Buol	YES
Yuma	5	<1	50.00	3458-FP	SE	SE	30	5	S	44	Lengel	YES
Total		**<1**	**787.10**									
Kit Carson	5	1-3	160.00	14953-FP	NW	SE	22	4	S	42	Schulte	YES
Kit Carson	P	1-3	213.00	19700-FP	NE	NW	36	6	S	45	Adolf	NO
Total		**1-3**	**373.00**									
Kit Carson	P	3+	240.00	12443-FP	SE	SE	14	8	S	42	Amack	YES
Kit Carson	P	3+	126.00	5457-FP	NE	NW	23	10	S	46	Chapin	NO
Kit Carson	P	3+	117.00	15621-FP	SW	SW	18	10	S	46	Chapin	NO
Kit Carson	P	3+	111.00	3970-FP	NW	SW	26	9	S	46	Cure	NO
Kit Carson	P	3+	486.00	11566-FP	NW	NW	26	8	S	46	Cure	NO
Kit Carson	P	3+	777.00	5560-FP	SW	SW	35	8	S	45	Hinkhouse	YES
Kit Carson	P	3+	90.00	13508-FP	NW	NW	14	7	S	47	Hornung	YES
Kit Carson	P	3+	120.00	15620-FP	NE	SW	34	7	S	47	Hornung	YES
Kit Carson	P	3+	257.00	12440-FP	NW	SE	15	6	S	48	Hostetler	YES
Kit Carson	P	3+	108.00	19697-FP	SE	SE	8	8	S	45	Kramer	NO
Kit Carson	P	3+	170.00	3591-FP	SW	SE	17	8	S	46	Pautler	YES
Kit Carson	P	3+	58.00	12360-FP	SE	NW	33	8	S	46	Pautler	YES
Kit Carson	P	3+	151.00	18615-FP	NW	SW	7	7	S	47	Schulte	YES
Kit Carson	P	3+	92.00	9536-FP	NE	NE	15	8	S	46	Schulte	YES
Kit Carson	P	3+	214.00	10797-FP	NW	SE	7	7	S	45	Strobel	YES
Kit Carson	P	3+	252.00	4611-FP	NW	NW	31	8	S	42	Weaver	YES
Kit Carson	P	3+	93.00	9055-FP	NE	NE	36	8	S	43	Weaver	YES
Phillips	P	3+	210.00	18998-FP	SW	NE	1	8	N	46	Duell	YES
Phillips	P	3+	237.00	6938-FP	SE	SW	14	7	N	45	Goddard	NO
Phillips	P	3+	130.00	5216-FP	SE	NE	28	7	N	45	Owens	NO
Sedgwick	P	3+	132.00	18119-FP	NW	SW	30	10	N	42	Marquardt	NO
Sedgwick	P	3+	107.00	18269-FP	NE	NE	31	10	N	42	Marquardt	NO
Yuma	3	3+	130.00	6670-FP	NW	NE	16	5	S	44	Boden	NO
Yuma	P	3+	247.30	16650-FP	NE	SW	20	5	N	47	Day	NO
Yuma	P	3+	156.00	15529-FP	CN	SW	5	1	S	48	Goeglein	YES
Yuma	P	3+	148.00	15762-FP	NE	NW	13	2	S	48	Lungwitz	YES
Yuma	P	3+	300.70	22113FPR	SW	NW	10	1	S	48	Smith	YES
Total		**3+**	**5,260.00**									
Grand Total			**6,420.10**									

Components of total groundwater supply in Republican River Basin



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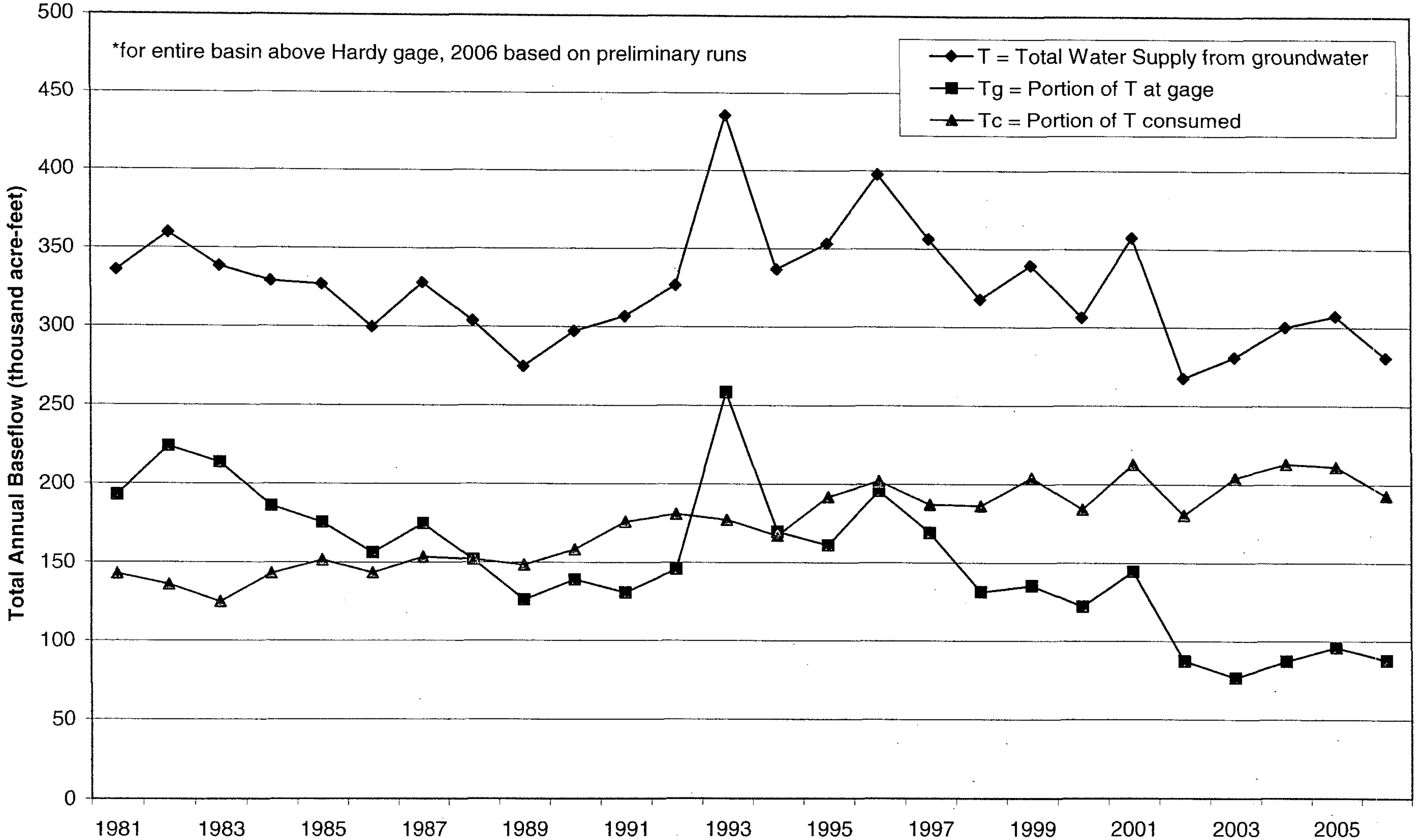
Components of total groundwater supply in the Republican River Basin



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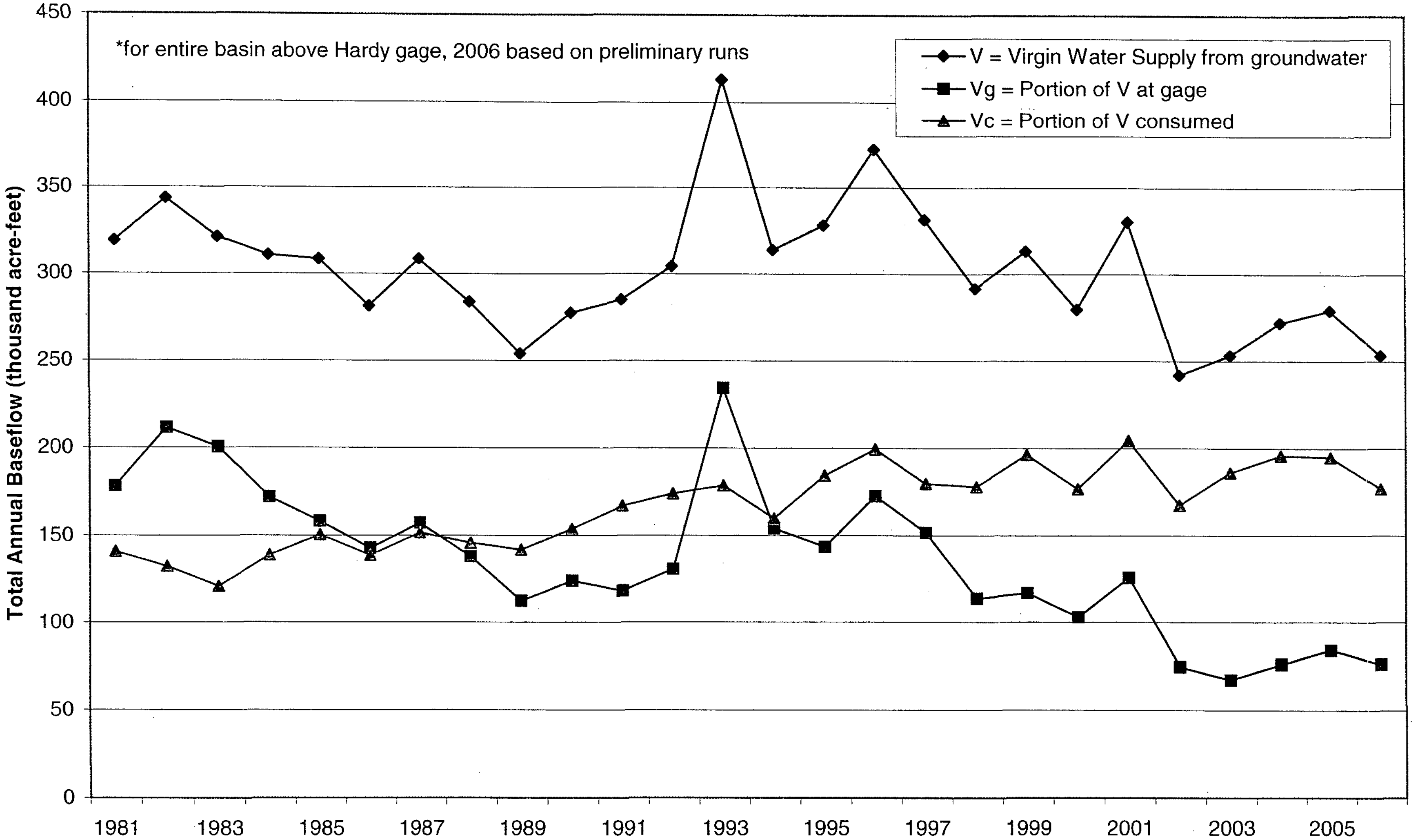
Components of virgin groundwater supply in the Republican River Basin



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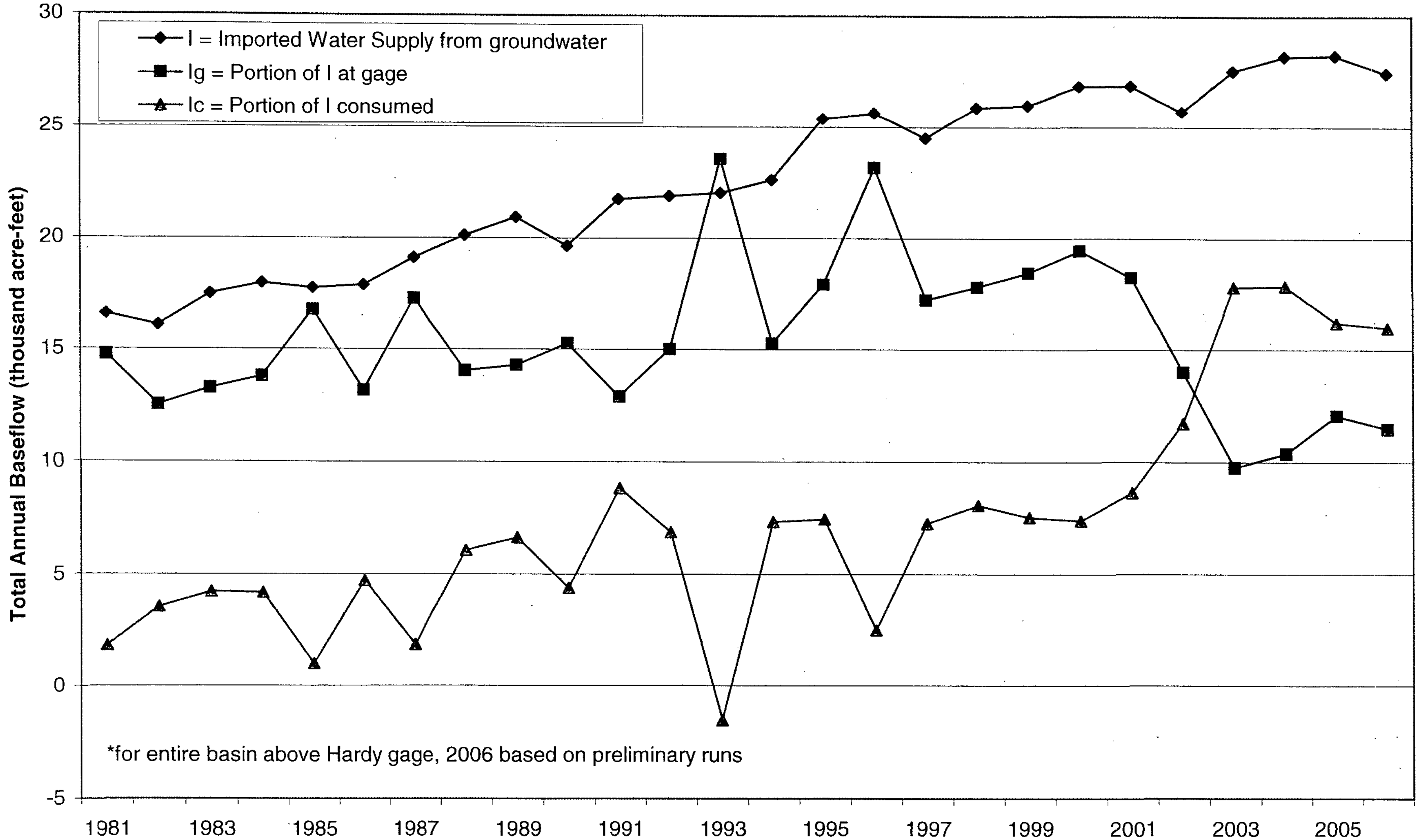
Components of imported groundwater supply in the Republican River Basin



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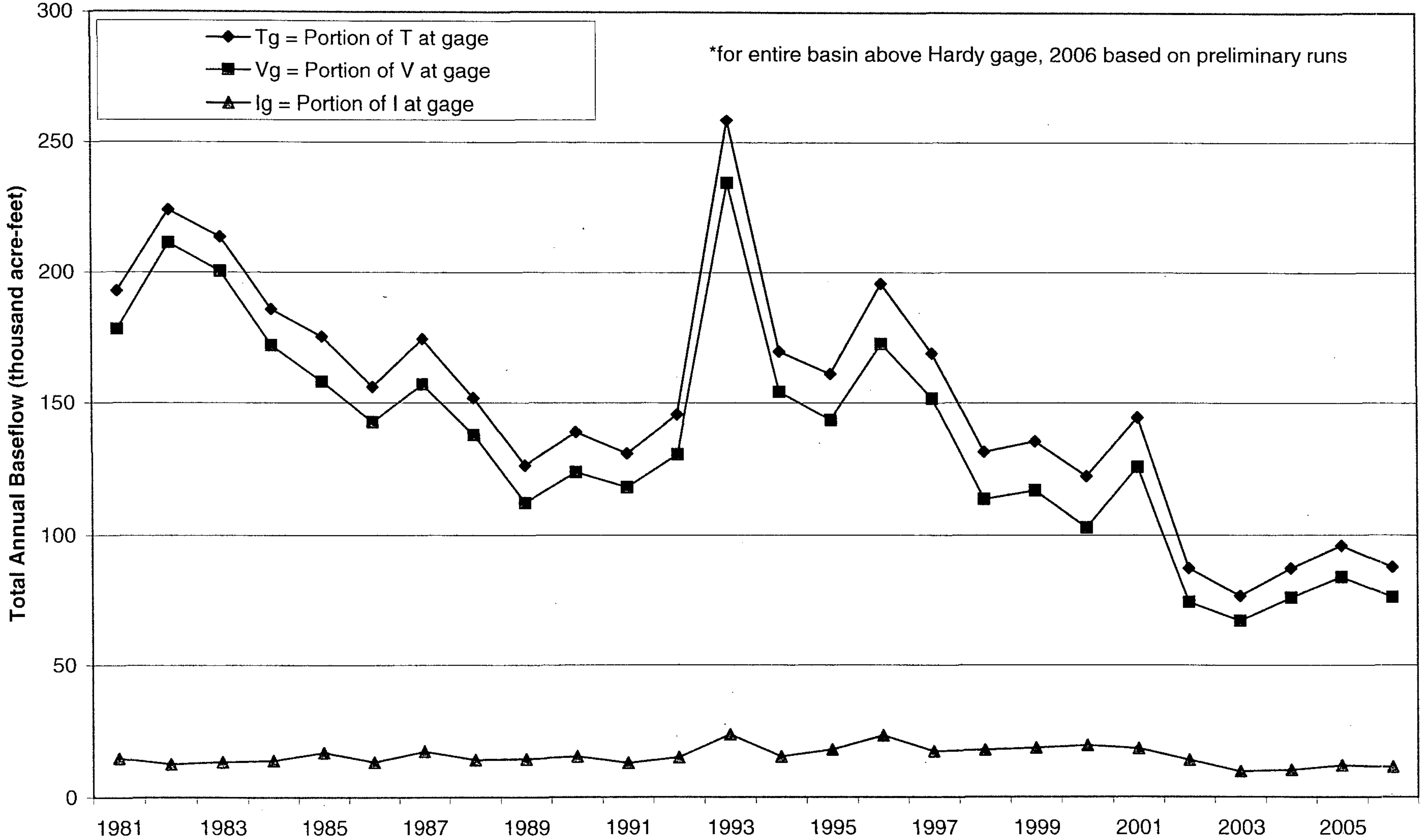
Components of gaged baseflow in the Republican River Basin, as simulated by the model



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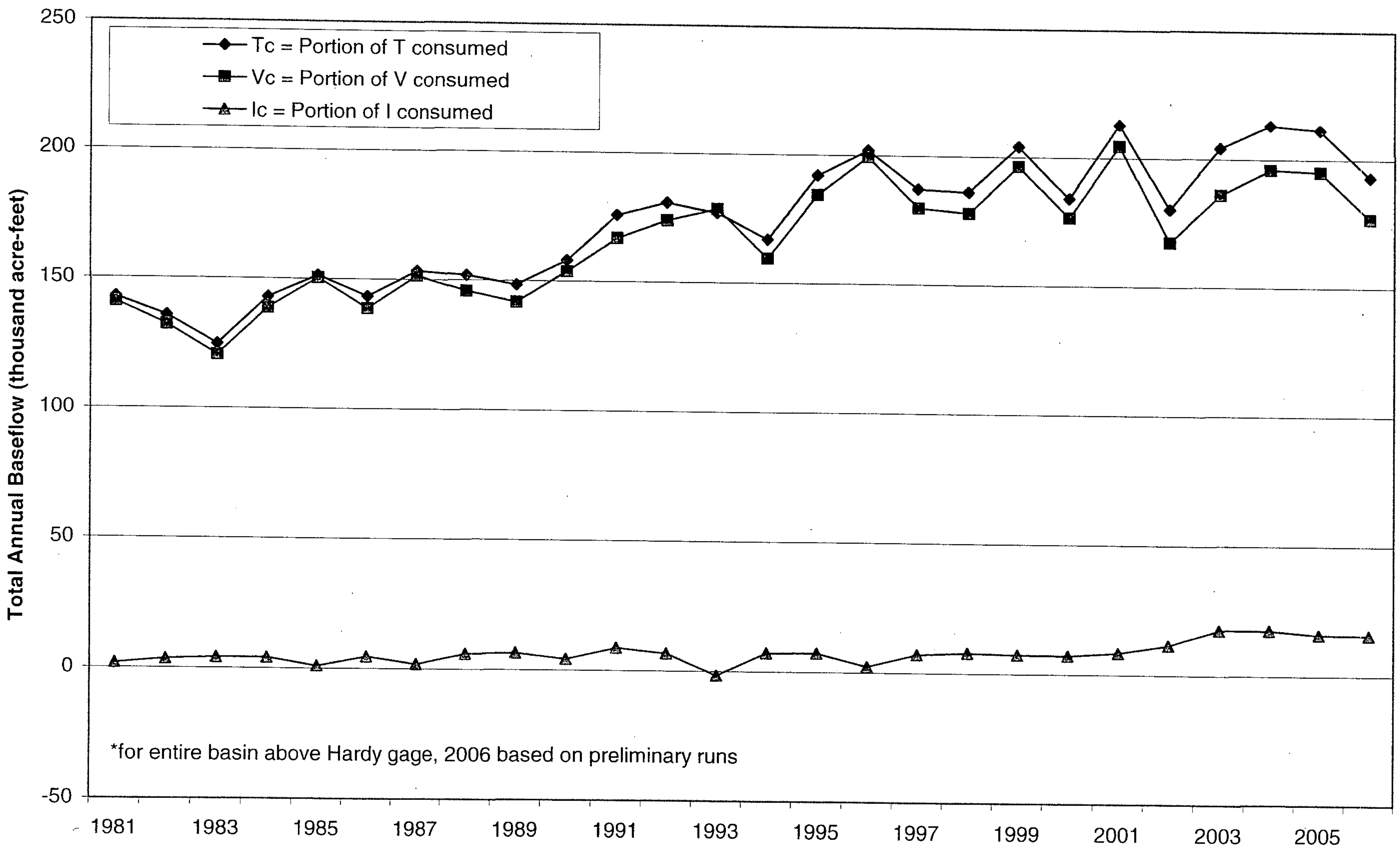
Components of groundwater consumption in the Republican River Basin



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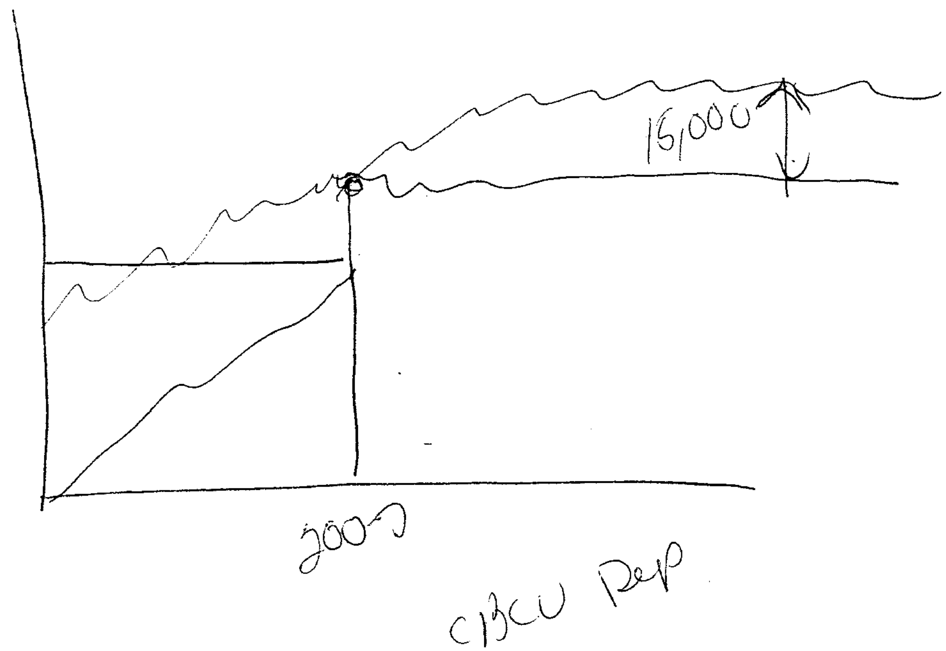
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