WATER CONSERVATION IN INDUSTRIES, MUNICIPALITIES AND AGRICULTURE

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The National Water Use Picture.

We have learned to use great quantities of water in the United States. We now require about 1,500 tons per person, per year or more than one acre foot. In ancient times, a man could carry his daily supply of several quarts in a goat skin swung over his shoulder. How we have grown in water use can be shown by the following figures:

1940	135	BGPD*	OR	414,450	ACRE FEET, per day
1950	203	"	"	623,210	" " " "
1960	312	" (Est)	"	957,850	" " " "
1975	453	" (Est)	"	1,390,710	" " " "

*Billions of gallons per day. Source - U.S. Department of Commerce.

How this water was used in 1955 and how it is estimated it will be used in the year 1957 is shown by the following figures:

1955	1955	1975
Irrigation	119.84 BGPD	169.68 BGPD
Public Water Supplies	17.00 "	29.80 "
Domestic Supplies	5.40 "	7.20 "
Industrial and Misc.	60.00 "	115.40 "
Steam and Electricity	59.00 "	131.00 "

Since the term billions of gallons will be used many times in this and other discussions at this meeting, it might be well to get a mental picture of what a billion gallons represents. A billion gallons is about 3,070 acre feet or enough water to cover 4.8 sections of land 1 foot deep. Total water use in the United States for the year 1960 is estimated at 957,849 acre feet per day. This would cover the state of New Mexico one foot deep with water in 80 days or 5 feet deep in one year.

Total water falling as precipitation in the United States in one year is estimated at 4,300 billion gallons per day. Stream flow, after evaporation, is estimated at 1,200 billion gallons per day which is about 4 times our present use and 2½ times the estimated use in 1975. This may seem a

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safe margin for future use planning. Unfortunately, as we in the West know all too well "water is where you find it" and this may be far from the point of intended use. While the Pacific Northwest may have the Columbia River with great quantities of water rushing unused to the sea, New Mexico, Arizona, and other states have many acres of fertile land which could use this water if it were available.

Water Use in New Mexico

We are particularly interested in water use in New Mexico and what can be done to conserve the available supplies. As has been shown, the area of the state is 77,856,240 acres. With an average annual precipitation of 1.156 feet annually the potential supply is:

77,856,240 x 1.156 = 90,013,373 acre feet plus the inflow from streams which probably averages about 1,901,050 acre feet annually, giving a grand total of 91,914,423 acre feet.

In speaking of potential water supplies, as measured by the yard stick of precipitation, it must be remembered that much of the rainfall is in showers too small to be effective and which evaporate immediately. This evaporated water may fall again as rain and be measured again. That evapo-transpiration losses are great can easily be seen by comparing the run-off of our western rivers with the total precipitation falling on the basin. This may prove to be as low as 3 or 4% in some cases.

Water use in New Mexico has been variously estimated but I have chosen the following values as representative:

Domestic and Municipal Use......	91,500	Acre	Feet	Annually
Irrigation Requirements.........	2,328,000	"	"	"
Out Flow Major Streams..........	2,200,470	"	"	"
TOTAL	4,619,970	"	"	"

Potential Supply................	91,914,423	acre	feet	annually
Present Use.....................	4,619,970	"	"	"
Annual Difference........	87,294,453	"	"	"

What becomes of the more than 87 million acre feet of water falling as precipitation on the state? This question can be answered in a general way as follows:

> Immediate evaporation accounts for a large portion of it. Forests, grasslands, parks, crops and other vegetated areas use some. There is about 6 acre feet per acre evaporation from reservoir surfaces. Phreatophytes use valuable underground supplies.

If by some means of careful conservation, we could effect a saving of even 5% of the vast potential water supply not now used, for irrigation and municipal and industrial uses it would amount to more than 4,000,000 acre feet annually.

Industrial Uses in New Mexico.

Industrial and related uses account for about 23% of the total in the national water picture as estimated by the Department of Commerce for the year 1960. If we include that consumed by steam and electrical power, the figure becomes 48%.

In New Mexico, the industrial uses of water are not great, probably not more than 1% of the total. The amount so used is estimated at about 39 million gallons per day or about 120 acre feet used mostly by the potash and oil industries. For a year, the industrial use becomes 43,800 acre feet, an amount to be reckoned with in water planning.

Expansion of industry can be expected in New Mexico. At present the use of industrial water is the lowest of any state in the union. The total income of the state is also among the lowest and can be expected to rise in years to come. Agriculture does not contribute a great deal to the state's total income probably not more than 10 to 12%. It is worthy of note, however, that New Mexico ranks as high as 7th in the United States with 39 million barrel annual production of oil and with 731 billion cubic feet of gas production annually it ranks 3rd. The ranking is also high in total energy production when we consider 3½ million tons of uranium ore.

It may be remembered that Randall F. Montgomery, Manager of the Hobbs District, New Mexico Oil Conservation Commission gave this Conference, in 1958, and estimate of the industrial needs of the state as projected 20 years into the future. His figures were as follows:

USE	NO OF ACRE FEET NEEDED ANNUALLY
Oil Well Drilling	1,688
Gasoline Refining	7,933.3
Oil Refining	2,000
Potash Production	14,887.7
Uranium Processing	3,773.05
Carbon Black Manufacture	613.85
Generation of Electricity	7,372
Secondary Recovery	32,228.90
TOTAL	70,496.85 Acre ft. Annually

This represents only about 1½% of the present water use of the state and small economies of use will not affect the state water picture materially. It is the matter of industrial wastes and saline and brackish waters causing contamination which are important. Contamination of good water supplies is the same as waste. Main sources of contamination are mining, milling, and manufacturing waste, sewage and saline waters. Extent of this contamination and its control will be and have been discussed by speakers better qualified for the part than I.

Use of Water By Municipalities

The present use of water by municipalities in the United States is estimated at 22 billion gallons per day or about 7% of the total daily use for all purposes. In New Mexico the total annual use by municipalities is about 91,500 acre feet or only about 2% of the amount used for all purposes.

Small economies in municipal use will not greatly affect the total water picture for the state but some economies are possible. Good metering of all users is one of the most important. An economy enforced in some cities is the reconditioning and reuse of water from air conditioners.

In the case of most cities, about ½ of the waste water is returned to the water economy without pollution. The other half is polluted from sewage or other wastes. There is a general move among municipalities to take advantage of the 30% grant offered by the Federal Government for construction of sewage treatment plants.

There is need for better sewage treatment where effluent is discharged into rivers from which other cities further down stream receive their water supply. Lack of proper treatment is causing concern in many quarters and the Public Health Service is beginning to enforce stern measures.

Use of Water By Agriculture

It is estimated that irrigation will use about 43% of the presently available water supply of the United States in the year 1960. This amounts to 135 billion gallons per day or 414,450 acre feet. In one year, it is about 150 million acre feet or 5 acre feet per acre for every acre irrigated.

It is now estimated that the present, irrigated acreage in the United States is approximately 30 million. There is much more land which could be developed for irrigation if there were water available with which to irrigate it.

As has been shown, the total volume of water diverted from streams or pumped from the ground for irrigation purposes is about 5 acre feet for each acre irrigated. This speaks of low efficiency in irrigation practice and such is well known to be the case. Probably not more than 1/3 of all water diverted or pumped ever reaches the plant root zone. An analysis of irrigation losses will be presented in coming paragraphs.

Water Use For Irrigation in New Mexico

Irrigation agriculture in New Mexico accounts for about 2,328,000 acre feet of water of the 4,619,970 total acre feet now used for all purposes. This is about 50% of the total or slightly above the national average. However, it represents only about 2% of the total water used for irrigation in the United States. Estimating the irrigated area in New Mexico to be 645,750 acres, the total diversion and pumping is about 3.6 acre feet per acre which is well below the national average. This figure would tend to show better than average irrigation efficiency.

It is generally admitted that irrigation efficiencies are low. If this be the case, where are the losses and what can be done to improve the situation? Some of the more obvious causes of water loss between the point of diversion and the plant root zone are:

1. Reservoir Evaporation

Evaporation from the free water surface of a reservoir in New Mexico is about 6 acre feet per acre of surface per year. Loss from the Elephant Butte Reservoir alone is estimated at 150,000 acre feet or more per year. At the state average of consumptive use, this would irrigate more than 40,000 acres of additional land. Reservoir evaporation may eventually be reduced by the use of films of various types placed on the surface. Various chemicals, one of which is cetyl alcohol, tend to reduce evaporation by forming a layer on the water surface which is one molecule in thickness. Investigations by the Bureau of Reclamation in this country and by other agencies in Australia seem to show some promise.

2. Loss By Phreatophytes

Loss by phreatophytes has been discussed in a previous paper on this program. It is a loss which cannot be disregarded since it removes water from underground storage where it is safe from evaporation and some other losses. Blaney of the U. S. Agricultural Research Service estimates the loss to agriculture from this source at 25 million acre feet of water annually in the United States. In 1955 T. W. Thompson of the U. S. Geological Survey estimated that New Mexico has at least 300,000 acres of these plants and that the loss occasioned by them was 900,000 acre feet annually. In many areas of the West, it has been estimated that at least one half of the infested areas could be profitably cleared with a great saving of water.

3. Seepage Losses From Canals and Reservoirs

Losses in water delivery systems probably account for from 1/4 to 1/3 of all water diverted from streams or pumped from the ground. Losses from the point of diversion to the irrigated field are sometimes difficult to pinpoint. Some water evaporates from canal and reservoir surfaces, some is transpired by plants growing on or near the canal banks, and a great deal is lost by seepage. Some water entering the transportation system and counted as diverted water is delivered back to the stream from which is was diverted and is called regulation losses. It is next to impossible to divert the exact amount of water which the irrigators may be using at any particular time.

It is sometimes advantageous to allow a canal company to carry a much larger volume of water than it ordinarily uses and dump it back to the river again at point down stream since the canal may be a far more efficient means of transportation than a shallow river bed grown up to willows.

It has shown that 4.52 acre feet per acre are diverted in the Mesilla Valley for the irrigation of alfalfa. Normal consumptive use of water for alfalfa in that region is about 2.49 acre feet per acre. This would seem to indicate a loss of 2.03 acre feet per acre of 45% due to seepage, deep percolation, poor application and other losses.

Actual measurements of transportation losses have been made on the project at Tucumcari in New Mexico. This was done by comparing the actual volume of delivery at the farm headgates with volume released at Conchas Dam. As I remember the loss was about 45 to 50%. Measurements by the Bureau of Reclamation average about the same.

What becomes of the seepage water? In some cases it may reach aquifers which carry it directly back to the stream from which it was diverted or to the body of ground water from which it was pumped. In far too many cases it waterlogs land at lower levels, rendering them unfit for further agricultural use. By capillary and by actual static pressure, much of the seepage water may reach the land surface where large areas are exposed to evaporation or transpiration by useless plants. The evaporated moisture may be carried far from the irrigated area and fall as precipitation in some humid region. As a byproduct, seepage waters often carry chemical substances harmful to plant growth. Seeped areas impregnated with salts and alkali are difficult and costly to reclaim. The 1950 census shows New Mexico with 42,324 acres of irrigated land artifically drained and 10,741 acres of such land in need of drainage. In the western 17 states the irrigated acreage in need of drainage is well over 1,000,000.

Return flow from seepage and over application of irrigation water which reaches a stream may be diverted and used again. In some cases this process is repeated further and further down stream until the water becomes so impregnated as to be almost unfit for use in periods of reduced flow. Seepage losses from irrigation may never reach a stream for reuse but be lost thru deep percolation to unused, underground supplies. In many cases return flow reaches the stream from which it was diverted to far down stream or too late in the season for irrigation use, in which case it is lost to the irrigated area.

Attention should be called to the usual western river as an inefficient means of water transportation. The Platte, the Arkansas and the Rio Grande expose broad surfaces to evaporation and loss by transpiration thru water loving vegetation. A gradation below large river dams is not helping the situation. Vegetative growth forming in the old channel may, in some cases, call for heavy dredging operations.

In the early development of the West hundreds of small irrigation enterprises were formed. In one western state there are more than 200 varying in size from one or two users to two hundred. The maze of small canals and ditches are poorly maintained and the banks are overgrown with cottonwoods and willows often getting more water than the farmers. There are many cases in which one small farm unit is served by as many as three irrigation companies and traversed by two canals which do not serve it. It is estimated that there are more than 137,000 miles of canals or ditches of more than 5 cubic foot capacity in the United States. In some cases one well designed and maintained system could replace a dozen of these small innefficient sysems with a great saving of water.

4. Losses From Application

Application losses result from the use of more water than is required. Examples of water waste can be seen in almost all irrigated areas with few exceptions. If the farm irrigation schedule is laid out with consideration of the moisture holding properties of the soil and the depth of root zone of the plants, water can certainly be saved if only enough is applied to fill the root zone reservoir when it is depleated.

The term consumptive use refers to the amount of water used in building plant tissue and in transpiration plus that evaporated from the soil in the irrigation process. It may be expressed in acre inches or acre feet per acre per season or in various other ways. Consumptive use measurements have been made in many areas for many types of crops. It may vary from 12 acre-inches per acre per season for grain at Davis, California, to 52 acre-inches per acre for alfalfa at Mesa, Arizona. In one western area in which the average consumptive use was known to be 24 acre-inches per acre per season the farmers were applying more than 60 inches. This over-application resulted not only in water waste but caused many acres of land at lower levels to be deserted due to poor drainage.

Losses after water reaches the farm are due to evaporation from ditches and wet land surfaces, transpiration from plants on ditch banks, runoff from lower ends of fields, and from deep percolation below the plant root zone. Water lost by over application meets about the same fate as that from seepage from laterals. Some returns to the stream from which it came; some waterlogs lower areas; some evaporates in road ditches and stagnant pools; some joins the underground supply and may or may not be reclaimed.

One of the most conspicuous losses in the application process is the water which runs from a field. The seriousness of this type of loss is best exemplified by the pump irrigator in the High Plains of Texas who fills the road ditch for two miles with water lost from the lower end of a cotton field. Most of this water evaporated probably to fall as rain in the humid regions of the East. This loss is reflected not only in the farmers pocket book, but is a loss to the whole community since it added to the lowering of the water table without gain to anyone.

In general, however, I have observed that pump irrigators are far more careful to avoid loss than those who receive water from surface sources. Pump irrigation areas almost never have a drainage problem. The pump irrigator pays for water at about the same rate at which he uses it. True, some fixed costs continue even when the pump is idle, but operating costs stop when the pump stops.

<u>How Can Water Be Conserved In Irrigation</u>

We now have the technical knowledge to prevent most of the losses which occur in irrigation practice. Some of the cures are too costly or legally involved but great progress is being made to bring corrective measures within the reach of the farmer and the irrigation district. Some of the measures now in use are listed:

1. Lining of canals and ditches.

In the field of water transportation, ditch lining and the use of pipe are the bright stars on the horizon of progress. The unlined ditch has almost passed out of the picture in some short water areas. One may drive for miles in California to see no ditches as all distribution is made by underground pipe. The state of Texas reports more than 4,000 miles of underground pipe installed in the last 7 years. Many concrete pipe factories are springing to life in western states and doing good business. Large diameter cast-in-place pipe is now being laid in sizes ranging from 24 to 60 inches in diameter for the use of irrigation districts and companies with large flows of water to handle.

Lining of irrigation ditches is taking place everywhere. The use of concrete linings using the slip-form method is making great strides particularly in the Southwest. The cheapness of cost and the rapidity with which it can be constructed has an appeal for the irrigator. Little or no handwork is required as the form operating as a combination screed and trowel strikes off the concrete to the desired thickness and imparts to it a smooth finish as it moves along.

There has always been need for a type of ditch lining which is relatively low in cost, durable and yet flexible enough to use even under unstable earth conditions. The Agricultural Research Service, under the guidance of Mr. Lauritzen at Logan, Utah, and with the cooperation of the Indian Jute Mills Association and the Flintkote Company of New York have in the process of development a lining which is prefabricated of strong burlap and a special type of asphalt. It is in strips about 33 inches wide, is not tacky and can be joined by heating with a blow-torch. It can be quickly placed in a ditch with inexperienced help. Experimental installations seem to hold good promise of a lining which can be installed and used under conditions in which less flexible linings would fail.

There are now available many types and sizes of plastic, rubber, and canvas surface pipes for convenient and economical transportation of water. These can be used from pump or ditch outlet to any part of a cultivated field. It has been shown that a butyl rubber pipe will withstand considerable static pressure. Light, metal surface pipe has been gaining in popularity in almost all irrigated areas.

Improving Application Methods

Good application methods begin with the choice of the right system for site conditions of the land to be irrigated. If conditions call for a sprinkler system good results can probably not be had with surface methods. Preparation of good conservation maps of the area is a good start. Soil topography, quality and quantity of water supply, and type of crops to be grown are all important factors to be taken into consideration.

Good water use for surface methods begins with good land preparation. Modern methods of land grading often permit the use of large flows of water on border strips and furrows alike with little or no land slope. Where soil and other conditions permit, quick flooding of the surface to pre-determined depths makes for good efficiency of both labor and water. Water enters the soil uniformly over the entire flooded area and, if properly regulated, will fill the soil to field capacity through the root zone of the crop. This method is being used even in areas of high average annual rainfall but where irrigation is necessary due to protracted, summer drouth periods.

Bench leveling on lands with natural slope is a great step to water and soil conservation. It is possible with it to conserve almost all natural rainfall, control irrigation water so that no erosion or run-off occurs and high application efficiencies are obtained with a minimum of labor.

The Fort Sumner Project in New Mexico is a fine example of what can be done with proper land preparation, large delivery heads of water, and lined ditches. A story could be written about almost every farm on the project. It could tell of the water waste and labor of the old, weed infested ditches where now highly efficient irrigation is done with a minimum of labor. The same water volume which barely served the 6,500 project acres is now being used not only for the old project but for many acres of new land which is being developed for irrigation. Time will not permit a discussion of the many techniques of good water application. Let it be said that we have the knowledge but the widespread putting of that knowledge into use has been slow.

<u>What of the Future</u>

What are some of the ways that present water supplies can be extended for future use? There are some ways with which we are all familiar:

1. Use of River Basin Developments.

Use of river basin developments such as that now being brought into being on the Missouri will make use of water now being lost to the sea and permit all water in the basin to be put to use where it will produce the greatest good for the greatest number.

2. Reclamation of Sewage and Other Waste Water.

The reclamation of waste water has not been given much thought in the times when water was plentiful. Now in areas of scarce water supply waste water is being reclaimed. All the sewage water from the city of Lubbock, Texas, is used for the irrigation of more than a thousand acres of land.

3. Development and Utilization of Saline Water Resources.

4. More Efficient Use of Industrial Water.

5. Increased Irrigation Efficiency on Irrigation Projects and Farms.

6. Use of Underground Aquifers for Storage of Water Which Would Otherwise Runoff as Waste.

7. Destruction of Phreatophytes.

8. Lining of Irrigation Canals and Ditches and Use of Pipe for Water Transportation.

9. Appraisal of Entire Water Law and Water Right Structure.