PROCEEDINGS
COLORADO DROUGHT WORKSHOPS

Sponsored by
Colorado Water Conservation Board
Colorado Drought Council

Planned and conducted by
Colorado Water Resources Research Institute
Colorado State University Cooperative Extension Service

November 1977

Colorado State University
Fort Collins, Colorado

Information Series No. 27

PROCEEDINGS

Colorado Drought Workshops

Grand Junction, Colo., Nov. 28, 1977
Denver, Colo., Nov. 29, 1977

Sponsored by:

Colorado Water Conservation Board
Colorado Drought Council

Planned and conducted by:

Colorado Water Resources Research Institute
Colorado State University Cooperative Extension Service

INTRODUCTION

Two workshops were held in late November of 1977 under sponsorship by the Colorado Water Conservation Board and the Colorado Drought Council. They were planned and conducted jointly by the Colorado Water Resources Research Institute and the Colorado Cooperative Extension Service.

The workshops were held November 28 in Grand Junction and November 29 in Denver to explore several key questions relative to the drought experienced in Colorado during the preceeding months. Included in the goals of the workshops were: to learn what emergencies occurred, what steps were taken to solve particular problems, what might have been tried, what legal constraints and institutional problems were encountered, and what preparations ought to be made to better meet future drought emergencies (see Appendix B).

The participants were individually invited (see Appendix A) and represented agricultural, municipal, industrial, and recreational water users and managers (Appendix C). Procedurally, the workshops involved three opening talks and a luncheon speaker (see printed texts, following). Also included is a talk by Marvin Thurber, City of Westminster, presented at the Denver Workshop. The participants were arbitrarily divided into small workgroups without regard to subject areas at the Grand Junction session, and divided according to subject areas (all agriculture in one group, for instance) at the Denver meeting. Each group, guided by a group leader, then explored the six basic questions (Appendix B). The results of those sessions are printed on the following pages.

Those serving as group discussion leaders were Dr. Norman Evans, director, Colorado Water Resources Research Institute; Professor Henry Caulfield, CSU Professor, Political Science; Dr. Hugh Henderson, assistant director, agricultural development, CSU Extension Service; and Dr. Raymond Anderson, research economist, Economic Research Service, U.S. Department of Agriculture. The workshop manager was Mr. Gary Bennett, CSU Extension Serivce, Editor.

TABLE OF CONTENTS

Page

INTRODUCTION.....i

INDIVIDUAL PRESENTATIONS

"Precipitation Update and Weather Modification".....1
by John Le Compte

"State Drought Council Activity and Policy".....11
by George Lamb

"Western Water Conservation Concepts".....15
by Norman Evans

"Challenge to Innovation".....19
by W. D. Farr

"The Challenge of the Future".....23
by John Fetcher

"The Westminster Water Conservation Plan".....25
by Marvin Thurber

WORKSHOP SESSIONS

Grand Junction Workshop Group I.....33

Grand Junction Workshop Group II.....37

Grand Junction Workshop Group III.....39

Denver Workshop Group I.....42

Denver Workshop Group II.....45

APPENDIX A.....47

APPENDIX B.....48

APPENDIX C.....49

Precipitation Update and Weather Modification

John Le Compte
State Weather Modification Coordinator

Presented at
Colorado Drought Workshop,
Grand Junction, Colorado
November 28, 1977

First, I'm going to go through the past water year's (October 1976-September 1977) precipitation record and bring it up-to-date in segments which I think reflect periods of precipitation in which various interest groups here today are interested. I think this one is probably the key precipitation period for all the winter tourist and ski industry people because they want the snow on the slop at Thanksgiving if they can get it there, and by Christmas for sure.

In Figure 1 the percent of normal for this period is plotted using a 1951 to 1970 average. You can see that all of the Western Slope was extremely dry (at Steamboat Springs about 30 percent of normal). Down in the San Juans it was generally 20 percent of normal. If you can find a 40 percent figure on here (there is one), you're doing pretty good, but basically you can see that we were extremely dry as of January 1977. This was about the period of time when people in the state started getting concerned about what they were seeing weatherwise regarding the drought, and the period of time when the emergency response to drought really started to occur.

The second period of time which I think is very important is October through April. This is the period during which most of our snowpack accummulates in the high country and would represent the amount of water that most of the irrigation users would have to work with since they rely mainly on runoff and snowpack. Again, as can be seen in Figure 2, even as of April 1977 the figures are not much better, although we see a few more 40 to 45 percent values. Actually, the area around Granby and Hot Sulphur Springs did better than any other region in Western Colorado. (It had 60 percent of normal precipitation). The San Luis Valley actually did fairly well; the lower San Luis Valley had between 80 and 100 percent of normal. However, most of the Western Slope was extremely dry. The circled numbers represent a few Soil Conservation Service percent-of-average water in snowpack measurements. The one on Grand Mesa was only 4 percent of normal snowpack as of April 1977. I think this dramatizes how severe the drought actually was.

Two questions which always occur at this point are: "How likely is this drought to occur again?" and "Was it a record-setting drought?" To answer these questions we collected some data from various Western Slope towns. It's probably best to look at Grand Junction, since we're here. Figure 3 is not as confusing as it might look. The percentages of mean precipitation are indicated in the top box. The precipitation in inches is shown below that, and the likelihood of that occurring is indicated across the top of the figure. Note that on only 20 percent of the years, or one out of every five years, is there likely to be less than 74 percent of normal precipitation in Grand Junction. On the other end, in only one out of every five years is Grand Junction likely to get more than 124 percent of normal precipitation. What this means, or what this says to me, is that the towns in the mountainous areas of Colorado have a fairly regular precipitation, unlike the large extremes of the eastern plains. Here in the mountainous area of Colorado the record is very regular. The graph indicates that this was a record-setting drought, which it was. These are just a few of the towns in Colorado which set records. Aspen set a record low for October through April precipitation, as did Grand Junction, Durango, Meeker, Montrose, and Steamboat Springs (see Figure 4).

It spread throughout western Colorado.

I think that without a doubt we can say one of two things, and they are both practically the same thing: this was the worst drought in western Colorado since the turn of the century, or this was the worst drought in western Colorado since we started keeping records. They both occur at about the same time. A few of our records go back into the early 1800's, but this was definitely the driest year in western Colorado since we started keeping records. The north central mountains have been dry for the past two or three years. However, I think the drought there may be more the result of an accumulative effect, whereas in the San Juans it was an extremely dry year.

I came through Grand Junction last fall on a series of Extension Service drought workshops in which we were talking to various ranchers and farmers in the area. It was very plain that many of them were on the verge of having to make serious decisions about what to do with their livestock operations. In early August they were at the point of having to start to feed their cattle very soon. Figure 5 shows the May through September 1977 precipitation. Although we had an extremely dry winter, the summer in western Colorado was not that dry. Most of the San Juan region and the Gunnison area got nearly 100 percent of the normal amount of precipitation for this period. Again, the Granby and Hot Sulphur Springs area and on up into Rabbit Ear's Pass did well between May and September. Grand Junction and the area towards Meeker were very close to their normal amount of precipitation. What happened was that these areas received rainfall in September and early October. Many of the ranchers with whom I spoke in early August who were anticipating having to feed their cattle actually got a couple of extra months' worth of pasture out of these summer rains and did not have to start feeding until the time they normally do. So, for a number of the ranching industries in Colorado, these summer rainfall amounts were really life-saving values regarding the entire drought picture in 1977.

In summary, the 1976-77 water year (see Figure 6) for western Colorado was an extremely dry one. The severe water shortage began in the early winter season when very little snow fell in the Colorado high country. Summer rainfall boosted the water year precipitation totals, although much of it fell too late to benefit parched agriculture and range lands. Eastern Colorado generally received near or above normal precipitation during the 1976-77 water year. However, mountain water supplies in eastern Colorado were also extremely limited.

October was another fairly good precipitation month in western Colorado. In Figure 7 I've outlined the areas which got above normal precipitation. Out on the northwest end, the LaPlata Mountains, the upper Gunnison, and again the Granby and North Park areas did quite well. The other areas were down somewhat. I think this represents a certain wind flow direction, mainly a west to a northwest wind flow, and more orographic precipitation because in October we started getting our snowfall. The areas that did quite well correspond to that flow direction. They had one very good precipitation event in October which took these areas above their normal precipitation levels. I think most of that precipitation would be reflected in snowfall in those areas.

That brings us right up-to-date, except for the month of November, which is the month we are in now. I can say that the month of November looks very promising. I talked with the forest service people before I left on Sunday, and they had recorded another .4 inch of precipitation at Berthoud Pass from Saturday until Sunday morning. Since November 17, Berthoud Pass has had 3.5 inches of water content and 44 inches of snow. I think the normal precipitation for the month of November is somewhere between 2.5 and 3.25 inches of water; thus, much of the Continental Divide and the high mountain areas probably will have normal to above normal precipitation for the month of November. I think our winter precipitation is looking very good at this point.

It is very interesting that they always let me talk about the current situation, which is very easy, and then they always add something on the end called a look to the future. Not being a long-range weather forecaster, I never quite know how to answer that part. In this case, I think I'll talk about two things in the look to the future, and I think these are the things we may want to consider today as we go into our working groups.

One is long-range weather forecasting. What value does it have for us in making drought decisions? I think one of the most confusing things for the public at this point, and even for myself, is the predictions that we keep hearing from long-range weather forecasters. One forecaster tells you it's going to be warm and dry in the West throughout the winter, while another forecaster tells you it's going to be cold and wet. So I think that it is very confusing to the public and to me. One of the reasons it is extremely confusing is that this is an ongoing research area. There is at least one person at CSU and other scientists throughout the nation who are trying to figure out how to make long-range weather forecasts. They think they have some ideas. They have some things that correlate. In other words, they see the sea surface temperature changing in one region of the Pacific, and they see the weather patterns over the United States changing in a certain direction. However, that doesn't mean that it's a direct correlation. There could be other things which are much more important in affecting those weather patterns, things that we have not yet discovered. The news media keep inquiring because it's a field in which everyone is very interested. We think it could help us a lot. So the media keep inquiring, and we keep getting little bits and pieces about long-range weather forecasts which vary because it's such an ongoing research field. These are presented to the public, and I think it makes it very confusing and very difficult for the public to understand.

Even if we can do long-range weather forecasting in the near future, I have a question for you as decision makers and people who are very concerned about water and how to use it. How valuable is long-range weather forecasting going to be to you? If I could stand up here and tell you with absolute certainty that we are going to suffer a drought over the next three years and tell you about how much water we are going to get, what would you do in response to what I had just told you? What can you do in response to what I have just told you? I think these are some of the questions we may want to investigate.

The second thing I think we need to examine in the future is weather modification. We are beginning to examine it now. I think we have to discuss primarily it's limitations. Mainly, it cannot generate clouds; it cannot change weather patterns. In the winter of 1976-77, we used it as a short-range emergency measure to help get us a little bit more precipitation that would help get us through the drought period. It should be known that weather modification gives the least amount of water in a drought year. It works as a percentage of what we normally get. If normal precipitation goes down, the amount of water obtained from modification goes down. If the natural precipitation increases, the amount that can be obtained from weather modification increases. Evidently, then, it produces the least amount of water in a dry year and produces the most water in a wet year. How can we work this into a decision-making plan, a plan of how to face drought? As I said, it was used as a short-term emergency measure during the past year, and I foresee its use again this year as the same type of thing. The second question, then, is should it be a long-term water planning measure? Should we be thinking about weather modification in the good years as well as the bad years? I think that is a question we need to discuss and think about.

As far as I'm concerned, I think those are two of the key questions in looking to the future. I'm not going to present a

long-range forecast. I don't think that's my job, and I can't do it anyway. In looking to the future, I think these are at least two of the key questions that I would like to see addressed today. Thank you.

Figure 1. - Precipitation for period October 1976 through January 1977 as percent of average (1951-1970).

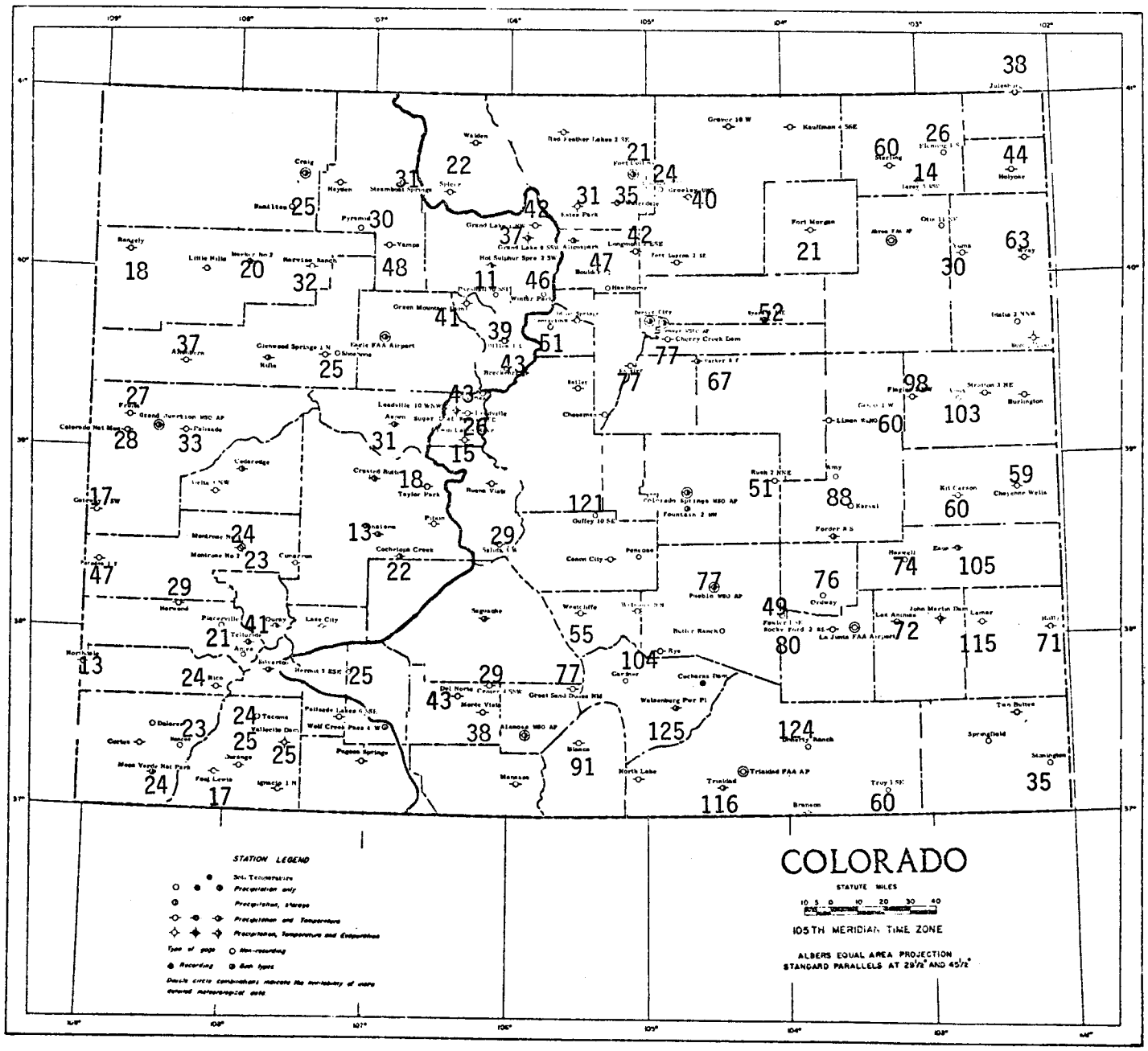


Figure 2. - Precipitation for period October 1976 through April 1977 as percent of average (1951-1970).

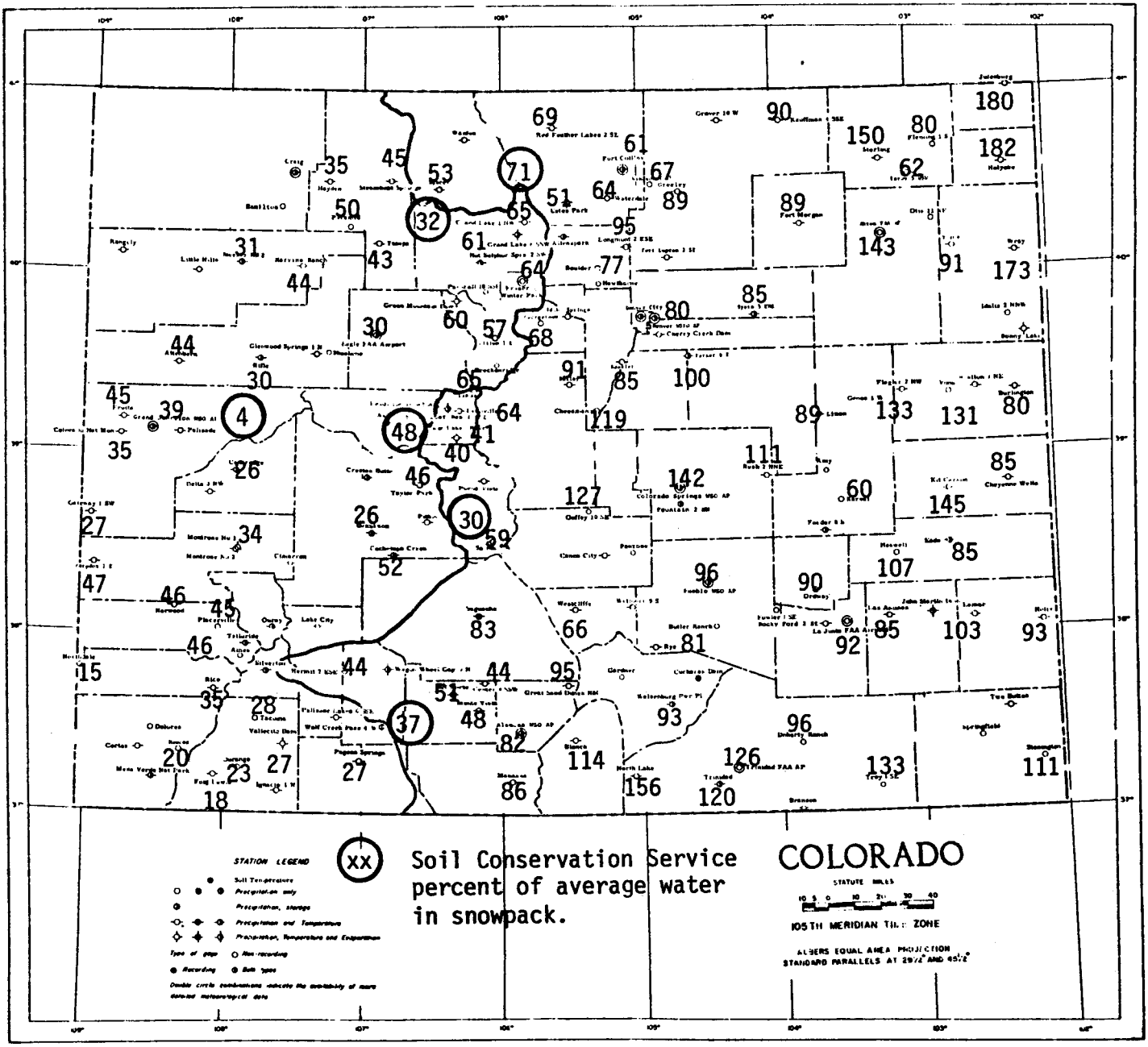


Figure 3. Precipitation and Percent of Mean Precipitation with Probability

		Equal to or Less Than				and Greater Than		
		20%	30%	40%	50%	40%	30%	20%
Alamosa	% of Mean P	71	80	88	96	105	115	127
	Precipitation (inches)	5.06	5.69	6.27	6.85	7.47	8.17	9.04
Durango	% of Mean P	81	87	93	98	104	110	118
	Precipitation (inches)	15.04	16.22	17.28	18.30	19.37	20.55	22.00
Glenwood Springs	% of Mean P	76	84	90	97	103	111	120
	Precipitation (inches)	12.21	13.38	14.43	15.47	16.55	17.76	19.25
Grand Junction	% of Mean P	74	82	90	97	104	113	124
	Precipitation (inches)	6.08	6.74	7.34	7.93	8.56	9.26	10.13
Meeker	% of Mean P	86	91	95	99	104	108	114
	Precipitation (inches)	14.97	15.84	16.61	17.35	18.12	18.96	19.97
Montrose	% of Mean P	78	85	91	98	104	111	120
	Precipitation (inches)	7.43	8.09	8.69	9.27	9.88	10.55	11.38

Figure 4.

Location	Precipitation, inches 1977	Previous record and year	
Aspen	5.95	7.50	1954
Durango	2.52	3.45	1931
Grand Junction	1.84	1.97	1902
Meeker	2.95	4.33	1946
Montrose #2	1.66	2.40	1902
Steamboat Springs	6.86	8.11	1966

Figure 5. Precipitation for period May 1977 through September 1977 as percent of average (1951-1970).

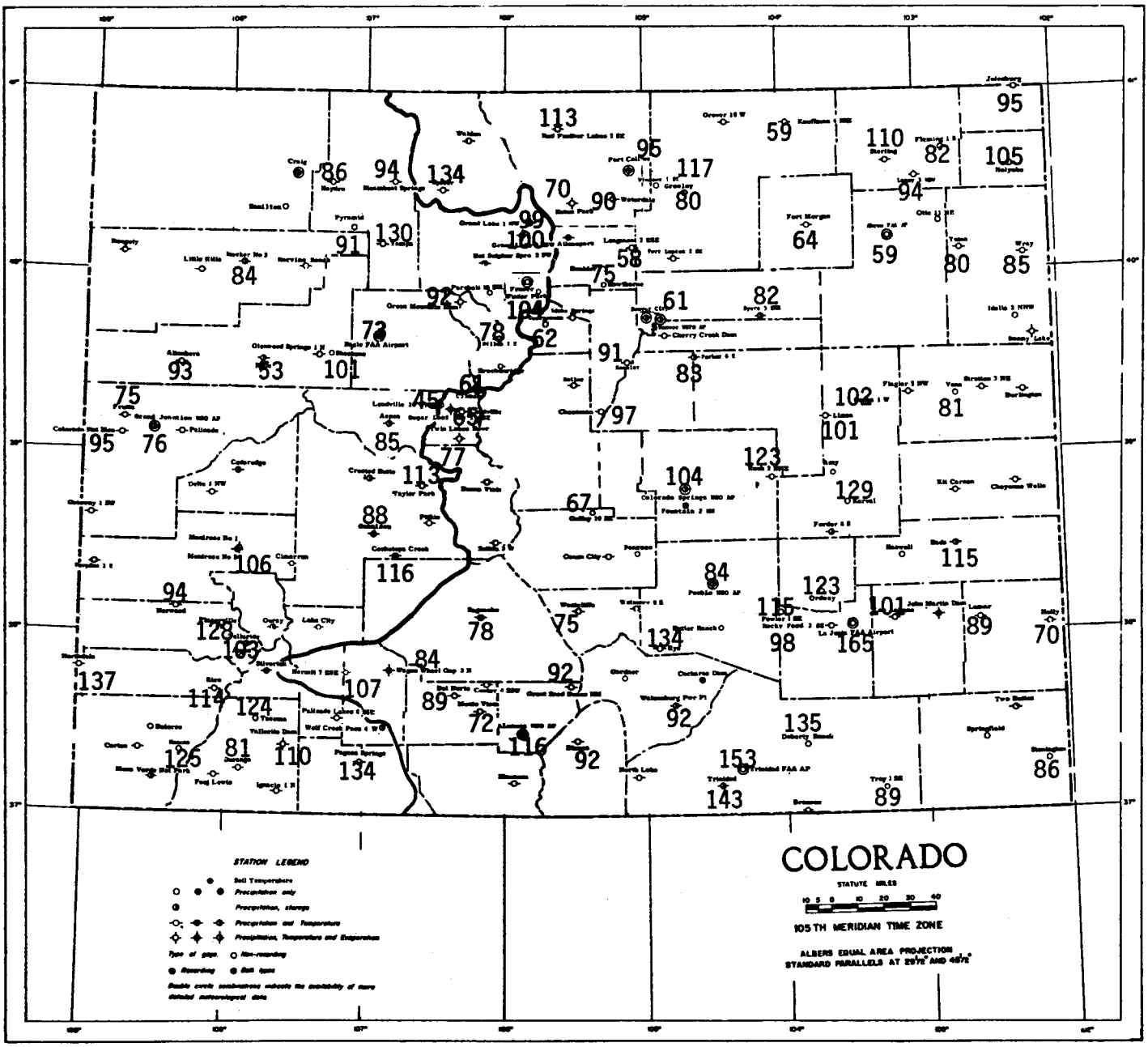


Figure 6. Precipitation for period October 1976 through September 1977 as percent of average (1951-1970).

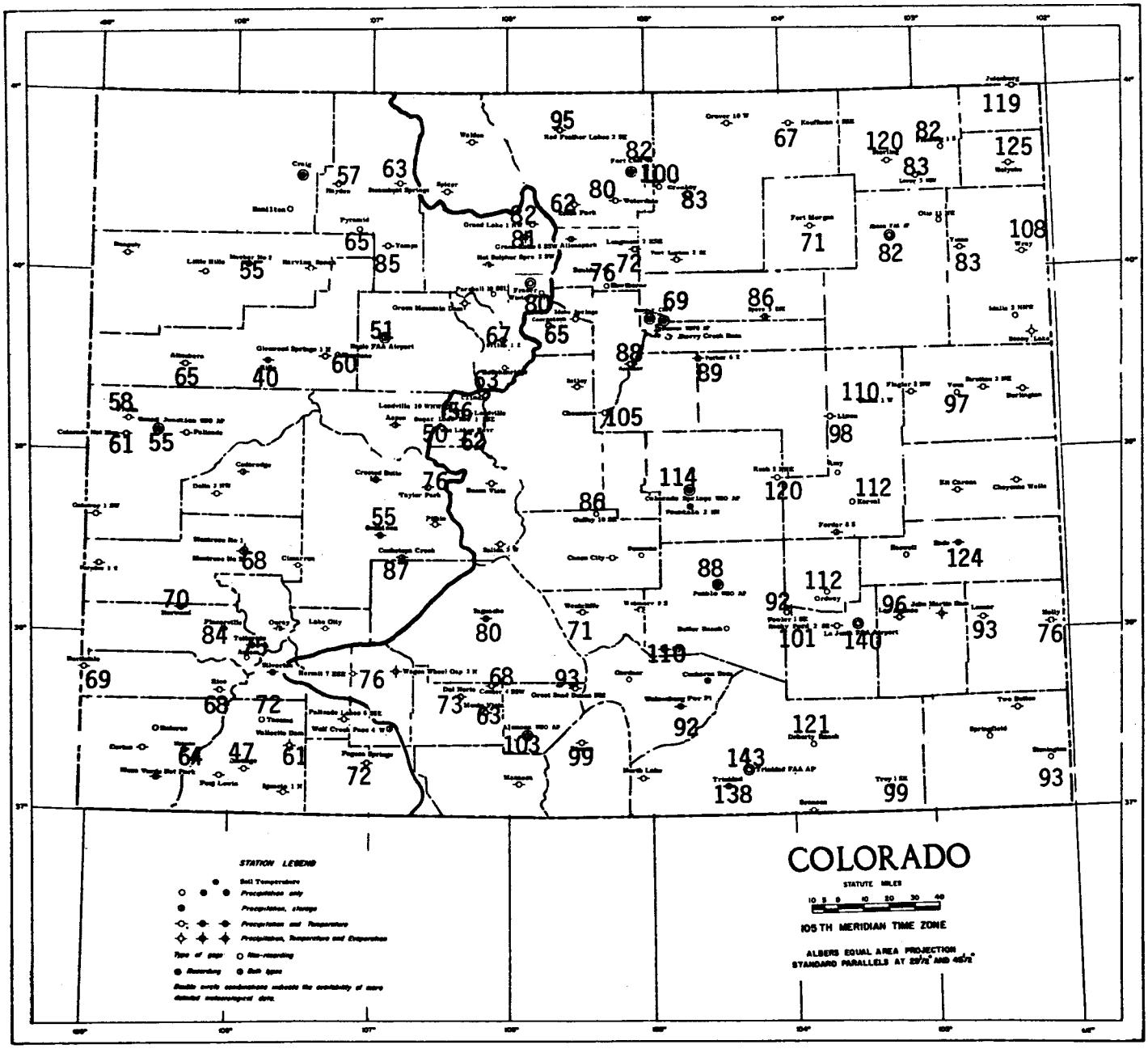
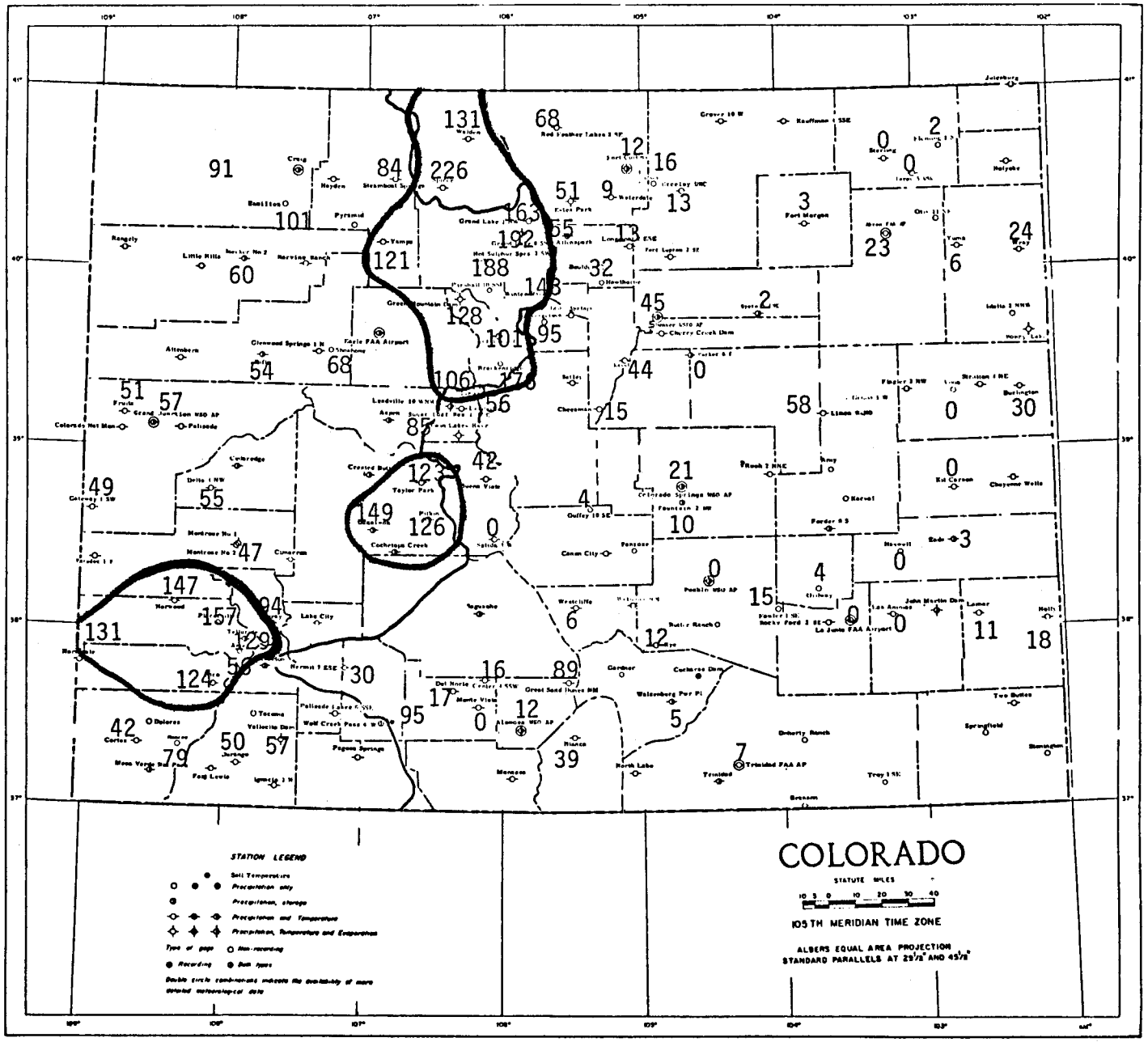


Figure 7. Precipitation for October 1977 as percent of average (1951-1970).



State Drought Council Activity and Policy

George Lamb
Coordinator, Colorado Drought Council

Presented at
Colorado Drought Workshop,
Denver, Colorado
November 29, 1977

It's a pleasure to be here with you this morning to represent the Governor's Drought Council, to meet with you, and to learn from you. Hopefully, we will move ahead and improve our program.

The workshop announcement that has been sent out says that we are here to consider two primary things. First, we must seek recommendations for improved future emergency responses. That concern incorporates: (1) assessing the effectiveness of the measures we have already tried; (2) reflecting on alternative measures not yet tried but which might have promise; and (3) considering possible legal and institutional changes for long-term measures that might be implemented. The second principal objective is to look at the term "water conservation," discuss it and try to develop a concensus of just what that term means and how it is applied here in the West.

Looking at the first objective, maybe it would be best if I briefly run through how we got where we are today from an institutional standpoint, and what things were done at the statehouse in Denver to put together the state drought response. This covers a period of about 12 months.

A year ago at this time, as you recall, we were probably not yet aware of, or at least not too highly concerned about, the weather patterns and the precipitation to that date. By mid- and late-December, though this situation had changed, concern was beginning to grow. Water conservancy board people and ski area folks were becoming concerned. There was a lot of peering to the west and watching for cloud patterns and discussing blocking systems and jet streams that seemed to have moved north. People began to ask: "What's causing all this weather that we are supposed to have to be falling in the eastern Great Plains and the Buffalo area? What are we going to do about it? How can we proceed?"

Anxiety grew, and early in the calendar year the western governors met in Denver to develop a collective effort to address drought. Drought was not new in some of the areas of the West; California was in its second or third year, and North and South Dakota had experienced stress the year before. We were beginning to move into it.

The governors decided that they would assemble a group called the Western Region Drought Action Task Force, to be headquartered and housed with the Western States Water Council in Salt Lake. That became the hub, if you will, for the collective effort from the western governors. From that effort, signals were sent to Washington saying: "We think we need help out here, we need support, we see a drought problem. What can possibly be done? What programs can be augmented? What new programs would you suggest?"

The Washington machinery began to work on that problem and to think about it. The Western Regional Drought Action Task Force sent two people back to Washington to monitor, to observe, to become knowledgeable, if you will, about existing federal programs and to pass the word back as to what might be done at the moment and also later on.

By March the administration had done its homework. The drought coordinator for the president had been named and placed in the White House. A package had been put together that had an initial price tag of $844 million. This was somewhat subjective because some of the issues were open-ended, and it was the best guess of how much should

be appropriated for the first go on some of these open-ended programs. It was sent to Congress and began working its way through the machinery. Also, the Western Drought Action Task Force suggested that the governors appoint a central point within state government to act as a clearing house for information requirements going both up the organizational ladder and back down. The governor formed a drought committee which acted as an advisory panel to him. About the first of March, I moved from the Colorado Department of Agriculture to a temporary assignment as state drought coordinator.

The original drought council had as its immediate problem a consideration of what it could do. One of the first things that came to mind was to start talking about weather modification and to get a program going. Realizing that much of the water year, and the snow production time, was rapidly passing us by, we assumed that any effort would be better than no effort at all. The weather modification legislation went through as House Bill 1722. Early in February 1977, the program got under way with three areas in the state being targeted for weather modification programs. We thought that not only general funds should support that effort, but private contributions as well. As you all know, that program moved out through May 15 of this year.

Within state government, the Division of Disaster Emergency Services began a survey of the response or participation by state agencies to drought as a problem, identifying who the actors were and what they might be able to contribute. Of course, every agency that made a drought response had to substitute that effort for something that was ongoing or figure out a way that it could be paralleled with ongoing work. Everything that was accomplished was taken out of hide, so to speak, or actions that were under way were redirected and focused toward drought action.

The question of how to interface state government with local government was a subject of considerable debate. One of the early proposals was to channel aid through water conservancy districts. Later, the resolution of the problem was to use the regional councils of government as focal points for the activity, and it was that idea that was incorporated in the precursor to House Bill 1723 (sent to the legislature about April 1). The state legislature considered that program and by the end of May it was clear that that concept was not going to be totally acceptable. House Bill 1723 was written and passed through the legislature, with the concept of focus through regional councils of government deleted. However, it did fund the Office of State Drought Coordinator, an assistant and secretary, and approximately $100,000 for special projects which would be approved by the executive committee of the State Drought Council.

By late May, the Washington drought package emerged. It had two propositions. One was for original legislation which is principally the authority for the Economic Development Administration (EDA) to proceed with municipal water projects for cities of greater than 10,000 population. This was a first-time effort for EDA in this arena.

The rest of the package from the administration was program augmentation or supplemental funding for existing programs. For instance, the Bureau of Reclamation had money appropriated for no-interest loans for organized associations. Grant money is now available for wildlife preservation. Through the U.S. Bureau of Reclamation, the state received $89,000 for a study on how to improve irrigation transmission system efficiencies (a study now being conducted for us by Dr. Norman Evans at CSU), a $90,000 package to the Colorado Water Conservation Board for technical assistance and studies, and $600,000 to the Colorado Water Conservation Board for this year's weather modification program.

The other federal agencies (ASCS, Soil Conservation Service, Bureau of Land Management, Forest Service, and Farmers Home Administration) were the targets of individual applicants for relief and assistance. They were, as I said, principally augmented programs, existing programs restructured under the drought package.
the process of adding counties to the drought declaration. By early May we had obtained approval for 46 counties for emergency drought programs. At the time that the administration package was passed, an Interagency Drought Committee was formed in Washington. The U.S. Department of Agriculture, Department of Interior, Department of Commerce, and the Small Business Administration were signators to the administration's program. They agreed that drought disaster approval or declaration by anyone would be sufficient for all, at least as far as the drought program was concerned.

At that time we requested, and had approved, statewide drought designation. All 63 counties came into the program and were declared eligible as of May 13, 1977. Through all of this, however, the Emergency Livestock Feed Program continued as "an old program," and with the advent of the new program, we had the problem of keeping track of the old programs as well. Old programs, such as the Emergency Feed Program, were worked through the normal process. ASCS County Committees requested counties to be eligible for the feed program and, upon obtaining State Emergency Committee approval, the Governor requested the declaration through the Federal Disaster Assistance Administration. We continued that process until just recently, when the new farm bill was signed. That process is no longer required. Any agricultural producer who can show a 40 percent loss in feed production can apply to his ASCS county office and be considered for the program.

When it became clear that the concept of regional drought coordinators would not pass through our legislature, we began discussions with EDA for funding of the concept. This was approved in late June, and in early July we began contacting the regional councils of government. We obtained from them the authorization to proceed with the concept. This was completed, essentially, in July, and since that time we have been operating under the concept of focusing the state's drought effort through the regional councils of government.

In considering the second purpose of this drought workshop, (the defining of the term "water conservation"), I would like to read just a portion of an opinion from the Denver Post editorial section dated November 22, 1977. The headline is "What is Water Conservation?" It talks about a meeting held in Denver during which someone from Marin County (California) stressed the need for municipalities to enter into water conservation programs and reduce consumption.

I quote: "The message is plain. Denver and the suburbs must continue to conserve water. In fact, the metro area last summer, under rationing pressure, did cut about 30 percent. All cities, towns and urban industries in Colorado use less than 5 percent of the water put into use. The 95 per- is used by agriculture. Considered alone, municipalities use only 3 percent of the water. So, the far better question from an overall viewpoint is, what are farmers doing to save water? A 25 percent water savings from a handfull of farmers would save more water than the combined conservation efforts of all house owners in Colorado."

I just wanted to point that out. As the information was published for the general readership in Colorado, I would say that therein lies one of the issues that we need to address today. In my mind, the writer was thinking of water as a resource, a resource in which each member of society in Colorado has an equal interest and equal share.

The issue, however, doesn't turn on water as a resource. The nub of the issue is water administered according to the doctrine of prior appropriation. It would appear that that is a concept which few in Colorado really understand. So, we are faced with two tasks. One is to educate the

general public concerning the elements of water administration as it exists here in Colorado. The second is to reduce the source of irritation to the general public. In other words, investigate how the concepts of water conservation can be applied through the agricultural as well as the urban community and, equally important, let the results of these efforts be known.

We welcome the opportunity to meet with you this morning and to benefit from your experience. One last thought I leave with you is an opinion published recently in the Boulder paper. The article was about Boulder and it's elitism, but some words I can excerpt and apply. I'm directing these words from me, as one who is trying to help pull together the state response, to you who are living with drought on a day-to-day basis and are faced with the problems and need the solutions. Henry Fairlie, in the last of his recent series of essays in the New Republic, says that pride is the first of the seven deadly sins. He said, of the seven deadly sins, pride leads to others: sloth, envy, glutton, and the rest. For example, the prideful become intellectually slothful because real intellectual inquiry will deflate their own prideful prejudices. Hence, they resort to slogans rather than thoughtful discussions to support their proud position. Conversation becomes self-reinforcing redundancy.

Pride leads to isolation. It sets one apart from other people, first, in the view of the prideful and, by reaction, in the view of those outside of the exclusive circle. Pride and isolation lead to arrogance.

Drought, as an issue, cannot be solved through pride, isolation, or arrogance. It's something that we need to keep in front of us as we work on the problem daily, and from that we sincerely and earnestly solicit your open and frank discussion of the problem. We want to know what went well last summer, what did not go well last summer, and what we can learn from that to improve in the future. Thank you.

Western Water Conservation Concepts

Dr. Norman Evans
Director, Colorado Water
Resources Research Institute

Presented at
Colorado Drought Workshop,
Grand Junction, Colorado
November 28, 1977

Introduction

There is no subject more on the minds of people throughout this nation today than water conservation, because of water shortages almost everywhere. Periodically, when drought strikes, emergency measures are sought, and the first of these is water conservation.

As a nation, we do take water for granted, perhaps because we are a young and growing nation. After all, until the decade of the 1960s, population pressures were not a conscious concern of most citizens. Land, water, and space resources seemed to be almost boundless save in a few metropolitan areas. The average annual runoff in surface streams of the United States is 1,200 billion gallons per day (one bgd equals 3,065 acre-feet per day; 1,200 bgd equals 3.678 million AF per day). Americans withdraw 1.287 million AF/day from all sources including groundwater storage. However, of water withdrawn, only slightly over one-fourth is actually consumed (0.294 million AF/day). Consumed water is that which is no longer available for reuse, including that incorporated in growing plants and evaporated or transpired into the atmosphere, for example. That means on the average only 8 percent of the total annual surface runoff is actually consumed in American homes, industry, and agriculture. Although this sounds reassuring it is a misleading figure because surface runoff is not uniformly distributed and available across the nation in either time or space.

In the western region, we are keenly aware of the pivotal role played by water in all aspects of life. Here, 49 percent of all water withdrawn from all sources of supply is consumed. This is in sharp contrast with 31 eastern states, where only 16 percent of withdrawals is consumed. In many river basins of the West, the entire surface annual runoff is consumed (Rio Grande, Lower Colorado River).

Annual withdrawals in Colorado total 30,650 acre-feet per day, of which 8,275 acre-feet per day are taken from groundwater storage (37 percent).

The problems of supplying water to meet new demands are nationwide, although they take different forms in different localities. Everywhere, they are becoming increasingly complicated. Water supply may involve storage, distribution, treatment and quality control, and financing. Good planning, new and improved technology and construction are essential elements. Increasingly, public regulation on surface and underground sources is expected to force better "efficiency" in use of available supplies. Social, legal, and institutional changes are being made as communities and even states adjust to the problems of increasing demands on limited water supplies.

Perhaps 1977 will turn out to be the year in which this country finally awoke to the vital importance of water. In general, prior to this time, water shortage impacts have been more localized and less severe. When one must ask for a glass of water in a restaurant, the situation seems desperate.

Rivers have provided the most accessible supply, but as the natural runoff has become inadequate, storage reservoirs have become necessary to hold water for future use. As easy sites for reservoirs have been used up,

construction of additional ones has become increasingly expensive. Underground sources have been tapped by wells, and in many cases the water table has been lowered beyond economic recovery. The Ogalalla aquifer of the High Plains, for example, is yielding water which has taken thousands or millions of years to store. Replacement of storage is virtually nil; the water is being mined at a rate designed to remove 40 percent of storage in 25 years.

Industries have shown themselves able to cut water demand substantially in regions where water costs are high or water is scarce. Home water use may also be reduced somewhat through water-saving devices and other practices such as recycling.

Water is fundamental to life; we cannot do without it in our homes, in producing our food, or in making the products we buy. To maintain a desirable standard of living, we need to develop additional water sources, conserve our available supplies, and use water with the best possible efficiency. All citizens have a vital interest in obtaining an adequate supply, and this is especially true in the western region.

The concepts of water conservation and efficient use of water are therefore both of high interest and importance to citizens of the western region. Indeed, we think of them as the "way of life" that has been practiced of necessity in the arid West, where the water supply is always scarce, where every year is a drought year. But the concept of water conservation and the concept of efficient use of water are not necessarily the same in that application to the western region as they may be in the eastern region. For that reason we would like to have you discuss the meaning of these terms in your workshop groups today in order to clarify their meanings as these terms are applied to water management in Colorado and in the western region.

The terms efficiency and conservation are very similar and, in many cases, may be used interchangeably. According to the dictionary, conservative use means protecting a resource from being used up. For water resources, it means practices which minimize the amount of water necessary to be withdrawn from the source of supply. Efficiency is defined as those practices which produce the desired effect without waste. Again, in the case of water, it means getting the maximum output for each unit of water withdrawn from the source of supply. Efficiency is really one factor in conservative use; it might be thought of as an independent variable in an equation in which conservative use is the dependent variable. That is, in a simple equation, "volume of use equals volume withdrawn times efficiency".

In the rest of my remarks I would like to discuss the concept of efficiency as it applies to the western arid region. I do not imply in any way that there is anything wrong with conservative use or better efficiency, but I do want to make clear that efficiency is a concept which must be applied to a hydrologic unit, such as the river basin, rather than to a single point in the basin. This is simply because the hydrologic system is a "flow" system where one user's waste becomes another user's supply, and in the water-short West, the water imperative is to maximize the utility of available supply rather than to maximize efficiency at each individual point of use. I'll try to illustrate this point in the following examples.

In many cases, an individual benefit from improved efficiency might be offset by a larger detriment when all the impacts from that action are taken into account. For example, the Snake River area in Idaho is a case where the return flows from inefficient irrigation improve stream quality and at the same time level out the flow downstream. The water has better temperature for fishery purposes, and some other quality characteristics are improved in the groundwater return flows that come back to the river after irrigation use. In this case, low efficiency in irrigation is really not a detriment at all, but a benefit.

The Grand Valley in Colorado is a contrasting case. It is said that low irrigation efficiency in this valley results in increased salt pickup by return flows leading to water quality degradation in the Colorado River. A low irrigation efficiency in the Grand Valley produces a detriment.

One misunderstanding which occurs all too frequently is that by improving efficiency, additional supplies will automatically be made available for new uses. There's certainly no axiom in the West which says that more efficiency results in more supplies. For example, in the South Platte Basin, we have had a quick assessment of what might be the consequences of improving the efficiency of agricultural water use in that basin. Under present conditions, the withdrawals are just under 1.6 million acre-feet annually. If agriculture were to line canals to reduce the seepage from canals and conveyance, and if more efficient irrigation practices were applied on the farms, the projected withdrawals would have to increase by 46,000 acre-feet. In other words, it would take more water to serve the same acreage of agriculture at the same level of productivity. Improved irrigation efficiency would in fact be a detriment in that basin.

Although this is a preliminary assessment based on some very gross assumptions, most professionals agree that it is probably correct. It's the question which George Lamb mentioned in his remarks and which is now under study. Fortunately the Colorado Water Resources Research Institute had developed the basin modeling technology necessary to make such a study. But I don't think there really is any question about the fact that in that particular basin the so-called inefficiency of conveyance of water in irrigation canals is the key factor that makes the overall basin water use efficiency very high.

In that basin the reuse system depends critically upon recharge to groundwater from canal seepage and to some extent from irrigation itself. It's the character of the basin which through time has been developed into a very efficient total water system. Native flow (watershed yield) plus imported water from outside the basin total 2.261 million acre-feet per year, which is essentially the full supply available. Withdrawals in accord with legal water rights total 4.587 million acre-feet per year. This means a reuse made possible by groundwater recharge of more than two times for each volume of original supply.

To interfere with that present system would take some serious thought, but it's not uncommon to hear opinions that if canals were lined there would be additional water for new uses. That suggests, for example, that if you're losing 30 percent of the water in conveyance and reduce loss to 10 percent, then that water saved becomes new water to meet some of the growing demands for municipal water. Nothing could be further from the facts. The main conclusion is that the question of whether or not improved efficiency is good must be answered for each site and situation and that such generalities can't be applied in the West.

Now I want to repeat here that conservation of water is important; it's not "pie-in-the-sky." I think every user of water would agree that the conservative use of water is desirable, but that might mean entirely different things in different situations.

Take a municipality, for example. It is commonly suggested that a municipality ought to do all things to minimize the amount of water necessary to be delivered through its piping system. Normally there could be no argument with that because it costs something to treat every gallon of water and it costs something to convey it. But in a situation that I know well, the City of Fort Collins, this has not been the case. The city has delivered water historically without metering, and the per capita delivery of water is relatively high (probably around 225 gallons per capita per day). The part of delivery which isn't returned to the river immediately through the sewer system is returned through groundwater

return flow, which in fact improves the flow in the Poudre River later in the season when the river flow is normally low or zero. The high gallon per capita per day delivery experience of the city happens to have been an advantage in this period of rapid population growth and rapid increase in water demands. The system has had a built-in buffer supply by virtue of having what many would say are oversized lines. Being oversized, the lines are able to deliver new demands without new pipeline construction.

Now there are conservation measures that most municipalities would find useful in reducing the amount of the total water being delivered. Whether or not these measures are applied is again an individual case-by-case question. Metering and pricing the water so that increasing volume of water requires higher per-unit costs is one strategy that can be used. It is a particularly attractive step for system management reasons, and the reduction in water demand appears to be around 10 or 15 percent. On the other hand, municipal systems are notoriously leaky. Generally speaking, around 10 percent would be a figure that most municipal utility managers would use as an estimate of system losses by leakage. So, one could say that conservation through reduced demand by metering and pricing might just about offset the system losses from leakage.

There's another conservation strategy gaining a lot of popularity, and that's called recycling. At the time a subdivision is built, for example, a grey water recycling system is installed that would take the water from shower and bath and run it though the toilet for flushing. That's a practical thing to do that can save around 20 percent.

Public education for the development of a conservation ethic is becoming pretty well known as a strategy that can be effective to the extent of 10 or 15 percent. This, plus some sort of watering restriction, is the usual emergency measure taken in drought times.

So there are pros and cons to water efficiency. I'm just trying to throw out a few of them to indicate how truthful it is that water use efficiency has several sides and ought to be carefully considered. The most intuitively obvious conclusion may prove to be wrong, at least in the West.

In closing, I want to say that the technology for improving irrigation efficiency is available to us today. There have been research projects all over the state showing how better efficiency in irrigation can be achieved by the operator. For example, the many years of irrigation studies in mountain meadows, with which many of you are familiar, show that it is common practice for irrigators to divert water in amounts of 10, 20, or even more acre-feet per acre for meadow irrigation. Cutting that down to 15 acre-inches per acre can increase yields from 1 or 2 tons per acre to 3 or more tons per acre with efficiency of water use approaching 100 percent. In this case, efficiency pays in crop yield, but what does it do to the efficiency of use of the total basin supply? The prevailing practice results in temporary groundwater storage which improves later season supply downstream. This benefit to "inefficiency" would be lost unless surface storage were added to the basin.

In other irrigated areas of Colorado, experiments with maximizing the efficiency of irrigation on several crops has shown that with reasonable investments in land preparation and irrigation equipment, water application efficiency of 90 to 95 percent is easily obtained. The technology, the science, the experience, and the demonstration are ample and adequate to guide us in those cases where an increase in the efficiency with which water is used in agriculture will provide an overall benefit to the basin water system.

Challenge to Innovation

W. D. Farr
Chairman, City of Greeley Water and Sewage Board

Luncheon speech at
Colorado Drought Workshop,
Denver, Colorado
November 29, 1977

I am very pleased to be included in these sessions today. Water and water use have been part of my life, and somewhat of a hobby for many years. The opportunity to discuss the future of Colorado water with this group is very challenging.

Water is Colorado's most basic and precious asset. Water laws, water rights, and water use are tremendously important to our state and its citizens. Our Colorado water rights and the use of these rights are quite complex, and certainly not understood by very many people. We have had over a hundred years of experience in developing and putting to beneficial use the waters of Colorado. When we think of changing our water law and water use, we must consider the past and why the laws and rules were written as they are.

Our present water rights and water laws were developed primarily for agricultural production with a relatively small supply for the cities. These laws have been excellent to manage the water situation as it has been. What this group must be thinking about is how to change the water laws and rules, so that our total water resources can be developed and managed to the utmost. When we think about the water needs of five million people living in the South Platte Valley, plus the desire and need to maintain maximum agriculture, then we begin to realize that today's water laws and water rights will not properly serve the Colorado of the future.

Colorado has been a rapidly growing state since World War II. Our water problems of today are based on that growth. Twice as many people and a changing land use in many areas of our state have changed the economic value of our water.

The Arab oil embargo in October 1974 raised the question of energy for the future. Colorado happens to be in the middle of the largest energy deposits in the United States. Coal, oil, gas, oil shale, and uranium are all found in this area. Now only three years later Denver is being titled the energy capital of the United States. No one knows what this title really means to Denver and Colorado. However, the present growth of downtown Denver and all of the surrounding area are proof that our water problems will become much more severe in the near future.

Before going further with this discussion, I would like to say that I am somewhat familiar with water problems all over the state of Colorado, but most of my specific knowledge is in the South Platte Basin. My thoughts and suggestions are specific for that area; however, I am sure that the ideas are workable for the entire state with modifications for the various drainage basins.

Drought and water economics have brought water to the front pages of our newspapers. In fact, drought has brought this group together today. For the first time everyone in Colorado realizes that water is important. We are going to make it through this drought period; but many of us realize that with Colorado's booming growth rate and another drought cycle due in about twenty years, there could be tremendous crisis developing at that time.

I believe it is the responsibility of this group and others to start diligently looking into the future and developing plans of how to best develop, conserve and manage our water resources.

Remember, that the future of Colorado is limited only by its water resources.

Now to be more specific, I would like to make some suggestions as to how I believe our water resources could be enhanced and much better managed than they are today.

First, we must establish volumetric water rights. We speak of putting water to beneficial use. Our present water law allows diversion of a set number of second feet of water every day from May first to November first, provided the water is running in the stream. Crops do not need water on that steady basis; even cities do not use water on steady flow basis. Much water is poorly used and even wasted in the early summer, when crops are young and small. All of you have actually seen crops of all kinds stunted by application of too much water too early in the growing season.

Why would an owner waste water and labor by over irrigating? There are two reasons. First, he feels that maybe his priority won't be good later on, so he must over irrigate while he has the water. The second reason is because he owns a good water right and he wants to use it. He is proud of his senior right, and he doesn't want a junior right using his water. In my judgment, these illustrations are not true beneficial use.

If the same farm or ranch had an allocation of water by volume which could be called on at anytime during the growing period, the farm would not use as much water and better crops would be grown. To prove this point, I would suggest that you check some crop yields on the crops just harvested. It was a dry year, farmers had to conserve water. They did not waste it, but in spite of this Great Western Sugar Co. has reported record breaking yields in many areas.

I realize this is a complex suggestion. It means combining to some extent what we commonly call river or direct run water with reservoir storage water. It means that the state engineer would have to administer the river on a different basis. Our modern technology would suggest that an in depth computer study of the hydrology of the South Platte and its tributaries would outline the feasibilities of this suggestion.

In order to make volumetric water rights work to the utmost, I am sure that a downstream channel reservoir such as "the Narrows" is probably a necessity. Since we are thinking about changing water laws and water rights, why not form a consortium of all or most of the ditch companies and all of the cities of the river basin. This new entity could build the Narrows so that it could be managed for the benefit of the whole South Platte Basin, not just the extreme lower end of the river.

Another suggestion is to better use our tremendous ground water resources. The present law is completely wrong as far as water conservation is concerned. The only thing it accomplishes is to try and keep old priority surface rights satisfied in a dry year. When the dry year occurs, the state engineer shuts down the wells or forces them to run other surface water down the river to augment the old priorities. This is certainly not a good total use of water resources.

Our ground water is our greatest unused water resource. It should be thought of as a savings account, and it should be used on that basis. When snowpack is short and the runoff is minimal, every pump should be running and withdrawing our underground savings account when it is needed.

To be a little more specific on this point, I firmly believe that when there is a good year with a sufficient stream flow of water, then I should not be allowed to use my wells. We should conserve and build up our ground water reserves in those years. On the contrary, when water supplies are short, I should be forced to use my wells. My ditch water and reservoir water should go to my neighbors who do not have an underground supply. If our water supplies were managed in this manner, I would guess that our total yearly supplies of water

would be increased by almost one-third.

My last suggestion is an idea of how to structure the management of water resources of the South Platte Valley for the future.

The philosophy of water right ownership is very sacred to many people. There has been a lot of blood, sweat and tears go into the development of those rights. In many cases, there was a very heavy debt load that took years to pay off. Therefore as we talk of changing water rights in order to more efficiently develop Colorado's total water resources, we must have a thorough game plan to show that current water rights owners will not be injured.

What is needed is a total management plan for the total use of our water on a year to year basis. Our present water owners, ditch companies, cities, underground water users and individuals all do a fine job of managing their own water rights. The problem is the fragmentation of hundreds of owners trying to be sure that no one gets a drop of <u>their</u> water. The use of Colorado - Big Thompson water in the South Platte Valley has softened this competition the past few years. The flexibility of moving water from one tributary to another has become a great asset.

Flexibility is the key to the future of managing Colorado's water. The ability to move water upstream or downstream, from one tributary to another, or from a high loss reservoir to a more efficient reservoir. These are the tools that are needed. There is not very much <u>more</u> water that can be developed. The problem is to best manage and utilize our total water supplies, not only on a day to day basis, but on a prudent plan for years ahead.

I believe that the ultimate authority and legal entity to enforce water rights and rules must be the state engineer and his deputy river commissioners. The management office would cooperate with the state engineer and all water right owners.

In the case of the South Platte, the legal entity that would plan, manage and execute the distribution of water to all users would be the Northern Colorado Conservancy District.

I am making this suggestion after much thought and observation. I have served as a director of this district for twenty years. We have had three managers, J. M. Dille, Bob Barkley and now Earl Phipps. The directors are all appointed by the district judges. There are no politics, no elections or no favors to anyone. The board's responsibility is to handle the Colorado Big Thompson supplementary water supply for the total benefit of the district. No individual, city, or ditch company is favored.

The Northern Colorado Conservancy District was the first conservancy district organized in the United States. The board and management have had to make the law and the rules as experience has shown us.

The strength of this type of management is obvious. The district office already deals with all ditch companies, rural domestic water systems, towns and cities. They now have a staff of highly trained engineers. They have an office organized with fine accounting systems. They maintain very complex detailed records of land and water ownership. The office works very closely with all county treasurers. The management has the confidence of everyone they deal with.

By cooperation between ditch companies, rural domestic water systems, cities, state engineer's office and the conservancy district, our total water supplies could be gathered, stored in the best locations, and delivered to the users and owners with much less shrink, evaporation and waste. The district office would be in constant touch with the river commissioners, the various ditch company superintendents, the Bureau of Reclamation, and the city water directors. Through all of these operating entities, the best plans could be made to best use the water supply available each year.

The ditch companies would continue to run their ditches. They would make their assessments for operation and maintenance; farmers would pay their own power bills.

All wells would be metered and a yearly report of acre feet pumped would be collected and recorded. The district office would have some type of authority to issue the orders to pump or not pump. There would have to be some very fair method of establishing costs and making adjustments between power bills and ditch assessments.

Some agreeable value of water on an acre foot yearly basis would have to be established in the spring of each year. Then water could be exchanged on a day to day basis with merely a bookkeeping transaction.

Drought is always a threat, and written into new laws and or rules there should be plans that could be implemented by the total management group. Cities, ditch companies, conservancy district, and state engineer would all meet and study how limited water supplies were at that moment. A plan would be adopted and followed as long as the drought situation remained the same. If weather became more severe and water supplies were less than anticipated, then a more stringent plan would be put in use. Or if rain came and water supplies were better, then rules could be relaxed.

Probably some evaluation of water rights and uses would have to be made, then agreements reached by all parties. When a drought occurred, the plan would already have been adopted. Certain ditch companies might know that their system is the most wasteful user of water. They would know that they should not plant any crops to be irrigated this year. Or if the drought appeared later in the season, they might have to abandon some crops. Either way, they would be compensated on a formula that had been agreed on using current costs, returns, etc. The water saved from those sources would be diverted to the cities, rural domestics, or industry where it was a necessity. These emergency users would pay the agreed compensation for the water.

The important part of drought plans is to make all of the plans years ahead of how to operate under severe conditions. Water and water use in drought years becomes very emotional. Good plans cannot be made under stress.

These ideas will not meet with great water user enthusiasm. Underground water users prefer to pump every year. They can shut down the wells at night or on weekends, so they can go fishing. Ditch companies have to deliver water twenty-four hours every day. Surface water owners will not like the volume measurement. All water owners will object on the basis of invasion of property rights. My answer to them is that I agree with them. I own both wells and many different ditch rights. The question is, do they want federal intervention and federal water policy or perhaps state intervention? Or do they want a system with local control where they have input into the water management plan? Certainly we can manage our water rights at the grass roots more efficiently than any other way. Colorado is no longer a pioneer state. We have matured. Our population is rapidly expanding. We cannot stop the influx of people into the state. We must adopt plans, laws, and rules that we can all live with.

Water is finite in Colorado. The challenge is to develop new management to maximize the use of Colorado's water resources.

The Challenge of the Future

John Fetcher
General Manager, Mt. Werner Water and Sanitation District

Presented at
Colorado Drought Workshop,
Grand Junction, Colorado
November 28, 1977

Gentlemen, I am a little bit sorry I do not say "Ladies and Gentlemen." It surprises me that we have no ladies present because I know that they are as much interested in water as we are.

The subject I was given, without being consulted, was "The Challenge of the Future." It is a difficult subject for an engineer because, as you know, engineers generally deal in practical matters, and they quite often do not look into the future too much. I am going to change the subject a little bit and say, "What Does the Future Hold for Water Resources?" I will make a few predictions, few enough to get back on our schedule.

First of all, the demand for water resources and the supply of water depends on many factors, such as population distribution, the future of weather modification, the world needs for food and fiber, municipal and and industrial requirements, and more recent environmental demands for minimum flows and improved water quality. Finally, water policy, and therefore water uses, are subject to political whims.

To zero in on some of these areas of use, I would like to talk a little bit about agriculture. It happens to be the subject with which I am most familiar. The president's "hit list," with which we are all familiar, may have been the result of a misconception on the part of government officials concerning how agriculture uses irrigation water. The president himself may have been misled by a document issued in late 1976 on western irrigated agriculture.

This document, which I do not think many of you have seen, states on the front page that "over half of the water delivered to farms for irrigation is wasted through overwatering, which can limit production, increase farming costs, and contribute to water pollution." This was a document used during the transition period from November to January of 1976, to establish the new federal water policy. It had some influence, I am sure, on the water storage "hit list." As Wayne Aspinall has said, we absolutely must have storage. I will say as one of my predictions that perhaps we will not see gigantic storage projects, but I think we are going to see many smaller storage reservoirs. This is the only way we are going to have water through the drier months, since it is very hard to waste water if you don't have it.

I think we are going to see more sprinkler irrigation in spite of the practical difficulties of using it on rough terrain. I also would make a prediction that on lands which are difficult to irrigate because of their irregularity, we are going to see a great deal of land leveling or, rather, land planing. We know, on our own ranch, that on meadows we have planed not only have we been able to increase hay production to approximately three tons to the acre, but we can decrease the time it takes us to irrigate those fields. On one particular meadow we have decreased the irrigation time from four or five days before planing to two days. Water use was correspondingly decreased and the quality of the hay improved.

Now, I'd like to move on to other uses, for instance the industrial uses. I don't really know what is in store for industry, but I do see that there will be much more recycling of water. Industry is finding ways to use some of the so-called polluted waters. For example, the mining people are going to use water that will come from way down deep. They will be able to use it for purposes which do not require the pure

water which we need for domestic use. I also think that industry is going to have to provide it's own storage. There is no way that the power companies can provide (from flow rights) the amount of water they are going to need for their demands. They will have to build their own storage.

Let's talk a little bit about municipal uses. Again, the pattern mentioned by Dr. Evans this morning is that we are going to see more reuse of water from municipal sources. I think we are going to see a great deal of waste water put back on the land. In fact, I understand that this is a controversial subject in the Grand Junction area right now. It may be impractical in this area to put the water back on the land, but whether you like it or not, throughout our country we are going to see more and more of that type of application.

I also predict that there will be a change in the size of our lawns. The people who move to our Western Slope, for the most part, have their roots in the East, where they are used to large expanses of grass. I was born in Chicago. In that area, perhaps twice during the summer, we would water our lawns. As you know, in this part of the country we cannot depend on the rainfall to keep our lawns green.

You all know that the State Conservation Board is appropriating water, which in many ways does not exist for minimum stream flow. The environmental people, who have a very strong and important influence, are going to insist that there is water in the streams. Somehow these rights are going to be implemented so that there will be flowing water at all times. Even though constitutionality of the law may be questioned, I somehow feel that question will eventually be resolved because of the influence the preservationists are going to have on our society.

In conclusion, I would like to say a few words about the 208 Program which is now under way throughout the state. When it was first explained, many of us thought it was just another federally imposed planning effort. I have changed my feelings because I do think that the job that is being done, which really zeros in on nonpoint discharge, is going to have a rather significant impact down the line on our use of water. So, do not discount the 208 Program. I think some good will come out of it.

Those are some off-the-top-of-my-head predictions. The future will tell us how accurate they are.

The Westminster Water Conservation Plan

Marvin Thurber
Operations Director, City of Westminster

Presented at
Colorado Drought Workshop,
Denver, Colorado
November 29, 1977

It gives me a great deal of pleasure to talk about the Westminster plan. Many of the people in this room have contributed to the planning for the Big Dry Creek Plant, especially Colorado State University -- for instance, the work done under Dr. Norman Evans, Director of Environmental Resources Center and, especially, Dr. Anderson's report of 1976 about the effects of water condemnation in the Big Dry Creek Basin.

Westminster did not have a drought problem this year. We have water storage carry-over from last year, we have water for next year, and we have water for the year after. But as we grow, Westminster must develop a sufficient supply of raw water to serve that growth. We must change our strategy in order to stay in that position. How much storage water is needed? We used to think that three years' worth of a back-up water supply was needed to have a good water system. I don't know if Colorado cities can afford that luxury anymore -- maybe we now need a year and a half, followed by water rationing or other combinations.

The rules are changing; the game is changing. We hope we are capable of keeping up with the changing times.

Westminster doesn't feel that the Big Dry Creek Basin can survive without involving the farming community. We are one system. Westminster is very involved in the whole Front Range planning effort through DRCOG and the 208 process, and we also belong to the Metropolitan Denver Sewage District No. 1.

One of our main problems, one I think you have seen here today, is that all agencies act like a covey of quail, flying in different directions.

If you have an "environmentalist bent," growth management is too often synonymous with stopping growth. If you're a Chamber of Commerce executive, growth management is something every official is doing, even with boom-year construction and obvious sprawl.

The issue receiving the most publicity locally -- water availability and scarcity -- is not the fundamental problem. Growth is the fundamental problem, and water availability is a related issue. Eliminate the demand for growth, and you largely eliminate the issue of water scarcity.

Only an in-depth, honest analysis of these issues reveals the truth, and too often that truth is overlooked when it doesn't conform to the position being advanced. As long as it is more politically expedient to believe in popular myths, the issues related to growth and raw water will go unresolved.

Water availability, the whipping boy on both sides of the growth issue in Colorado, is absurd.

Water availability should be a function of a growth plan and goals program, along with fiscal solvency, balanced land use, energy availability, and proper programming of the myriad of additional public services and resources needed as growth occurs.

The more legitimate issue that should be faced by the state, and by every political subdivision responsible for either land use or water availability, or both, should be:

"Can growth be managed to result in improved quality of life?"

Hopefully, this type of meeting will bring out some sharing of what we are doing well, what we are doing poorly, and how we get it all together.

I was pleased with Mr. Farr's talk at lunch. (See text of W. D. Farr elsewhere in this publication.) I like to hear people talking like that. New concepts are needed.

We think we are doing a better job of water management on a small scale and in one basin. Of course, the first reaction to anybody who talks about water rights change, especially if he wears a black hat from a city, is how do we prove him wrong and keep him out of our water? I truly believe the time has come for the rural and urban interests in Colorado to get together and cooperate in developing the water resource options and minimize all our losses. The Farmers' High Line Canal stockholders and Westminster have proven that it can be done.

Under the same theory that "necessity is the mother of invention," the Westminster Growth and Resource Management Plan grew out of a gradual understanding and refinement of the issues and, ultimately, an attempt to "surround" the total problems of the urban system.

Growth levels, land use priorities, water conservation, successive use, and fiscal planning were integrated into a total, comprehensive system. While on the surface this will look like many other "master plans," it is very different.

Each component carries unique features, and perhaps most importantly, each is inextricably linked with every other component.

A) Growth Levels

The absolute level of growth over each period covered by the plan (the first period of two and one-half years) is determined by integrating all levels of utility planning with capital availability and municipal service absorption. Growth levels cannot realistically be established in isolation but must be a function of the physical, environmental, and fiscal capacities of the urban system.

B) Land Use Priorities

"Zoning" was eliminated from the system because it was unresponsive and imprecise. Instead, all undeveloped properties in the city were "catalogued" with an analysis of the characteristics of those properties (broken down to two and one-half acre tracts). Our inventory of undeveloped properties describe the physical, environmental, and fiscal characteristics and issues relative to the property. Each parcel of land, therefore, can be evaluated regarding the impact of proposed plans for new development.

The system of land use, therefore, is designed to accomplish two goals -- first, what land may be developed (given the impossibility of all lands being developed too soon), and secondly, how the land may be developed. It accomplishes these goals by integrating all other components of the system.

C) Water Conservation

It makes a great deal of fundamental sense to maximize the supply of a scarce resource. If 100 units of water can serve 200 homes under conventional methods, how many homes could be served, without disrupting the quality of life, with the same number of water units by managing the resource differently?

In other words, can waste be eliminated, and further, can the resource be saved by eliminating its use on unproductive or marginally productive activities? Because new supply is both scarce and expensive, existing supply has to be made to go farther.

Historically, little has been done to manage water resources except during droughts. Typically, in times of drought, water rationing occurs, with severe restrictions on water use. These restrictions are lifted as the drought subsides, and the urban system again allows growth under conventional, water-intensive demands.

Can water be managed to reduce demand on the system so that, regardless of temporary drought, year in and year out, the supply is stretched? What can be done to manage water as a permanent scarce resource (as it is in Colorado), rather than reacting to the temporary vagaries of nature?

Over a period of time, the city has adopted a program aimed at reducing consumption permanently and throughout the system without seriously infringing on the quality of life. The plan has several points:

First, all existing utility customers were offered inexpensive water conservation devices to retrofit their homes. These devices were delivered to the homes at the wholesale price paid by the city. Cost for the devices (about $5.00 per house, depending on the number of appliances) could be added on to the utility bill or paid over several months in the event of hardship.

Secondly, the water rate structure was inverted, and the price per thousand gallons of water increases as the number of thousand gallons consumed increases. An historical average in the city to keep a single family home with average size yard healthy was determined. Beyond that average the price increases sharply. Through this restructuring, the price of water has stabilized for small-volume water users, increased moderately for the medium user, and raised sharply for high medium and high volume users.

Next, the minimum water bill was eliminated, and users now pay only for what is "consumed." In the case of elderly persons and small-lot homeowners, water bills were reduced by 50 percent.

A separate rate schedule is incorporated for the six irrigation months as opposed to the six nonirrigation months. This improves cash flow to the city over the 12 months and recognizes potential for waste in a combative sense.

Regarding new construction, once plans have been approved (per components A and B of the plan), builders are required to incorporate a schedule of permanent water conserving appliances in their building program, including insulation of hot water piping within the super-structure.

Builders may, at their option, incorporate a variety of water conservation measures outside the home. In the case of a subdivider building residential homes, these measures can be anything from soil preparation (before bluegrass) to irrigation systems to "dryscaping" a part of the lot, with bluegrass on a smaller area than the entire lot. All such measures must be from an approved schedule.

To provide an incentive to builders to conserve water in the building program outside the home, "bonus units" of construction are offered to those who use the conservation plan. In other words, if a builder is limited to 100 homes, he can receive approval on an additional 20 percent, or 20 more homes, by incorporating water conservation in the "outside" program.

D) Successive Water Use

Much has been written and discussed about successive use of water, but the current state of the art does not support inexpensive, total recycling of water resources. Other options, almost as effective, are available, however.

One such means is to use conventional water sources within the municipal system and, through the wastewater treatment process, treat effluent specifically to benefit agriculture and return the effluent to the stream. There are major advantages to be achieved.

The city is able to "borrow" new water resources, owned by the farming community, to use in the municipal system. This avoids debt financing to purchase or condemn these water rights for municipal use. In the wastewater treatment process, bacteria, heavy metals, and other harmful chemicals are removed, but valuable nutrients are left intact. This process of wastewater treatment is less expensive and, therefore, of benefit to the citizen paying the bill.

This process has two primary advantages to the farming community. First, when properly treated, municipal effluent is more valuable than raw ditch water. Because of the nutrients, fertilizer costs to the farmer are reduced. Secondly, the agricultural stream can be regulated concerning flow during dry years.

In Colorado, 1977 was a classic example of the problem of stream regulation to the farmer. Ditch water, the lifeblood of Eastern Colorado farmland, was plentiful last year until about the middle of July. The year's supply of mountain runoff was then exhausted, with crops in the ground

depending on more irrigation for successful harvest.

Using properly treated effluent, stream discharges can be regulated throughout the irrigation season to provide sufficient dependable water from the beginning to the end of the season. (In 1977, the city of Westminster loaned 1,500 acre-feet of water to the Farmers' High Line Canal Company in September to bring in drought stricken crops.)

The expansion of the city of Westminster's BIG DRY CREEK WASTEWATER PLAN, for which ground was broken December 13, 1977, is the first federally funded successive use project in the state of Colorado.

E) Fiscal Planning

Financial planning is not a result of the other components, nor are the components a function of financial planning. Financial planning is more than an annual decision of whether or not to build a fire station or improve a street. Financial planning is an exhaustive analysis of the strengths and weaknesses of the city's total fiscal system over a multitude of years.

In the growth management area, it begins with the public policy questions of whether the immediate public cost of new growth should be shared by the community at large, paid by the new residents moving into the new homes to be constructed, or something in between.

Financial planning should be evaluated in the same priority as new water resources. It is properly a function of the total system, addressing each of the other goals and responding in a positive sense to all other components.

The financial plan must be the final means of implementation of the goals, as well as the realistic limitations on which the goals are originally designed. Financial planning must be linked directly with land use and assessed in both the short and long run. Each of the separate components, especially land use and successive use, are complicated and lengthy.

Historically, growth has more often been deleterious to the quality of life rather than an improvement of it. Recognizing this as the case, however, does not prove that all growth is detrimental, but rather that it has usually been improperly managed.

Just as nature has provided an elaborate ecological balance, intricate, delicate, and interdependent regarding the natural system, there exists a like balance, equally interdependent in the extension of the urban system. Ironically, man has rightly come to respect, appreciate, and protect the natural systems yet continues to flounder in ignorance when it comes to understanding and managing the system through which the city exists as a viable and healthy organism.

What will the cost of a subdivision be in in terms of new demands on the system (libraries, police, fire, street improvements, traffic lights, utility pump stations, reservoirs), and will the growth return, through taxes and service charges, sufficient revenue to cover those costs? What impact to the environment will occur, as well as what impact will growth have on the city's physical system through which services are provided?

Therefore, a decision concerning zone property or the approval of a subdivision should be made only after a total evaluation of the impact on the urban system, just as a decision to dam a stream should be made only after a means has been devised to compensate for the disruption of the natural system. When this impact assessment is used by public officials for delay, denial, or prevention, it is no longer legitimate; it is then "anti" honest public policy and against the public interest. The horror stories associated with so many federally required EIS's need not be repeated here. Also, with enough information beforehand, an "urban EIS" can be produced in a matter of days.

In Colorado, water availability, a necessary component of new growth, is extremely scarce and carries a high social, political, and economic value. Because this is the case, water is an important priority to evaluate--in many cases, the most important. The water problem must therefore be

dealt with in ways which may not have been acceptable or popular in the past.

When energy was inexpensive, and seemingly inexhaustible, who went to the expense and trouble to properly insulate their homes? We know more about the energy problem today, and so we manage the resource differently.

We know more about water problems today, and we must manage that resource differently. We must manage water differently but only as a component in a total Growth and Resource Management Plan.

The program was developed primarily with Westminster staff, using outside consultation on the data gathering and programming for portions of the plan.

The particular policies which we have incorporated were designed to deal with the growth and resource problems of this community. Some components of the plan probably make sense everywhere; others would be unresponsive or even counter to the goals of a given community.

The one overall aspect of the plan that is and should be adaptable anywhere is nothing more or less than recognizing that the urban system, like a natural ecological system, is composed of a great many interdependent factors, and the total system can most efficiently be managed by recognizing the intricate balance that exists throughout.

THE WESTMINSTER PLAN

The city of Westminster is totally committed to a program of comprehensive growth and resource management--and a very important part of that total program is maximizing the use of presently owned resources in such a way that the urban, suburban, and rural environment and economy benefit. This program includes the following elements.

1) Incentives for builders who incorporate in-house and outside water conservation measures in their new subdivisions by allowing participating builders to build more new homes.

2) Elimination of "minimum" water billing to customers.

3) A rate structure which penalizes higher-than-normal water consumption by increasing the price of water as the volume consumed increases.

4) A wholesale price and delivery of conservation devices to customers in the Westminster system (water dams for toilets and shower head restrictors).

5) An exchange agreement which will allow the city to use additional raw water currently going to agricultural irrigators and repay the stream with treated effluent, highly beneficial to agricultural application.

6) Cooperation among basin utilities to maximize available resources.

The results of such a program will include:

1) Lowering water consumption per unit in the Westminster system.

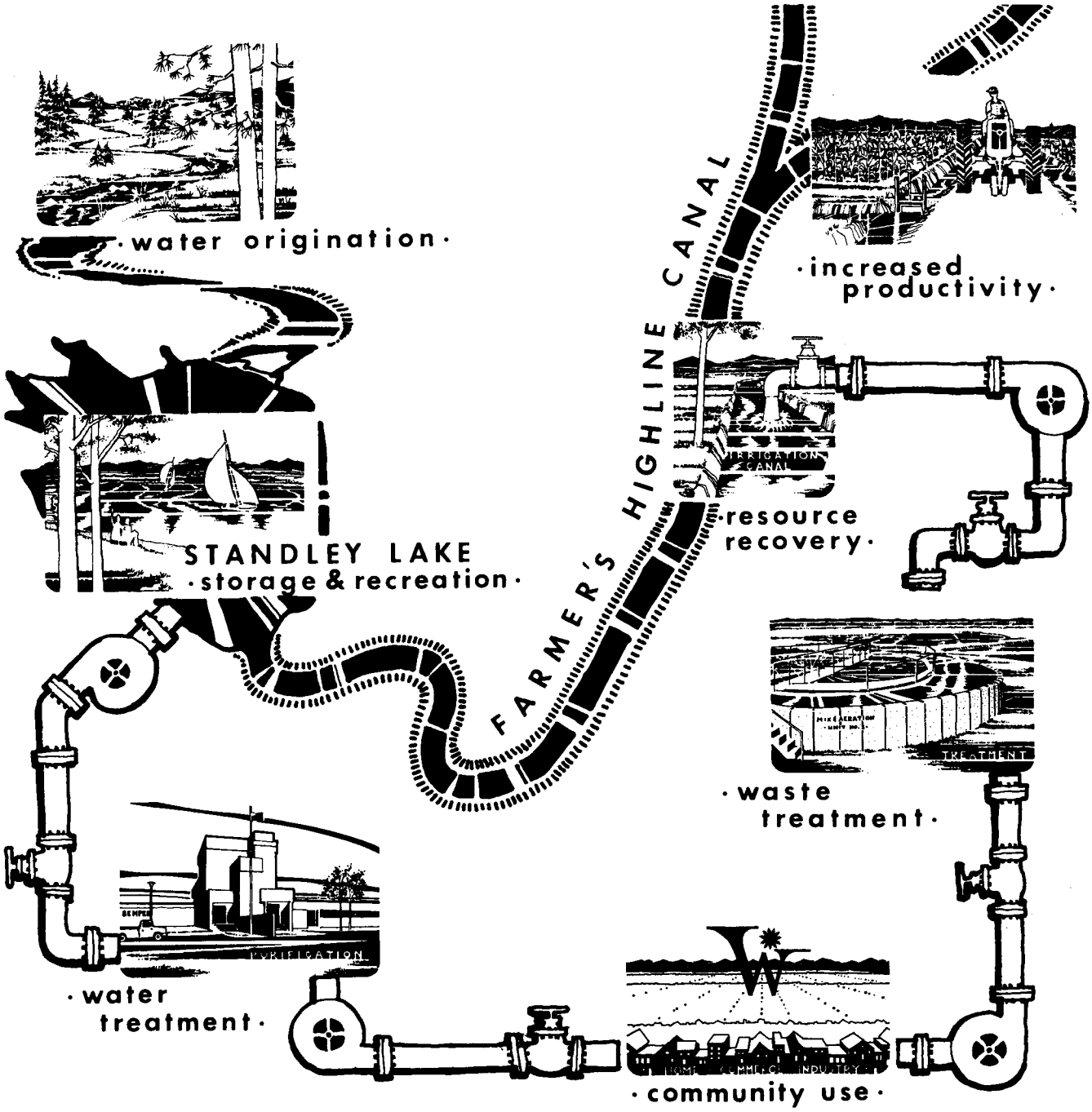
2) Decreasing the price to low-volume water users, stabilizing price to mid-range users, and increasing price to high-volume users.

3) Incorporating water-saving devices in new homes being constructed.

4) Maximizing resources to the benefit of municipal interests and agricultural interests.

5) Agreements among basin utilities to more efficiently use scarce water resources.

(See water use illustration on following page.)


·water origination·
·increased productivity·
FARMER'S HIGHLINE CANAL
·resource recovery·
STANDLEY LAKE
·storage & recreation·
·waste treatment·
·water treatment·
·community use·

Following are the reports from the workshops held in both Grand Junction and Denver. The reports were compiled by designated representatives to those sessions. While we have attempted to be as accurate as possible, it should be remembered that the information is based upon the opinions, views, and experiences of a wide variety of people. Frank and open discussion was encouraged and only constructive criticism of individuals, organizations, or agencies is intended. Moving from one section of the state to another and from one type of water use to another, the reader will find some repetition. We believe this serves to illustrate the common nature of some of the problems faced during the past drought year.

The session reports combined the information obtained from all types of water users and managers including agricultural, municipal, recreational, and industrial. We have not attempted to separate these areas in the reports as it became evident that all of those sectors, at one time or another, have been required to work together in solving common problems and that this pattern will be no less evident in the future.

There were a number of common problems faced by all those dealing with severe water shortages. Among them is the need for more timely responses by agencies in a position to offer drought emergency assistance; further development and refinement of weather modification technology; increased development of water storage projects for both agricultural and municipal uses; increased cooperation and coordination between the various water users and managers; public education on water conservation techniques and needs; examination of current water rights laws as they relate to full beneficial use of stream flows and subsurface water supplies; and increased research and research application in the area of water use for crop and livestock production.

As illustrated in these workshops, some areas of the state were more severely affected by the drought than others and needed more stringent measures to solve their problems. Colorado, so far, has not been as critically affected by this drought as some other western states. At the same time, the drought in 1977 afforded the opportunity for many individuals and organizations to examine and develop ways in which they can cooperate to alleviate the stresses of short water supplies. This can be viewed as a positive benefit. It also has become evident that there is a lack of knowledge and documentation of past efforts to deal with drought. It is the hope of the workshop sponsors that sessions such as the Grand Junction and Denver workshops and the reports from those sessions will serve in the future as a guide for action and a stimulant for further examination of this serious problem. Whether one believes that droughts occur in cycles or at the whim of nature, it is obvious that natural water shortages will happen again and that plans of action are needed to meet the problems before and as they develop rather than after the fact.

Experiences and Remedies

Norwood, Nucla, Naturita, and Dove Creek suffered severe shortages in municipal water supply. Tank trucks were used to haul water for domestic use. Water in storage owned by the Colorado-Ute Power Company might have been used by the towns except that the storage right is for hydropower, a nonconsumptive use. A suspension of the rules governing administration of this water right would have allowed municipal use, but it could not be obtained. Approximately 4,000 acre-feet could have been made available to the towns.

Many towns in western Colorado have water right holdings inadequate to supply the growing water demands and have relied on excess water being available in the surface streams. In a dry year, these towns face severe shortages. Cases were cited where holders of irrigation rights allowed them to be used by the municipality to meet emergency needs. In one case, the Colorado Division of Wildlife made water available from a storage reservoir as an emergency supply.

Fruit growers in the Paonia area exhausted their water supply early in the season. Water was offered for sale at $100 per acre-foot, a prohibitive price compounded by the fact that ditches in that area lose about 50 percent in conveyance, making the effective price $200 per acre-foot. Farmers in this area felt that a conservation pool in the Paonia Reservoir could have been tapped for emergancy irrigation water without irreparable damage to its purpose, particularly since it has never been a good fishery. Additionally, improvement in conveyance efficiency is seen to be important in minimizing the impact of water shortage. Pipelines are being constructed by many water users.

Livestock and rural domestic wells dried up in the rangeland of the northwest area. The use of tank trucks proved to be a partial answer, and timely rains saved the livestock industry there. Water storage facilities are seen as the only answer to a drought crisis in this region.

Industrial emergencies were very limited. The Nucla Power Plant faced a crisis in the supply of water for cooling when the San Miguel River became dry. The emergency was met with storage water to avoid shutting down the plant. The need for more storage in the upper reaches of western watersheds is evident.

Obstacles to Emergency Action

Several cases were described where storage water was unavailable for emergency use by towns or industry because the storage right was for nonconsumptive use (hydropower), or the water in storage was reserved for conservation pool purposes. Conference participants felt that such water should be made available in an emergency such as the 1977 drought. It was recognized that nonconsumptive storage rights contain water rights for consumptive use downstream, and their preemption may cause a hardship on downstream water right holders. However, participants felt this problem could be resolved by negotiation.

Cases were cited in which responsible officials and boards of directors of water user associations had failed to take initiatives toward meeting the drought emergency. For example, an irrigation association could have obtained emergency water through negotiation with the U.S. Bureau of Reclamation had the board of directors taken timely action. However, the board failed to do so, leaving the initiative up to individual members. Apparently the organizational leadership was unable and unwilling to take the emergency action.

Although municipalities may have the ability to condemn water rights, there is insufficient time in a drought emergency for the necessary steps to be taken. Furthermore, most municipalities would be reluctant to take that action in the interest of community harmony, even in an emergency period. However, adequate water rights must be acquired by the municipalities to meet at least

the minimum water demands during drought emergencies. Water rights can be acquired by purchase and, of course, storage may be essential.

Heavy emphasis was placed on the vital role of water storage in western Colorado. The economics of storage projects in relation to frequency of water shortages ought to be investigated. Many felt that negative economic impacts on water users in all sectors are substantial due to both sustained drought and seasonal shortages.

Financing for water storage projects is a key issue to be considered. State and local financing will be necessary. Federal cost sharing to the extent of national or regional benefits ought to be included in some form, possibly through guaranteed loans.

There is considerable agreement that serious consideration should be given to quantifying water rights in terms of volume and in relating the right to beneficial use. These are perceived as changes which would facilitate state administration of an increasingly limited water supply.

In connection with storage projects, there is urgent need for state-federal collaboration to facilitate state use of reservoir sites on federal lands. Given the large amount of federal lands in Colorado, this is a serious constraining factor to increased state self-determination in water resource development and management. Arrangements need to be developed with the federal government that will allow state determination in the issues which presently block such projects.

Recommendations for Future Drought Planning

Experience within one rural water service district showed that water pricing can have an impact upon demand. A penalty charge of $3 per 1,000 gallons above a specified minimum delivery was effective in reducing expected demand by 50 percent. The water supply was from storage and the water users readily accepted this charge, although it was felt that they probably would not have accepted it had the supply been from direct flow diversion. Conservative use of stored water is readily accepted by the local community, whereas conservative use of direct flow water which might not benefit the local community but which would help downstream users is less readily accepted. A basinwide viewpoint is seldom taken by the individual water user.

Conserving water during conveyance by substituting pipelines for open ditches is recognized as a beneficial conservation practice in most of the western slope region. Combined with water storage, such practices would effectively extend the utility of available supplies.

Specific site conditions are always important in determing benefits from conservation measures. It was noted that heavy water application to mountain meadow lands during the spring season effectively stores early runoff for later downstream use. Replacing such practices with efficient irrigation would immediately suggest the need for alternative early season storage capacity at the higher elevations. The same site-specific principle holds for all water conservation practices. They may be generally beneficial, but in certain situations the disbenefits may be excessive.

Agriculture should be prepared to substitute crops having low water demand in order to better meet a drought emergency. For example, collaboration between the Cooperative Extension Service, the Agricultural Experiment Station, and the Holly Corporation last spring resulted in information to farmers about the potential for sunflower production in the Holly district as a replacement for sugar beets. The Experiment Station should be developing drought-tolerant strains of the common crops for use when necessary.

The workshop suggested that Colorado should move rapidly toward developing the Colorado River water to which it is entitled. Storage projects are essential toward this end. The possibility of loss of water rights due to preemptive uses downstream remains a serious threat. Better projections of future water demands and more extensive analyses of impacts due to alternative water allocations

are felt to be needed. It is suggested that hydrologic modeling be accelerated to provide the necessary tools and that economic modeling is equally needed.

Everything possible should be done to facilitate the construction of water storage projects in the upper reaches of the river system. State financing must be provided. It was noted that Oregon is considering a water projects fund of $700 million . Although Colorado has established a construction loan fund, it is too small.

Provisions need to be made for cutting red tape in administration of water resources during droughts. Contingency plans ought to be established for suspension of certain operating rules and administrative procedures when a critical need arises.

Everything possible ought to be done to minimize time and red tape in administering the state construction loan fund. The legislature ought to put complete responsibility on the appropriate state agency in the interest of timesaving. Inflation can offset the advantage of low interest. For example, experience has shown the time involved in getting a loan through the federal Small Projects Act at low interest results in a larger total cost compared to financing through bond sales because the added cost due to inflation exceeds the interest cost.

The state-federal partnership in water projects is in need of improvement, particularly with respect to cost sharing. National objectives and benefits from energy-water projects ought to be recognized through federal cost sharing because most of the energy will be exported from the state. It is recognized, however, that Colorado must assume full developmental costs of many water projects. It is also important that state capability be strengthened for comprehensive planning and design in such projects.

New state initiatives in public education on the facts and characteristics of Colorado's water resources is highly recommended. Both Cooperative Extension Service and the Colorado Water Resources Research Institute ought to expand their services in this regard. It was also noted that water users are at a disadvantage in fund raising for public information compared to anti-water development organizations.

Experiences and Remedies

The participants reported a diversity of negative experiences due to the drought which seriously affected the Western Slope residents. These experiences varied because of their particular indirect and direct needs for water.

The most visible negative impacts were made in the municipal area. Water shortages due to inadequate storage recharge and reservoir drawdown resulted in the passage of ordinances restricting, and at times ceasing, the irrigation of lawns, flower gardens, and vegetable gardens of urban dwellers. These experiences resulted in unsightly lawns, loss of plants, and reduced plant vigor. The loss of vegetable gardens resulted in possible economic loss and a social cost. This is a major activity for the elderly and low income groups. Nurseries and garden centers also suffered from the drought both in reduced sales and in drought damage to plant materials.

Drought impacts were accutely felt in those communities which had recently experienced accelerated population increases. Many communities had difficulty in establishing priority needs because of demands and a lack of institutional arrangements and strategies to meet drought adversity. The entire general community economy became depressed, especially those which depend heavily upon agriculture.

Ski resort communities suffered losses in the general economy because of the reduction of snowpack. Tourism declined radically, and the seasonable labor market became depressed during the winter period. Many resort businesses doubted they could take another season of drought.

The agriculture of the area suffered because of the restricted use of irrigation, the deterioration of the range forage, and the lack of available water for livestock. The livestock sector was not only hit by drought but by a depressed market. These contributing factors resulted in the premature selling of cattle and or the moving of cattle to the Eastern Slope for grazing. A subsequent problem that could have long-term negative impacts is the poor condition of the grazing lands. The drought has so severly damaged the grass that it will take several years to recover from the prolonged drought. This, together with a continued depressed market could cause more severe consequences to the Colorado livestock market.

Additional economic hardships were caused by the delays due to "red tape" in receiving emergency assistance from various federal relief programs. The Farmers Home Administration and the Agricultural Stabilization and Conservation Service programs were mentioned as the main federal agencies responsible for the delays.

Other federal delays were experienced by municipalities in getting permits for construction of pumping stations and other types of water supply facilities. The agencies involved are the U.S. Bureau of Reclamation, U.S. Corps of Engineers, U.S. Economic Development Administration, U.S. Environmental Protection Agency, and the U.S. Fish and Wildlife Service.

Another indirect experience of the drought was the expression by a farm group of its opposition to any federal involvement in Colorado's water laws or any change in the appropriation doctrine.

Water quality in some areas declined because of increased salinity caused by inadequate stream flows.

Remedies implemented to meet water scarcity varied both in type and degree. Effectiveness varied as to the method used and the timing of the response.

Municipalities initially instituted public information programs on water conservation in the hope that voluntary conservation would prove effective. However, since the drought was extensive, prolonged, and severe, additional regulative restrictive conservation ordinances were passed by

cities. Some of the regulations were: allowing watering of lawns, etc. on selected days. (Restrictions in some communities were based on street names and numbers); no watering of vegetable or flower gardens; and no automobile washings.

Farmers and ranchers had to haul water to livestock. In some cases, the Bureau of Land Management supplied water tanks to ranchers. Livestock was occassionaly shipped by truck to Eastern Slope grazing lands in order to attempt to make profitable sales.

Ski resorts had to increase artificial snow-making facilities and even translocate snow from frozen lakes and ponds to the slopes. Expensive national public relations campaigns were used to encourage skiing and to offset the negative publicity about the lack of snow.

Weather modification (cloud seeding) programs were instituted with the support of most communities and the state legislature. One county opposed this program because of the hazards from increased avalanches. (At the time of the conferences the effectiveness of the program was yet to be evaluated.)

Obstacles to Emergency Action

Previously reported delays in receiving federal assistance programs were the major obstacles or "bottlenecks" cited. In emergency situations, such as drought, the time should be shortened in order to make such assistance more effective.

Water storage and transportation project funds should be allocated for construction. Lack of adequate storage was cited as a major reason for urban water shortages. (Note: Not inefficient domestic and industrial use.)

There were examples cited of a lack of cooperation between city and county and the urban and rural areas in general regarding the restricted use of the reduced amount of water.

Generally, there was a lack of public understanding about the nature of drought and what public actions are effective in water conservation. Public education efforts should be increased regarding effective conservation methods.

A tentative conclusion can be made that federal and state agencies and local governments did not have adequate institutional arrangements and strategies to deal efficiently with the negative impacts of prolonged drought. The causes of this inadequate response should be studied and appropriate adjustments in procedure taken. Drought is a normal natural phenomenon, and institutional responses should be adapted to meet human needs during drought periods.

Recommendations for Future Drought Planning

Communities urged that planned and proposed water storage and transportation projects should be developed, especially in those regions where population has increased.

City and county government are beginning to organize institutional arrangements and strategies to cooperate when future droughts occur.

The federal bureaucracy is attempting to reduce the "red tape" delays in application for assistance.

Research is being conducted in order to develop more efficient methods in utilizing available water supplies through conserving technologies and methodologies. Research is currently being done in agricultural irrigation, weather modification, forest management watershed practices, and ski slope-snow management.

Experiences and Remedies

A common agricultural problem in western Colorado and elsewhere caused by the drought in 1977 was a tendency to over irrigate in the spring, as low supplies were anticipated later on. In some instances, crops suffered because of too much water early in the growing season and the lack of adequate supplies later on. There was virtually no hay crop, for instance, in the upper Yampa River Valley because of the lack of water for irrigation. It was reported that at one time during the summer of 1977 the Yampa River fell to 16 cubic feet per second and that minimum releases of storage water prevented that stream from drying completely. In one instance, the Colorado Division of Wildlife allowed the town of Craig to take water from their reservoirs to overcome a shortage of municipal water.

In the northwest section of the state, ranchers reported the early shipment of cattle because of feed and water shortages. Some ranchers sold out entirely. In general, the hay crop ranged from one-third to one-half of normal production.

The U.S. Bureau of Land Management moved wild horse herds from Colorado to the Red Desert in Wyoming.

The situation on the Ute Mountain Indian Reservation was reported as critical, in that they had no direct flow from their stream water rights in 1977. However, they expect the Dolores River Project to help some when it is completed. The most serious problem for the reservation was lack of water for cattle herds, resulting in the sale of 2,000 head (or one-half of the herd) because feed could not be produced. Early cattle sales consisted mostly of calves. Cattle were moved off the reservation for the winter to permit reseeding of pastures damaged by drought. In the future, the reservation management expects to allot grazing areas, a practice which is meeting with some resistance because it has never been done in the past.

During 1977 some wells were dug and sprinkler systems installed, steps which they hope will stablize hay and pasture production.

The reservation representatives reported that various federal programs have been of some assistance in alleviating drought impacts (hay subsidy, pasture renovation, etc.).

Representatives in the U.S. Bureau of Reclamation felt that timing of the drought act (P.L. 9518) was poor because it came about too late to be of assistance. The establishment of a water bank also didn't help; there were no willing sellers because the price offered was too low. In general, most projects and programs came about too late to help in the 1977 drought period. Red tape was blamed for the slowing of many activities which had potential.

Among actual programs initiated were: the Florida Water District deferred a loan payment of $35,000; the Minnesota Ditch received a $10,000 loan for rehabilitation of that structure; the Orchard Mesa Ditch and Reservoir Company installed pumping and pipelines with $270,000 it received; the North Fork Water Conservancy District deferred payment on a $15,000 loan and; the Colorado Division of Wildlife made available $450,000 for mitigation of drought problems.

The city of Grand Junction experienced its lowest water supply for the year in June 1977 but eventually received one-third of the municipal supply from the Gunnison River, although the pumping capacity was limited. Increased revenues of about $150,000 from increased water rates during that period allowed the installation of additional pumps in the Gunnison River, the upgrading of existing pumps, and the funding of studies on improvements of the delivery system.

Reservoirs in the lower storage areas were kept as full as possilbe. In addition, a covered pipeline was installed from Kanah Creek, a key water supply for the Grand Valley municipal users.

Lawn watering in Grand Junction was not forbidden, but use was severly restricted by

increased rates. While some let their lawns die out, others paid up to $150 per month to water lawns (thus the increased revenue mentioned earlier).

There was 15 to 20 times the normal number of well applications by farmers, cities, and smaller towns. Permits were slow in being granted, and many were turned down. One growing concern in this respect is the number of wells in areas of tributary streams. It is feared that such wells eventually will deprive stream water right holders of their supplies if wells draw too heavily.

It was reported that, during the irragation season, from 15 to 20 percent of the ditches in District 4 were not operated. Some 500 ditches received no water at all because of low runoff. (As an aside, it was noted that there were fewer conflicts over water than in some years simply because there was not much water to fight over). Low existing storage in the Gunnison and Blue Mesa Reservoirs is a current problem and could become more severe if the snowpack is low during the winter of 1977-78.

There is an apparent problem in the public understanding of low water supplies for domestic and lawn and garden use. Many cities don't own early water rights which would help in a low year.

There was some criticism of government programs which were publicized and not delivered. One participant said he knew of no government program which actually helped save crops during the 1977 drought year.

In the Hotchkiss and Eckert areas, farmers paid up to $200 an acre-foot, or as much as $7,500 per farm, for watering fruit trees. There were some water rights trades, mostly to save perenials such as fruit orchards.

Some felt that, in the future, fruit and other farmers will need to consider drip irrigation, pipeline delivery of irrigation water, gated pipes, and other methods of saving water. It is believed that storage and water conservation methods go together.

Water problems in the southwestern Colorado area were critical in 1977. An effort was made to organize the San Miguel Basin Drought Council which was composed of agricultural, industrial, and municipal water users.

A number of meetings were held to address the problems being created by the drying of the San Miguel River. The groups inventoried uses, set priorities (municipal use was number one), and worked out strategies to deal with the problems.

Farmers in the area made water available for use by the Union Carbide uranium mill and for the town of Norwood, which eventually ran out of water. Although farmers Home Administration financing for wells in that area was quickly made available, residents experienced difficulty in obtaining well permits from the State Engineer's office. One problem which is difficult to handle is how to be responsive to emergencies while protecting water rights at the same time.

The Norwood and Naturita communities were drilling a large well for municipal use. The well was located with the assistance of the Colorado School of Mines.

More knowledge needs to be gained about underground aquifers--where they are located and the amounts of water they contain. In addition, there is a need for funding in small amounts to develop springs and other sources. There also is a need for more storage for municipal water supplies. A

ordinating water use and development.

There is a concentration of coal development in the northwest area of the state which could apply further pressures to existing water supplies. A company representative said that his company uses water for dust settling and other environmental uses but that they otherwise don't require large water supplies. From his point of view, one of the biggest problems is the treatment of water used in mining to meet quality standards. Mine water drainage also is a concern.

Obstacles to Emergency Action

In an effort to avoid the most serious consequences of water shortages, the people

of the various communities tended to cooperate for the most part. Extremely low stream flow caused the greatest problems. People with early water rights in a number of cases gave up the right to divert water so that domestic water supplies could be provided. Plans were also made so that industries could continue to operate.

The administration of water rights, in some cases, made it difficult to make desired changes in water use. The programs set up by the state and federal governments proved, for the most part, to be ineffective in dealing with the drought of the summer of 1977. The programs were enacted or started too late. The processes needed to implement them took too long to do any good during the period of lowest water supply. Under the programs, it was impossible to develop additional supplies for cities that had run out of water. No crops were saved by programs developed in response to the drought.

Recommendations for Future Drought Planning

One of the themes running through most of the discussion was the lack of water available to cities and towns during the summer of 1977. Irrigators also noted the inability to hold some of the spring runoff for use later in the season.

The lack of reservoir storage was felt by almost all water users. Therefore, more storage needs to be created on almost all streams in western Colorado to hold at least enough water for municipal purposes during periods of extremely low flow, such as 1977. This storage might only be used intermittently but is extremely valuable during periods of low flow.

Reservoir storage for agriculture also is important in providing better timing of irrigation supplies. Storage of spring flows, even in a year as low as 1977, would provide much more effective use of limited water. Now crops are irrigated to excess for a short time early in the spring only to fail later in the season because of a lack of water. More control of the water supply would lead to better use and to better planning of how to cope with drought situations. As the situation currently exists, water supply is almost totally exhausted in some situations, and severe repercussions are inescapable. With growing populations and industries on the Western Slope, provisions must be made to avoid such high dependence on stream flow. Reservoirs need to be built to allow a more controlled supply and a longer planning period.

Experiences and Remedies

It was reported that the town of Nunn in Weld County had a problem of providing water for the town residents during the summer. The one well owned by the town was pumped down to extremely low levels and was unable to supply the town's requirements. Emergency supplies of water were obtained from an adjacent, privately owned well which carried them through the period. Arrangements were made to extend an emergency pipeline, but it was not needed. At the town's request, the State Water Conservation Board did a feasibility study on providing a new well. Funds have now been made available for this purpose, and it is expected that a new well will be operational prior to midsummer of 1978.

No ditches in the Northern Colorado Water Conservancy District ran dry; however, there were shortages of water near the end of the irrigation season. Many farmers traded water supplies; others sold their water outright, and there were many instances of short-term rental of water.

In some cases, wells were pumped in order to maintain ditch flows, and an application was filed with the U.S. Bureau of Reclamation for grants to install additional wells for that purpose. The application was turned down by the Bureau on the basis that the wells were outside of the intended purpose of their funds.

A ditch company in the Arkansas Valley reported that in 1976 they were able to allocate only three-fourths of an acre-foot of water to their customers. In 1977, this was further reduced to one-half acre-foot of water per customer. In 1977, many farmers in that area did not plant crops and, for those who did, there were many acres abandoned during the growing season because of the lack of water.

The valley is extremely dry and subject to severe wind erosion. Since there is not enough moisture in the ground to turn up clods, emergency tillage would be of no value in controlling dust erosion. Because of the dry conditions, many of the distribution ditches are being filled with blowing dirt, and thus ditch maintenance has become an extremely costly part of their program.

Early in the year the ditch company applied to the State Engineer's Office to construct an 8,000-acre-foot storage reservoir to impound flood waters on a lateral dry basin adjacent to the main stem of the Arkansas River. This was turned down by the State Engineer on the basis that the water was, in fact a part of the adjudicated water belonging to the Arkansas River. They are in need of additional reservoir storage.

A farmer and stockholder in the ditch company, said that all of his planning and management decisions are based on snowpack and other information released by the State Engineer and the Soil Conservation Service. He stated that the reports are very useful and necessary, and he thought the level of information was adequate for his decision-making purposes.

It was reported that, during the past year, the ditch company was able to work out a compact with the states of Kansas and Colorado to store the company's entire supply of water in the John Martin Reservoir instead of using its less efficient reservoir storage. The arrangement made available an additional 11,000 acre-feet of water to their customers which would not have been possible if the arrangement had not been made. It was pointed out that water rights below the Pueblo Dam called for a flow of 6,000 cubic feet per second, but the Army Corps of Engineers have established 5,000 cubic feet per second as a maximum flow permitted in the river to prevent flooding. Thus, the need for clearing the river channel of debris and unwanted tree growth was pointed out. Both felt this was a high priority and that federal and state assistance would be required to get agreements on one hand and to pay the costs on the other hand.

Obstacles to Emergency Action

Most representatives of the Arkansas River Valley were in agreement that wells and small watershed impoundments were drying up the river year by year. They felt that this was an infringement on downriver rights and that water laws were not presently being enforced. They felt that the State Engineer's Office has neither the budget nor the people to police the priority system and, as a result, laws are being violated.

Regarding fire protection, there were many areas in the state that did not have local supplies of water available, and it was suggested that the creation of small impoundments at strategic locations could serve this emergency purpose.

Recommendations for Future Drought Planning

Most of the group members agreed that there is need for additional water storage in all the areas of the state and that the development of additional water storage should be done through the leadership of state and local people with state and local funding. There was little optimism that the federal government would be of long-term assistance in future water development.

Weather modification was discussed, and the group agreed that this should be a permanent standby program to be put into effect whenever the need arises rather than being treated as a temporary measure requiring legislative action each time the program was put into effect.

It was pointed out that the San Luis Valley now has approximately 1,200 center pivot sprinkler systems in operation and that this is the predominant method of irrigation in that valley. Thus, it becomes critical to maintain ground water levels and flows for at least 7 to 10 years so that the farmers can pay off their investments in center pivot systems. It also was noted that reservoir storage in the valley was needed and that there is not a single impoundment in Colorado on the Rio Grande system.

The group generally was in agreement that legal cost of maintaining ditch companies and water rights is now a heavy financial burden that was not originally contemplated. They felt that the state could and should provide assistance in this area in the form of an ombudsman to provide legal advice to the various ditch companies.

Since energy cost for irrigation pumping has doubled during the past four years, the group felt that energy cost forecasting was greatly needed.

The organization structure and function of the Agricultural Conservation Task Force of the State Drought Council was reviewed. The question was raised as to whether their activities of trying to coordinate get-togethers of the various water users by river basins was of value. It was the concensus of the group that the meetings last year were extremely helpful and their continuance for 1978 was encouraged.

A participant pointed out that the total water supply in the Arkansas River system could be improved by mountain watershed vegetative management. The amount of snow trapped and resulting in runoff could be increased as much as one-third with selective patch cutting, utilizing checkerboard clearings with diameters one and one-half times the height of the surrounding trees. For the plains area, windbreak plantings could increase the amount of snow trapped and resulting moisture by as much as one-half; however, this practice requires a 10- to 20-year lead time to have maximum effectiveness.

Large cottonwoods along ditches, canals, and streams could be harvested as an economic crop and thereby generate funds for this activity. It was pointed out that a large cottonwood utilizes from 100 to 200 gallons of water per day. Selective cutting should be made in order to make the practice environmentally acceptable.

Experiences and Remedies

Attending the Denver conference were representatives of rural areas, urban communities, and cities. The rural representatives expressed concern that a continued drought would create large land sales because of the financial inability of farmers and ranchers to continue. This outmigration could cause increased social, political, and economic problems for the affected rural and urban communities. The residual lands could suffer major soil and water erosion problems due to abandonment or consolidation.

Participants believed that most of the drought problems in rural communities stems from officials not wanting to admit to a problem and from inadequate funding and facilities to cope with drought.

Farmers not only faced shortages of water for irrigation but the irrigation ditches were silted by blowing dust. Dust storms in the Great Plains were a major public health and environmental problem which could increase in frequency and scope should the drought continue. Accurate damage data due to dust storms is elusive due to inadequate survey methods.

An increase in forest fires and in western pine bark beetle damage are feared because of drought. During periods of extreme drought, the amount of fuel increases and becomes more volatile. Any large-scale fire could cause serious negative impacts to the forest watershed and therefore impairs future supplies of water.

There was a general lack of water for normal lawn and garden care in all Front Range cities. The shortage was compounded by population increases in recent years. These increases in population were largely from areas where drought and arid climates were not common and the population was generally unaware of the nature of drought.

Industries such as cement, sugar processing, steel, and general construction were some of the examples cited as having difficulties because of the lack of water. There was inadequate water for cooling electrical power plants and operating air pollution control stack scrubbers. The drought, therefore, was an indirect cause of increased air pollution due to dust storms and from emissions and particulates from smokestacks.

Remedies used depended upon the nature of the shortage. Cities represented in this session reported taking action similar to that described in Workshop II of the Grand Junction conference. Among the methods cited was lawn and garden water scheduling. Water metering, together with inverted water rates, was discussed as another alternative. However, there were questions of equity and efficiency in their use. Continued need for public education regarding the nature of drought and conservation methods is needed to motivate a water conserving ethic. Some communities have initiated cooperative agreements between municipal and agricultural users in order to more efficiently utilize available water. Municipal water is treated and recycled for agricultural irrigation, and recycling of water is increasing in agricultural, industrial, and municipal use.

Weather modification is used in the mountains, but further research is needed before it can be used with reliability on the Great Plains.

In some municipalities, landscape modifications are being encouraged. Homeowners are urged to adapt their gardens to more arid conditions by reducing the amount of grass and/or by changing to a more drought resistant species of grass.

Obstacles to Emergency Action

The major "bottlenecks" discussed also are covered in the Grand Junction Workshop II report. They were mainly federal and state agency bureaucratic delays in receiving public assistance. In coping with the drought, there was a general lack of adequate funds, methods, and coordination among various public agencies.

Concern was expressed that most Colorado streams were over-appropriated and that current water law favored agriculture. There were suggestions that Colorado's water laws should be re-examined in view of the increasing and competitive demands of an expanding urban population as well as energy and agricultural demands.

There was no central coordinated program of monitoring, forecasting, and warning of drought that was adequate for communities to prepare for shortages.

Recommendations for Future Drought Planning

There was continued insistence on the further development of water storage and treatment facilities. Conservation and recycling programs would continue to be developed. Most communities were able to test and establish emergency facilities and procedures. More efficient methods of irrigation were being developed. Weather modification research and development was continuing.

Institutional arrangements were formalized to coordinate conservation efforts between municipal and rural users.

APPENDIX A

Following is the letter sent to participants who had been contacted previously by telephone.

November, 1977

TO: Drought Workshop Participant

Thank you for participating in the upcoming Drought Workshop at the Ramada Inn, Grand Junction, Colo., at 8:45 a.m. on Monday, November 28 or the Denver Hilton, 16th and Court Place, at 8:45 a.m. on Tuesday, November 29. We look forward to the information you will bring and the recommendations you will have for improving future emergency responses.

The workshop is being sponsored by the Colorado Water Conservation Board, the Colorado Drought Council and Colorado State University. Our purpose is to bring together a cross-section of people who have been forced to cope with severe water shortages during the current drought. Representatives such as yourself from agriculture, municipalities, industry and recreation will share their experiences in drought management, assess the effectiveness of measures already tried, and reflect upon alternative measures not yet tried but which have promise.

Consideration also will be given to possible legal and institutional changes for long-term improvements in drought management, and to short-term measures which could be implemented in emergencies.

The meaning of the term "water conservation" will be discussed by the conferees in the context of western water resources. There is considerable lack of understanding of its meaning to the western region among many in the Washington bureaucracy. For that reason, it is felt that a comprehensive definition and narrative explanation is needed.

The workshop will be a working meeting in which participants will be asked to report upon their experiences and to make their suggestions and recommendations for future action and new policies for future drought management. If you have written material already prepared about your drought experiences, or if you would like to submit some written information at the workshop, it will be welcomed (but not required). The product of the workshop will be a printed proceedings summarizing those views.

Attached is a detailed agenda for the day. We will provide lunch and dinner. If for any reason you will not be at either of the planned meals, please call me, collect, no later than Monday, November 21, so that we can give a correct count to the catering service.

Travel and subsistence will be covered by the workshop for those whose employing organization cannot support them. If you require reimbursement for expenses, please complete the attached sheet and give it to me at the workshop. Please make your own travel and lodging arrangements. Receipts will be required for lodging and air fare; not for meals. The maximum allowed per individual for lodging will be $15.00 per day. Meal allowances are $2.50 for breakfast, $3.50 for lunch, and $5.50 for dinner.

Again, thank you for your interest and participation in this workshop project. We believe the results will be of great value in the future to you and others dealing with emergency drought situations.

Sincerely,

Gary L. Bennett
Workshop Coordinator
c/o University Communications
Aylesworth Hall
Colorado State University
Fort Collins, Colorado 80523
Phone: 491-6432

APPENDIX B

Following is the abbreviated instruction given to workshop participants at the beginning of the sessions. This represents the main body of information being sought through the workshops.

WORKSHOP INSTRUCTIONS
Experiences and Recommendations in
Emergency Drought Management

The following are typical questions which should be addressed during the workshop discussions:

1. What emergency situations have developed as a result of the 1977 drought? (Describe each situation in enough detail that the proceedings will reflect the true nature of the situation.)
2. What measures were taken to ameliorate the adverse impacts reflected in the circumstances above? (Describe the steps taken and assess the degree of success.)
3. What alternative measures might have been taken that were not tried? (Describe the alternatives and suggest why they have promise.)
4. What legal problems were encountered that interfered with effective emergency action?
5. What institutional arrangements impeded effective emergency action?
6. What changes (innovations) in either legal or institutional arrangements ought to be made now in preparation for future drought emergencies?

APPENDIX C

Participant List
Colorado Drought Workshop
Grand Junction, Colorado
November 28, 1977

Staff Support

Ray Anderson, USDA
Economic Research Service
CSU

Gary Bennett
Extension Editor and
Workshop Coordinator
CSU

Henry Caulfield, Professor
Political Science, CSU
State Drought Council

Hank Deutsch
Session Recorder and
Graduate Student
CSU

Norman Evans
Director
Environmental Resources Center
CSU

Hugh Henderson,
Assistant Director
Cooperative Extension Service
CSU

Participants

Wayne Aspinall
Palisade, CO 81526

Jim Barger
City Water Superintendent
230 26-1/4 Road
Grand Junction, CO 81501

Larry Beidleman
Director of Planning
Aspen Ski Corporation
P O Box 1248
Aspen, CO 81611

Senator Tilman Bishop
State Drought Council
2697 G. Road
Grand Junction, CO 81501

Robert Burford
State Representative
113 Mira Monte Road
Grand Junction, CO 81501

Fred Daubert
Colorado Water Conservation Board
State Centennial Building
1313 Sherman Street
Denver, CO 80203

Al Durham
Hamilton, CO 81638

John Denison
District Forester
Colorado State Forest Service
1129 Colorado Avenue
Grand Junction, CO 81501

Ben Eastman
Route 2
Hotchkiss, CO 81419

Lee Enwald
Division 5 Engineer
P O Box 396
Glenwood Springs, CO 81601

John Fetcher
Box 5220
Luncheon Speaker
Steamboat Springs, CO 80477

J. J. Harris
Drought Coordinator
District 10 Regional Planning Com.
P O Box 341
Montrose, CO 81401

Ernest House
Ute Mountain Ute Indian Tribe
Ute Mountain Ute Agency
Towaoc, CO 81334

Duane Jensen
City Utility Engineer
250 N. 5th
City Hall
Grand Junction, CO 81501

Tom Kelley
Division 4 Engineer
P O Box 456
Montrose, CO 81401

George Lamb, Coordinator and Speaker
Colorado Drought Council
Office of the Governor
State Capital Building
Denver, CO 80203

John LeCompte, Speaker
State Weather Modification Coordinator
CSU

T. J. Longley
Colorado Water Conservation Board
Grand Junction, CO 81501

Bill J. McCleneghan
Western Engineers Inc.
P O Box 571
Grand Junction, CO 81501

Glen Miller
Baggs Route #74
Craig, CO 81625

Bill Nelson
The Daily Sentinel
Grand Junction, CO 81501

Kenneth Norris
Manager, General Planning
Colo-Ute Power Company
P O Box 1149
Montrose, CO 81401

Bill Raley
Box 130
Norwood, CO 81423

Blaine Richards
Operations Division
Bureau of Reclamation
Box 1728
Grand Junction, CO 81501

J. R. Rinckel
Bureau of Reclamation
Box 1728
Grand Junction, CO 81501

Wesley Signs
Division 6, Engineer
Colorado Division of Water Resources
P O Box AE
Steamboat Springs, CO 80477

Richard Steckel
Route 1
Crawford, CO 81415

T. E. Taylor
Ute Mountain Ute Agency
Range Conservationist
Bureau of Indian Affairs
Towaoc, CO 81334

John Ward
Colo-Wyo. Coal Company
443 Breeze Street
Craig, CO 81625

Wayne Weathers, Manager
Ute Water Conservation District
P O Box 460
Grand Junction, CO 81501

Participant List
Colorado Drought Workshop
Denver, Colorado
November 29, 1977

Staff Support

Ray Anderson, USDA
Economic Research Service
CSU

Gary Bennett
Extension Editor and
Workshop Coordinator
CSU

Henry Caulfield, Professor
Political Science, CSU
State Drought Council Member

Hank Deutsch
Session Recorder and
Graduate Student
CSU

Norman Evans
Director and Speaker
Environmental Resources Center
CSU

Hugh Henderson,
Assistant Director
Cooperative Extension Service
CSU

Participants

Don Beckett
Moffat County Commissioner
Box 638
Craig, CO 81625

Ron Brenton
Great Western Sugar Company
P O Box 5308
Denver, CO 80217

Kirk Bryant
Denver Water Department
144 W. Colfax
Denver, CO 80254

Clarence E. Burr
Star Route
Walden, CO 80480

Charles Calhoun
Bureau of Reclamation
Denver Federal Center, Building 20
Denver, CO 80225

Carl Carlson
Colorado Rancher and Farmer
2765 South Colorado Blvd.
Denver, CO 80222

Kenneth Carter
Star Route 1
Ordway, CO 81063

Fred Daubert
Colorado Water Conservation Board
State Centennial Building
1313 Sherman Street
Denver, CO 80203

Franklin Eddy
Rio Grande Water Conservancy District
P O Box 816
Alamosa, CO 81101

Charles M. Elliott
Attorney-At-Law
Holland and Hart
P O Box 8749
Denver, CO 80201

W. D. Farr, luncheon speaker
P O Box 878
1914 14th Avenue
Greeley, CO 80631

Joe Griess
Drought Coordinator
Division of Wildlife
P O Box 2287
Fort Collins, CO 80521

Herb Gundell
Denver City Extension Director
1300 E. Virginia Avenue
Denver, CO 80209

Tom Hays
City of Fort Collins
Water and Sewer Department
Fort Collins, CO 80521

Pete Juba
Drought Coordinator
P O Box 400
Pueblo, CO 81003

George Lamb, Coordinator and speaker
Colorado Drought Council
Office of the Governor
State Capital Building
Denver, CO 80203

John LeCompte
State Weather Modification Coordinator
and Speaker
CSU

Frank Milenski, President
Catlin Canal Company
c/o Route 1
La Junta, CO 81050

Elton Miller
12251 Road 22-1/2
Fort Lupton, CO 80621

Robert Northrup
Box 392
Lamar, CO 81052

Earl Phipps, Manager
Northern Colorado Water Conservancy District
P O Box 679
Loveland, CO 80537

Leo Pollart
Amity Canal Company
Route 2, Box 47
Holly, CO 81047

Buford Rice
Farm Bureau
P O Box 5647
Denver, CO 80217

Bill Strabala
The Denver Post
P O Box 1709
Denver, CO 80201

Charles S. Thompson, Manager
S.E. Water Conservancy District
P O Box 440
Pueblo, CO 81002

Elwood Thueson
Farmers Home Administration
Room 231-Diamond Plaza
2490 W. 26th Street
Denver, CO 80211

Marvin Thurber
Operations Director
City of Westminster
3031 W. 76th Avenue
Westminster, CO 80030

Roger VanValkenburgh
(Hydro-Product Managing,
Public Service)
1800 W. Sheri Lane
Littleton, CO 80120

Lowell Watts, Director
Cooperative Extension Service
CSU

Ron Zeleny
Staff Forester, Fire Protection
Old Forestry Building, Room 203
CSU