EXPANSION OF WATER DELIVERY BY MUNICIPALITIES AND SPECIAL WATER DISTRICTS IN THE NORTHERN FRONT RANGE, COLORADO 1972-1982

by

Raymond L. Anderson

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COLORADO WATER RESOURCES RESEARCH INSTITUTE

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FOREWORD

A critical factor in the continuing economic development and population growth along the Colorado Front Range is the water resource base. Accompanying the transfer of agricultural land to urban uses is the increasing domestic demand for water which has been used for irrigation.

This is an updating of earlier studies done in 1974 and 1979. It is concerned with the municipal, industrial, and rural use of water in the northern Front Range area. Specifically, analysis is directed toward the pricing and delivery of water through municipal and rural-domestic water systems.

Information used in this study was gathered from a wide variety of sources, among them: the water departments of various cities, the rural water districts and associations, the Northern Colorado Water Conservancy District. Population and other data were obtained from the U.S. Census of Population, the Agricultural Census, and the Colorado Division of Planning. Several people reviewed early drafts of the manuscript and made many useful comments and suggestions.

Special acknowledgment is due Charles Sperry, who gathered data from the rural-domestic water districts, and to Steven Piper, who contacted the water utilities of the various towns and cities in Boulder, Weld, and Larimer counties.

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EXPANSION OF WATER DELIVERY BY MUNICIPALITIES AND SPECIAL WATER DISTRICTS IN THE NORTHERN FRONT RANGE, COLORADO, 1972-1982

Raymond L. Anderson*

The demand for water to supply municipal domestic and industrial uses has been increasing rapidly all along the Front Range of the Rockies in Colorado since the 1960s. The population of the northern region, consisting of Boulder, Weld, and Larimer counties, increased by 203 percent, or more than 325,000 inhabitants, between 1959 and 1983. The location of a number of major industries and the accompanying population growth led to expansion of municipal water systems and to development of rural water systems to supply domestic water service to large areas of the countryside in the three counties. In this semi-arid area, where virtually all water has been appropriated, increases in domestic use must come primarily from irrigation water supplies. Water converted to domestic use typically comes from supplies formerly used to irrigate farmlands. As irrigated farmland is urbanized, water is released for domestic use. A portion of the water converted to domestic purposes in the Boulder, Weld, and Larimer county area has come from the Colorado-Big Thompson (C-BT) project, which was developed as a source of supplemental irrigation and municipal water supply.

The purpose of this study is to examine growth of domestic use of water in the northern Front Range area. There are two major types of domestic water systems in the area: the traditional municipal water systems serving cities and towns, and the rural-domestic systems designed to serve extensive rural

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areas. The municipal systems are owned and operated by the cities and towns in the region. In the past, Greeley served areas outside the city but currently it serves only the town of Evans.

The rural-domestic systems, most of which were built in the 1960s, are organized as either special districts or as associations. These systems serve rural areas beyond the boundaries of the cities and towns. The rural water systems have difficulties with nearby cities that frequently annex into rural water service areas, displacing the rural domestic system.

MUNICIPAL WATER SYSTEMS

With the increases in population, the larger cities and towns have been expanding their water systems and acquiring additional water to serve the new population as the cities expand their boundaries. Most of the municipal systems have grown up with the cities and have been operating for decades, but new facilities are needed to serve larger areas and growing populations.

Municipal systems in the Front Range area derive most of their water supplies from streams flowing from the mountains. Some of the water is taken directly from the streams running through or near the towns; some of it is captured in reservoirs in the mountains for release during periods of high demand or low runoff. As municipalities grow, there are three ways to increase water supplies: 1) by acquiring irrigation company stock from land that is being urbanized; 2) by upgrading or building new reservoirs in the mountains to catch flood flows; 3) acquiring units of C-BT water from the Colorado-Big Thompson project. C-BT water is readily accessible to most municipal systems within the Northern Colorado Water Conservancy District, can be transferred without legal difficulty, and avoids the hydrologic uncertainty of other sources.

The water from mountain streams and C-BT reservoirs is of very good quality that requires only minimal treatment. Distribution expense is low in most systems as most can use the natural gradient from the mountains to the plains to develop water pressure. From an economic point of view, these systems are somewhat unusual in that they are high-fixed cost and low-variable-cost operations. Once the capital is invested, it makes little difference in variable costs whether the systems are run at 50 percent or 90 percent of capacity. Indeed, running at near capacity lowers both fixed costs and variable costs per unit delivered.

In these data, we consider total water delivered through the systems, and relate it to revenue derived per acre-foot, and gallons per capita delivered to the general population. It is necessary to do this because of a lack of data on specific water charges and amount of delivery to various classes of users. In considering total water delivery to a community, all water use is assigned to the residents, regardless of the purpose for which used: water used by business and industry provides jobs; water used for municipal purposes such as park watering, firefighting, and street washing is in the interests of the general citizenry.

Revenue derived from water delivered through water systems of the larger municipalities in northern Colorado ranged from $253 per A.F. in Greeley to $629 in Broomfield in 1983 (table 1). Of the larger cities, Boulder collected $297 per A.F., Longmont collected $365 and Fort Collins, $306. Revenue in Loveland increased from $115 per A.F. in 1974 to $456 in 1982. Loveland's water system was heavily damaged by a flood in 1976 and it installed meters in 1982. The city of Boulder installed water meters in the mid-1960s in an attempt to control water use. Boulder and Broomfield were the only large

Table 1--Water delivery by the larger municipal water systems, northern Front Range, Colorado, 1972-83

City	Year	Population[1]	Annual water delivery	System delivery per capita[2]	City water delivery	City per capita delivery[3]	Average revenue per A.F.
			A.F.	Gal./day	A.F.	Gal./day	Dollars
Boulder	1972	70,000	14,533	185	12,644	161	160
	1973	73,800	15,395	186	13,394	162	165
	1974	75,800	17,299	203	15,050	177	160
	1975	76,000	16,716	194	14,544	169	158
	1976	(77,800)	16,952	194	14,748	169	161
	1977	(78,220)	16,043	183	13,957	159	177
	1978	76,289	17,810	208	15,495	181	172
	1979	76,400	17,916	209	15,587	182	173
	1980	76,685	19,875	231	17,291	201	174
	1981	78,787	17,315	196	15,064	171	191
	1982	80,651	17,869	198	15,546	172	221
	1983	82,667	17,473	189	15,202	164	297
Broomfield	1972	10,605	1,663	140	1,563	133	233
	1973	12,278	1,838	134	1,727	127	248
	1974	13,951	2,472	158	2,280	150	239
	1975	15,500	2,566	147	2,412	139	243
	1976	17,700	2,673	135	2,513	128	249
	1977	19,100	2,805	131	2,664	125	247
	1978	20,050	3,383	151	3,224	143	249
	1979	21,613	3,365	139	3,197	132	350
	1980	22,497	3,903	155	3,708	147	434
	1981	22,893	3,505	137	3,330	130	500
	1982	23,028	3,415	132	3,244	126	576
	1983	23,624	3,308	125	3,143	119	629
Longmont	1972	31,500	8,148	231	7,862	223	131
	1973	33,060	11,387	308	10,988	297	98
	1974	34,887	9,637	247	9,330	238	122
	1975	36,130	8,982	222	8,668	214	139
	1976	38,056	9,106	214	8,787	206	148
	1977	(41,120)	10,939	238	10,556	229	132
	1978	39,020	12,535	287	12,159	278	152
	1979	41,270	10,343	224	10,033	217	249
	1980	42,942	11,265	234	10,927	227	198
	1981	43,500	11,297	232	10,958	225	259
	1982	45,000	11,257	223	10,919	217	322
	1983	47,840	11,654	217	11,304	211	365
Fort Collins	1972	52,350	14,007	238	13,413	229	66
	1973	55,800	14,327	228	13,684	219	76
	1974	57,900	16,811	258	15,806	243	81
	1975	60,600	15,185	223	14,329	211	119
	1976	62,500	15,160	212	14,283	200	130
	1977	63,500	15,216	210	15,039	200	137
	1978	64,030	16,426	229	15,566	198	162
	1979	66,685	14,168	190	13,439	180	195

Table 1 (cont'd.)

City	Year	Population 1/	Annual water delivery	System delivery per capita 2/	City water delivery	City per capita delivery 3/	Average revenue per A.F.
			A.F.	Gal./day	A.F.	Gal./day	Dollars
Fort Collins	1980	70,000	17,339	221	16,707	210	177
	1981	72,500	16,280	200	15,748	190	237
	1982	74,000	15,594	188	14,176	171	283
	1983	75,330	16,865	200	15,332	182	306
Loveland	1972	19,710	5,876	266	5,582	253	135
	1973	21,570	6,367	264	6,049	250	147
	1974	23,425	7,508	286	7,132	272	115
	1975	25,280	7,056	249	6,703	237	133
	1976	27,520	6.925	224	6,579	213	219
	1977	(29,760)	7,134	214	6,777	203	190
	1978	(31,222)	7,884	222	7,489	210	118
	1979	29,738	7,654	230	7,271	218	121
	1980	30,244	8,940	264	8,493	251	195
	1981	30,758	8,317	241	7,901	229	373
	1982	31,765	6,706	188	6,371	179	456
	1983	32,500	6,489	178	6,165	169	564
Greeley	1972	45,800	15,674	305	11,755	229	69
	1973	48,550	16,175	297	12,131	223	74
	1974	50,975	16,758	293	12,570	220	87
	1975	(53,500)	17,626	294	13,220	220	85
	1976	(54,595	18,081	295	13,455	222	85
	1977	(56,230)	19,063	303	14,297	226	86
	1978	(60,200)	19,255	286	14,873	220	97
	1979	(64,580)	18,584	257	15,271	211	121
	1980	53,006	20,339	343	16,401	276	137
	1981	54,000	19,186	317	16,233	268	177
	1982	55,933	20,094	321	16,982	271	193
	1983	55,977	20,244	323	17,005	271	253

1/ City estimates of population may exceed census of population figures during some years.

2/ Water delivery divided by city population. It includes industrial, commercial, municipal uses (i.e., street washing, park use, etc.) in addition to residential use.

3/ City delivery subtracts water delivered outside the corporate boundaries.

towns that universally metered domestic water. By metering water, Boulder delivered roughly 10 gallons less water per capita per day than Fort Collins during the past 6 years. In 1982, however, delivery in Boulder and Fort Collins was virtually identical with 172 and 171 gallons per capita respectively.

Within-city per capita water delivery ranged from a low of 119 gallons per capita per day in Broomfield to 271 gallons per day in Greeley. Fort Collins delivered about 182 gallons per capita day while Longmont delivered 211 gallons per day. Most of the larger towns continued to show a downward trend in per capita deliveries during the 1970s. Yearly variations occur in response to weather conditions prevailing during the growing season. Water use per capita has declined in response to conservation appeals and changes in housing patterns. Some variation in per capita use is due to changes in population estimates of some of the cities after the last census. City estimates in Boulder, Longmont, Loveland and Greeley were higher than census figures. Most of these cities reduced population estimates resulting in somewhat higher per capita use rates for water.

The price of water delivered in the six larger cities of the northern Front Range increased rapidly between 1972 and 1982. Average revenue ranged from $66/A.F. in Fort Collins to $233/A.F. in Broomfield in 1972. By 1982, the least increase was to $253/A.F. in Greeley and the most, $629/A.F. in Broomfield. (Broomfield is the only city in this group outside the N.C.W.C.D. boundary and has less opportunity to easily expand its water supply.)

Loveland's increases in water delivery charges went up $429 per acre-foot, followed by Broomfield which raised water rates an average of

$396 an acre-foot. On the other end of the scale, Boulder increased water rates only $137/A.F. and Greeley went up $184/A.F. delivered. Longmont increased by $234/A.F. and Fort Collins, $240.

Water use per capita behaved rather erratically among the cities in response to increases in rates. Loveland, with its large increase in water rates and installation of meters, reduced water delivery per capita by almost 54 percent. The effects of this are very apparent in the condition of landscaping in residential areas. Lawns, trees, and shrubbery around many homes evidence a lack of adequate watering. Many homes and businesses are changing to gravel yards or simply abandoning landscaping. Fort Collins recorded the second largest reduction in water use with a 20 percent decline in delivery per capita. Water conservation measures and somewhat denser settlement in new areas probably account for the bulk of decline in water delivery.

Boulder, on the other hand, remained relatively constant in water use per capita over the period. Water use had been curtailed during earlier periods and seems to have stabilized around 160-180 gallons per capita per day. Greeley seems to have remained in the same delivery pattern as earlier, but industrial use and other factors account for its delivery pattern.

Broomfield remains an anomaly. Its water delivery was less than other towns in 1972 with a much higher price and it continues to have very high water charges with delivery of only 119 gallons per capita per day (see table 2).

Overall during the period, population of the towns grew by 34 percent but water delivery increased only 26 percent. Total water delivery

Table 2--Revenue per acre-foot of water delivered and change in water use per capita, six cities, northern Colorado Front Range, 1972 to 1983

City	Average revenue/ A.F. delivered		Change	Average water use per capita per day		Change
	1972	1983	1972-83	1972	1983	1972-83
	- - Dollars - -		Percent	Gallons		Percent
Boulder	160	297	+ 85	161	164	+ 1.8
Broomfield	233	629	+170	133	119	-10.6
Longmont	131	365	+178	223	211	- 5.4
Fort Collins	66	306	+363	229	182	-20.6
Loveland	135	456	+338	253	179	-53.8
Greeley	69	253	+267	229	271	+18.3

Population - six cities: 1972 219,360; 1983 294,314. Population increase = 34%

Water delivered - six cities: 1972 51,259 acre-feet; 1983 65,008 " ". Water use increase = 26.8%

of these towns increased from 51,259 acre-feet in 1972 to 65,008 acre-feet in 1983. From the large increase in water rates generally in all of these towns it is apparent that some of the costs of growth are being levied against existing water users as the systems expand to serve the larger populations. All of the systems have been upgrading filter plants, transmission lines and numbers of personnel; however a major part of the increased cost of water service comes from extending water mains to serve larger areas and connecting more homes and businesses to the system. Most cities require substantial tap fees, fees for water acquisition or water supplies, but it is impossible to put all the cost of growth on the new population.

The smaller towns generally charge more per acre-foot of water delivered than larger towns (table 3). This is because fewer customers are supporting higher per capita capital investment. Water deliveries per capita in some small towns are generally higher than in the larger cities but in some cases, deliveries are lower. The towns that are dependent on another city's water system frequently use less water, such as Evans. Johnstown delivers large amounts of water per capita while its neighbor, Milliken, supplies very little water per capita. The variation in these cases is largely due to whether the town provides irrigation water or not and supplies local industry. Irrigation ditches and yard wells probably supply a good portion of the water for lawns and gardens in many small towns.

Table 3 --Water deliveries by the small municipal systems, northern Colorado Front Range, 1972-1983

City	Year	Population	Annual water delivery	System delivery per capita[1]	City water delivery	City per capita delivery[2]	Average revenue per A.F.
			A.F.	Gal./day	A.F.	Gal./day	Dollars
Ault	1972	880	129	131	129	131	--
	1973	895	129	129	129	129	--
	1974	915	129	126	129	126	367
	1975	932	175	167	175	167	311
	1976	953	186	174	186	174	276
	1977	975	196	179	196	179	285
	1978	--	--	--	--	--	--
	1979	998	--	--	--	--	--
	1980	1,018	178	156	178	156	177
	1981	1,056	169	143	169	143	320
	1982	1,066	182	152	182	152	283
	3/1983	1,135	93	125	93	125	418
Evans	1972	2,924	556	170	444	136	227
	1973	3,101	623	179	498	143	246
	1974	3,278	663	181	530	144	273
	1975	3,455	666	172	532	138	262
	1976	3,655	687	168	549	134	276
	1977	3,860	771	178	615	142	273
	1978	5,000	770	137	770	137	--
	1979	5,063	743	131	743	131	--
	1980	5,160	813	141	813	141	--
	1981	5,190	767	140	767	140	--
	1982	5,386	900	149	900	149	255
	1983	5,506	793	129	793	129	323
Firestone	1972	690	45	58	45	58	628
	1973	750	51	61	51	61	590
	1974	810	65	71	65	71	520
	1975	869	87	89	87	89	428
	1976	907	99	97	99	97	428
	1977	986	102	96	102	96	481
	1978	1,100	153	124	153	124	373
	1979	1,150	155	120	155	120	425
	1980	1,179	165	125	165	125	426
	1981	1,200	166	123	166	123	605
	1982	1,260	165	118	165	118	735
	1983	1,309	164	113	164	113	735
Johnstown	1972	1,345	--	--	--	--	--
	1973	1,415	854	539	726	458	77
	1974	1,480	1,002	604	852	514	74
	1975	(1,550)	945	544	803	463	85
	1976	(1,600)	934	521	794	443	89
	1977	(1,650)	808	437	686	372	92

Table 3 (cont'd.)

City	Year	Population	Annual water delivery	System delivery per capita[1]	City water delivery	City per capita delivery[2]	Average revenue per A.F.
			A.F	Gal./day	A.F.	Gal./day	Dollars
Johnstown	1978	1,527	411	240	349	204	--
	1979	1,530	412	240	350	204	198
	1980	1,535	700	407	595	346	140
	1981	1,538	734	426	624	362	163
	1982	1,540	764	443	649	376	160
	1983	1,543	667	386	567	328	222
Milliken	1972	686	87	89	85	87	183
	1973	951	71	67	69	65	231
	1974	1,034	97	84	95	82	243
	1975	1,117	104	83	101	81	380
	1976	1,194	109	81	106	79	325
	1977	1,271	110	77	107	75	585
	1978	--	--	--	--	--	--
	1979	--	--	--	--	--	--
	1980	1,506	--	--	--	--	--
	1981	1,522	172	101	172	101	427
	1982	1,599	180	100	180	100	629
	1983	1,650	189	102	189	102	657
Windsor	1972	1,564	261	148	261	148	222
	1973	1,689	274	145	274	145	225
	1974	2,045	338	148	338	148	251
	1975	2,426	323	118	323	118	352
	1976	2,605	307	105	307	105	409
	1977	2,880	347	107	347	107	418
	1978	3,460	520	134	520	134	369
	1979	--	403	--	403	--	549
	1980	4,277	632	132	632	132	414
	1981	4,292	591	123	591	123	520
	1982	4,612	724	140	724	140	499
	1983	4,657	740	142	740	142	518
Lafayette	1972	4,971	--	--	--	--	--
	1973	5,547	1,003	162	703	113	253
	1974	6,468	--	--	--	--	--
	1975	7,353	1,050	127	743	90	263
	1976	(7,713)	1,040	121	737	86	275
	1977	(8,919)	--	--	--	--	--
	1978	7,700	1,440	167	1,440	167	264
	1979	8,200	--	--	--	--	--
	1980	9,020	--	--	--	--	--
	1981	10 074	1,392	123	1,392	123	598
	1982	10,724	1,642	137	1,642	137	539
	1983	11,374	1,415	111	1,415	111	732

Table 3 (cont'd.)

City	Year	Population	Annual water delivery	System delivery per capita[1]	City water delivery	City per capita delivery[2]	Average revenue per A.F.
			A.F.	Gal./day	A.F.	Gal./day	Dollars
Louisville	1972	3,288	--	--	--	--	--
	1973	3,470	950	244	945	243	--
	1974	3,658	1,082	264	1,077	263	--
	1975	4,093	951	207	946	206	174
	1976	4,470	1,276	255	1,270	254	145
	1977	4,945	--	--	--	--	--
	1978	5,000	--	--	--	--	--
	1979	5,200	971	167	967	166	
	1980	5,593	1,319	211	1,316	210	
	1981	5,705	1,331	208	1,323	207	
	1982	6,067	1,487	219	1,481	218	
	1983	7,200	1,336	166	1,336	166	394
Lyons	1972	1,005	252	223	243	216	130
	1973	1,023	313	273	302	266	108
	1974	1,038	230	198	222	191	146
	1975	(1,152)	211	164	204	158	166
	1976	(1,218	310	227	299	219	124
	1977	(1,288)	244	170	235	164	161
	1978	1,099	206	167	--	--	193
	1979	1,115	213	171	--	--	240
	1980	1,132	271	213	--	--	204
	1981	1,149	291	226	--	--	204
	1982	1,166	320	245	--	--	240
	1983	1,184	300	226	--	--	314
Berthoud	1972	--	--	--	--	--	--
	1973	--	--	--	--	--	--
	1974	--	--	--	--	--	--
	1975	2,072	621	267	583	252	117
	1976	(2,358)	776	294	729	276	82
	1977	(2,645)	614	207	577	195	158
	1978	2,150	689	286	648	269	176
	1979	2,259	661	261	621	245	173
	1980	2,369	738	278	694	262	255
	1981	2,487	693	249	651	234	284
	1982	2,611	666	228	626	214	446
	1983	2,741	583	190	548	178	483

Table 3 (cont'd.)

City	Year	Population	Annual water delivery	System delivery per capita[1]	City water delivery	City per capita delivery[2]	Average revenue per A.F.
			A.F.	Gal./day	A.F.	Gal./day	Dollars
Estes Park	1972	1,893	1,605	--	1,364	--	106
	1973	1,972	1,530	--	1,300	--	115
	1974	2,030	1,672	--	1,421	--	121
	1975	2,052	1,917	--	1,629	--	121
	1976	2,079	1,520	--	1,292	--	171
	1977	2,105	1,462	--	1,243	--	210
	1978	2,500	961	343	776	277	285
	1979	2,632	707	240	571	194	583
	1980	2,703	--	--	--	--	--
	1981	2,835	631	199	509	160	777
	1982	2,900	644	198	520	160	766
	1983	2,960	659	199	531	160	752

1/ Water delivery divided by city population.

2/ Adjusted delivery subtracts water delivered outside the corporate boundaries of the cities.

3/ June-October data missing.

Table 4--Water deliveries by selected small systems, northern Colorado Front Range, 1982 and 1983

City	Year	Population	Annual water delivery	System delivery per capita[1]	City water delivery	City per capita delivery[2]	Average revenue per A.F.
			A.F.	Gal./day	A.F.	Gal./day	Dollars
LaSalle	1982	1,910	655	306	(Over 90 percent		120
	1983	1,997	674	301	goes out of city)		131
Dacono	1982	2,323	323	124	323	124	562
	1983	2,349	344	131	344	131	542
Eaton	1982	1,923	644	299	644	299	171
	1983	1,975	650	294	650	294	196
Frederick	1982	1,075	205	170	205	170	461
	1983						
Kersey	1982	935	107	102	107	102	687
	1983	----------Unchanged----------					
Platteville	1982	1,800	577	286	577	286	139
	1983	----------Unchanged----------					

1/ Water delivery divided by city population.
2/ Adjusted delivery subtracts water delivered outside the corporate boundaries of the cities.

Water Delivery and Population Density Per Acre of Land in Municipalities

Another way to look at water use is in terms of acre-feet of water per acre delivered on an annual basis, much as irrigation systems look at water deliveries to irrigated farmlands. This gives an idea of how water intensive urban development is compared to irrigated agriculture in the region. Table 5 shows the water deliveries on an acre basis and population density of the larger municipalities in the region. Table 6 shows the same data for the small towns.

If one looks at the water use per acre in the larger towns over the past decade it appears that water use per acre has dropped in all cities from the early 1970s to the early 1980s. One might say that conservation efforts have paid off and that much less water is being used per acre than formerly. But when one looks at population density within the city limits it is apparent that density has also decreased over the past decade. What has happened is that the cities have been annexing land ahead of population growth with annexation outdistancing population growth. This means there are large areas of undeveloped, idle land within the city limits that do not as yet receive water service. Development of housing, business or industry has not taken place and the cities do not yet provide water service to the undeveloped areas. Throwing the undeveloped land in with intensively used land dilutes the average delivery per acre within city limits. Looking at population density per acre, all of the major cities have gone down in density since 1972. This doesn't mean there are less

Table 5--Water delivery and population per acre, selected cities, northern Front Range, Colorado, 1972-1983

City	Year	Acres in city	Estimated annual water delivery/acre	Population density/acre
			A.F.	
Boulder	1972	8,760	1.41	8.00
	1973	8,968	1.45	8.23
	1974	8,972	1.62	8.45
	1975	9,122	1.55	8.44
	1976	9,325	1.54	8.34
	1977	12,239	1.19	6.28
	1978	12,239	1.46	6.23
	1979	12,770	1.40	5.98
	1980	13,142	1.51	5.84
	1981	13,522	1.28	5.83
	1982	13,899	1.29	5.80
	1983	14,276	1.22	5.79
Broomfield	1972	2,500	0.64	4.24
	1973	2,920	0.60	4.20
	1974	3,650	0.64	3.82
	1975	3,890	0.63	4.00
	1976	4,290	0.59	4.13
	1977	4,640	0.57	4.11
	1978	4,640	0.73	4.32
	1979	4,718	0.71	4.58
	1980	4,818	0.81	4.67
	1981	5,323	0.66	4.30
	1982	5,437	0.63	4.24
	1983	5,926	0.56	3.99
Longmont	1972	5,000	1.51	5.30
	1973	5,010	1.43	5.10
	1974	5,115	1.58	5.20
	1975	5,285	1.42	5.30
	1976	5,922	1.33	5.60
	1977	6,045	1.30	5.70
	1978	6,203	1.95	7.15
	1979	6,390	1.62	6.46
	1980	6,691	1.68	6.42
	1981	6,994	1.59	6.43
	1982	7,844	1.44	5.74
	1983	8,694	1.34	5.50

Table 5--(cont'd.)

City	Year	Acres in city	Estimated annual water delivery/acre	Population density/acre
			A.F.	
Fort Collins	1972	8,333	1.61	6.28
	1973	9,082	1.51	6.14
	1974	10,380	1.52	5.58
	1975	10,572	1.36	5.73
	1976	10,624	1.34	6.00
	1977	10,746	1.40	6.24
	1978	12,800	1.28	5.50
	1979	13,530	1.05	4.93
	1980	13,856	1.25	5.50
	1981	16,154	1.01	4.49
	1982	17,498	0.89	4.23
	1983	17,658	0.96	4.27
Loveland	1972	3,737	1.51	5.30
	1973	4,246	1.43	5.10
	1974	4,511	1.58	5.20
	1975	4,744	1.42	5.30
	1976	4,941	1.30	5.60
	1977	5,199	1.30	5.70
	1978	5,519	1.39	5.76
	1979	6,446	1.19	4.61
	1980	7,204	1.24	4.20
	1981	8,437	0.99	3.65
	1982	9,228	0.73	3.44
	1983	9,548	0.68	3.40
Greeley	1972	--	--	--
	1973	6,507	1.87	7.46
	1974	6,639	1.89	7.68
	1975	7,000	1.89	7.64
	1976	7,212	1.87	7.57
	1977	7,541	1.87	7.34
	1978	8,368	2.30	7.19
	1979	8,733	2.13	7.39
	1980	10,204	1.99	5.19
	1981	11,884	1.61	4.54
	1982	13,490	1.49	4.15
	1983	13,867	1.46	4.04

Table 6--Water delivery and population per acre, small towns, northern Front Range, Colorado, 1972-1983

City	Year	Acres in city	Estimated annual water delivery/acre	Population density/acre
			A.F.	
Ault	1972	98	1.30	2.57
	1973	145	0.89	2.61
	1974	194	0.66	2.67
	1975	241	0.73	2.72
	1976	290	0.64	2.78
	1977	337	0.58	2.84
	1978	337	--	2.89
	1979	472	--	2.11
	1980	472	0.38	2.16
	1981	472	0.36	2.24
	1982	472	0.39	2.26
	1983	472	0.34	2.40
Evans	1972	1,350	0.33	2.20
	1973	1,350	0.37	2.30
	1974	1,350	0.39	2.40
	1975	1,350	0.40	2.60
	1976	1,350	0.41	2.70
	1977	1,400	0.44	2.70
	1978	1,435	0.54	3.48
	1979	1,435	0.52	3.53
	1980	1,435	0.57	3.60
	1981	1,435	0.54	3.62
	1982	1,595	0.56	3.38
	1983	1,595	0.59	3.45
Firestone	1972	160	0.28	4.30
	1973	160	0.32	4.69
	1974	160	0.41	5.06
	1975	160	0.54	5.43
	1976	200	0.50	4.54
	1977	804	1.26	1.18
	1978	804	0.19	1.37
	1979	980	0.16	1.17
	1980	980	0.17	1.20
	1981	980	0.17	1.22
	1982	980	0.17	1.27
	1983	980	0.17	1.34

Table 6 (cont'd.)

City	Year	Acres in city	Estimated annual water delivery/acre	Population density/acre
			A.F.	
Johnstown	1972	320	2.13	4.00
	1973	335	2.14	4.22
	1974	343	2.48	4.31
	1975	343	2.34	4.52
	1976	343	2.31	4.66
	1977	343	2.00	4.81
	1978	343	1.20	4.45
	1979	343	1.20	4.46
	1980	343	2.04	4.48
	1981	343	2.14	4.48
	1982	343	2.23	4.49
	1983	347	1.92	4.45
Milliken	1972	480	0.17	1.81
	1973	480	0.14	1.98
	1974	520	0.18	2.00
	1975	520	0.19	2.15
	1976	520	0.19	2.30
	1977	520	0.20	2.44
	1978	--	--	--
	1979	--	--	--
	1980	--	--	--
	1981	630	0.27	2.42
	1982	630	0.29	2.54
	1983	674	0.28	2.45
Windsor	1972	550	0.47	2.81
	1973	722	0.38	2.33
	1974	1,045	0.32	1.96
	1975	1,066	0.30	2.28
	1976	1,095	0.28	2.38
	1977	1,100	0.32	2.61
	1978	1,100	0.47	3.14
	1979	1,200	0.34	--
	1980	1,200	0.53	3.56
	1981	1,200	0.49	3.58
	1982	1,200	0.60	3.84
	1983	1,200	0.62	3.88

Table 6 (cont'd.)

City	Year	Acres in city	Estimated annual water delivery/acre	Population density/acre
			A.F.	
Lafayette	1972	2,275	--	2.19
	1973	2,342	0.30	2.36
	1974	2,827	--	2.29
	1975	2,827	0.26	2.60
	1976	2,827	0.26	2.73
	1977	2,840	--	3.14
	1978	2,840	0.51	2.71
	1979	2,840	--	2.89
	1980	2,900	--	3.11
	1981	3,033	0.46	3.32
	1982	3,172	0.52	3.38
	1983	3,312	0.43	3.43
Louisville	1972	480	--	6.85
	1973	497	1.91	6.98
	1974	733	1.48	5.00
	1975	733	1.29	5.58
	1976	735	1.73	6.08
	1977	1,092	--	4.53
	1978	1,885	--	2.65
	1979	3,165	0.31	1.64
	1980	3,645	0.36	1.53
	1981	4,005	0.33	1.42
	1982	4,450	0.33	1.36
	1983	4,530	0.30	1.59
Lyons	1972	570	0.42	1.76
	1973	570	0.53	1.79
	1974	570	0.39	1.82
	1975	570	0.36	2.02
	1976	570	0.52	2.14
	1977	570	0.42	2.25
	1978	570	0.36	1.93
	1979	570	0.38	1.96
	1980	570	0.48	1.99
	1981	570	0.51	2.01
	1982	570	0.56	2.05
	1983	570	0.53	2.08

Table 6--(cont'd.)

City	Year	Acres in city	Estimated annual water delivery/acre	Population density/acre
			A.F.	
Berthoud	1972	--	--	--
	1973	--	--	--
	1974	--	--	--
	1975	425	1.37	4.88
	1976	425	1.72	5.55
	1977	425	1.35	6.22
	1978	425	1.62	5.06
	1979	431	1.53	5.24
	1980	484	1.52	4.89
	1981	515	1.35	4.83
	1982	527	1.26	4.95
	1983	527	1.11	5.20
Estes Park	1972	2,000	0.68	0.95
	1973	2,000	0.65	0.98
	1974	2,505	0.57	0.81
	1975	2,505	0.65	0.82
	1976	2,505	0.51	0.83
	1977	2,750	0.45	0.77
	1978	2,750	0.35	0.91
	1979	2,750	0.26	0.96
	1980	2,750	--	0.98
	1981	2,750	0.23	1.03
	1982	2,880	0.22	0.91
	1983	2,880	0.23	0.93

Table 7 --Water delivery and population per acre, selected small towns, northern Front Range, Colorado, 1982 and 1983

City	Year	Acres in city	Estimated annual water delivery/acre	Population density/acre
			A.F.	
LaSalle	1982	560	1.17	3.41
	1983	560	1.20	3.57
Dacono	1982	692	0.47	3.36
	1983	692	0.50	3.39
Eaton	1982	430	1.50	4.47
	1983	430	1.52	4.59
Frederick	1982	960	0.22	1.12
	1983			
Kersey	1982	152	0.70	6.15
	1983	----------unchanged----------		
Platteville	1982	550	1.05	3.27
	1983	----------unchanged----------		

people per acre in developed areas; it is just that there is a large amount of open land around the core areas of the city that is included when calculating city density. Indeed, if only land actually occupied by housing were used to calculate density per acre it would probably be higher than the 1960s and early 1970s due to the development of large condominium, townhouse, and apartment complexes that have been built in the recent past. The trend seems to be toward smaller lots, row houses, narrower streets, surrounded, in some cases, by common areas.

For instance, population density in Boulder dropped from 8 people per acre in 1972 to 5.79 by 1982. Greeley went from 6.28 people per acre to 4.27; Loveland declined from 5.30 to 3.40 during the 12-year period. Fort Collins dropped from 6.28 to 4.27 people per acre in 1983. Broomfield changed very little, 4.24 in 1972 to 3.99 in 1983. Longmont grew slightly more dense, moving from 5.3 in 1972 to 5.5 in 1983.

The population density of the small towns is generally much lower than the larger cities in the area (table 6). Mostly the density has hung around 2 to 3 people per acre with Johnstown, Berthoud, Louisville, and Firestone being exceptions. Johnstown started at 4.0 and rose to 4.45 people per acre; Berthoud had 4.88 and rose to 5.20; Louisville at its highest had a density of 6.8 but fell to 1.59 in 1983 through aggressive annexation of undeveloped land. Firestone also declined from 4.3 to 1.34 in 1983. Population density of towns for which we have only recent data is shown in table 7.

A study of gross irrigation water supplies available to irrigated lands in the region shows that irrigation systems average from 2.5 to 2.9 A.F. of water per acre. 1/ From the data shown in tables 5 and 6 it can be seen

1/ Robert G. Evans, Hydrologic Budget of the Poudre Valley, Appendix D, Environmental Resources Center, Colorado State University, September 1971.

that water delivery in the municipalities is lower on a per-acre basis than in the surrounding irrigated farmlands. We do not have complete data on return flow through the waste treatment plants, but in 1976, Fort Collins returned 11,192 A.F. of the 15,870 A.F. taken into the municipal water system. This amounted to a 70.3 percent return or a consumptive use of .43 A.F. per acre in the city. Greeley water works delivered 14,297 A.F. to the city and returned 8,988 A.F. through their waste treatment plants for a return flow of 63 percent or .70 A.F. consumptive use per acre.

If all of the irrigation water that is used to irrigate farmlands that are converted to urban uses is transferred to cities, there should be ample water supplies for the cities. The process would simply be one of converting irrigation water and farmland to urban uses. However, it would be difficult to meet year-long municipal demand from the essentially short-season water supply used for irrigation purposes. Thus ownership of irrigation stock is not sufficient to supply growing cities. Storage must be provided to even out supply and use over the year.

The municipal water supply per acre to the small towns is generally smaller than that of the larger cities (table 6). All small towns have supplies of less than 1 acre-foot per acre except Johnstown, which consistently reported over 2 acre-feet per acre. Population density in the small towns, as noted, is generally less than the larger cities so they can get by with less water per acre, particularly where other sources of water are available for outside watering.

The growth in urban population means that the cities and towns have to acquire additional water supplies to serve the growing populations. We have gathered data on five of the larger cities on the changes in ownership of

irrigation company stock and Colorado-Big Thompson water by these cities from 1972 to 1982 (table 8). Some of these cities have developed reservoirs of their own (such as Joe Wright by Fort Collins) and six of the major towns are participating in the Windy Gap project which will add a total of 54,000 A.F. to their water supplies. Therefore the data in table 8 do not constitute total water available to these cities.

The major cities and towns within the Northern Colorado Water Conservancy District have added substantially to their water supplies during the period 1972 through 1982. The five major cities added about 26,250 acre-feet of water of irrigation company stock. Irrigation company stock held by cities increased by 34 percent in Boulder to 182 percent in Fort Collins. Most of the irrigation stock was added to city supplies between 1972 and 1977. Acquisition of irrigation company stock has slowed during the past five years.

In addition to irrigation stock, the cities have been acquiring Colorado-Big Thompson water for future urban use. Between 1977 and 1982 the five cities added 24,380 units of C-BT water to their holdings. Very little activity in purchase of C-BT units occurred between 1972 and 1977. During this period the price of C-BT units soared to $1200 - $2000/unit. After 1980, the price of C-BT units slid off sharply, and it was after the drop in price that the cities again began to acquire C-BT units to add to their water stocks. Only 2,857 units were acquired by the towns between 1972 and 1977 while between 1978 and 1982, 24,380 units were picked up by the cites.

This eleven-year period shows two distinct phases. Irrigation company stock was acquired aggressively between 1972 and 1977 and then dropped off during the period 1978 to 1982. The opposite was true with C-BT water. Little activity took place while prices soared but picked up rapidly with the price

Table 8--Growth in water supply of the larger towns, northern Front Range, Colorado, 1972-1982

City 1/	Irrigation company stock 2/			Percent change	C-BT water 3/			Change
	1972	1977	1982	1972-82	1972	1977	1982	1972-82
	A.F.			Percent	-- Units --			Percent
Boulder	5,838	7,802	7,802	+ 34	13,647	14,592	20,785	+ 52.3
Ft. Collins	5,856	15,696	16,510	+182	6,906	7,410	10,899	+ 57.8
Greeley	4,774	6,235	8,982	+ 88	12,362	12,879	18,672	+ 51.0
Longmont	5,226	9,452	12,454	+138	5,180	5,527	10,494	+102.6
Loveland	3,611	4,970	5,814	+ 61	4,498	5,042	8,988	+ 99.8
Total	25,305	44,155	51,562	+103.7	42,593	45,450	69,838	+ 64.0

1/ Cities hold water rights of their own which are not listed here. This table lists only irrigation company stock and C-BT units owned in 1972 or acquired since.

2/ Average yield of water to irrigation company stock.

3/ Water yield from C-BT units varies yearly according to a quota set by N.C.W.C.D. The quota tends to be higher in dry years and lower in years with ample water.

decline in C-BT units. Irrigation company stock prices dropped during the 1978-1982 period also, but C-BT probably represented a better value to the cities.

Irrigation company stock yield is average yield of water to that stock. Ownership of C-BT units are listed; the yield varies from year to year depending on the delivery quota issued by the Northern Colorado Water Conservancy District. The quota tends to be higher in dry years and lower in wet years.

Cities do not typically go out and buy C-BT water or irrigation company stock. The water comes into city ownership as a result of development requirements that developers must supply water to the city as part of the annexation process. The developer can give to the city irrigation company stock, C-BT units or money in the equivalent of X acre-feet of water per acre.

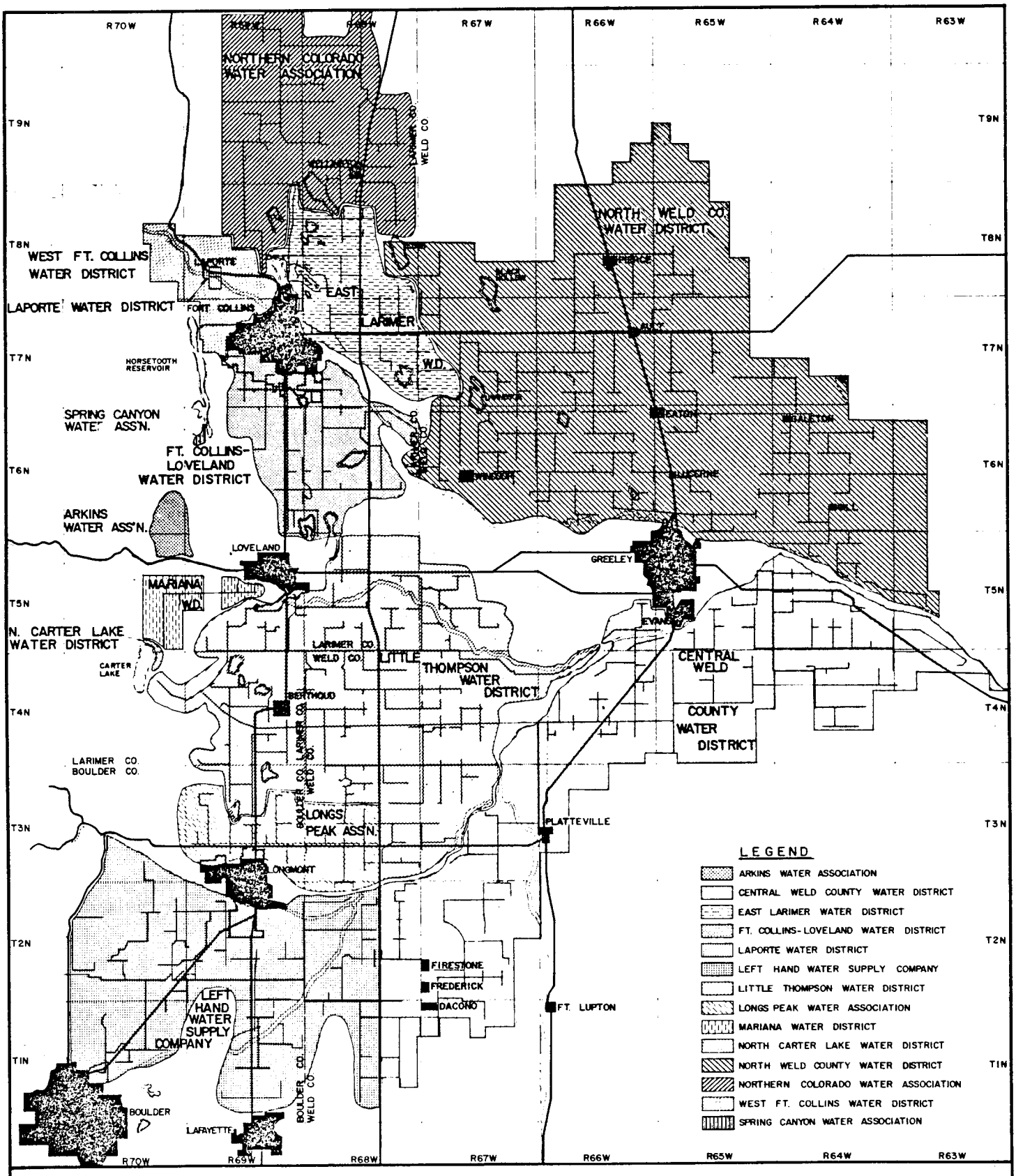
The cities monitor prices of water traded in the area and adjust the money payment to be close to water trading prices. When one type of water or money becomes cheap relative to the others, the cities begin to receive most of the water from that source, such as irrigation company stock during the 1970s and C-BT units during the latest period. We have no data on money payments to cities in lieu of water, but some of the money may be converted into either irrigation stock or C-BT units.

RURAL-DOMESTIC WATER SYSTEMS

Beginning in 1960, rural-domestic water systems were built that cover practically all of the irrigated and some non-irrigated areas in Boulder, Weld, and Larimer counties (see map). These systems got their start in response to programs sponsored by the Farmers Home Administration (FmHA) to bring domestic water to rural areas without adequate household or livestock water supplies. Rural water systems developed rapidly in the northern Front Range area, impelled by poor domestic water sources and the beginnings of rapid population growth. Ten of the 12 systems in the area were organized during this period.

During the organizational period, several of the rural-domestic systems became too large for FmHA financing of water treatment and distribution facilities. Consequently, these systems abandoned the FmHA sponsorship in favor of the more flexible special district type of organization (under Colorado Revised Statutes), which gives the organization the ability to levy taxes on real property and allows financing through the commercial bond market. Much more capital can be raised through special districts than through FmHA financing. Disadvantages of the special district organization are that special elections are required to organize and specific boundaries of the service area have to be established. Expanding the boundaries of special districts is cumbersome after the district has been in existence for some years, due to tax equity problems and election requirements.

Of the rural water systems, eight were organized as special districts and four as water delivery associations. Water associations generally have smaller service areas and a limited number of customers. Recently, the associations are facing another problem in that the State is attempting to levy a property tax on the associations, while the special districts, as



RURAL DOMESTIC WATER SYSTEMS
LARIMER, BOULDER & WELD COUNTIES

(as of 1972)

CSU DRAFT SECTION I.G. BENTON

government units, are exempted from paying this tax. Special legislation has been introduced in the state legislature to relieve the burden, but many associations may have to reorganize as special districts to escape the tax burden.

The rural-domestic water systems organized as special districts cover extensive areas and operate in a manner designed to accommodate significant expansion in terms of water users (see map). During the early development period some of the water systems were adding customers at the rate of 10 percent a year. Recently the expansion rate has been slower, from less than 1 percent per year to 6 percent for a couple of systems. West Fort Collins Water District lost customers because of a change in service area (?).

A comparison of rural-domestic system size, average revenue per acre-foot of water sold, number of taps, miles of line, bonded indebtedness, and mill levy per district is shown in table 8. Revenue per acre-foot sold in 1982 ranged from $347 to $725. The smaller rural water systems charge from about $500/A.F. upwards while the large rural-domestic districts generally retail water for below $400 per acre-foot. Only 2 of the 8 water districts do not levy a tax on real property within the district. Millage rates vary from 30 mills for one small district to generally 4 and 5 mills for most rural-domestic water districts. Those systems organized as associations or companies cannot levy taxes on property.

Total water delivered by system, estimated population served, and estimated delivery per capita are shown in table 9. The larger systems deliver up to about 2,900 A.F. with small systems delivering only 20 to 500 A.F. Populations served by systems range from about 200 to over 13,000 in the

larger systems. Miles of water lines range from 5 at the smallest to 800 for the largest. Bonded indebtedness of the systems seems to have stabilized with many systems carrying less debt than in 1972. Most rural-domestic systems deliver relatively small amounts of water compared to the larger municipalities, but many deliver more water than the small towns. In some cases, rural-domestic systems have become the supplier of water to small towns. Under the rural-domestic systems customers, for the most part, are widely dispersed, making water delivery through the system low in relation to the area served (see map). Water delivery per capita varies from quite low to amounts similar to municipal systems.

Except for the major distributor lines, water lines in rural-domestics consist of plastic and asbestos pipe, some of which are only 2 inches or less in diameter. The operators are building storage tanks on hills throughout the service areas of the larger systems to serve rural subdivisions and other customers located in widely scattered areas. Many dairy farms and feedlots throughout the area are served by rural-domestic systems.

Water Pricing Under Rural-Domestic Water Systems

Water rates under the rural-domestic water systems are substantially higher than those for municipal systems--contrast revenues per acre-foot in table 9 with those in table 1. Table 9 shows average revenues from water sales ranging from $228 to over $700 per acre-foot. Spring Canyon charges more, but it is a very small system. The higher water rates are necessary for several reasons. Most of these systems, being relatively new, have high capital costs to pay off. Low customer density in many areas of the systems and fairly low total water delivery mean water rates have to be high to cover capital and operating costs. As customers become more dense in certain areas

Table 9--Size of system, taxing status, and outstanding debt for selected rural-domestic water organizations, northern Front Range, Colorado, 1972, 1977, and 1982

Name	Year	Average revenue per A.F.	Number of taps	Miles of line	Bonded indebtedness	Mill levy	Per capita indebtedness
		Dollars			Dollars		Dollars
Central Weld County W.D.	1972	168	692	200	4,600,000	2	--
	1977	259	1,029	215	5,815,000	4	831
	1982	357	1,150	250	5,099,209	5	1,267
East Larimer County W.D.	1972	295	1,450	175	--	0	--
	1977	312	2,107	250	--	0	--
	1982	347	2,590	195	--	0	--
Ft. Collins-Loveland W.D.	1972	252	1,123	100	1,370,000	4	391
	1977	207	2,400	--	3,000,000	4	391
	1982	228	2,900	250	3,043,369	2.7	328
Left Hand Water Supply Co.	1972	369	1,850	280	4,500,000	--	500
	1977	522	2,316	293	3,749,357	--	323
	1982	492	2,722	368	4,029,281	--	296
Little Thompson-Mariana W.D.	1972	235	1,675	270	2,160,000	0	485
	1977	279	2,353	270	1,115,000	0	150
	1982	313	3,259	300	4,002,000	0	409
North Weld County W.D.	1972	292	1,300	600	3,500,000	2	700
	1977	268	1,603	800	4,375,000	5	688
	1982	397	1,800	600	--	5	--
Longs Peak Water Assn.	1972	278	469	55	--	--	--
	1977	267	607	60	700,000	--	271
	1982	496	633	60	--	0	--
West Ft. Collins W.D.	1972	282	300	23	690,000	10	328
	1977	423	600	30	487,000	10	174
	1982	497	750	30	--	8	--
Arkins Water District	1972	515	140	10	--	--	--
	1977	529	210	10	140,077	--	167
	1982	823	290	13	--	--	--
North Carter Lake W.D.	1972	661	50	5	--	--	--
	1977	610	64	5	97,000	11.7	542
	1982	608	83	5	154,000	30	664
Northern Colorado Water Assn.	1972	--	400	125	1,000,000	--	--
	1977	424	525	150	978,323	--	652
	1982	725	603	150	829,863	--	481
Spring Canyon W.D.	1972		80	5	--	--	
	1977	1,313	190	5	375,000	18	625
	1982	--	--	--	--	--	--

due to rural subdivision development, the rural-domestics must upgrade the distribution system by installing additional lines and larger lines, installing storage tanks, expanding filter plants, and buying more water, all of which require additional funds to make the capital investment.

The fact that new users continue to join the rural-domestic water systems indicates that the water charges are not so high as to discourage domestic users from locating in these areas. The large systems added customers at rates varying between 22 percent and 66 percent in the 1972 to 1977 period. Small systems grew faster--between 50 percent and 100 percent. However, growth was slower in the 1978 to 1982 period. Growth rates were on the order of 15 to 31 percent for the period. Population served by rural-domestic water systems grew from an estimated 34,000 in 1972 to around 52,000 in 1977, a growth of 53 percent in 6 years. In 1982, it was estimated 65,000 people were served by rural-domestic systems, up 25 percent from 1977.

The very high rates that people are willing to pay shows the inelasticity of demand for domestic water. Probable reasons for this are: 1) even with high rates, total budgetary expenditures for water are not burdensome for many families; 2) trade-offs of various types such as a country home, room for horses and pets, and freedom from the restrictions of urban-type housing more than offset the higher costs of domestic water; 3) in many rural situations irrigation water is available for outside use.

In deriving water deliveries per capita under the rural-domestic systems we find a range of from 282 gallons per capita per day down to 101 gallons per day on the larger systems (table 10). The smaller systems generally report less than 100 gallons per capita per day. Some of these, North Carter Lake, Arkins, and Spring Canyon, for instance, serve seasonal homes

Table 10-Water deliveries per capita in major rural-domestic systems, northern Front Range, Colorado, 1972, 1977, and 1982

Name	Year	Total water delivered	Population served	Per capita	Per capita per day
		A.F.		Gallons	Gallons
Central Weld County Water District	1972	981	4,389	72,832	199.5
	1977	1,835	7,000	85,420	234.0
	1982	2,360	10,500	73,239	200.6
East Larimer County Water District	1972	975			
	1977	1,515	--	--	--
	1982	2,160	--	--	--
Ft. Collins-Loveland Water District	1972	847	3,500	78,856	216.0
	1977	1,354	7,680	57,448	157.0
	1982	2,940	9,280	103,233	282.8
Left Hand Water Supply Co.	1972	811	9,000	29,362	80.0
	1977	1,183	11,601	33,228	91.0
	1982	1,546	13,610	37,014	101.4
Little Thompson Valley-Mariana Water District	1972	1,170	4,450	85,673	234.7
	1977	1,698	7,430	74,467	204.0
	1982	2,192	9,777	73,056	200.0
North Weld County Water District	1972	1,594	5,000	103,881	284.0
	1977	2,091	6,351	107,283	294.0
	1982	2,098	7,200	94,968	260.0
Longs Peak Water Assn.	1972	344	1,640	68,349	187.0
	1977	536	2,580	67,696	185.0
	1982	523	2,690	63,353	173.5
West Ft. Collins Water District	1972	229	2,100	35,533	97.0
	1977	337	2,800	39,218	107.0
	1982	420	2,250	60,889	167.0
Arkins Water District	1972	43	560	25,020	68.5
	1977	70	840	27,154	74.0
	1982	--	1,084	25,703	70.4
North Carter Lake Water District	1972	11	120	29,869	81.8
	1977	18	179	32,767	90.0
	1982	23	232	32,304	88.5
Northern Colorado Water Association	1972	189	--	--	--
	1977	302	1,500	65,604	170.0
	1982	376	1,724	71,067	195.0
Spring Canyon Water District	1972	16	300	17,378	47.6
	1977	33	600	17,922	49.0
	1982	--	--	--	--

and cabins. Per capita water delivery figures are difficult to develop and may be inaccurate because the systems serve some farms that have feedlots and dairies, where large quantities of water are used for livestock in addition to domestic use. There is some lawn watering from rural-domestic systems, but many rural residents irrigate the grounds around their homes from existing irrigation ditches or wells, or they have native landscaping that is not watered. Consequently, it is difficult to develop data that allow comparison between city and rural water systems.

The rural systems studied collect a wide range of revenues per acre-foot delivered: Central Weld County Water District averaged $357; Left Hand Water Supply Company averaged over $492 per acre-foot delivered; Spring Canyon Water Association collected the most with $1,313/A.F. while Fort Collins-Loveland Water District derived the least, $228/A.F. (see table 9). Among the larger municipal systems only Broomfield collects over $600 per A.F. delivered (see table 1). Evans pays $273/A.F.; it is supplied by the Greeley water system. Small town systems charge anywhere from $92/A.F. (Johnstown) to $581/A.F. (Milliken).

Table 11 shows the monthly water rate structure for the rural-domestic water systems. All systems have a declining-rate structure so that water becomes cheaper with larger quantities. Some have a slightly different minimum monthly delivery than indicated here, but these have been standardized to 5,000 and 10,000 gallon increments for comparative purposes. From 1977 to 1982, pricing structure for varying quantities of delivery changed among the rural-domestic districts. Eight of the rural-domestics raised water rates in all categories. One large district reduced its water rate across the

Table 11--Monthly water rates per 1,000-gallon delivery for selected rural-domestic water organizations, northern Front Range, Colorado, 1977 and 1982

Name	Year	Thousands of gallons/month								
		5	6	10	15	20	40	60	80	100
		Dollars								
Central Weld County Water District	1977	3.00	2.83	2.20	1.80	1.60	1.18	1.01	0.91	0.85
	1982	3.90	3.50	2.70	2.30	2.10	1.55	1.32	1.18	1.09
East Larimer County Water District	1977	2.01	1.82	1.44	1.21	1.08	0.83	0.73	0.68	0.65
	1982	2.24	2.06	1.71	1.54	1.45	1.27	1.13	1.07	1.04
Ft. Collins-Loveland Water District	1977	1.17	1.16	1.02	0.85	0.71	0.48	0.41	0.37	0.35
	1982	1.60	1.33	1.12	0.92	0.76	0.51	0.43	0.38	0.36
Left Hand Water Supply Co.	1977	2.80	2.47	1.83	1.47	1.29	0.89	0.76	0.70	0.66
	1982	2.80	2.47	1.83	1.47	1.29	0.89	0.76	0.70	0.66
Little Thompson Valley W.D.	1977	2.00	1.89	1.50	1.23	1.10	0.90	0.83	0.80	0.78
	1982	2.00	1.67	1.00	0.67	0.58	0.45	0.40	0.37	0.36
North Weld County Water District	1977	1.29	1.29	1.29	1.19	1.09	0.91	0.76	0.68	0.63
	1982	3.60	3.08	2.05	1.53	1.27	0.89	0.76	0.69	0.65
Longs Peak Water Association	1977	2.80	2.47	1.80	1.43	1.23	0.86	0.74	0.68	0.64
	1982	3.90	3.58	2.99	2.47	2.16	1.71	1.55	1.49	1.43
West Ft. Collins Water District	1977	2.40	2.33	1.40	1.07	0.93	0.71	0.64	0.61	0.58
	1982	3.15	2.75	1.95	1.55	1.35	1.05	0.95	0.90	0.87
Arkins Water District	1977	2.10	1.75	1.45	1.30	1.35	1.42	1.45	1.46	1.47
	1982	--	--	--	--	--	--	--	--	--
North Carter Lake W.D.	1977	3.00	2.50	1.50	1.00	0.75	0.38	0.25	0.19	0.15
	1982	4.00	3.33	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Northern Colorado Water Assn.	1977	2.70	2.44	1.93	1.60	1.44	1.09	0.98	0.92	0.89
	1982	2.75	2.72	2.67	2.58	2.53	2.37	2.31	2.28	2.27
Spring Canyon Water District	1977	4.00	3.66	3.00	2.33	2.00	1.50	1.33	1.25	1.20
	1982	--	--	--	--	--	--	--	--	--

board except for the smallest monthly delivery. Some categories were reduced by half. One system kept the same rate structure and two did not provide information on current rate structure.

Table 12 shows the retail price per acre-foot delivered at different quantities per month under the various systems. Declining block rate pricing is not popular among the conservation community, but from a business point of view declining block rates make sense because the capital costs and variable costs are spread over more units of water delivered. This justifies high charges for minimal service and also justifies lower unit costs to large users such as cattle and sheep feedlots and dairy farms. These businesses could not carry the burden of the rates charged to small household users. Variable costs tend to be low so that large deliveries do not increase these substantially while larger deliveries spread the fixed costs over many more units of water. In any case, deliveries of water through all of the rural-domestics is small compared to municipal water delivery and very small compared to total area water supply.

The principal source of water for the rural-domestic systems is the Colorado-Big Thompson project. Rural-domestic systems have been acquiring C-BT water since their inception in the early 1960s. C-BT water is drawn principally from Carter Lake and Horsetooth Reservoir, filtered and sent to the various distribution systems. Several districts and associations have joined together to build the filter plants that serve their systems and some have begun to cooperate with nearby cities to intertie with municipal systems. The Northern Colorado Water Conservancy District, which controls and delivers C-BT water, has modified its operating procedures and delivery rules to accommodate the needs of the rural-domestic systems and the municipalities

Table 12--Retail value of water per acre-foot for selected rural-domestic water organizations, northern Front Range, 1977 and 1982

Name	Year	1,000 gallons per month: 5	6	10	15	20	40	60	80	100
		Dollars per acre-foot delivered								
Central Weld Co. Water District	1977	977.60	922.16	716.91	586.56	521.39	384.52	329.13	296.54	276.99
	1982	1,270.82	1,140.49	879.80	749.46	684.29	505.07	430.12	384.50	355.18
East Larimer Co. Water District	1977	654.99	593.05	469.25	394.30	351.94	270.47	237.88	221.59	211.81
	1982	729.91	671.25	557.21	501.81	472.48	413.83	368.21	348.66	338.89
Ft. Collins-Loveland Water District	1977	381.26	377.99	332.38	276.99	231.37	156.42	133.61	120.57	114.05
	1982	521.36	433.38	364.95	299.78	247.65	166.18	140.16	123.82	117.30
Left Hand Water Supply Co.	1977	912.43	804.85	596.34	479.02	420.37	290.02	247.66	228.11	215.07
	1982	912.43	804.85	596.34	479.02	420.37	290.02	247.66	228.11	215.07
Little Thompson Valley-Mariana Water Dist.	1977	651.73	615.86	488.80	400.82	358.45	293.28	270.47	260.69	254.18
	1982	651.73	544.17	325.85	218.32	189.99	146.63	130.34	120.56	117.31
North Weld County Water District	1977	420.35	420.35	420.35	387.78	355.19	296.54	247.66	221.59	205.30
	1982	1,173.06	1,003.62	667.99	498.55	413.83	290.00	247.65	224.84	211.80
Longs Peak Water Assn.	1977	912.30	804.85	586.56	465.99	400.82	280.25	241.14	221.59	208.55
	1982	1,270.82	1,166.55	974.29	804.85	703.84	557.21	505.07	485.52	465.97
West Ft. Collins Water District	1977	782.08	759.23	456.21	348.68	303.06	231.37	208.55	198.78	189.00
	1982	1,026.43	896.09	635.41	505.07	439.90	342.14	309.56	293.27	283.49
Arkins Water District	1977	684.29	570.24	472.48	423.61	439.90	462.71	472.48	475.74	479.00
	1982	--	--	--	--	--	--	--	--	--
North Carter Lake Water District	1977	977.60	814.63	488.80	325.87	244.40	123.83	81.47	61.91	48.88
	1982	1,303.40	1,085.08	651.70	651.70	651.70	651.70	651.70	651.70	651.70
Northern Colorado Water Assn.	1977	879.84	795.08	628.92	521.39	469.25	355.19	319.35	299.80	290.02
	1982	896.09	886.31	870.02	840.70	824.40	772.27	752.72	742.94	739.58
Spring Canyon Water District	1977	1,303.47	1,192.61	977.60	759.27	651.73	488.80	433.40	407.33	391.04
	1982	--	--	--	--	--	--	--	--	--

to provide year-round water service to these systems. The high elevation of Carter Lake and Horsetooth Reservoir provides a good head of water to carry water well out onto the plains to the east.

Starting with no C-BT water in the very early 1960s, the rural-domestics had acquired 16,584 units by 1973. In 1977, they held 18,227 units and by 1982, the total C-BT units had risen to 18,881. Water delivery by the rural-domestic systems amounted to 14,724 acre-feet in 1982. All but 376 A.F. of this was C-BT water. Table 13 shows the water delivery and ownership of C-BT units by the rural-domestic water systems. Most of the systems do not have a large excess supply of C-BT water, so as expansion occurs, it will be necessary for them to acquire additional C-BT water from farmers in the region. As of 1982, rural-domestic organizations held 6 percent of total C-BT water; together with municipal ownership, about 33 percent of C-BT water is now held for nonagricultural uses. Currently only about half of this is actually used for domestic purposes, but rural-domestic systems now use more than 80 percent of their C-BT water each year.

By acquiring C-BT water from farmers, the cities and the rural-domestics have removed most of the marginal supplementary irrigation supplies. The price of C-BT units that are transferred from one user to another had risen from about $30 per acre-foot unit in the early 1960s to the $2,000-$2,500 range by 1980. Prices took a sharp break after this and stood around $1,000 in 1983. With about 33 percent of the C-BT water held by municipalities and rural-domestic systems, it is getting increasingly difficult to find C-BT water that is excess on farms. Further purchase of C-BT water from farmers could cut into needed irrigation supplies and could seriously affect the water supplies of some irrigation companies.

Table 13--Water delivered in 1982 and C-BT units owned by rural-domestic organizations in Boulder, Weld, and Larimer counties, 1972, 1977, and 1982

Name	Water delivered 1982	1973 C-BT units owned 1/	1977 C-BT units owned	1982 C-BT units owned
	A.F.			
Central Weld County Water District	2,364	2,475	2,865	3,272
East Larimer County Water District	2,160	1,283	1,264	2,308
Ft. Collins-Loveland Water District	2,940	2,605	3,084	4,320
Left Hand Water Supply Company	1,545	2,427	2,525	3,347
Little Thompson Valley-Mariana Water District	2,192	3,355	3,913	5,498
North Weld County Water District	2,098	2,985	3,085	2,046
Longs Peak Water Assn.	523	560	682	712
West Fort Collins Water District	420	761	779	960
Arkins Water Assn.	85	103	0	241
North Carter Lake Water District	21	15	15	20
Northern Colorado Water Assn.	376	0(well water)	0	2
Spring Canyon Water District	--	15	15	43
TOTAL	14,724	16,584	18,227	18,881

1/ A unit is nominally an acre-foot, but the district delivers between .5 to 1.0, depending on water supply conditions.

Source: Records of the N.C.W.C.D.

SUMMARY

The data from municipal water systems show a wide range of water deliveries per capita and a wide range of prices for domestic water delivery. In the larger cities and towns of the northern Front Range, water deliveries per capita range from 119 gallons per day in Broomfield to 271 gallons per day in Greeley. Average revenue collected by the cities ranges from $253 per acre-foot in Greeley to $629 per acre-foot in Broomfield. The larger cities and towns of the area have raised water rates ranging from 85 percent to 363 percent in the period from 1972 to 1982. Boulder had the lowest increase in revenue, up $137/A.F., Loveland the largest increase, up $429/A.F. During the period, Greeley's water revenue increased $184/A.F.; Longmont's, $234/A.F.; Fort Collins's, $240/A.F.; and Broomfield's, $396/A.F.

The larger cities and towns increased their raw water supplies substantially between 1972 and 1982. The amount of irrigation company water owned by cities increased by 103 percent, for a total of about 26,257 A.F. on average yield. Boulder's holdings of irrigation company water increased by 34 percent while Fort Collins's holdings of irrigation water stock increased by 182 percent. City holdings of Colorado-Big Thompson water also increased by 64 percent or 27,245 units between 1972 and 1982. The holdings of Boulder, Fort Collins, and Greeley increased by about 50 percent while those of Longmont and Loveland increased by about 100 percent.

The smaller towns show a somewhat different pattern; water deliveries in some cases are lower than in larger cities and in some cases, higher. Milliken delivers only 102 gallons per capita per day, while Johnstown sometimes delivers around 350 gallons per capita per day. Water revenue per acre-foot delivered through small systems also tends to be higher in most cases. Estes

Park and Milliken collect the highest revenue with $766/A.F. and $657/A.F. respectively. Johnstown collects $222 per acre-foot delivered with the other small towns falling in a range of about $222/A.F. to $766/A.F.

Water deliveries per acre in the larger cities fall below 2 A.F. in all cases, with Broomfield delivering only .56 A.F. per developed acre in the city. The small towns also supply very little water on a per-acre basis, except Johnstown, which supplies over 2 A.F. per acre.

Rural-domestic water systems have grown to cover most of the irrigated areas of Boulder, Weld, and Larimer counties since 1960. Some foothill areas in Larimer County are also served by them.

The larger rural-domestic systems serve from 2,500 to over 13,000 people while the small ones serve from 120 to 1,000 people. The larger systems have up to 800 miles of transmission lines with the smaller ones having 5 to 30 miles of line. Water deliveries under the rural-domestics range from 18 acre-feet in the small systems up to 1,000 to 2,360 A.F. in the larger systems. Water delivery estimates on a per-capita basis range from 100 gallons per capita per day to 260 gallons per capita day in the larger rural-domestic systems. Small systems deliver very low volumes of water per day, from about 50 gallons per capita per day on one system to 90 gallons on another. These systems serve a number of seasonal dwellings, however. Average revenue per acre-foot of water delivered under the rural-domestics is generally much higher than municipal systems. The larger systems derive from $228 per A.F. up to $497 per A.F. Rates charged by the small systems generate revenues from $600 and $823 per A.F. One small rural-domestic averages over $1,300 per A.F. delivered.

The rural-domestic water organizations are basically low-density, low-volume delivery systems designed primarily to serve farms and rural homes. Subdivision development in many rural areas places severe strains on capacity and requires upgrading of sections of the service area. Water rates under rural-domestic systems are several times typical municipal rates. Nevertheless, the rural systems continue to expand as more homes and businesses locate beyond the water service areas of municipalities. As the cities annex land around their peripheries, conflicts arise between municipalities and rural districts. The rural-domestic systems lose customers. The people included in the annexations are required to bear the cost of installing the municipal water system and often must continue to pay taxes to the rural water district.

Water, in this region, is a renewable flow resource. Supplies are regenerated annually from the snowpacks of the high mountains. Most of the water has been captured and used for decades, primarily for irrigation. As urbanization continues, it occurs mainly on irrigated land, displacing irrigated agriculture. As land is converted to urban use, it is reasonable to expect that water formerly used for agriculture also will be shifted to urban uses. As was noted earlier, the acre-foot volume of water used by urban areas is substantially less than was used on the irrigated lands. Thus, much of the new urban area can be served with the raw water supply that has traditionally served the land. In addition to using less water per acre, consumptive use in the cities is less--on the order of 30 percent to 35 percent--resulting in a higher return flow than from formerly irrigated lands and adding an additional increment to the area's water supply.

People who live in semiarid areas, such as this, tend to bring the values of a humid environment with them. Green lawns and parks are part of their expectations and these are important features in the urban environment. In addition to having an aesthetic value, lawns have a cooling effect and keep down dust and erosion. Trees are important in providing shade in the summer to hold down daytime temperatures, and they also break up the high winds that occasionally sweep the area. At current rural-to-urban conversion rates for rural land and water, there seems little need to deny this expectation through a stringent domestic water use policy. With water use and consumption in urban areas less than for irrigated agriculture, growth of cities will not take water from agriculture as much as population growth will displace agriculture through competition for land as living space and, in the process, will acquire the water formerly used on the irrigated lands.

Graphical Displays of
Selected Data From Municipalities

* Total Acreage and Water Deliveries, Larger Cities of the Northern Front Range, 1972 and 1982.

* Average Revenue per Acre Foot of Water, Major Cities of the Northern Front Range.

* Average Revenue and Per Capita Gallons Use, Greeley, 1972-1983.
  Average Revenue and Per Capita Gallons Use, Fort Collins, 1972-1983.
  Average Revenue and Per Capita Gallons Use, Boulder, 1972-1983.

* Average Revenue and Per Capita Water Use, Loveland, 1972-1983.
  Average Revenue and Per Capita Water Use, Longmont, 1972-1983.
  Average Revenue and Per Capita Water Use, Broomfield, 1972-1983.

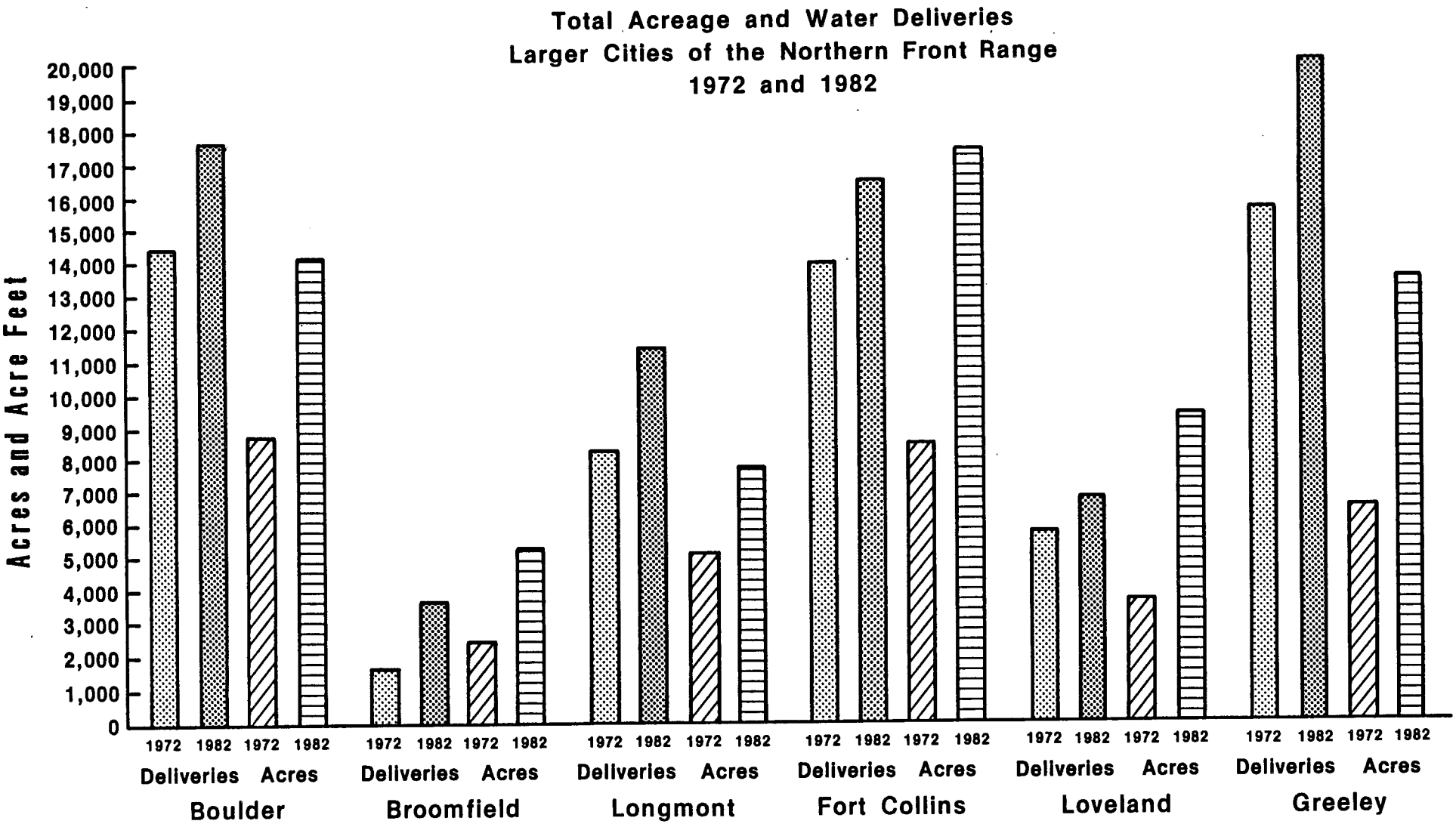
* Population in Small Cities, Northern Front Range, 1972 and 1982.

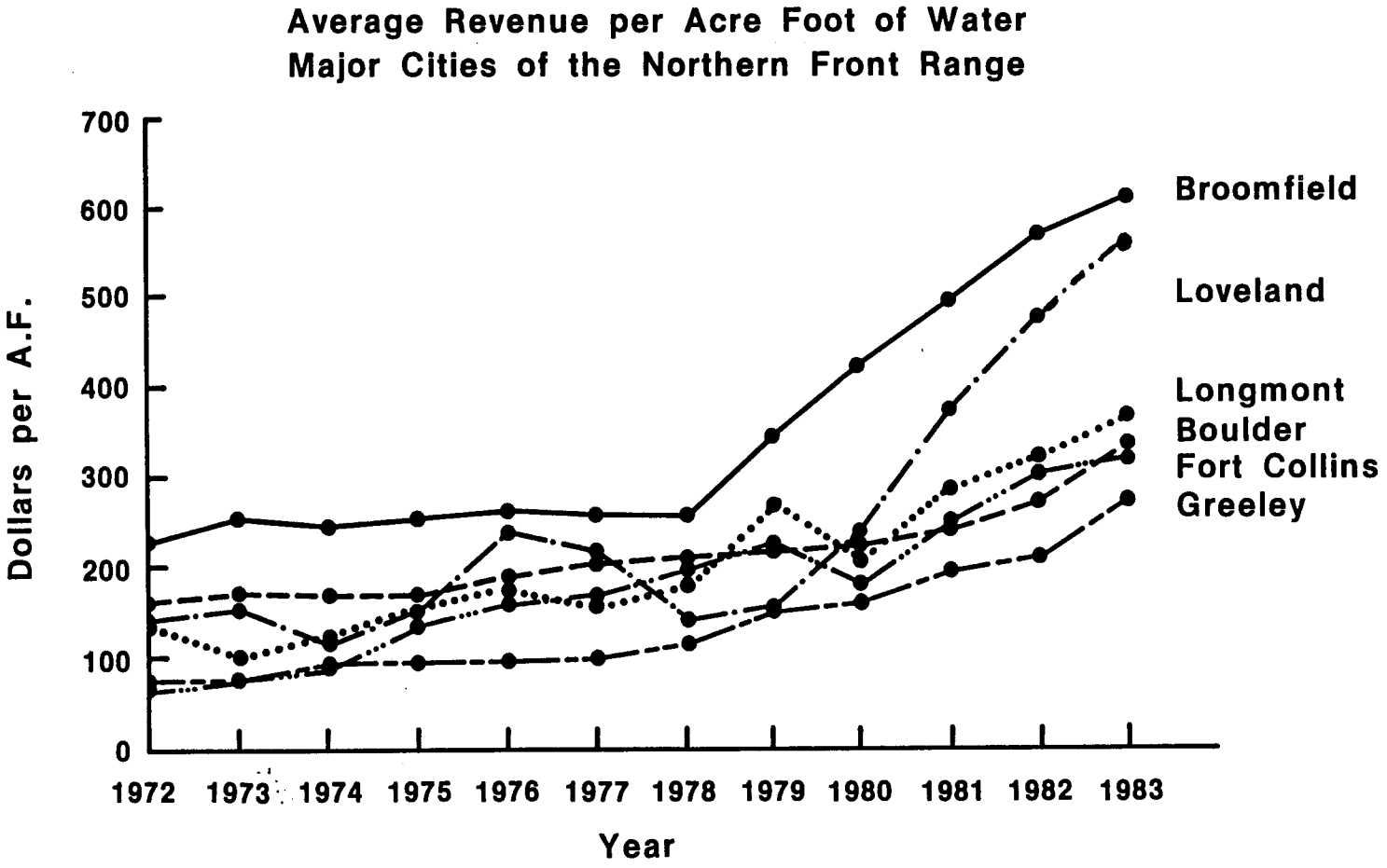
* Average Revenue per Acre Foot in Small Cities, Northern Front Range, 1972 and 1982.

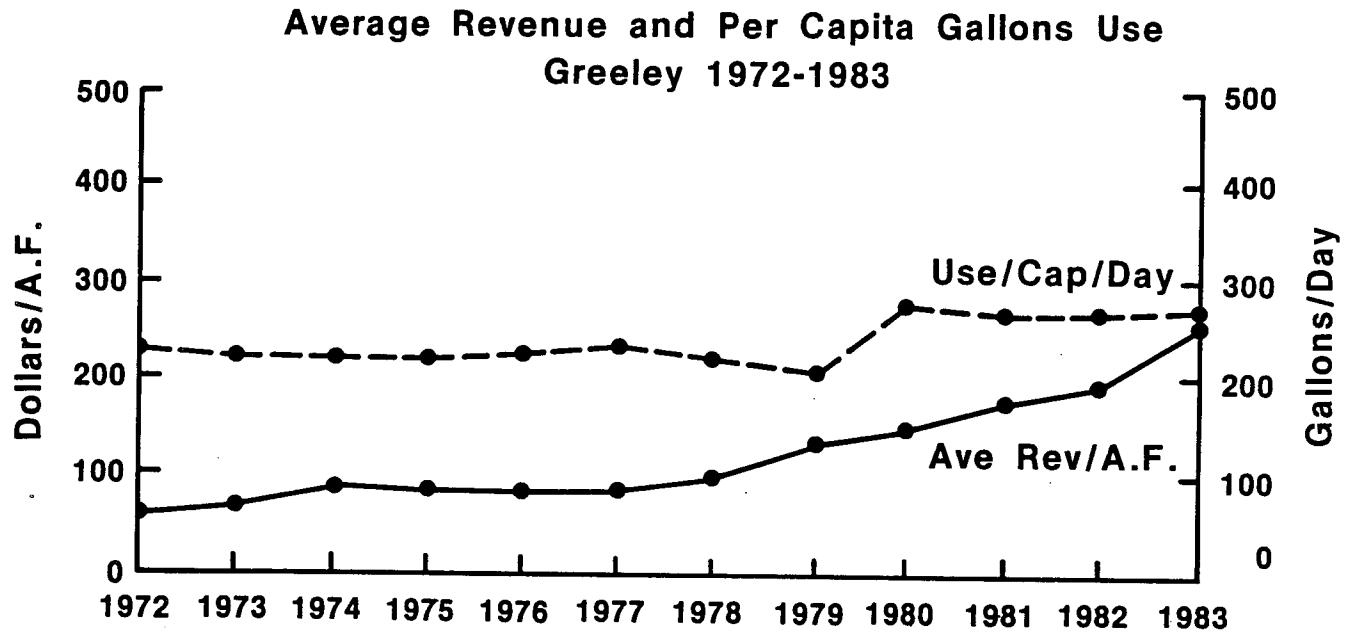
* Total Water Deliveries in Small Cities, Northern Front Range, 1972 and 1982.

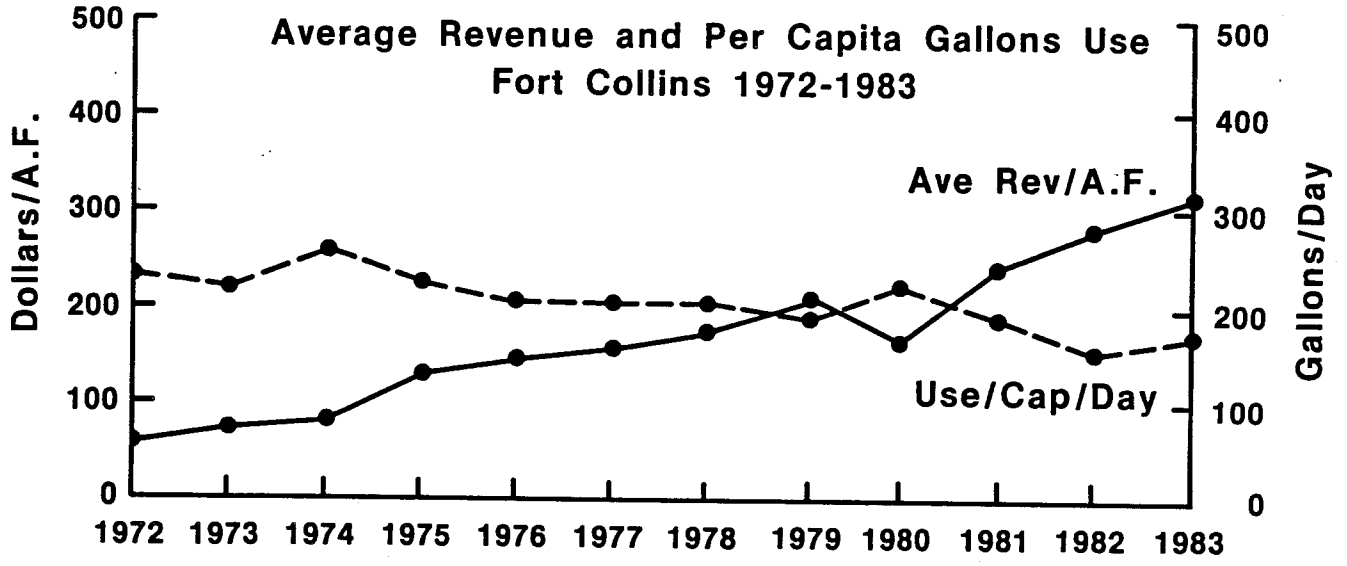
* Estimated Annual Water Delivery per Acre, Small Cities in the Northern Front Range, 1972 and 1982.

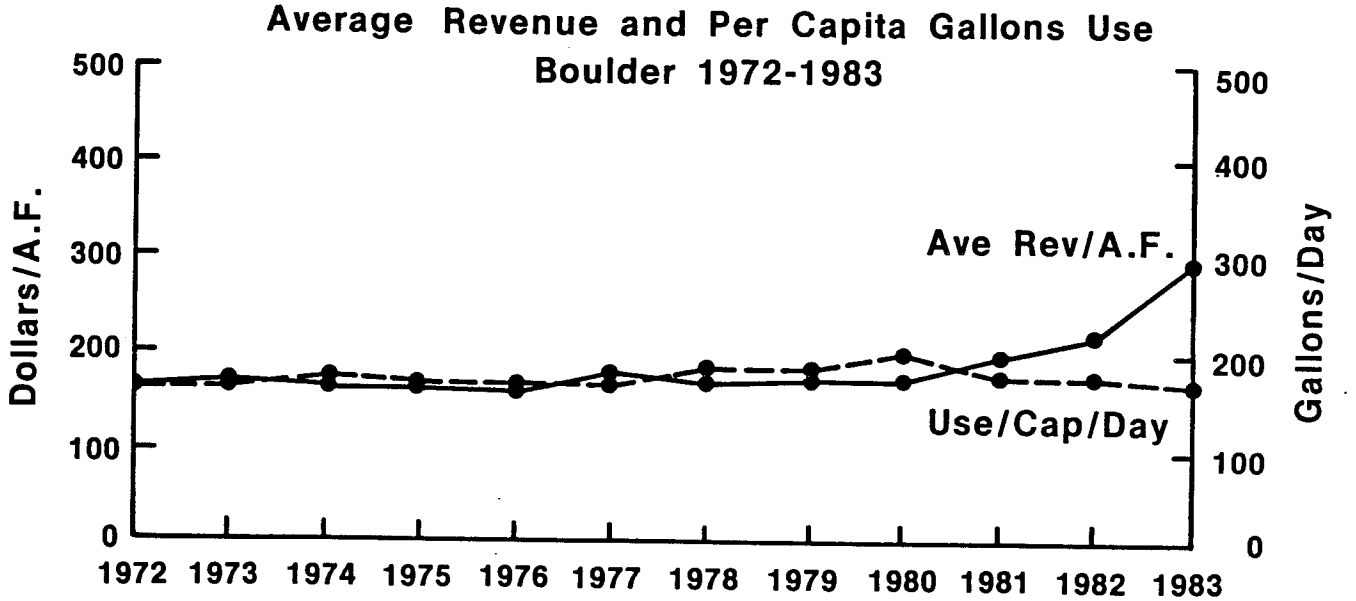
* Per Capita per Day Water Use in Small Cities, Northern Front Range, 1972 and 1982.

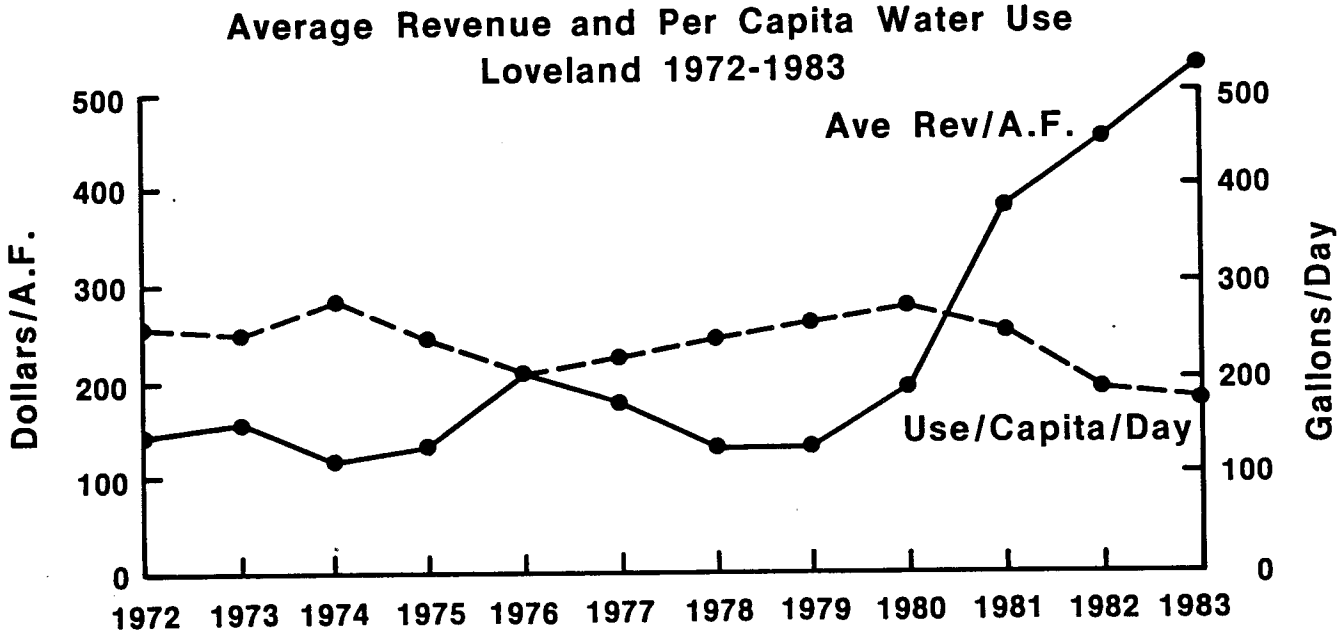

Total Acreage and Water Deliveries
Larger Cities of the Northern Front Range
1972 and 1982
Acres and Acre Feet
20,000
19,000
18,000
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1972 1982 1972 1982
Deliveries Acres
Boulder
Broomfield
Longmont
Fort Collins
Loveland
Greeley

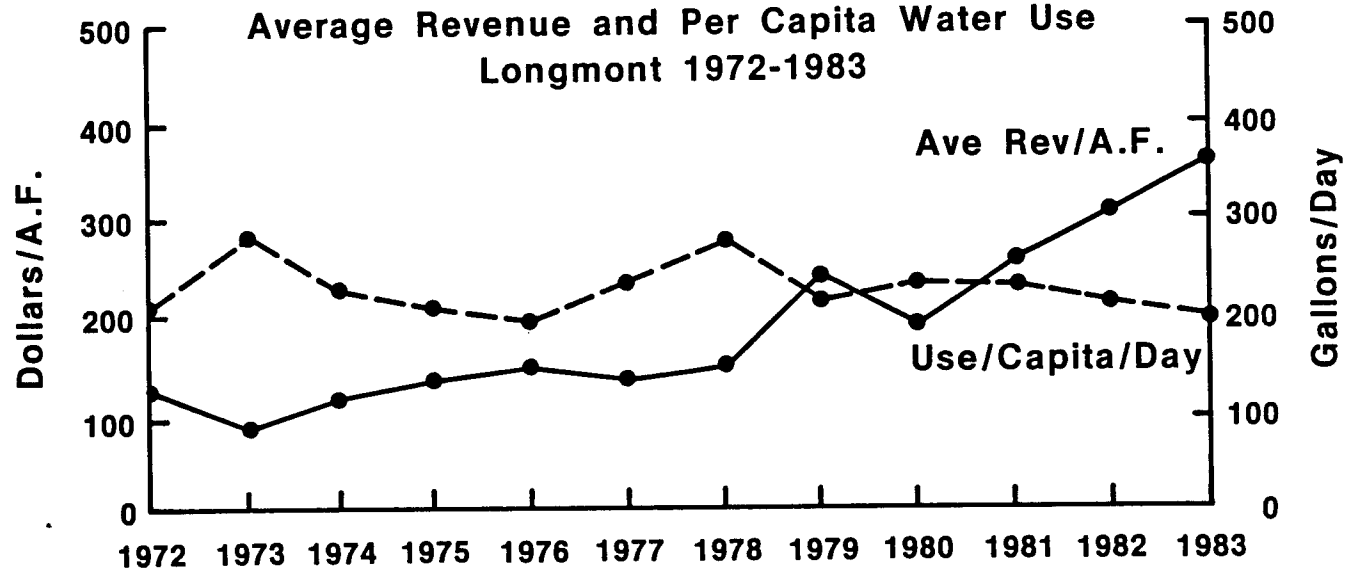

Average Revenue per Acre Foot of Water
Major Cities of the Northern Front Range
Dollars per A.F.
700
600
500
400
300
200
100
0
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
Year
Broomfield
Loveland
Longmont
Boulder
Fort Collins
Greeley

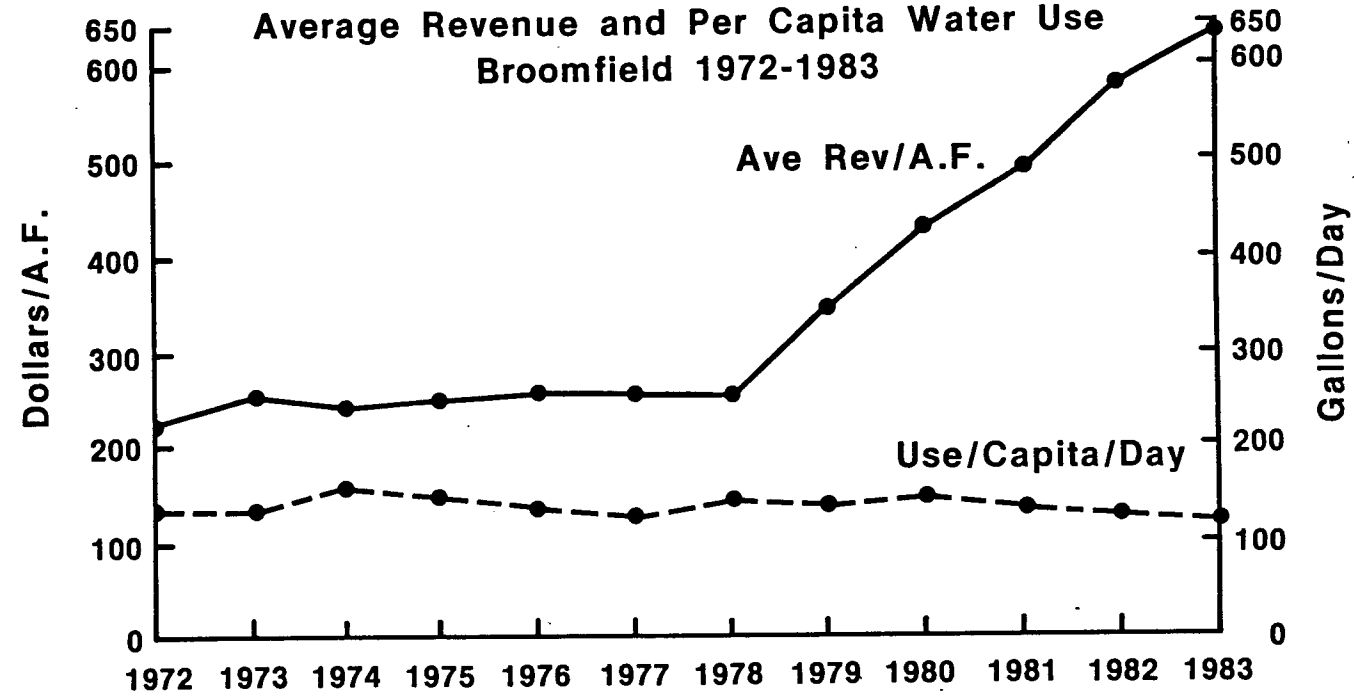

Average Revenue and Per Capita Gallons Use
Greeley 1972-1983
Dollars/A.F.
Gallons/Day
Use/Cap/Day
Ave Rev/A.F.
0
100
200
300
400
500
1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983

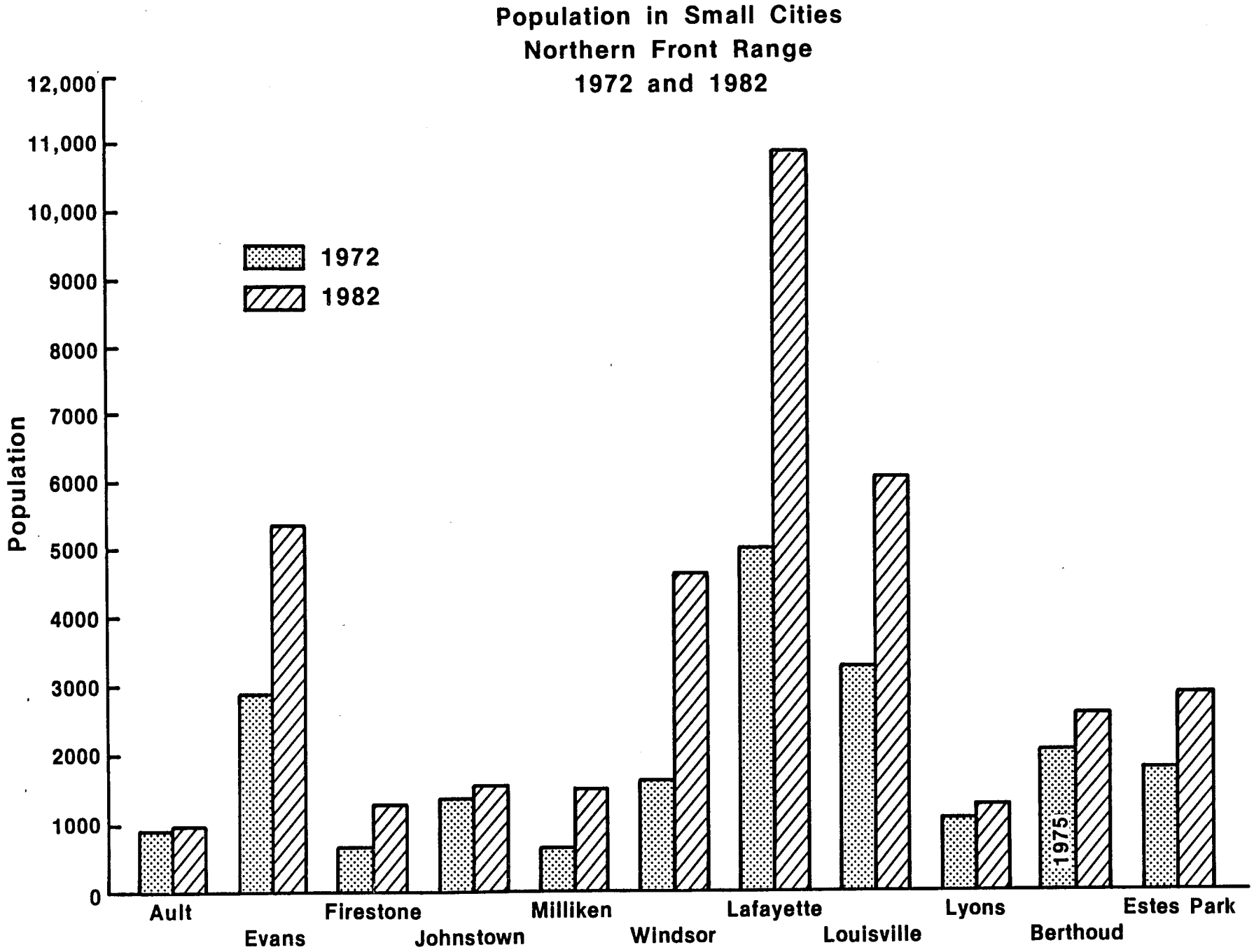

Average Revenue and Per Capita Gallons Use
Fort Collins 1972-1983
Dollars/A.F.
Gallons/Day
Ave Rev/A.F.
Use/Cap/Day
0
100
200
300
400
500
1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983


Average Revenue and Per Capita Gallons Use
Boulder 1972-1983
Dollars/A.F.
Gallons/Day
Ave Rev/A.F.
Use/Cap/Day
0
100
200
300
400
500
1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983

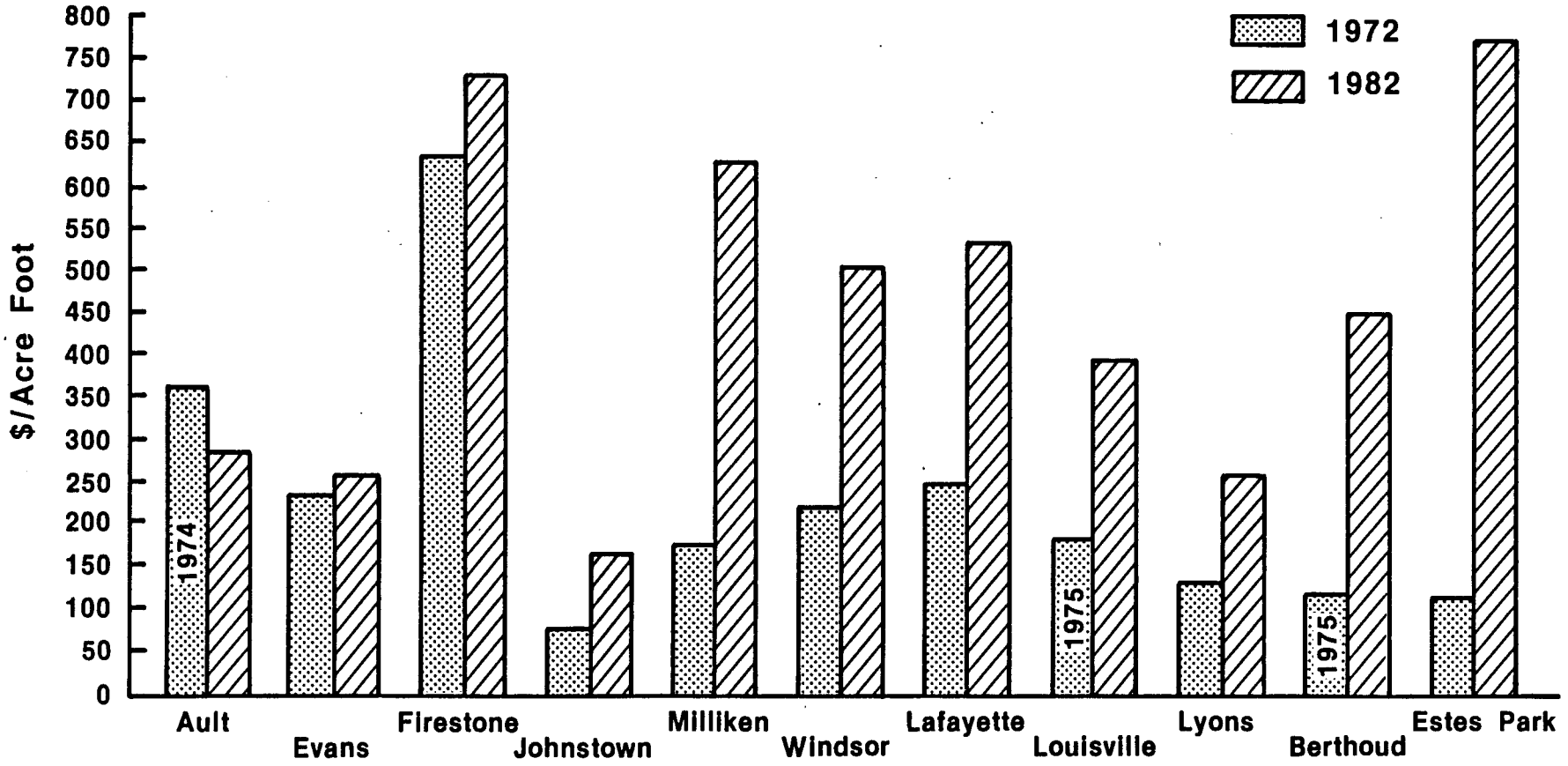

Average Revenue and Per Capita Water Use
Loveland 1972-1983
Ave Rev/A.F.
Use/Capita/Day
Dollars/A.F.
Gallons/Day
0
100
200
300
400
500
1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983

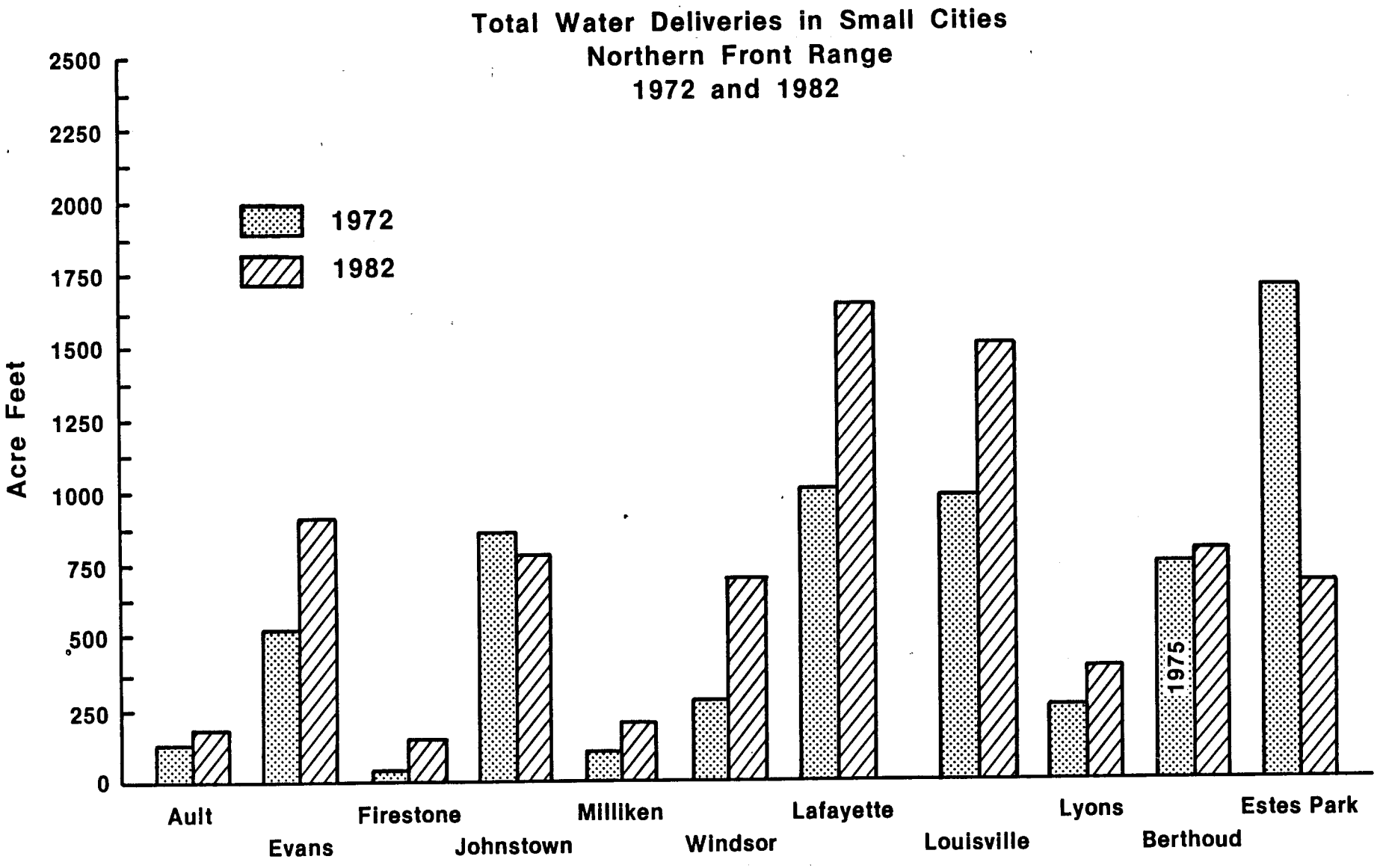

Average Revenue and Per Capita Water Use
Longmont 1972-1983
Ave Rev/A.F.
Use/Capita/Day
Dollars/A.F.
Gallons/Day
0
100
200
300
400
500
1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983

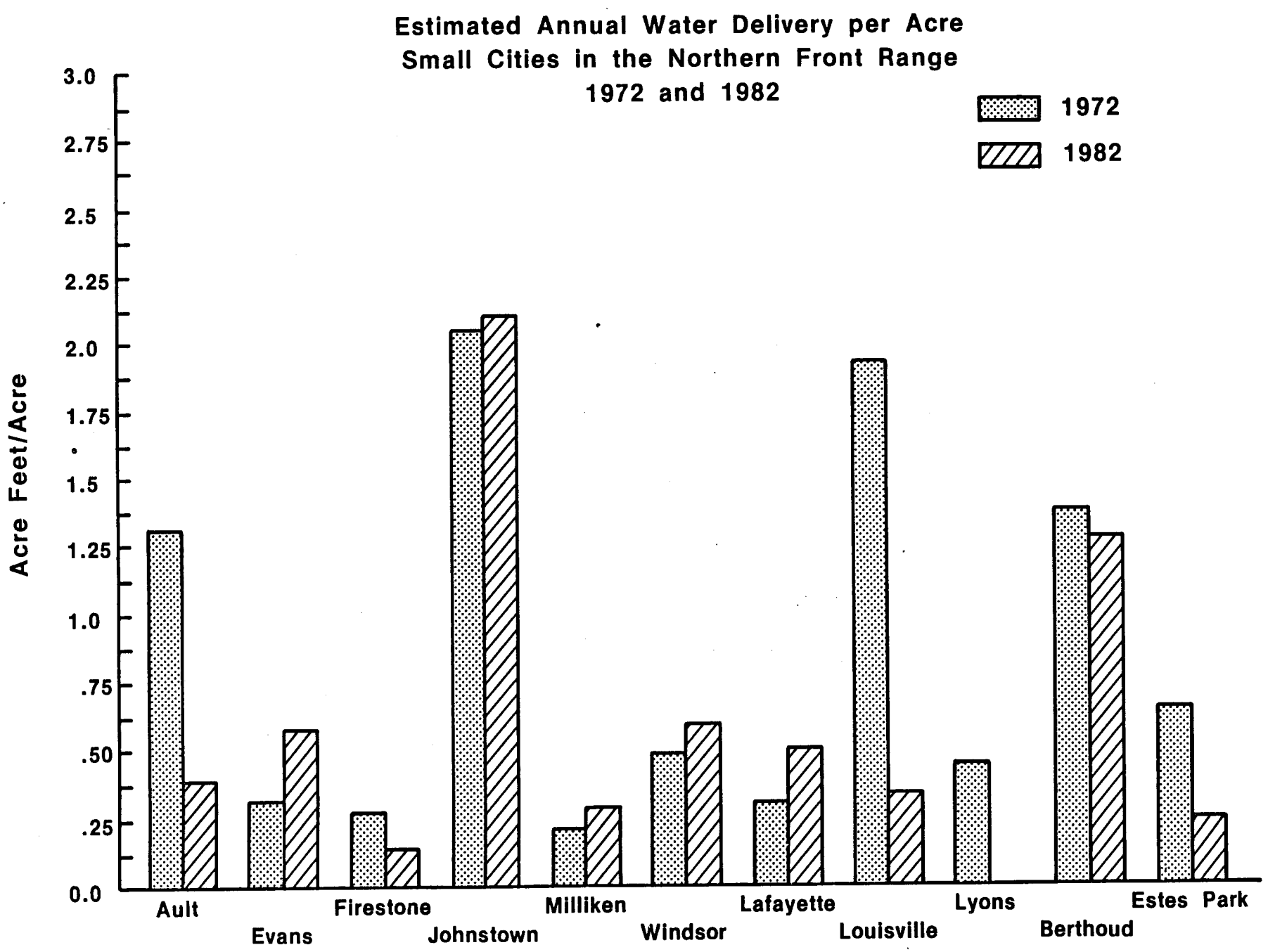

Average Revenue and Per Capita Water Use
Broomfield 1972-1983
Ave Rev/A.F.
Use/Capita/Day
Dollars/A.F.
Gallons/Day
0
100
200
300
400
500
600
650
1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983

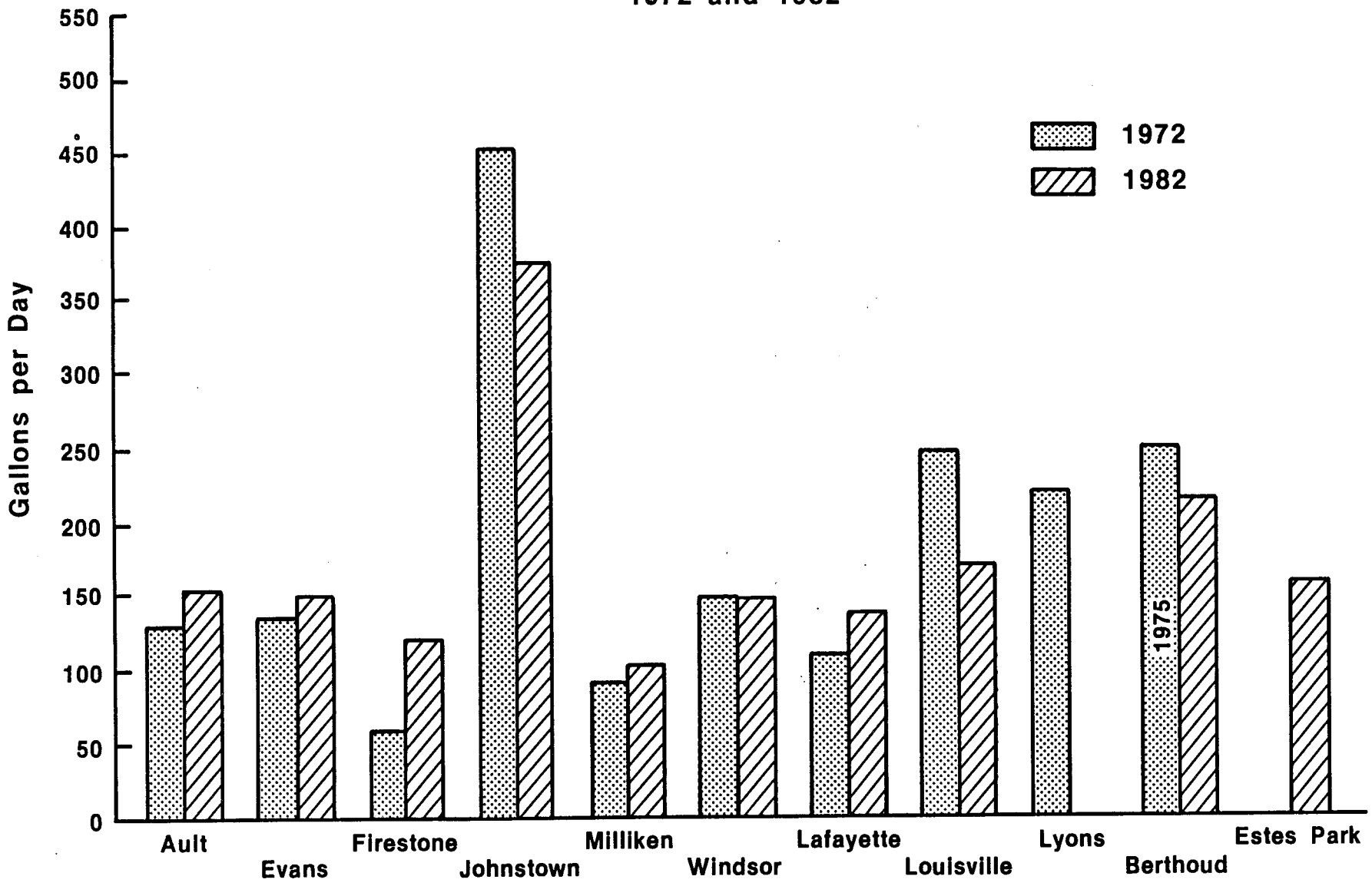

Population in Small Cities
Northern Front Range
1972 and 1982
12,000
11,000
10,000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Population
1972
1982
Ault
Evans
Firestone
Johnstown
Milliken
Windsor
Lafayette
Louisville
Lyons
Berthoud
1975
Estes Park

Average Revenue per Acre Foot in Small Cities
Northern Front Range
1972 and 1982




Total Water Deliveries in Small Cities
Northern Front Range
1972 and 1982
Acre Feet
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
1972
1982
1975
Ault
Evans
Firestone
Johnstown
Milliken
Windsor
Lafayette
Louisville
Lyons
Berthoud
Estes Park


Estimated Annual Water Delivery per Acre
Small Cities in the Northern Front Range
1972 and 1982
1972
1982
Acre Feet/Acre
3.0
2.75
2.5
2.25
2.0
1.75
1.5
1.25
1.0
.75
.50
.25
0.0
Ault
Evans
Firestone
Johnstown
Milliken
Windsor
Lafayette
Louisville
Lyons
Berthoud
Estes Park


Per Capita per Day Water Use in Small Cities
Northern Front Range
1972 and 1982
Gallons per Day
550
500
450
400
350
300
250
200
150
100
50
0
1972
1982
1975
Ault
Evans
Firestone
Johnstown
Milliken
Windsor
Lafayette
Louisville
Lyons
Berthoud
Estes Park