Drought Happens: Get Used To It!
Will Technology Help Us To Survive?

By

David W. Eckhoff
Vice President & Regional Manager
PSOMAS

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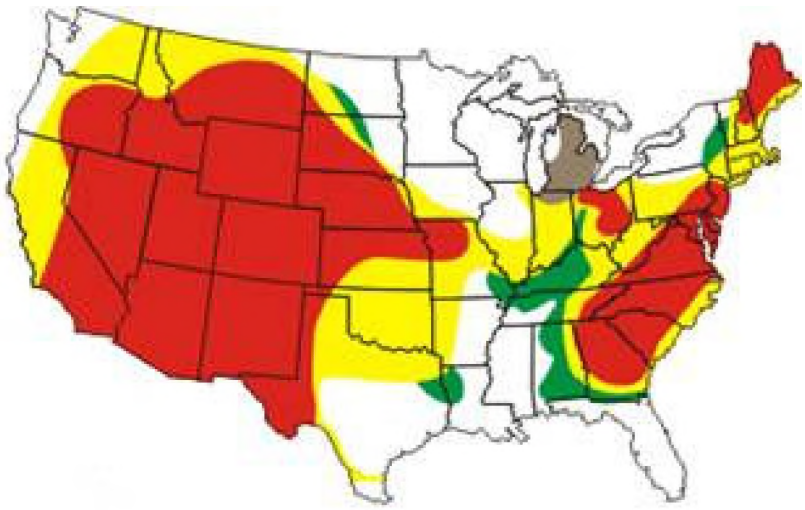
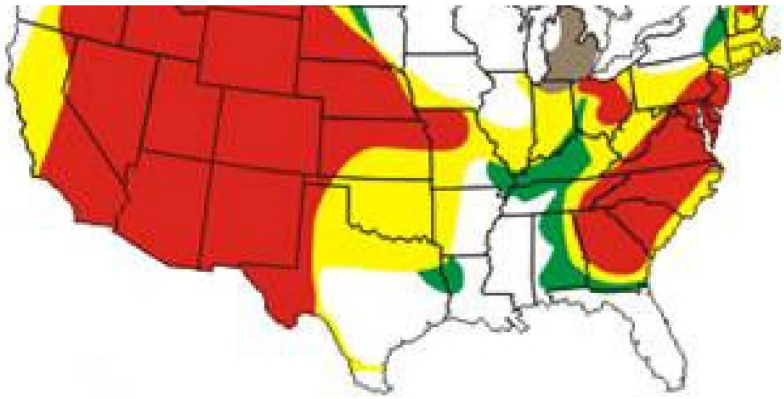
Introduction

Drought is not the most popular subject in the world. When I mentioned to a friend that I was going to talk about drought and technology, he said, "Won't that be about like talking about death? How can you put a positive technological spin on that?"

Actually, as opposed to death, I think there are some bright spots in the drought mitigation future. I will review some of these in this lecture, but I'm also going to discuss some of the downsides of drought, because you can't have one without the other. I do want to focus on technology, but I also want to talk about how people ***respond*** to technological advances. Probably some of the more sobering aspects of drought are the severe economic and human impacts that have resulted, particularly in the previous two centuries.

We are currently experiencing a severe drought in Utah and throughout the Western United States . It's very extensive. It has lasted a long time - about four years, and the forecasts are not reassuring. It's been compared to the Dust Bowl of the 1930s. Although





the old records are sparse, it probably equals, in many respects, some of the bad droughts that occurred in the 1800s. Outside of the fact that we know it's a drought by our experiences, how do we precisely define it? A drought, in a sense, is like illness. So you're sick: What are the symptoms? What are the prognoses? What are you going to do about it? The drought problem is very similar, because there are many facets.

We will review the ***hydrologic cycle*** , particularly as it expresses itself here in Utah and more specifically along the Wasatch Front. We have a unique situation in terms of how our water supplies are developed, how we subsequently store them and transport them, how we utilize them, and what we do with them when we are "done with them."

How Do We Use Water?

We have been accused of using a lot of water and wasting it. I want to take a definitive look at just how true this accusation is, and how we fit into the picture with the rest of the United States . Drought remedies, i.e. living with drought, coping with drought, in essence beating drought, really require a host of different considerations. First of all, anticipating it and preparing for it. One of the problems we will see is that drought does happen at least ***twice*** in most people's lifetime. However, the really bad events are usually far enough apart that we have forgotten about them, or we ***choose*** to ignore them. So when drought happens to us again, we perceive it as a whole new and surprising experience.

Water Conservation

The ways in which we use water significantly affect how droughts impact us. I will explore wastewater reclamation and reuse, something that we don't see very much of here in Utah , but

has seen extensive technological development in Southern California . I will discuss modern lifestyles and how they affect our view of this phenomenon of drought: how might we modify our lifestyles so that we can better accommodate drought in the future, and better achieve the things that we want to accomplish as a society? I will also review economic incentives and disincentives associated with water conservation. It's nice to have everybody cooperating on a volunteer basis, but sometimes you have to resort to the pocketbook to really make water conservation work.

Technology

Many types of technologies are being promoted: some are good, some are not so promising. The ones that I'll talk about today have demonstrated promise in terms of helping us to plan for, deal with, and beat drought. To what extent can technology do this and continue to do so in the future? A lot depends upon some key ***sociological*** as well as ***technological*** issues.

What is Drought?

The National Drought Mitigation Center has published the following definition:

Drought is a normal, recurrent feature of climate, although many erroneously consider it a rare and random event. It occurs in virtually all climatic zones, but its characteristics vary significantly from one region to another. Drought is a temporary aberration; it differs from aridity, which is restricted to low rainfall regions and is a permanent feature of climate.

Drought is an insidious hazard of nature. Although it has scores of definitions, it originates

> from a deficiency of precipitation over an extended period of time, usually a season or more . . . . Other climatic factors such as high temperature, high wind, and low relative humidity are often associated with it in many regions of the world and can significantly aggravate its severity.

Drought is a normal - *it's hard to believe, normal* - recurrent feature of climate. It occurs almost everywhere. It occurs in the most humid of climates. It occurs in the driest of climates. For that reason, defining drought becomes confusing. It depends upon regional differences: differences in needs, differences in water use, and, differences in perspectives of the people that live in those regions.

Aridity

Drought differs from aridity; this is an important distinction. Places like Utah are very arid, but are not always in a drought. (Utah has one of the driest climates in the USA .) About two months ago, an article in the *Deseret News* featured a serious misrepresentation of the relationship between drought and aridity. A representative of this university was taking some shots at farmers for what he called "subsidization of their water resources and water resource developments." The narrative went like this:

> Farmers and politicians call Utah 's fourth straight year of below average snowpack a disaster. But a University of Utah political science professor who writes on Western water issues says that ignores a simple fact, “Deserts are supposed to be dry. It is a mistake to talk about drought as a crisis,” says Dan McCool. “We are always in a drought. That is a definition of a desert. It is ignoring that Utah is a desert, and that's causing the problem.”

This statement is not only misleading, it is factually incorrect. Utah is not always in a drought. Although drought occurs periodically, we are an arid state with unique water requirements. Universities have the obligation to comment critically on all kinds of societal issues, but they also have an obligation also to be factually correct. The farmers who understood how to live in an arid climate developed most of the agricultural irrigation systems in Utah , sometimes with some state assistance; however, many municipal systems also received government financial assistance. If you don't like state financial assistance then you tend to call it ***subsidy*** . I have many friends in the Utah agricultural community and they were greatly offended by these remarks. We should be more careful, particularly when we are in the straits of a situation like drought, and realize that we're all in it together. We should pull together because we are a community, and every part of our community contributes in some way or another.

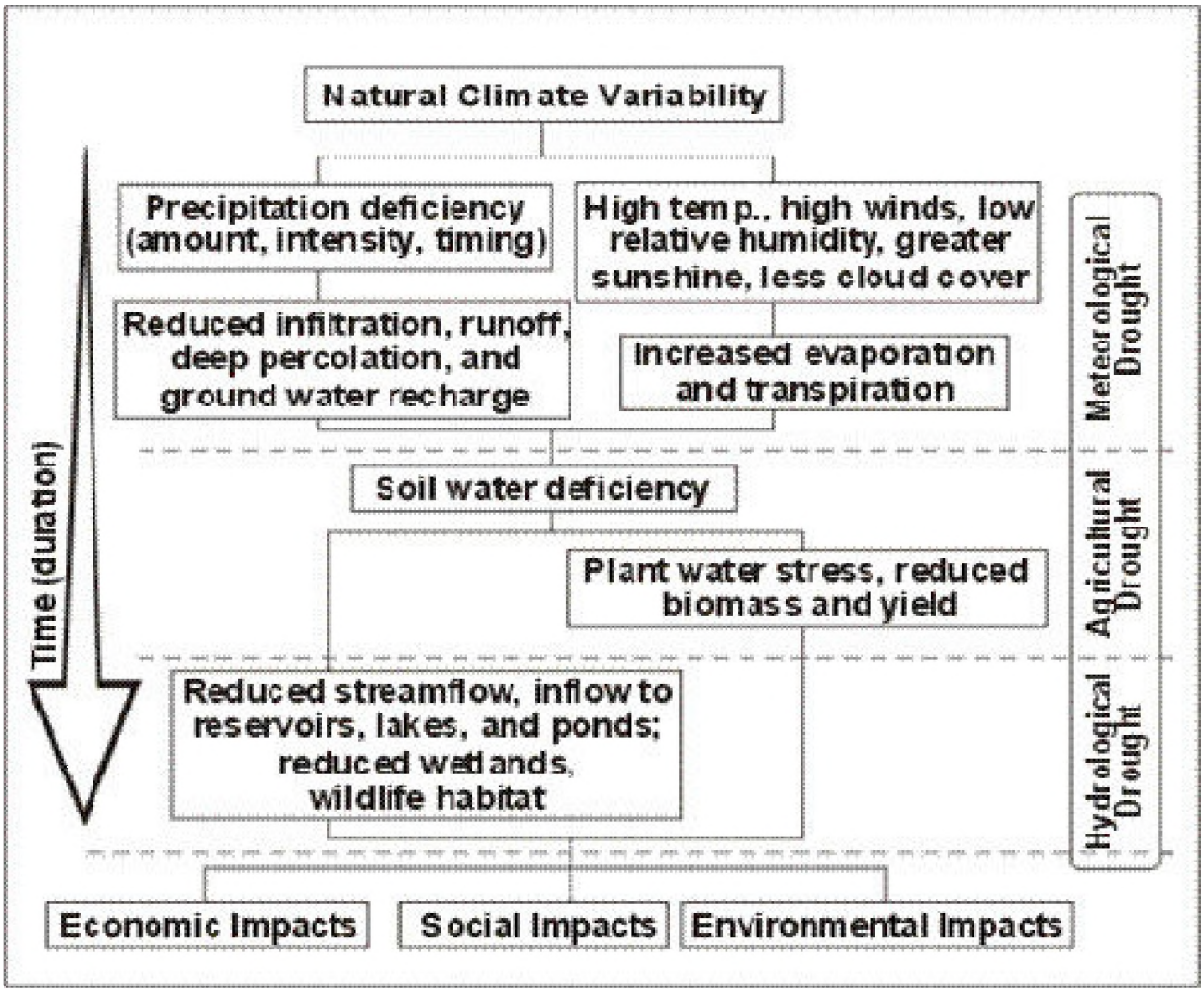
Drought is usually measured scientifically on what happens to soil parameters, such as soil moisture deficit. But the real impacts are on crops (damage) and, ultimately, on the financial resources of the farmer, his family and his community. We who live in an urban environment think we suffer damage because our lawns turn brown. But for the most part, our impacts are really minimal, especially when compared with some of the impacts of drought in the nineteenth century.

The next definition is sometimes a hard thing to comprehend. Drought is a ***natural hazard*** , which puts it in the same family as flooding, hurricanes, tornadoes, earthquakes, volcanic eruptions, and insect infestations. I guess, except for the volcanic eruptions, that might be a definition of Southern California . These other phenomena are all natural disasters with which we have learned to cope. The difference being, for the most part, that drought takes place over

such an extended period of time. Hurricanes cause a lot of damage, but they are in, they are out and they are gone. We get together, we clean it up and we move forward. Flooding tends to have a similar pattern. We get inundated, houses get washed off the hills, the damage occurs. We clean it up and we get on with our lives. Conversely, droughts, especially like the one we are experiencing now, last for years. They are persistent. We are now considered to be in the fourth year of drought in Utah . There is some likelihood, despite the rain we had last weekend, that the drought may continue into next year (it has!). If it does, I can assure you, we will see some vastly different impacts. We will see water shortages not only in the agricultural sector, but also in our municipal and industrial sectors.

Other factors, such as high temperatures, high winds and low relative humidity, serve to exacerbate drought. That's Utah ! We are dry. We are hot. We have a lot of wind, especially in the western parts of our state. When we were working on the West Desert Pumping Project, we found the average wind speed to be in excess of ten miles an hour. That is one of the reasons the West Desert is a desert. Wind keeps it consistently dried out and it exacerbates drought effects. Aridity is certainly prevalent, but it's not drought in itself.

Two things about drought that are most important are its intensity and its duration. These come into play when we examine the different kinds of scientific drought definition. The three scientific definitions that I will discuss today are: (1) ***Meteorological Drought*** , otherwise known as “Mark Eubank” drought; (2) ***Agricultural Drought;*** and (3) ***Hydrological Drought*** . The two are significantly different. They generally affect different sectors of our society and our economy, and they are sometimes out of phase. The figure below from NDMC depicts graphically the relationships between these three "stages" of drought and their predominant impacts.



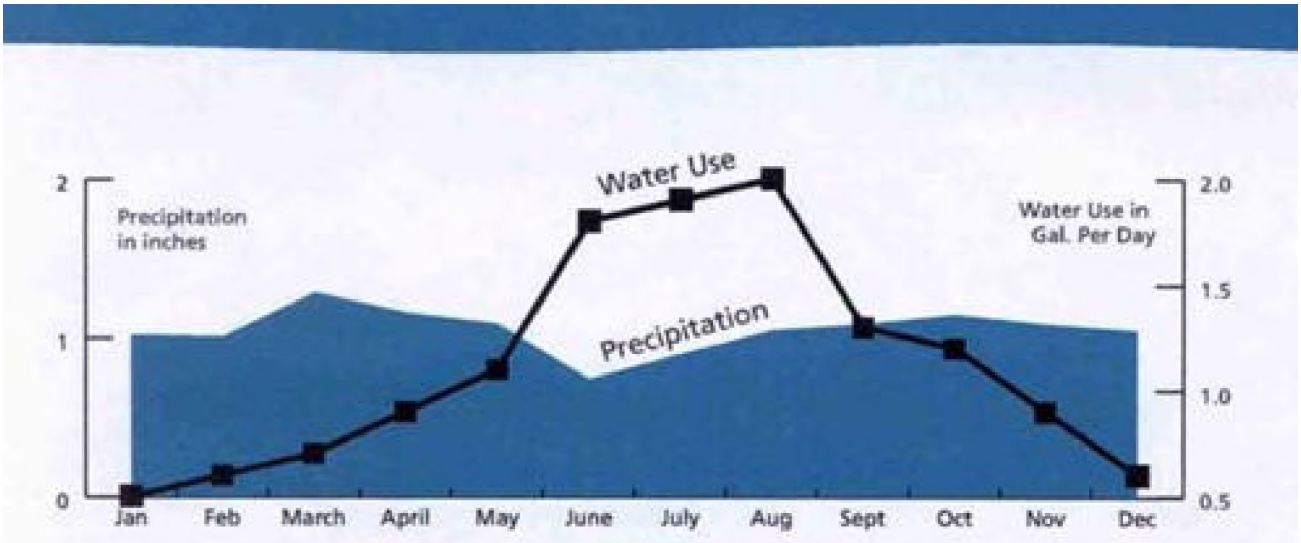
The downward-pointing time arrow on the left indicates increasing duration of drought. The central boxes illustrate the shifting and increasingly damaging impacts as the drought persists, moving from Meteorological to Agricultural to Hydrological Drought conditions.

Many of the weather-related contemporary news events focus on the upper box. Although the continuation of the drought situation leads from meteorological drought to agricultural drought, this condition is frequently not considered to be newsworthy. Significant long-term effects are

part of hydrologic drought. If the current drought extends to five years, we are ***all*** going to be in trouble. Resultant low reservoir conditions are a real threat to our urban water systems as well as many agricultural systems. Plus, recreational activities of our urban population are affected, and *this* is prime fodder for TV news!

Meteorological Drought

Meteorological drought is simply a deficit of rainfall over some period of time, usually short term. Mark Eubank uses this definition frequently on the Ten O'clock News. Some of these characterizations include periods of drought on the basis of the number of days or the number of seasons. There are a variety of ways to reference it. It's a simple definition and it's something that most people understand. In fact, if you really understand the impacts across the board, it's probably a most meaningful definition.



Utah's peak snow and rainfall comes during January through, but the highest demand occurs in July and August. (Utah State University Climate Center, 1998)

If we look at the normal monthly precipitation in the figure above and then compare it to our pattern of water use, we have an excellent demonstration of the root cause of water deficiency. In

the wintertime we are down very close to zero use on a relative scale and we peak out in the summer, usually in July and August. Supply and demand are definitely out of phase with one another. The monthly average precipitation across many parts of Utah tends to be, although low, rather uniform. If you looked at the same kind of graph for the Central Valley of California, even Southern California , for May through September, precipitation would be essentially flat - nothing. They have a very, very distorted supply-demand situation.

Agricultural Drought

Agriculture tends to be the first sector that's affected by drought. Why is this? It is because soil moisture tends to get depleted so fast that it can affect everything from the germination of the seed, to the development of the immature plant, to plant maturation, to the growth of the fruiting body on the plant, to the harvest. So you can't just say, "Things are dry, and, therefore, it affects the crops." It really depends on the degree of dryness and what stage the crop is in. But you know what? It really doesn't make that much difference when it's as dry as it is, for as long as it's been, for many of the farmers here in Utah . It's the end of the road for many of them. The game is over.

Hydrological Drought

Hydrological drought, as contrasted with meteorological drought and with agricultural drought,

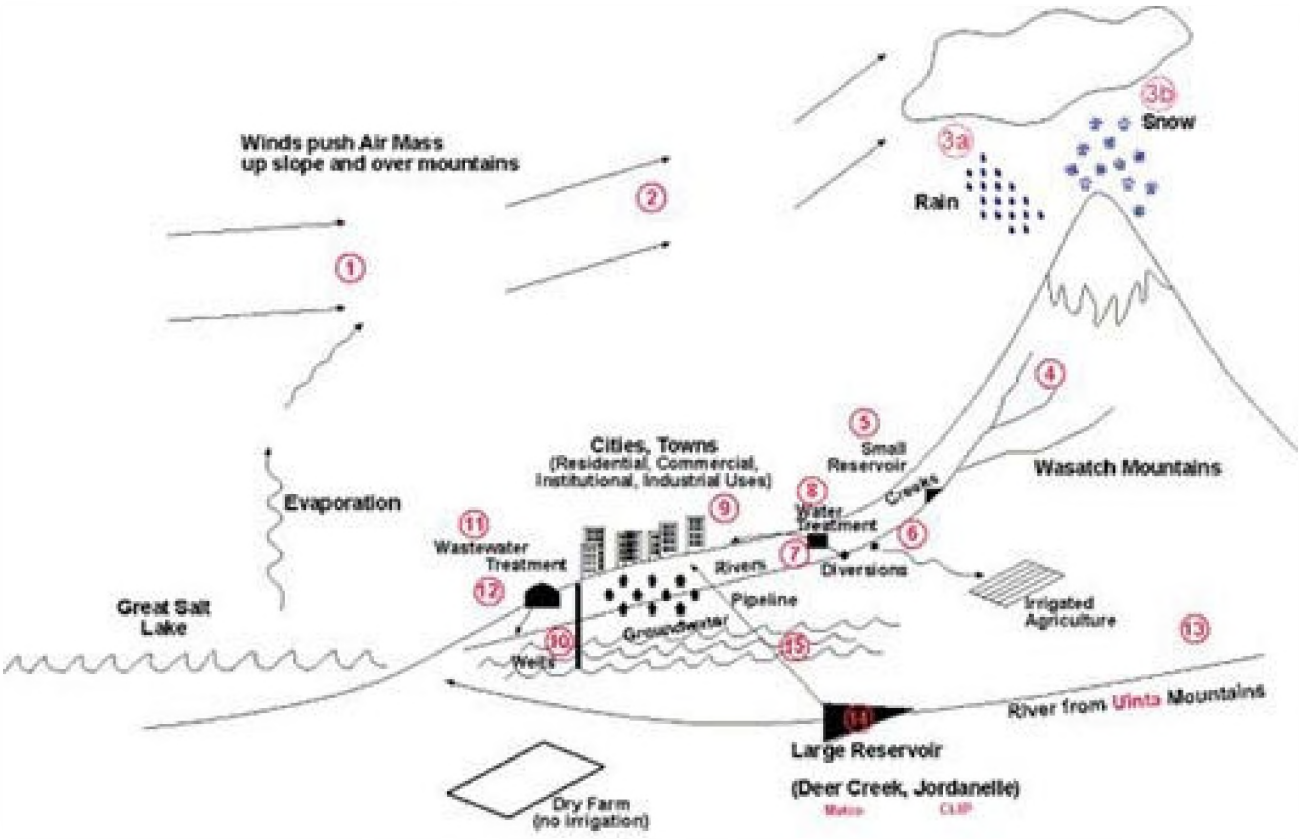
considers things on a broader geographic scale. For an entire river basin, for example, we want to examine how drought affects stream flows, reservoir levels, lake levels, and groundwater levels. Generally speaking, in most of the Western United States these things are not significantly impacted for at least two to three years. Into the fourth year, we begin to see strong effects, especially on reservoir and groundwater levels. Today, we do have a very, very low water situation for most reservoirs in Utah .

I am told that the current level of Deer Creek Reservoir is the lowest it's been since 1977, maybe

even longer than that. That's roughly a twenty-five-year span - what these drought intervals tend to be. It is beginning to pose problems for the people who rely on these reservoirs. Guess what? That's us. We live in the Salt Lake City urban area and Deer Creek is one of our principle water supplies. So urban users are frequently the largest group impacted by hydrological drought.

The Hydrologic Cycle and Drought Impact

Let's explore the hydrologic cycle here in Salt Lake City and along the Wasatch Front; it generally starts with winds that blow in from the northwest.



Wasatch Front Hydrologic Cycle

The winds have moisture with them, but they also pick up enhanced evaporation from Great Salt Lake [1]. The two factors then combine and the "juiced up" air mass heads for the mountains and is lifted [2]. We have a unique situation because we have an abrupt high mountain range directly behind a large body of water. They align in the path of prevalent winds during the precipitation cycle. As the air mass is lifted, it's cooled and when it's cooled, we get precipitation -- in the summertime rain [3a] and the wintertime snow [3b]. Rainfall then runs off (or the snow does later in springtime) into the mountain creeks [4]. These creeks may have smaller impoundments [5] that preserve some of this runoff for release at a later date. Irrigated agriculture derives much of its water from these creeks with their limited storage [6]. Thus irrigated agriculture does have some ability to withstand a drought. But much of the irrigated agriculture that takes its water

from surface streams has now been severely impacted for a couple of years.

Similarly, municipalities obtain much of their water from mountain streams [7]. About 35 percent of the population of the State of Utah depends exclusively on surface water for its water supply, mostly in the smaller communities. Some major cities do the same. This water must be treated [8] before it can be distributed for consumption. Many of you have seen the water treatment plant at the mouth of Big Cottonwood Canyon - a classic case. The treated water is piped to the urban residents and businesses for use [9]. After the cities use water, they send it to the wastewater treatment plant [11], where it's treated and discharged back into the river [12]. Along the Wasatch Front virtually all rivers flow into the Great Salt Lake . Very little re-use of treated wastewater takes place there.

Additional supplies that cities have are ground water aquifers. Many of our municipalities rely on groundwater wells [10] for a significant part of their water supply. Finally, originating in the Uinta Mountains are major rivers [13]: the Provo River , the Ogden River , and the Bear River , each of which flows into a large impoundment [14]. Deer Creek and Jordanelle Reservoirs are located on the Provo River . From these large reservoirs pipelines convey water to the cities [15]. You can see why cities are a lot more resilient, more drought resistant, than some of the other water users.

The most severely impacted by agricultural drought are the “dry farmers” and their grazing lands. They get whatever water falls out of the sky and when it doesn't come, they dry up. We have a lot of dry farming in Utah

and those people have essentially been put out of business. The next to be impacted, moderately so, are those in irrigated agriculture, because they rely on creeks and small impoundments that don't have a lot of capacity to carry them over in multi-year droughts.

Finally, the least impacted are our cities and towns, because they have so many types of water supply, including the creeks, small impoundments, diversions from the larger creeks and rivers, large reservoirs and groundwater supplies. Combined, these sources provide long-term drought insulation. Generally, only hydrological drought has significant impacts on cities.

Some Drought Comparisons

Making comparisons between the many effects of drought is more than educational. It is sobering, because drought is one of the most complicated of natural phenomena. It has so many facets that it's difficult to bring them all together and to present them in a consistent fashion. If you were to call several drought experts today and ask, “What has been the drought impact in the state of Utah in 2002?”, you would get neither a simple nor a consistent answer. Why? Because different people are measuring different things. Some of the determinations can't be made until the event is over. It is a complex issue.

Natural Disaster Costs and Losses			
	Drought	**Floods**	**Hurricanes**
Annual average	$6–8 billion	$2.41 billion	$1.2–4.8 billion
Worst recent event	$39–40 billion, 1988–89	$15–27.6 billion, 1993	$25–33.1 billion, Hurricane Andrew, 1993
Worst recorded	1930s or 1988–89		
Source: National Drought Management Center			

On an annual average basis, the costs of the losses from drought are in the range of six to eight billion dollars, as shown below.

Flood costs are only about a third of that total and those due to hurricanes only about a sixth. So that puts droughts and their impacts right at the forefront of all our natural disasters. Nationally, the most recent extreme drought event was in the late 1980s. We had severe drought throughout much of the United States . The costs of that were pegged at somewhere around $40 billion. That's a sizeable chunk of change. The worst recorded drought was either in the 1930s or in the 1800s. The problem we encounter in trying to compare the impacts of droughts from the 1800s with those that take place today, is that it is like trying to compare the baseball pitching records of the 1920s with those of 2002. It's an entirely different game now. It's played differently than it was before, although we still have four bases, nine players, a pitcher, a catcher, and a batter. Similarly, it is difficult to make meaningful economic comparisons between widely separated periods of time. I would like to quote couple of accounts of events that took place in the 1870s:

> Want and privation were more widespread on the upper Midwest and central prairie frontier during 1874 and 1875 than at any other time during the settlement of that region. Even with

the combined efforts of private relief, county and state aid, and federal help, there was untold suffering. Many of the men left home in search of work, leaving their wives and children alone, fearful, and in dire need. Army investigators found home after home where the mother and children were facing cold and hunger, hopefully awaiting word from the absent husband and father, or praying that help would come from some relief agency. The women displayed almost unbelievable courage in face of the most terrible circumstances. Reports of those who handled relief are filled with statements describing how women refused to give up. One little girl told an army officer that her father believed the family would starve when the present supply of flour was exhausted. But she quoted her mother as saying: 'God will take care of us.'

During the next few months the army distributed 1,957,108 rations to 107,535 adults and children in Minnesota, Dakota, Nebraska, Kansas, Iowa, and Colorado. Although there was not enough food to provide each needy person with a 30-day supply, in many cases this help seemed to be the difference between life and death. Sufferers in Kansas received more than half the total amount of food distributed. A farmer from Reno County wrote Governor Osborn that his family of six had drawn rations for 20 days, including 25 pounds of corn meal, 18 pounds of pork, and 3 pounds of beans.

On February 6, 1874, a single girl, Jennie Flint, of Murray Centre, Minnesota, wrote to Governor Davis that she must apply for assistance for herself and her 71-year-old father ". . . as we are here in this far western country and very poor withall. We have no money nor nothing to sell to get any more clothes with as the grasshoppers destroyed all of our crops what few we had for we have not much land broke yet as we have no team of our own we have to hire one in order to get it worked what little we have to sow so you see it is rather hard on us to hire so much and get along. We managed to raise a few potatoes and some corn and a

> little buckwheat and that is all we have to depend upon. We are very bad off for bedding not having but two quilts and two sheets in the house and have to make them serve for two beds. We have to use our clothing that we wear on the beds to keep us from suffering with the cold and then it [is] most impossible to keep warm for our house is so open. . . . we have not got our house plastered as yet only on the outside with mud could not get any lime to do it with for we had no money nor could not get any. We almost perish here sometimes with the cold. . . . Now if you will be so kind as to send us some bedding and clothes and yarn to knit us some stockings with we have no wool nor yarn. Or send us some money so we can get them ourselves we would be thankful."

By comparison, the current drought has had mild impacts.

Predicting Drought

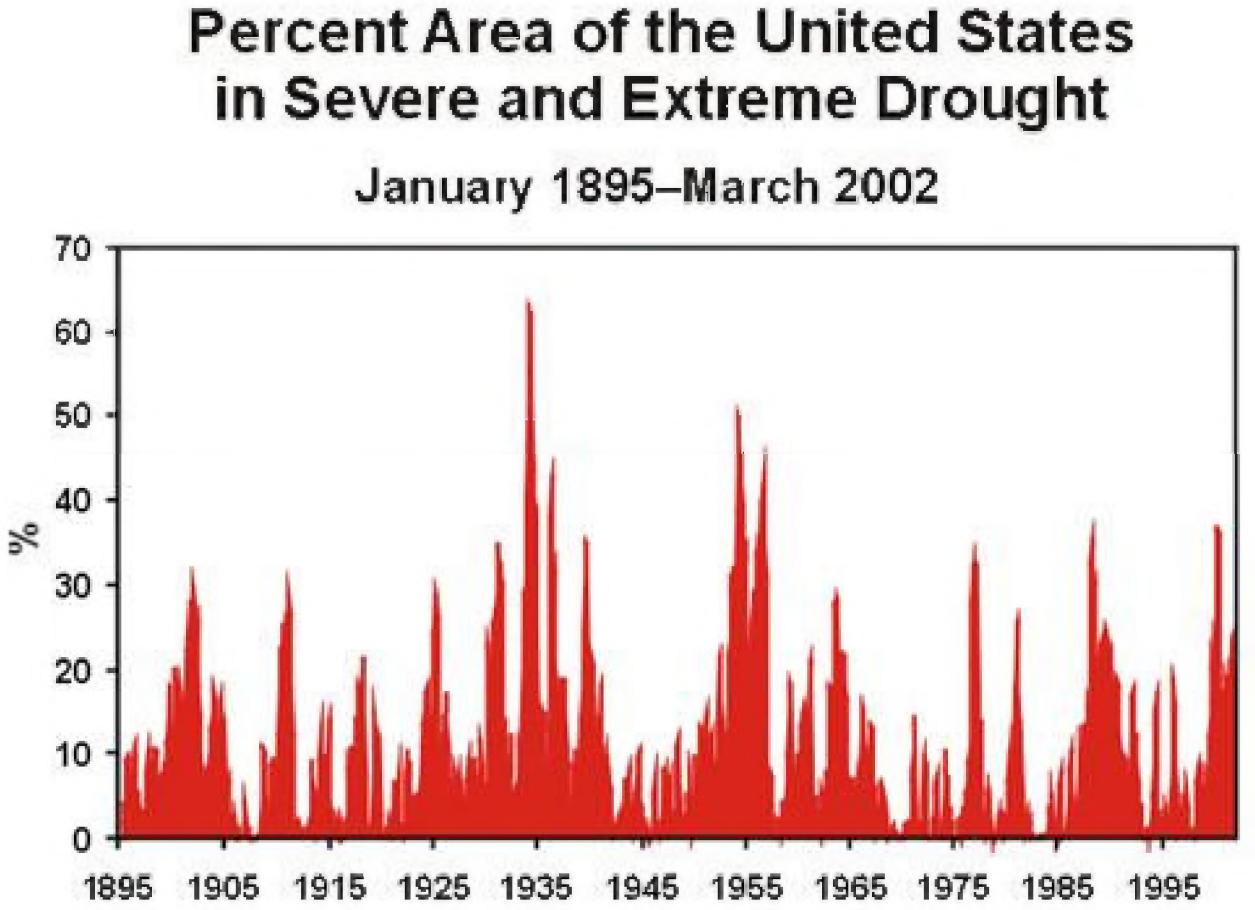
Predict drought? You can't do it. However, there is a probability of occurrence. Like many other natural events that ebb and flow, we can apply some reasonably useful statistics to it. Let's examine the frequency of drought, particularly in the Great Basin , and look at the 50th percentile value, or what happens at least half of the time. See table:

Out of the past 100 years there were nineteen years in which there was ***extreme drought*** throughout much of the Great Basin . In other words, on the average, about one

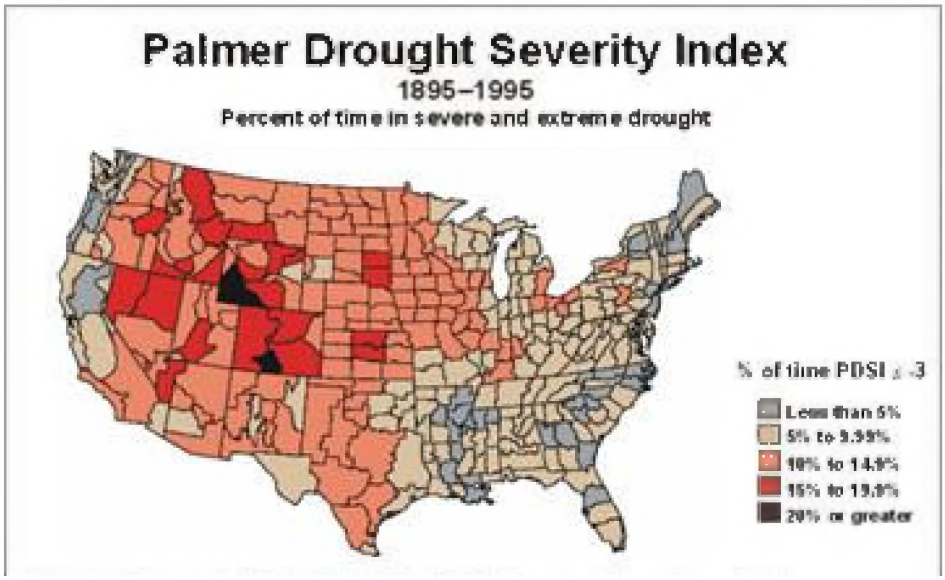
The table below lists the number of years that the United States has had severe or extreme drought in the 100 years from 1896 to 1995, based on the Palmer Drought Severity Index (PDSI).									
Percent of area of basin or region	>0%	>10%	>25%	>33%	>50%	>66%	>75%	>90%	100%
United States	100	72	47	33	7	3	0	0	0
Upper Mississippi	77	55	43	30	19	12	9	3	1
Mid Atlantic	60	40	32	24	12	5	1	0	0
South Atlantic/Gulf	79	42	25	15	5	3	3	0	0
Ohio	67	51	34	28	16	12	9	4	3
Missouri	90	70	43	33	17	10	4	3	0
Pacific Northwest	80	61	42	33	23	14	9	1	0
California	63	46	40	30	14	9	6	3	3
Great Basin	71	56	43	37	13	8	3	1	1
Lower Colorado	66	54	35	28	16	11	10	4	3
Upper Colorado	90	80	62	54	27	26	16	6	6
Rio Grande	66	46	32	24	13	8	6	2	2
Texas Gulf Coast	49	40	30	26	22	13	10	9	7
Arkansas-White-Red	65	48	37	23	14	7	4	1	0
Lower Mississippi	66	38	19	15	4	1	0	0	0
Souris-Red-Rainy	66	51	38	29	19	10	8	6	2
Great Lakes	73	58	32	23	9	3	2	2	0
Tennessee	91	81	37	24	21	16	10	6	5
New England	66	44	27	13	6	5	4	0	0
Source: National Drought Mitigation Center									

year out of five! Of course, if drought just occurred one year out of five, we would probably survive a lot better, but drought years tend to be bunched up. In fact, the really bad droughts have a recurrence interval of approximately twenty-five years.

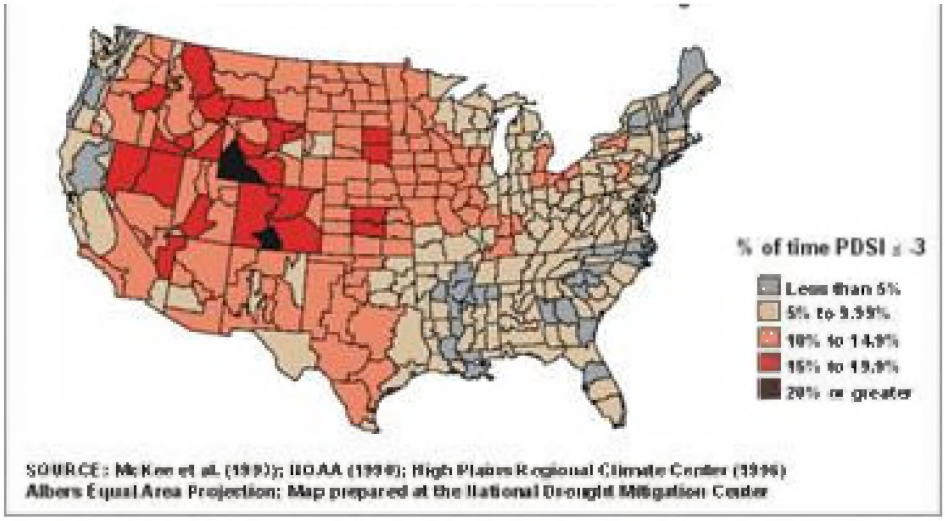
Another interesting fact is that in 100 years of record, from 1896 to 1995, each and every year some part of the United States had drought (see chart, next page). Looking at the percentage of the area of the US that had severe and extreme drought going back to 1895, I would pick the period of 1920-1940 as being one of the worst.



Source: National Drought Mitigation Center



Not necessarily because the drought was more intense than many others on record, but because the duration on that event definitely exceeded ten years and caused a lot of misery and suffering. It



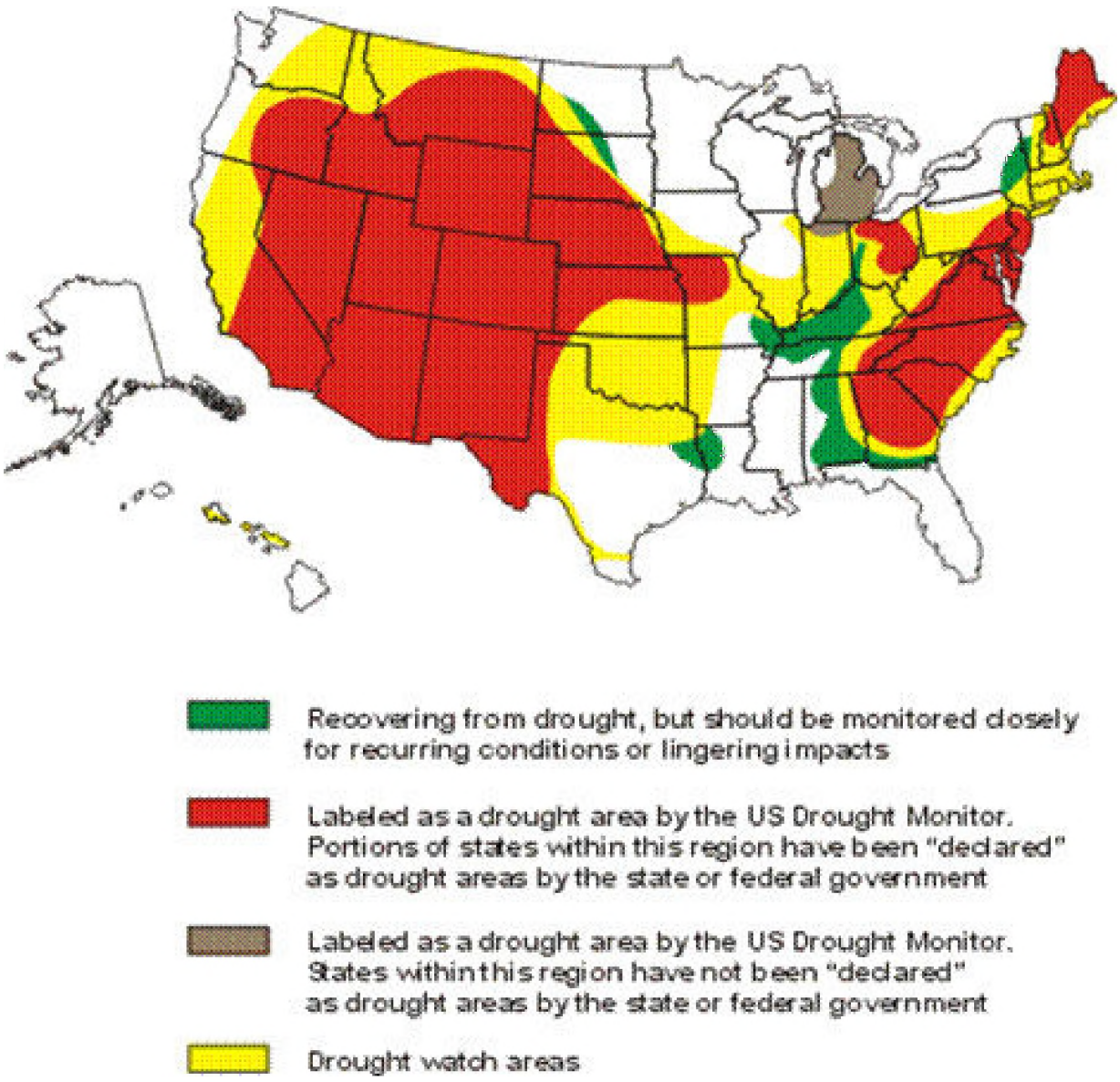
encompassed the "Dust Bowl" years of the mid-1930s. The data indicates that drought probably started in the mid-1920s and extended right up to 1940. Then there was the drought that dominated the 1950s, which most of us don't remember and, as mentioned above, the event of the late 1980s. We can also see the current drought starting in 1997 or 1998.

The figure at the right represents a longer-term historical view of the 100 years from 1895 to 1995. The darker colors show the time that the Palmer Drought Severity Index was greater than three (3.0). There are places, particularly in Wyoming and Colorado , where this has occurred twenty percent or more of the time.

From There & Then to Here & Now

So we know "drought happens." We know where it happens most frequently. In a sense, it is unfortunate that it doesn't occur more frequently or that our memories don't improve, so that we would be better prepared for it. In the Dust Bowl year, the middle parts of the country were hit very hard. The middle 1950s was an extremely severe drought period in parts of the country. Since we had learned how to deal with drought in the 1930s, the sociological effects in the 1950s weren't as bad. In the period from 1985 through 1995, one could foresee the precursors that led to the drought throughout the Intermountain area.

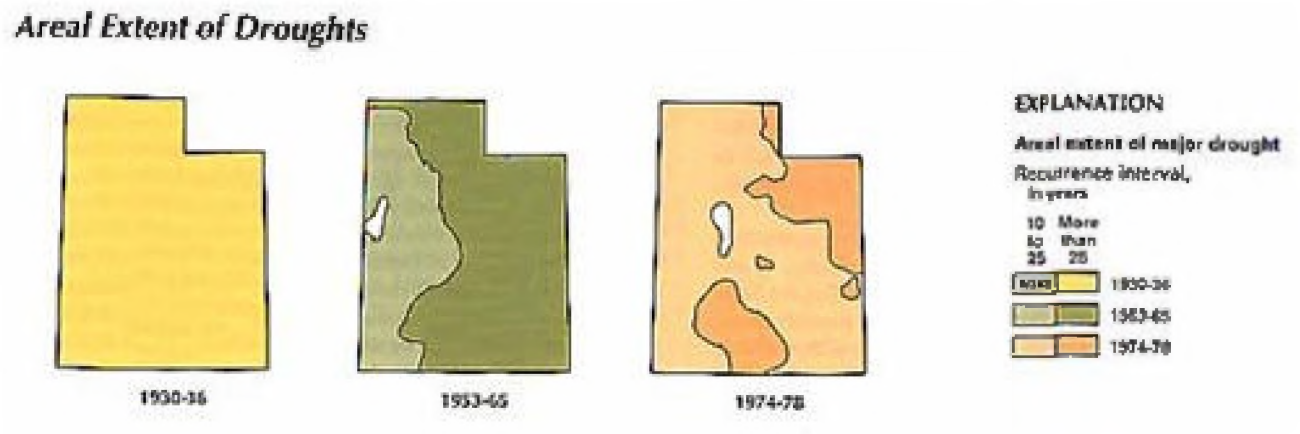
The current national situation is not good, as shown in the figure below . Red covers virtually everything from California to Iowa and from the Canadian border to Mexico , and it is severe. We are experiencing some monumental impacts.



What about Utah ? We are right in the middle of the "red blob." The current drought has been called (by KSL and the *Deseret News)* “the worst ever.” Most stream flows in the state are now down to around the ten percent level, with some less than one percent. Three towns, including Park Valley , Oak City and Ponderosa Ranch are hauling in water. If it continues into next year, there will be more communities that will be in similar situations. The negative result is that ranchers are liquidating their herds. The problem is that they are getting bottom dollar for their

livestock. In late August and early September, they were selling about twenty-five hundred animals a week. Most of them were not getting out of the animals what they had actually put into them, much less making a profit. It is the end of the road for many of them.

In addition to the drought impact, fires, particularly the ones that raged in the Uintas, scared off tourism to an estimated extent of about $50 million. Randy Julander, the Utah snow guru who generally is not prone to give dire predictions, did predict today's drought. In fact, he believes that we are in the worst drought (from a physical and a hydrological standpoint) that we have ever seen and it is likely we may see more of it next year (2003). There were three particularly bad times in Utah , as summarized in the graphic below.

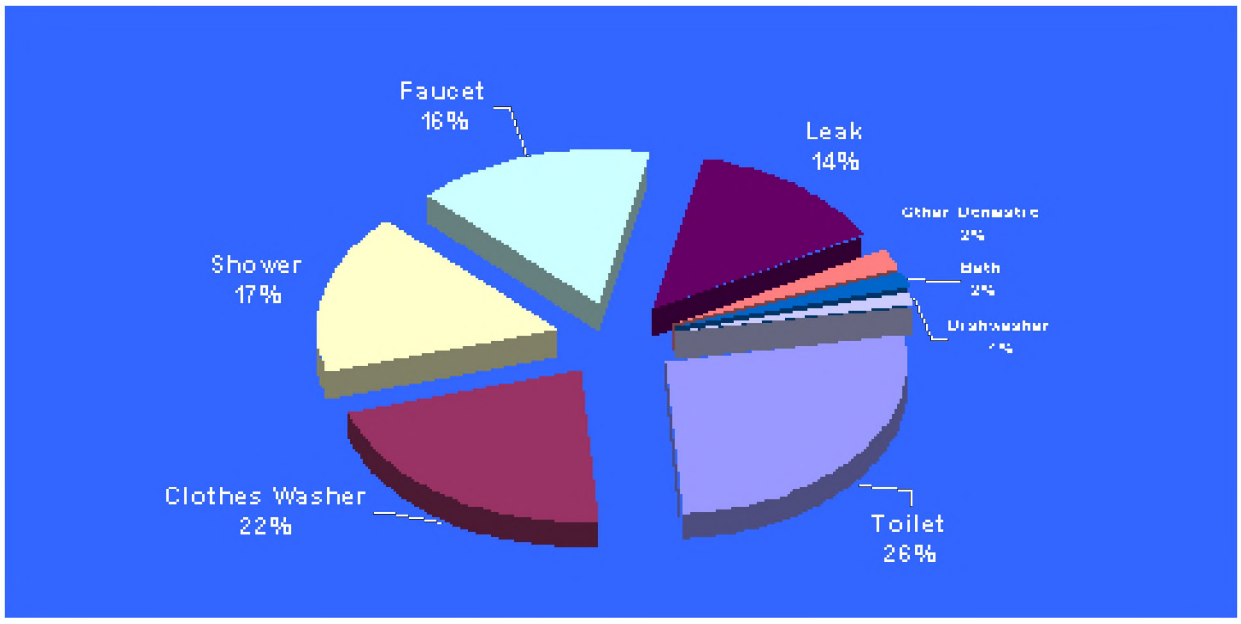


In early 1936, drought covered the entire state and, in terms of its intensity and duration, it had greater than a 25-year recurrence interval. What do you know? In the mid-1950s, less than twenty-five years later, we experienced another 25-year recurrence drought. Then, in the 1970s, again less than twenty-years later, we sustained another 25-year drought throughout much of the

state. It is something that we should take notice of! Drought occurs periodically and it does have some adverse long-term impacts. As I mentioned previously, surface water provides a great deal of the water supply in the state. It is estimated that 81 percent of the state's off-stream water originates as surface water and about 35 percent of the state's population relies strictly on surface supplies for domestic supply. That is one of the reasons that, even though we do have reservoirs and wells, if this drought continues for another year, we are going to be seeing some serious municipal water supply shortages.

How We Use Water

Okay, so much for the bad news. What about the good news? We do have some. I would like to discuss how we use water (historically and currently), what we have learned about our water use and what we seem to be doing about it. Let's look at inside water use, see illustration. (Data is from the American Water Works Association).

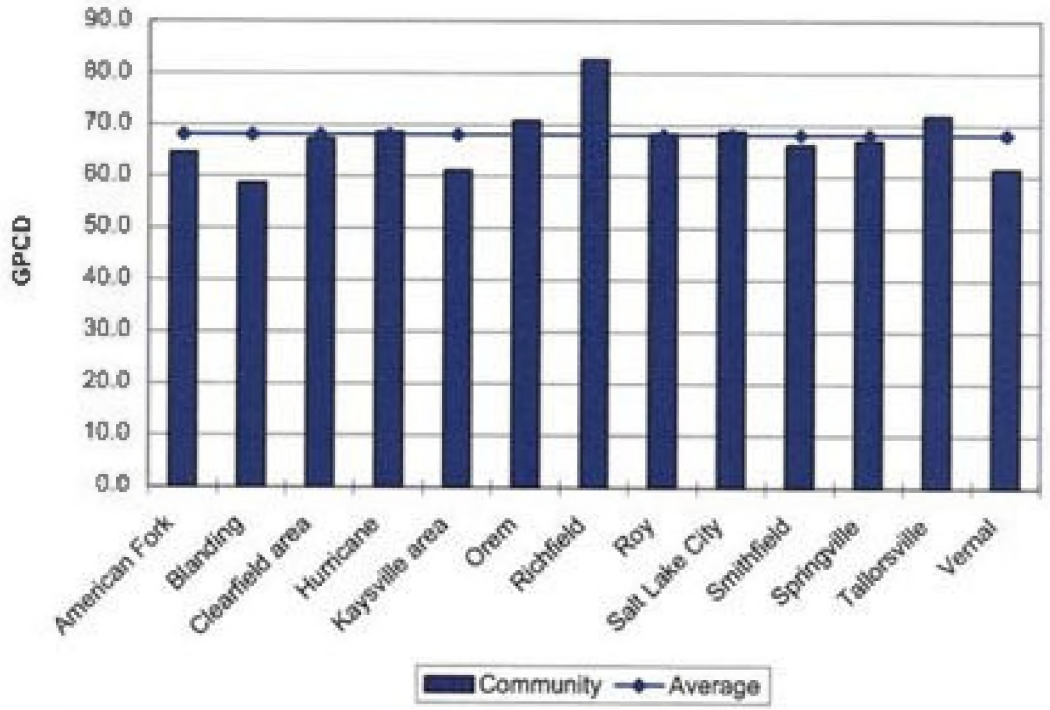


The biggest inside water users are toilets – twenty-six percent. Next are clothes washers – twenty-

two percent. ***Almost fifty percent*** of inside water is consumed by toilet and clothes washer use. Another area that really impacts your usage is that of indoor plumbing leaks that can average about fourteen percent of the water that flows through your meter. So, the inefficiencies of your internal system - leaky washers, faucets that are left on and things of that nature - use a significant amount of water. Right now, the typical American household washer uses forty-five gallons in a cycle of wash. That's a lot of water. (More on this subject later)

We, in Utah , have been accused of using water excessively. The United States Geological Survey indicated that we are usually first or second in the United States in per capita water consumption and that our total usage is ***321 gallons per capita per day*** (gpcd). The way the numbers are reported, our usage appears to be blatantly excessive; however, their numbers include all the water used in our homes, inside and outside, and in commerce, industry, parks, golf courses and other uses. The total water use is then divided by the number of people. We would expect the number to be large, especially knowing that we pour a lot of water on our lawns, parks and golf courses. But is it excessive?

The Utah Division of Water Resources (UDWR), in an independent study along the Wasatch Front, found indoor use to be about sixty-eight to seventy gallons per capita per day. Outdoor use averaged 115 gallons per capita per day. So the residential total of



the USGS's 321 gpcd is about 183 gpcd. The other figure that was illuminating from the DWR study was the finding that evaporative coolers burn off about forty-one gallons of water per day. In a similar national study, AWWA found that the nationwide mean indoor water use per capita was very close to that of Utah 's and almost identical to the DWR observation. Therefore, we can conclude that Utah 's indoor water use is reasonable: about average of what is seen across the United States and Canada .

The USGS found that our outside water use is 143 gallons per capita per day. By itself this number sounds enormous, but is it? Almost all of our outdoor water use is for irrigating our landscaping -- sod, flowers, etc. We have very high evapo-transpiration rates in Utah and consequently high irrigation requirements. In order to assess the reasonableness of residential outdoor water use in Utah , we used the following approach: “Take an average size lot (which at the time of the survey was about three-tenths of an acre); it has about 0.16-acre of landscaping.

Apply a reasonable amount of water to that. Divide by the average number of persons per household." The result: it adds up to about 140 gallons per capita per day. So, although the 143 gpcd seems high (and is high), given our average lot size at the time, it was a reasonable use of water. On the other hand, we really must change some traditional thinking -- both the average lot size and how we landscape and irrigate.

Water used for institutional and open spaces -- parks, golf courses, churches, cemeteries, etc -- amounts to another 45 gpcd. That figure compares to one the USGS said was 55. We think the two numbers are pretty close. From the USGS total of 268 gpcd, we can account for 253 gpcd in these use sectors. We can't reliably estimate commercial and industrial water use since it depends upon the location and we would have to go out and review every water user in the state. We believe that for the lifestyle we have, the type of homes and the size of lots we have, we have used water reasonably. Given the physical circumstances and community standards of the times, we do not believe that water usage in Utah has been excessive.

A more recent UDWR study showed that residential water use has dropped down to about 183 gallons per capita per day. Thus, we are seeing that some water conservation is already taking place. To help achieve further reductions, the governor has put together a water conservation team whose goal is to reduce water use by twenty-five percent in the municipal and industrial sectors.

Water Conservation

Water conservation is one of the best and least costly drought mitigation techniques. In the public opinion poll recently conducted by the Utah Division of Water Resources, ninety-six percent of the people queried said that they believe in water conservation (and probably motherhood, baseball and apple pie, too). Not surprising. When asked if they actually practiced

outdoor water conservation, ninety-four percent said “yes.” Looking at recent water usage numbers, I believe that we have already seen some positive results.

One of the areas where we can really save is the toilet. Replacing old toilets can save water - lots of water. A recent Seattle study measured water use in single-family homes before and after installation of high-efficiency toilets. About half the toilets installed were standard 1.6 gallon per flush (gpf) models. The other half were dual-flush toilets that offer a 0.8 gallon flush for liquid and a 1.6 gallon flush for solids.

Water use in homes with standard, 1.6 gallon, and dual flush toilets		
	Avg. Gallons per Flush	Avg. Gallons per Person Per Day
Non-conserving Home	3.61	18.8
Conserving home (1.6 gpf toilet)	1.54	9.1
Conserving home (dual flush toilet)	1.25	6.9
Source: American Water Works Assn		

What happens when a family of four replaces all their toilets with new high-efficiency models? The family would save more than 14,000 gallons of water per year by installing 1.6 gpf toilets. And more than 17,000 gallons of water per year by installing dual-flush toilets! That's a huge and hefty savings. In fact, it comes close to paying for itself. In California and in certain districts in Utah , the water agencies will help homeowners pay for some of these water-conserving appliances. The Jordan Valley Water Conservancy District just instituted a pilot program last week of furnishing low-flush toilets. If a family of four can save 17,000 gallons of water per year, I suggest you look at your own water bill and see how much you might save. Within five to ten

years you could possibly pay for that low-flush toilet.

Clothes washers are also important. Replacing your old clothes washer with a new high-efficiency model can save water - lots of water. Clothes washers are typically the largest indoor water users after toilets. The Seattle study measured water use in single-family homes both before and after installation of high-efficiency clothes washers. Three different makes and models of clothes washer were tested, all three saved water

Water use in homes with standard and high efficiency clothes washers

	Avg. Volume per Load (gal.)	Avg. Hot Water volume per load (gal.)	Avg. Loads per Capita per Day	Avg. Gallons per Person Per Day
Non-conserving Home	40.9	11.4	0.36	14.8
Conserving home	24.3	4.2	0.38	9.2

Source: American Water Works Assn

and all three received high satisfaction ratings from the study participants. Most major manufacturers now offer at least one high-efficiency model. Where should we concentrate our efforts to reduce residential use down from 68 gpcd? Obviously, toilets should be replaced first and washing machines second.

We also ought to take a look at what we are doing outside, because we currently over water our yards to the extent of about forty percent - a tremendous water loss. How might we reduce our usage in this area? Technology has some answers.

Landscape Irrigation Technology

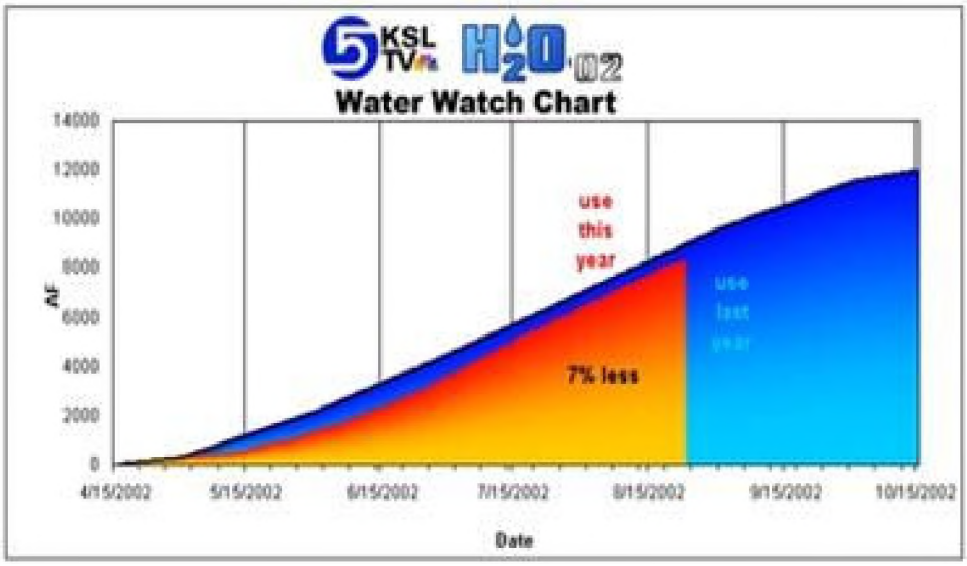
One of the several advanced technology studies under way is being conducted by the Irvine Ranch Water District (IRWD) in Southern California . This study is testing a prototype landscape irrigation controller that can provide weather-based irrigation adjustments via a broadcast signal at a reasonable cost. The field trials were in Irvine , California , in forty selected single-family homes served by IRWD. Each home's existing automatic irrigation controller was removed and replaced with the new test apparatus. The irrigation schedule for these homes was controlled via a remote satellite signal. The controllers were able to reduce total household water consumption by roughly thirty-seven gallons per household per day, representing a sixteen percent reduction in estimated outdoor use.

Communication and Publicity

Much of our water conservation progress here in Utah has to do with outstanding communications and publicity. The *Salt Lake Tribune* consistently features articles on xeriscape gardening. It has published several good articles that indicate what you, as a homeowner, can do to convert to xeriscape landscaping. Xeriscape doesn't mean “zero” scape. You can have a beautiful yard. The *Deseret News* has also had a very active campaign. If you go to their web page and click on ***H 2 O Watch*** , there are several good information sources. I commend both the *Deseret News* and *The Salt Lake Tribune* for their role in encouraging and fostering water conservation. The Jordan Valley Water Conservancy District has been an outstanding leader, stepping out and letting people know that we need to conserve. They show, by example, what you

can do -- both with their demonstration garden and by offering to conduct free water audits. I commend David Ovard, General Manager, of the Jordan Valley Water Conservancy District. We just got a card from JVWCD in the mail the day before yesterday thanking us for conserving water. It illustrates the positive approach that JVWCD has taken.

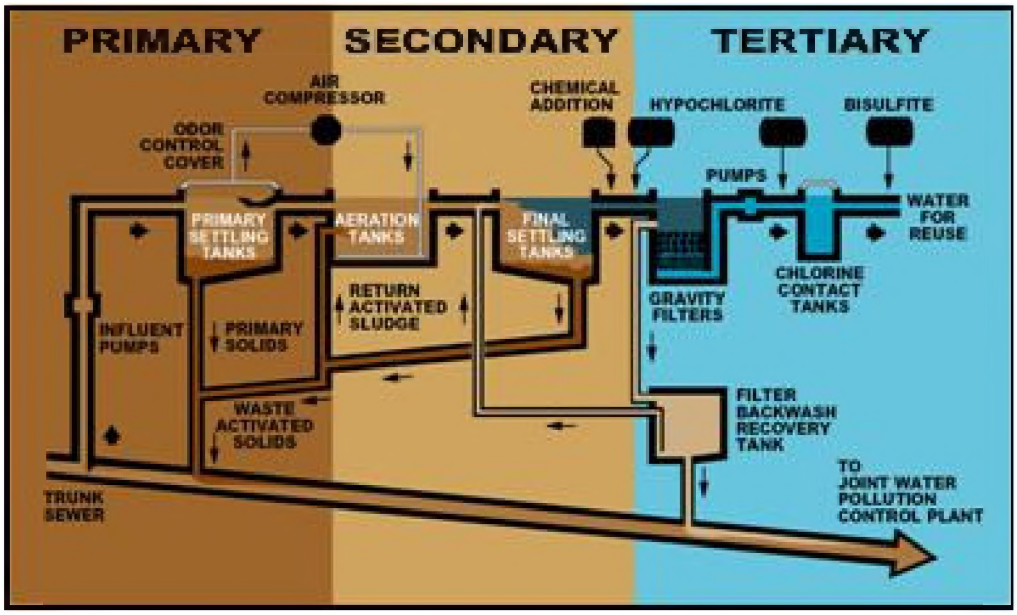
Mark Eubank, Chief Meteorologist for KSL-TV, also deserves kudos. Mark is not only a professional meteorologist, but he also understands how to communicate weather-related features to the average person. He's been able to interpret this drought, communicate it to people, talk about water conservation, and publicize it in terms that people respond to and can understand. I have a great deal of admiration and respect for Mark and his efforts. The figure shows the results of our conservation efforts this year and you've seen this chart during Mark's weather forecast on Channel Five. This year has been drier than last year. In normal circumstances we would have been expected to use more water than we did last year. In fact, this year as of about the first of September, we have used seven percent less water than we did last year. All of these water conservation publicity efforts have really paid off so far, and we can't revert to our old habits.



Another excellent water conservation example is Rice-Eccles Stadium at the University of Utah . The new turf installed over the summer in the stadium is not really grass! In fact, it is a revolutionary synthetic grass called "Field Turf." The surface looks so much like real grass it can fool fans and players alike. But while Field Turf looks like grass, there is one important difference -- it takes absolutely no water to maintain. That's a big savings for the University and the State of Utah . When the field at Rice-Eccles Stadium had a natural grass surface, **2.4 million gallons of irrigation water were applied during the last twelve-month period** . I commend the University of Utah for having taken this bold technological step forward and replacing the grass with Field Turf. The university also has several other water conservation projects underway.

Wastewater Reclamation

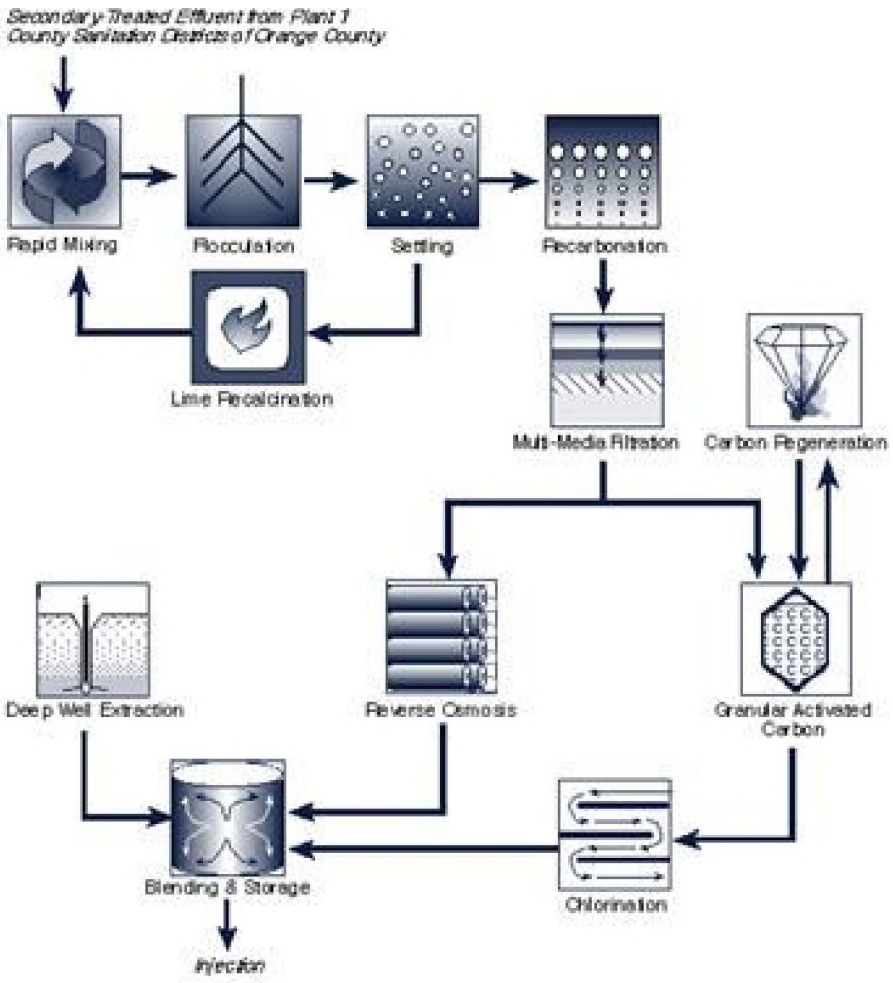
Wastewater reclamation needs to be seriously considered. Others have already done so -- extensively. California leads the nation in wastewater reclamation technology. One of the obstacles is the use of certain words. For example, "Toilet to Tap" is not exactly something you want to talk about at breakfast. And, in fact, that is not what happens, but sometimes the media get carried away with what they publish or broadcast and we have to live with it. In Utah , the approach should be as follows: rename the wastewater treatment facility ***"the water reclamation facility"*** and make some additional investments in processes and treatments. We should recover the water and, instead of dumping it into a stream and allowing it to run right back into the Great Salt Lake , reclaim it for a variety of non-potable uses in our communities. One of the challenges is that wastewater reclamation requires more processes and it requires transmission pipes to deliver it to the locations of reuse. These projects cost money. There is a seasonal water demand in Utah that is not experienced in California , at least not to our extent. There are also some reclaimed water-quality issues, but wastewater reclamation is a direction that we must go. We need to seriously consider it and we can learn a lot from California .



The Whittier Narrows Plant was one of the first water reclamation facilities in California . When it first came on line in 1962, I had the privilege of working at this facility doing some special research for the University of California . Originally, it was a standard primary and secondary wastewater treatment plant. It had physical treatment and biological treatment. The treated wastewater was disinfected and applied to spreading grounds to replenish the groundwater. All the “residuals” were put back into the sewer and sent down to the original treatment plant at the end of the main sewer line. They have now added tertiary treatment and additional processes and are still reclaiming the treated wastewater; however, California 's requirements have become a lot more stringent. In order to recharge groundwater with reclaimed wastewater now, it must be put through these tertiary processes.

The Irvine Ranch Water District is also practicing major wastewater reclamation; about twenty percent of their total water supply now comes from reclaimed wastewater and is a large chunk of their water supply need. It helps them reduce their imports. Eighty percent of all business and community landscaping is now irrigated with reclaimed wastewater. They are also supplying about a thousand acres of irrigated agriculture: fields and orchards planted with a variety of fruits and vegetables. I think it is a classic good example of what can happen. The Irvine Ranch

has also added filtration to polish the treated effluent. The effluent is pumped to a dual media filter where it flows down through anthracite coal to remove some of the dissolved organics. This process is an engineered mimic of what happens in nature; all they do is concentrate the natural process and speed it up. When the water leaves the filters, more than ninety-nine percent of all contaminants have been removed.



Orange County Water District has their version of wastewater reclamation in ***Water Factory 21*** . They have even taken the process a couple of steps farther. In addition to the steps that are

being taken at Irvine Ranch, Orange County has installed reverse osmosis that not only will reduce the mineral content, but also ninety percent of the smaller organic contaminants. Ninety percent of the total dissolved solids - organic and inorganic - are removed.

Economic Incentives: Tiered Water Rates

In 1990, IRWD sought to move from a *traditional flat rate structure* to meet a variety of District needs and goals. Because of drought, IRWD faced an increasing need to conserve water to meet state and regional water usage cutback goals. Reductions in water imports were a stark reality. Furthermore, wholesale price increases were imminent. The Metropolitan Water District of Southern California planned price increases or "new demand charges" for higher than historical use. If supply quantities were not reduced, the costs for increases were expected to jump substantially. There were also some significant political issues. The elected IRWD Board wanted to break the historical dilemma of requesting customer conservation that resulted in realizing reduced revenue from the demand reduction and subsequently having to raise water rates.

The district, after a thorough study, developed a Residential Allocation Protocol. The residential allocation is based on indoor water demand (gallons per capita per day) and outside water need (evapo-transpiration rate over the size of the landscape area). Adding the indoor and outdoor numbers together makes the residential allocation.

Water bills are based on the residential customer's actual water usage compared to the residential allocation. Consumers can use as much as they want, but the costs escalate rapidly as the residential allocation threshold is passed. The following table shows the billing rate multiples for the various usage tiers.

IRWD Ascending Block Rate Structure: (Residential)		
Tier	**Usage - Percent of Allocation**	**Cost**
Low Volume	0 - 40%	3/4 base rate
Conservation	41 - 100%	base rate
Penalty	101 - 150%	2 x base rate
Excessive	151 - 200%	4 x base rate
Abusive	**201% and above**	**8 x base rate**

The results have been significant and impressive. Residential water use **dropped nineteen percent** initially and leveled off at a twelve percent reduction with the adoption of the water budgets and incentive rate structure (compared to 1990 use). Landscape water use has **decreased fifty-four percent.** Over **85,000 acre feet** of water has been saved by landscape meters in seven years (1991-98). Saving landscape water has resulted in **$35 million** in avoided imported water purchases by the agency (customer savings).

What You and I Can Do?

You and I can have a positive and meaningful impact on water conservation and drought mitigation. It is a wonderful example of the citizen activist achieving good things for the community. Furthermore, the list of categories is not extensive and you can use your own judgment as to which specific things you want to do. The main choices are:

1. ***Conserve*** at home -- indoors and outdoors.

2. ***Promote*** conservation with your neighbors and friends.

3. ***Support*** programs that promote Conservation and Smart Growth.

4. ***Log on*** to the Internet for additional information.

Home Conservation

Look around your home. Do you have the older toilets with the larger flush tanks? Consider replacing these water wasters with newer low-flush or dual-flush units. They look much nicer, too. What about your washing machine? Wouldn't a nice low-water use machine with front loading be an improvement? There may even be rebate programs available through your local water department. Additionally, check for leaks . Leaks can waste an incredible amount of water, and it's a ***total waste*** .

Now, check your landscape irrigation system. It is automatic? Most are. How often do you set the schedule to actually meet the evapo-transpiration needs of your landscaping? Plant needs vary substantially during the season and the really hot period only lasts for about six weeks. If you have questions about this, call your water department and ask for help. Most departments have landscaping and/or water conservation specialists that can provide a wealth of information and practical assistance. If not, they can usually refer you to someone who can help.

Conservation Promotion

It might surprise you how much influence you have with your coworkers and neighbors, especially when you support something that is obviously so good as water conservation. Talk it up. Follow up. If conservation is perceived as something that everyone should be doing, then nobody will want to be singled out as a water waster. It really works! Give it a try.

Support Conservation and Smart Growth Programs In conducting our research on water usage, drought and water conservation, we found that the largest single contributing factor to

outside water use is ***lot size*** . Why? Because the larger the lot, the more landscaping is required -- disproportionately so. More landscaping requires more water. Yet the living experience is not necessarily increased with a larger lot. Furthermore, more grass needs more fertilizer and more mowing. Think about the prospect of having smaller lots in your community, one of the components of ***Smart Growth*** . Many municipalities still have prohibitions against more reasonable, smaller lots and walkable, mixed-use neighborhoods. One of the arguments that I have heard is the purported connection between residential density and crime. There is no scientific evidence for such a relationship. Mixed use allows for smaller, effective lot sizes and, therefore, reduced outside water use. Mixed use is water conservation friendly. **Water Conservation Sites on the Internet** Internet sites change with regularity. Such is the Web; however, three Utah-based sites should be around for a while. They are:

The Utah Division of Water Resources - **www.conservewater.utah.gov**

[note: this web link may no longer exist. -online ed. 7/04]

The Jordan Valley Water Conservancy District - **www.jvwcd.com**

[note: this web link may no longer exist. -online ed. 7/04]

KSL-TV - **www.ksl.com**

All these sites have a wealth of water conservation and drought management information for the average citizen who wants to help with drought mitigation.

For information on Smart Growth visit the ***Envision Utah*** web page at:

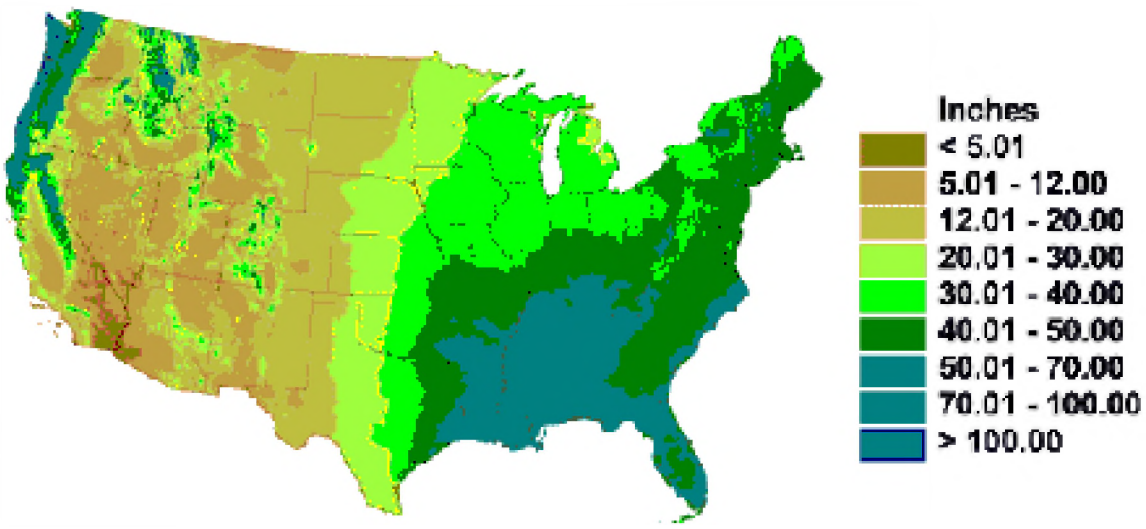
www.envisionutah.com

[note: this web link may no longer exist. -online ed. 7/04]

Conclusion

One of the root causes of the adverse impacts of drought is our infatuation with growth and development. Americans have been perpetually driven by a "more, bigger is better, commercial" mentality. Often times this attitude has driven people headlong into conflict with their environment. It's not that warning signs haven't been abundant; it just seems that we have a congenital aversion to acknowledging them.

In the 1870s, John Wesley Powell conducted an extensive natural resources survey of the West. His remarkable observations included the following, which he reported to Congress: "Much of this vast area [west of the green swath, below] is suited for grazing, but unfit for dry farming."



Railroad and land companies, town-site promoters and all types of speculators considered Powell a troublesome ignoramus who had better stick to his books. Unfortunately, the provisions of the Homestead Act were continued onto the Great Plains and the misery endured by many of the homesteaders was monumental. Drought was not only a problem, it was a killer. And, it was not unpredicted, just conveniently ignored.

We face similar resource limitation problems today. As we have seen, it's both an issue of average supply and an equal issue of the variability of supply, of which drought is a classic example. Characteristically, we tend to ignore both if they might restrict our perceived standard of living requirements. Thus the socio-economic factors must be acknowledged if we ever hope to be able to deal with drought and similar natural disasters. In California , a recent piece of legislation, and the subsequent commercial "bellyaching," illustrates this point very nicely. The bill regulates

greenhouse gases from cars and will include light commercial vehicles in the future. Many scientists say greenhouse gases, such as carbon dioxide and methane, contribute to global warming, which can alter crop yields, water supplies and ecosystems. The evidence is incontrovertible, in my opinion. We simply must cut down on the emission of these gases. The automobile industry opposed California 's new law and responded by stating:

" It will force the industry to design vehicles that are smaller, lighter, more expensive and less powerful, and reduce consumer choice."

Shades of the 1870s! I can't imagine a worse situation than “reduced consumer choice.” We're all in this together and we need to focus on those things that will enhance and support quality of life - and it's not necessarily quantity and consumption. We really need to pay attention to the world around us and its sustainability and not withdraw into a make-believe utopia where we think we can have whatever we want, whenever we want it, just because technology has provided another “drive up lane.”

Quality of life is not a “fast food” category.

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