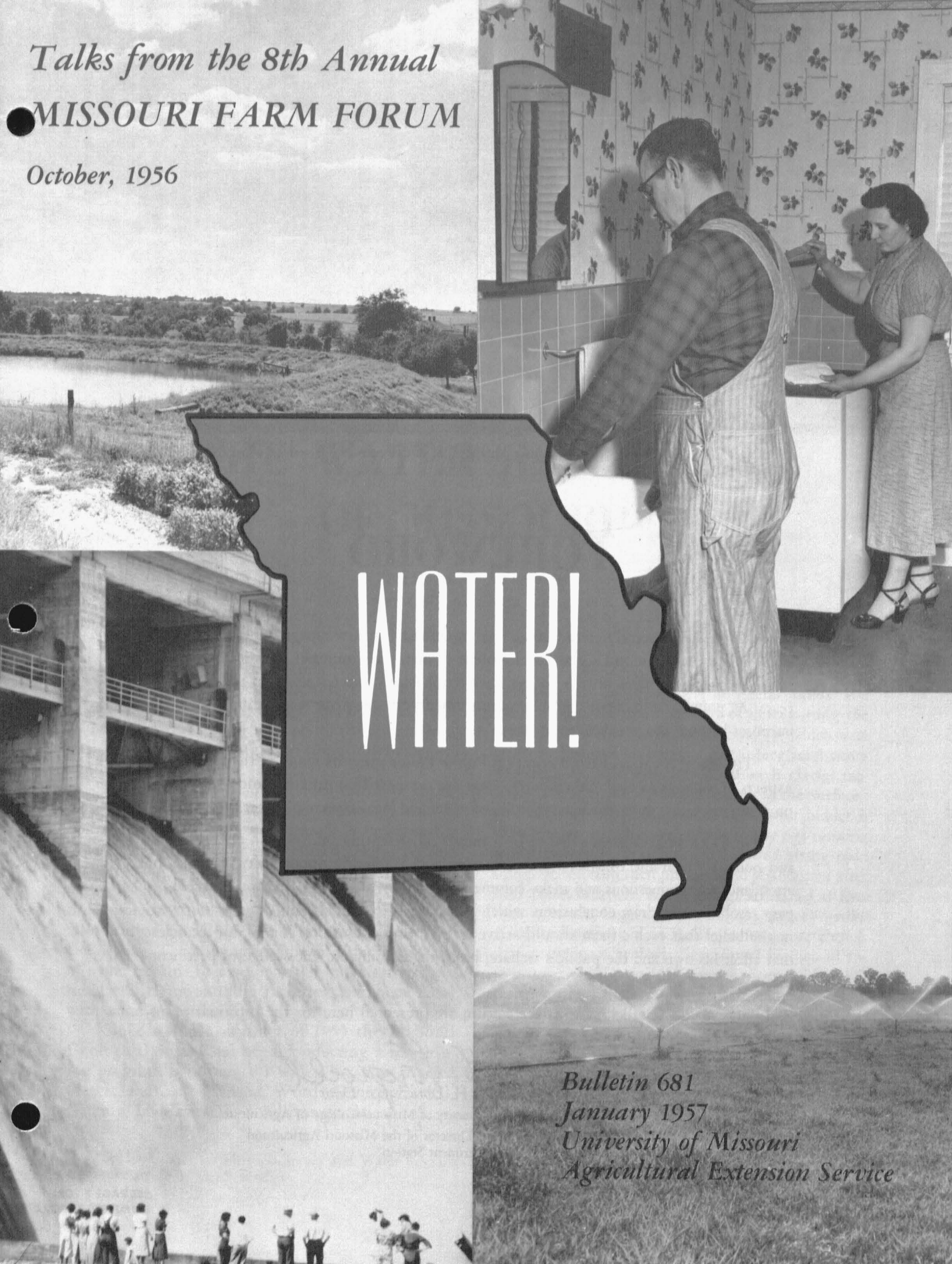
Talks from the 8th Annual

MISSOURI FARM FORUM

October, 1956



WATER!

Bulletin 681
January 1957
University of Missouri
Agricultural Extension Service

Panel discussions were effectively used during the entire two-day discussion on the subject of WATER!

FOREWORD

WATER, until recently considered a free commodity, is now recognized as a limiting factor in the economic and social development of many communities. Severe drouths in Missouri and other areas of the nation have emphasized water scarcity in the last few years. As population increases, problems concerned with adequate water supplies for all purposes become progressively more acute.

THE EIGHTH annual Farm Forum on Public Policy presents many of the important aspects of water as an essential resource. Here are presented information and viewpoints on water resources, water needs, economics of water and legal aspects of water.

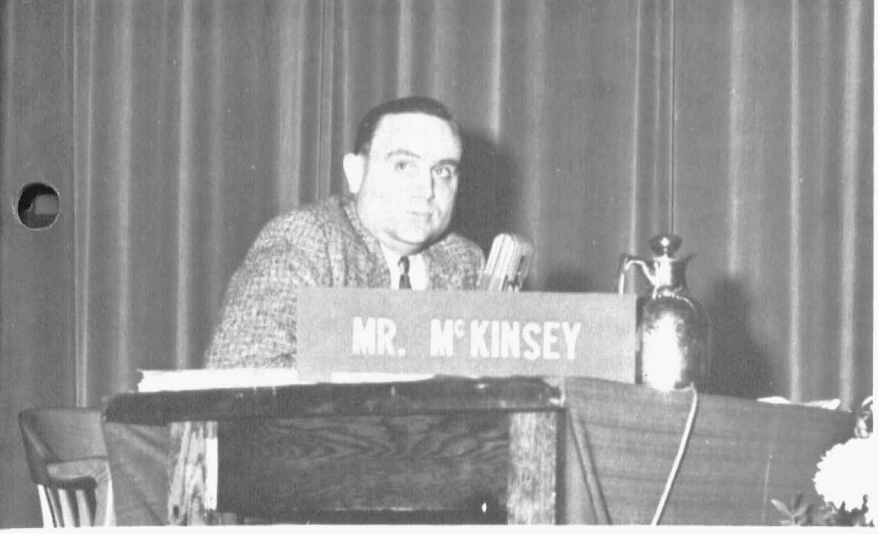
THE FARM FORUM is intended to be a means of presenting information on problems and policies which affect farmers and the nation and of offering opportunity to those in attendance to ask questions and make comments. Those in attendance are not expected to pass resolutions or draw conclusions which would lead to action. This plan is followed in the belief that each citizen should arrive at his own conclusions concerning policies that affect his own and the public's welfare, based on as complete knowledge of pertinent information as possible.

THE PRINCIPAL talks made at the Forum are presented here for the information of interested persons.

J. H. Longwell

—J. H. LONGWELL, *Dean*
University of Missouri College of Agriculture
and Director of the Missouri Agricultural
Experiment Station

SEE PAGE 7 FOR
COMPLETE PROGRAM



Moderator of the annual Farm Forum at which "Water" was the discussion theme, at the University of Missouri, Oct., 30-31, 1956, was J. Wendell McKinsey, left, Professor of Agricultural Economics, at the host institution.

THE WATER RESOURCES OF MISSOURI*

Thomas R. Beveridge
STATE GEOLOGIST OF MISSOURI

I AM guilty of taking much liberty with the title of this talk. Originally the title *Water Resources of the Midwest* was suggested. It has been narrowed to Missouri and I shall now restrict the discussion still further by confining it to the groundwater resources of the State.

Missouri is commonly divided into four major groundwater provinces which are shown on plate I.

Groundwater from the bedrock in Province I is generally scanty and/or mineralized. Major potable supplies can be obtained from alluvium in stream valleys or from the glacial drift where it is present in a sufficient thickness. Where there is little or no alluvium or glacial drift, it is necessary to use surface waters. The current drouth has reduced the flow of some streams to a point where some municipalities lacking impounding facilities have been faced with acute water shortages.

Since the late summer of 1955 the Missouri Geological Survey has been conducting a test-drilling program in Province I which has now covered Mercer, Putnam, Harrison, Worth, Gentry, Daviess, Grundy, Livingston, and Sullivan counties.

The test drilling project which represents an endeavor to locate aquifers in glacial sands and gravels has consisted primarily of determining the distribution and extent of the river valleys which were cut into bedrock in preglacial or interglacial times and are now so completely filled with glacial material that they are no longer visible at the surface.

Drilling under contract to the lowest bidder is now being done with two mobile rotary rigs running simultaneously. Test holes are drilled along road rights-of-way and then plugged and abandoned after they reach bedrock. Well cuttings are saved at five-foot intervals, logged in the field by Survey geologists, and preserved at Rolla for future reference.

A graduate geologist is assigned to each of the two test-hole rigs to log samples, note water horizons, collect water samples, verify the depth to bedrock, and plan the location of test-holes.

Test Drilling Shows Valleys

The existence of a major drift-filled, buried valley system approximately paralleling the course of the present Grand in Missouri has been known for

*See back cover for Missouri Survey and Water Resources map of Groundwater Provinces referred to in the above article by Dr. Beveridge.

many years, but data have been insufficient to verify the trends of the main valleys or the existence of many of the tributaries. In many cases buried valleys were postulated between subsurface control points as far as ten miles apart. Test drilling has shown the valleys to be from three to six miles wide and as great as 400 feet in depth or thickness of drift. The general results have been good.

Many of the test holes have flowed and the majority within the buried valleys have penetrated aquifers which may be sufficient for irrigation. The quality of the groundwater from glacial drift is much better than that from the bedrock and it is generally potable. Although pumping tests have not been made, it is believed that many of the aquifers will yield several hundred gallons per minute. These estimates are made on the basis of sandy porosity and permeability.

A multilithed report is released to the general public as soon as possible after test drilling is completed. This report contains county maps showing the areas most favorable for glacial drift wells and thicknesses of the drift. Also included are representative water analyses and the surface flow data available. Reports are furnished to county extension agents or may be obtained on request from the Survey at Rolla.

Province II is similar to Province I, but differs in that limited quantities of fresh water can be obtained in relatively shallow bedrock wells. The Missouri River is approximately the southern limit of glaciation, and thus much of this province cannot depend on glacial drift for water supplies.

Province III is endowed with the highest yielding aquifers in the State, for productions in excess of 1000 gallons per minute are common in the Bootheel. The quality of some of the groundwater from this province is likewise the best in the State. This area, with its combination of level land, fertile soil, and plentiful water is the best combination of natural conditions in the State for irrigation systems.

Province IV, although not as well endowed as Province III, has adequate water supplies except in the granite and porphyry mountain country centered in St. Francois and Madison counties and in the few areas of large cities where there is overpumpage.

One of the questions which is frequently asked is, "What is the drouth doing to the water level?" This question cannot be answered with a simple statement. In addition to the water in sands and gravels of glacial drift, alluvium, and residuum, there are aquifers in various porous, fractured, or cavernous permeable bedrock formations. Since these bedrock formations were laid down in a layer-cake manner, more than one aquifer can be expected in drilling a deep well. Thus, in the greater part of the State, there is more than one "water level".

The answer is that water yields have been generally diminished—in some cases to nothing—in the shallow wells and springs. When we speak of "shallow wells" we are referring to dug wells and drilled wells less than several hundred feet deep. Many small springs and surface streams have gone dry and the flow of all major springs and streams has been reduced in many cases to a record low. Yet the data available shows no general lowered production in deep wells.

The instances of lowered static water levels in these wells appear to be the result of overpumpage and crowded spacing in urban areas. Exceptionally high temperatures accompanying the drouth have increased the water consumption in air conditioning and watering of lawns, shrubs, and gardens. Furthermore, the increases in population have resulted in tremendous increases in the number of urban and suburban domestic water users.

In parts of Missouri, especially Provinces I and II, some municipalities and rural users cannot obtain adequate groundwater supplies locally—a condition which will not end with the end of the drouth. These users will find it increasingly more necessary to rely on surface waters. Undoubtedly the future will bring more instances of piping water from distant sources— a practice which is now viewed primarily as an emergency venture.

Groundwater Studies Made

For years the Missouri Geological Survey, located at Rolla, has devoted a large part of its efforts to groundwater studies and services to the public. Well drillers from throughout the State voluntarily save cuttings at five-foot intervals and send them to the Survey. These cuttings are washed and processed in the Survey laboratories before being studied and logged on colored graphic logs. These graphic logs show the formations and kind of rock penetrated, as well as all other pertinent data available such as location by section, township and range, elevation, yield, driller, date, owner, casing statistics, crevices encountered, mineral shows, *et cetera.*

Copies of the logs are retained in the Survey files and duplicates are sent to the driller and land owner. Sample sacks and log books are supplied gratis by the Survey, and samples are shipped to us express collect. As a result of this program we now have a file of approximately 20,000 logs. These logs

are in turn used answering the many inquiries from both private citizens and public and industrial agencies requesting information as to the depth to desired quantities and qualities of groundwater supplies.

All wells which wish approval by the State Division of Health must have the casing point confirmed by the Survey. Casing advice is given in answer to private well inquiries, but of course is not mandatory.

Eighteen of the Survey staff, including nine geologists and one geophysicist are devoting full time to groundwater studies and services. Four geologists study and log well cuttings, one answers inquiries for groundwater information, three are with the test-drilling rigs, and one supervises the test drilling program and the installation of continuous recorders in observation wells throughout the State.

The recorders just mentioned maintain a continuous graphic record of water levels in individual key wells. This program of recorder installation was begun in the summer of 1955; as a result it is much too early to make an analysis of the short-term records.

Missouri has her groundwater problems, but they cannot be solved without the use of sound geologic data. The Survey is doing its utmost to solve these problems and its services to the public, whether it be rural, municipal or industrial. If you are contemplating drilling a well or have water problems write to the Missouri Geological Survey, Box 250, Rolla, Missouri—we'll do our best to help you!

The Economic Significance of Water was the theme of the first day of the Farm Forum. Shown above, taking part in a panel discussion, are: Dr. Raymond J. Penn, left, Professor of Agricultural Economics, University of Wisconsin; Dr. Frank Miller, Professor of Agricultural Economics, University of Missouri; Clarence E. Klingner, Extension Professor of Agricultural Economics, University of Missouri, and Rod Turnbull, Editor, Weekly Star Farmer, Kansas City, Mo.

ECONOMIC SIGNIFICANCE OF WATER To Agriculture

Raymond J. Penn

PROFESSOR OF AGRICULTURAL ECONOMICS
UNIVERSITY OF WISCONSIN

IT IS obvious, of course, that no life can exist without water. It is almost equally obvious that water is one of the critical "raw materials" which agriculture uses in growing living plants and animals to supply the food and most of the fiber needs of the nation.

Because water is so critical to life nearly all rules governing water use give the highest priority to household and domestic uses. And where water is scarce more violent conflicts develop over who gets the water than over almost any other issue. The stories of the ditch rider wearing a gun do not exaggerate the intensity of conflicts over water rights.

To make matters worse water is not something that can be reduced to possession. A water right is not a right to a specific gallon or acre foot of water, but rather it is the right to use that much water if it comes by or if it is under your land when you want to pump it. The amount of water available may change drastically from time to time. At one time water may have little value or may in fact have negative value. A few days earlier or later to the same user it may be priceless. This is quite apart from the fact that like most other natural resources water is ample in some areas and short in others.

The critical nature of water, the fact that it is not always available in definite amounts, and the localized or area nature of water problems have intensified the conflicts that arise over water use. These conflicts will increase in the future rather than decrease.

Need for Water

Rapid technological change and sharply increasing population are the two main developments which are increasing our water needs and causing us to have major concern about uses and control of water. This is true in agriculture as well as in the other parts of our economy.

Agricultural technology has been keeping pace with that of the rest of the economy. The U. S. will produce about 2½ times as much goods and services this year as 15 years ago. And if the investment in increased production capacity and modernization that is tightening up the money markets this year is any indication of things to come, we should expect continuing increase in U. S. Production.

Although agriculture in the same period has only increased its production by about 50 percent, the efficiency per man employed in agriculture is much greater than the 50 percent increase in gross production would indicate. We have a million fewer farms than before the war, but each person employed in agriculture is producing nearly twice as much as 15 years ago.

Water comes into this picture in a rather unexpected way. Many farmers in southern Wisconsin and in Illinois will have fields which will yield more than 150 bushels of corn to the acre this year. Their technology is making full use of soil fertility resources, and moving toward a point where, even in an area which we think of as having water in abundance, water becomes the limiting factor on further increases in yield.

If we are to expect farm families to have incomes comparable with other families in our economy they will have to be able to produce as well as they know how. I suspect that this will mean that for at least 15 years agriculture will not need more total land in cultivation but farmers in increasing numbers will be wanting to irrigate. To date most of the irrigation in the 31 eastern states is on high valued specialty crops and the number of farmers irrigating is a relatively small percentage of the total number of farmers. Out of a total of 153,558 farms in Wisconsin only 545 were irrigating in 1954. They irrigated 18,199 acres.

The need for irrigation water is primarily in the future. The concern here is that only in the arid or semi-arid states have laws been developed that adequately handle irrigation.

Increase in population is a second development which is intensifying conflicts for water and in many areas making serious water problems for agriculture. Nearly all the increase in population is urban-oriented. The people live in the city or the adjacent area close by. Nearly one person in three now lives in one of the ten largest metropolitan areas of the U. S. This, as the other speakers have said, creates many problems. Cities are expanding their water systems to supply more users. They need more water. The pollution problem is increased. New industries are added and the new industries are high water users. And the people who live in close quarters want or will want more access to fishing, hunting, and other recreation, all of which involve water. These increased water needs of the expanding city pose a number of water issues for agriculture.

Fond du Lac an Example

Let me illustrate one of them with a Wisconsin case. Fond du Lac is a city of about 30,000 population in east central Wisconsin. It was short of water so it bought or optioned about 1,000 acres of land in a farming area. Wells were to be drilled to augment its water supply. The 500 farmers in the township didn't like the idea. They were afraid their own wells would go dry. The township passed three ordinances. One was a zoning ordinance which would not permit pumping stations. A second prohibited the transporting of water pumped in the town to a destination outside the town. And a third limited the size of well casings to something less than that which the city could practically use. The city, of course, attempted to have the ordinances set aside.

The farmers filed a counteraction to stop the city from drilling because they felt it would reduce the water table and require reconditioning their wells. The Wisconsin Supreme Court in June this year ruled for the city and against the farmers, pointing out that our present law permits the city to use any water it can get from under its own land. But the court acknowledged that this did not seem entirely fair to the farmers, and suggested that the matter be resolved in the legislature. Out of this and similar cases may come new water legislation in Wisconsin next year.

This is only one of the types of water conflicts between urban and rural users. You people in Missouri have had some experience with the flood water issue, and your neighbor, Kansas, has focused the issue for the nation. In Wisconsin, a more frequent issue arises between the farmers and the recreation user.

I expect conflicts between rural and urban water users to get much more severe in the next few years. The economic significance of water to agriculture is that agriculture will need more water and it will have to compete for it with a lot of others whose needs are also increasing. But this all seems quite obvious. The real problem we are faced with seems to me to be how can we resolve these conflicts so we know what we are doing, so we won't waste too much time or resources fighting each other, and so

that there is enough stability in our water policies to permit agriculture and industry and other users to make long-range plans for optimum use of total productive resources.

Resolving Water Conflicts?

The economist, of course, hopes that the market place will allocate resources efficiently. But the market has never done a very effective job of allocating water. Generally we have tried to tie water rights to land which can be bought and sold. In the eastern 31 states, at least, if you own land along a stream or a lake you have some rights to use the water. This is the riparian doctrine. It was formed out of a situation where there was adequate water for all uses. It assumed that the riparian landowner could use all the water he might want and still, for all practical purposes, not impair either the quantity or quality of the source on which he drew.

The landowner also has some rights in the water under his land. Most states have a reasonable use limit. I doubt if any state has as rigid rule here as we have in Wisconsin where the landowner has the right to all the water he can pump from his land so long as he does not impair municipal water supplies.

With respect to flood water the landowner usually has the right to treat it as a common enemy. He can do anything he wants to keep it from coming on his land or to dump it on his neighbor's land.

Each state has, of course, made major modifications in the water rights attached to land. However, the eastern 31 states generally have one set of rules for surface water, another for underground water, and another for flood water plus a miscellaneous assortment for drainage, water pollution, etc. In total they are inadequate to resolve the water issues facing us now, much less the more complex ones which obviously lie ahead. Nearly all states have some form of study group working on water problems.

Ideas in use in Wisconsin

Wisconsin will, I think, make some changes in its water law in the near future. Here are some ideas I think are important as we tackle that job. Perhaps some of them could be made useful to you in Missouri.

(1) We are not expecting to find any ready made answer from some other part of the country. We are looking at the experience in other states for ideas. But we see enough differences in our own situation to demand that we start from where we are and build to meet Wisconsin's particular needs.

(2) We are agreed that the land market has not adequately allocated water. More authority will probably have to be invested in some government agency. If sufficiently broad authority is given to an agency to permit its flexibility to act in a wide range of specific situations, we feel two types of safeguards should be included in the law. One is a general policy statement to furnish a guide to the agency. The other is a set of procedures which will not only protect the individual but will also require adequate information on which a wise decision can be made.

(3) It has become clear that water rules or priorities cannot be uniform even within a state. In one area the prime use must be urban, in another recreation or agriculture or hydroelectric power. In one area the water conflicts may be intense. In another they may be as yet almost nonexistent. We have suggested procedures to establish critical water areas with adequate rules to resolve conflicts in them. But these rules need not be applied to other parts of the state.

(4) We feel domestic uses of water should receive first priority in all areas. Beyond this, priority between beneficial uses should be resolved for specific areas after a study of the availability of water and the importance of the uses.

(5) We feel water should be considered as a single resource and not as three different things—flood, surface, and ground water, with three sets of rules and three agencies responsible for administering the rules. There is no point in legal differences when in a real situation they are all a part of one water resource. Surface water (streams and lakes) often is part of the underground pool, and the interchange is almost immediate. Only by a single set of rules for all three types of water, with one agency responsible for administration, can we allocate water uses adequately.

(6) We have picked up from the west the idea of "practical or reasonable adjustment" which I believe has real merit in Wisconsin and other eastern states. The administering agency should have the authority and encouragement it needs to work out reasonable arrangements between conflicting users and make them a condition of the allocation. Our Fond du Lac case could have been resolved in this manner. The city would have been willing to pay the cost of deepening the farmers' wells but could not legally spend taxpayers' money for this purpose unless it was "forced" to do so.

These are some of the ideas I am trying to get considered as we in Wisconsin look forward to changes in our water rules.

Water is critical for agriculture. Changes in agricultural technology will increase agriculture's need for water especially for irrigation. Increased population will make water a scarce resource in many parts of the humid areas and will increase the conflicts between water users. The real problem which we face in Wisconsin and which I suspect you are facing in Missouri is how to resolve these conflicts so as to get the best use of our water resources. We must, I think, go at this job together and not as separate groups of farmers, businessmen, municipalities and conservationists, each with an "all-or-nothing" program.

PROGRAM

WATER

Its Use and Control

Tuesday Morning

Presiding, Dean J. H. Longwell

10:00 REGISTRATION
10:30 PROGRAM ANNOUNCEMENTS
10:40 WELCOME—President Elmer Ellis
10:55 ADDRESS—"Water—Of Concern Today, A Problem Tomorrow" Albert E. Burke
11:45 Noon Recess

Tuesday Afternoon

1:45 A Symposium on

THE ECONOMIC SIGNIFICANCE OF WATER

Moderator, J. Wendell McKinsey

"Water Resources of Missouri"
Thomas R. Beveridge
"Economic Significance of Water to Agriculture"
Raymond J. Penn
"Economic Significance of Water to Industry and Municipalities"
R. O. Joslyn
Panel Discussion:

Thomas R. Beveridge	James McQuigg
Raymond J. Penn	George Smith
R. O. Joslyn	Ovid Bay
Richard Collins	A. E. Burke
Elmer Kiehl	Harold J. Schmitz

Wednesday Morning

8:30 A Symposium on

WATER USE AND CONTROL IN AGRICULTURE

Moderator, J. Wendell McKinsey

"Water-Rights in Missouri"
Willard Eckhardt
"Objectives of Water-Rights Legislation"
George Spencer
"The Considerations for Agriculture in Water-Rights Legislation"
Fred Clarenbach
Panel Discussion:

Willard Eckhardt	Karl Shoemaker
George Spencer	Jack Jackson
Fred Clarenbach	Wayne Leeman
Cordell Tindall	Ralph Ricketts
Frank Miller	Katharyn Zimmerman

11:45 Noon Recess

Wednesday Afternoon

Presiding, Director J. W. Burch

1:00 ADDRESS—"Making Water a Non-Limiting Production Asset"
Arnold W. Klemme
1:45-
3:00 Symposium Finale

Arnold W. Klemme	Ray Penn
Rod Turnbull	Willard Eckhardt
Frank Miller	Melvin Woell
Uel Blank	Karl Shoemaker,
Ray Schroeder	Clarence Klingner
Fred Clarenbach	Ted Mangner
George Spencer	

3:00-
3:15 Summary of Forum

Why Has Water Become Important Subject?

Scientists and geologists remind us that the average annual precipitation on the whole United States is about the same year in and year out—30 inches per year or 4,300 billion gallons per day. In other words, the quantity of water falling on the earth each year, from the clouds above has remained and probably will remain, a fairly constant figure year after year. If such is the case, the question immediately arises as to the reason for the extreme water shortages which we experience year after year in various parts of the country.

ECONOMIC SIGNIFICANCE OF WATER To Industry and Municipalities

R. O. Joslyn

PRESIDENT, LAYNE-WESTERN COMPANY
KANSAS CITY, MISSOURI

THE FOLLOWING headline appeared in the *Kansas City Star* of October 2, 1956:

"REQUEST BY SENATOR STUART SYMINGTON TO DEPARTMENT OF AGRICULTURE FOLLOWS TOUR OF NORTHWEST COUNTIES. ASKS FOR DROUTH STUDY."

In fact, in almost every edition of the newspaper and in every magazine, you will find a feature article about the shortage of water in certain areas such as Northern Missouri or an oversupply of water in flooded areas such as the appearance recently in the southeastern part of the United States, due to "Hurricane Flossie."

Outside of the political campaigns which will be over next week, the subject of water, or the lack of it, is just about the main topic of conversation of the day.

A look at the data regarding the water usage for the past several years will partly answer this question. The records show that the national water usage has jumped from:

40 billion gallons a day in 1900 to
262 billion gallons a day in 1955, and it is estimated it will be
453 billion gallons a day in 1957.

In other words, we are now using 6½ times the amount of water we used in 1900 without any increase in the annual supply and 25 years from now we will be in need of twice as much water as we consume at the present time. This high consumption of water is divided into five divisions as follows:

1. Irrigation
2. Public Water Supplies
3. Domestic Supplies
4. Industrial
5. Steam Electric Power Plants

1. Irrigation—which includes supplies from both surface and ground sources. The water demand for irrigation increased from 20 billion gallons daily in 1900 to 120 billion gallons daily in 1955.

2. Public Water Supplies—which includes the domestic, commercial, and industrial plants within the areas of distribution.

This supply rose from 3 billion gallons per day in 1900 to 17 billion gallons per day in 1955.

3. Domestic Supplies—which includes water supplies for farms, rural homes, and suburban fringe homes. This division used 2 million gallons daily in 1905 and 5.4 billion gallons in 1955.

4. Industrial—which includes manufacturing, industrial concerns, mineral industries, military reservations, and uses not included elsewhere—all self supplied. This jumped from 10 billion gallons daily in 1900 to 60 billion gallons daily in 1955.

5. Steam Electric Power Plants—which consumed 5 billion gallons in 1900 to 60 billion gallons daily in 1955.

These five divisions total 262 billion gallons daily and it is of interest to note that 41 billion gallons daily were taken from the ground or what is known as well supplies.

	BILLION GALLONS PER DAY				
	In 1900	In 1955	% of Total	% Increase	Ground Water
1. Irrigation	20	120	45.5	600	25.00
2. Public Water Supplies	3	17	6.5	600	4.18
3. Domestic Water Supplies	2	5.4	2.0	270	5.16
4. Industrial Water Supplies	10	60	23.0	600	6.13
5. Steam Electric Power Plants	5	60	23.0	1200	1.02
TOTAL	40	262	100.0		41.49

Now let us look at the picture which will develop from 1955 to 1975.

	BILLION GALLONS PER DAY	
	In 1955	In 1975
1. Irrigation Water Supplies	120	170
2. Public Water Supplies	17	30
3. Domestic Water Supplies	5.4	7.2
4. Industrial Water Supplies	60	115
5. Steam Electric Power Plants	60	131
TOTAL	262	453

Irrigation ranks as the No. 1 user of large quantities of water with an estimated demand in 1975 of 170 billion gallons a day; Industrial plants (including steam plants) come next and Public Water Supplies lag far behind in third place.

It is true that our population has increased from 75 million in 1900 to 165 million today, and we expect 210 million by 1975, but the public use of water on a national scale does not compare with the demands for water by irrigation and industry. Our population from 1900 to 1955 increased 220% and our water consumption increased 650%.

The increased demand for water has been largely due to the great industrial growth of this country. When we think of the steel mills, airplanes, chemical plants, cement mills, automobiles, air conditioning, electrical machinery, and the thousands of manufacturing plants in the United States today, that were not here in 1900, we begin to realize why our water supply demand is approaching the limit of the supply.

It has been said that one-half of the products that are now used were unknown 20 years ago and further, that one-half of the products which will be common in 1975 are not yet known or developed.

Water Unit Requirements

Here are a few unit requirements for water by manufactured articles.

It requires 65,000 gallons of water to manufacture 1 ton of steel.

It requires 1,500 gallons of water to manufacture 1 cotton bed sheet.

It requires 600,000 gallons of water to manufacture 1 ton synthetic rubber

It requires 300,000 gallons of water to manufacture 1 ton Magnesium

It requires 60,000 gallons of water to manufacture 1 ton of paper

It requires 3,600 gallons of water to manufacture 1 ton of coke

It requires 10 gallons of water to manufacture 1 gallon of gasoline

In many areas of the United States we are for the first time experiencing water shortages. We are beginning to find that underground water in many places is exhaustible. We are finding that there is a limit to which we can pollute our streams, either by municipal or industrial waste. We are finding that the industrial demands for water are almost beyond comprehension. We are finding that adequate water supplies in many cases are more important to the location of a new industry than are electric rates, freight rates, or even raw materials.

Although this presents a rather gloomy picture of our water situation, it is far from a hopeless one. In the five divisions mentioned above, 70% of our available annual water supply is being utilized but 30% (1,145 billion gallons a day) is going to waste by flowing down our rivers into the ocean where it becomes unusable salt water. If a part of this 1,145 billion gallons of water a day, that is going to waste, could be utilized and distributed to arid communities our problems of water shortage would become less acute.

Three projects which will tax the resourcefulness of the people in these United States in the near future are hereby proposed.

1. Endeavor to capture and conserve some of the water that is now going to waste and escaping to the ocean.

2. Discover new sources of water, over and above the quantity which we have available today.
3. Use more efficiently the water which is now available and at our command in underground storage.

1. To Capture Some of the Water Going to Waste.

Great strides have already been taken in conserving water by reclamation. Here are two examples.

The Bethlehem Steel Company at the Sparrows Point Mill near Baltimore, Maryland, presently uses 60 million gallons of water per day reclaimed from the effluent of the Baltimore, Maryland city sewage disposal plant and plans are being made to reclaim the entire volume of 150 million gallons per day.

Another outstanding achievement in the use of water conservation and reclamation is that the Kaiser Fontana Steel plant near Los Angeles which uses only 1700 gallons of water per ton of steel compared to the normal 65,000 gallons of water per ton of steel.

Many industrial plants are using the water over and over again by the installation of cooling towers, air cooled engines, and other water saving devices which results in water economy. In fact, a survey of the water leaks in a large steel mill turned up losses of 3 million gallons a day.

Increased regulations of streams by the construction of impounding reservoirs will be of great aid in storing water during periods of flood flows in the spring, and making this water available in the summer months of low stream flow. Not only the large reservoirs like Ft. Peck, Harlan County Dam, Ft. Randall, Kanopolis, and Tuttle Creek, but many smaller dams and ponds will go a long way to even out the stream flow.

Large quantities of potable water are now subject to contamination from the waste water of city and private plants. Our municipalities and industries will have to do a better housekeeping job and will have to refrain from dumping their raw wastes into the rivers and spoiling the water for the neighbor downstream. A study by the Department of Health and Education in 1951 revealed that in 1951 there were 11,800 sources of municipal pollution and 10,400 factory waste outlets into our streams and lakes.

Research organizations have been formed in various industries in an effort to find reasonable methods for treating their waste water. A certain chemical company ordered by the State Board of Health, to abate its pollution, found that the waste waters had a high vitamin content and today the vitamins are the main product of this company.

2. New Sources of Water

There are two possible sources of water which are now in the research stage. The first is the artificial induction of rainfall. When rain occurs naturally, only about 5% of the water in the clouds actually precipitates. If the fallout could be raised to 10% of the cloud content, the natural supply would be doubled. Such increase is attempted by providing nuclei to promote condensation by water vapor. Dry ice pellets and silver iodide crystals have been used successfully to bring about this effect.

There are wide differences of opinion, however, among meterologists and other experts in the field, over the results. Although much research will be necessary before efforts to increase rainfall can be satisfactorily evaluated, there is reason to believe that the technical problems will be solved eventually and that water supplies can be augmented by artificially increasing atmospheric precipitation.

Anyway, it is of interest to note that five State Legislatures have proclaimed their states sovereignty over the atmospheric moisture floating above the states. These legislative bodies have shown concern over the possibility that the other states might somehow steal moisture that rightfully was theirs. Cases of record have indicated that the actual rainfall may take place many miles away from the point of seeding activity.

Another possible source of fresh water is the production of usable water from the ocean. The Department of the Interior has been engaged for several years, in consultation with the National Science Foundation and various other government departments and agencies, in a program endeavoring to find some process for the de-mineralization of sea water by a method that will deliver substantial quantities at a cost which is within the reach of our economic, agricultural, and industrial potentials. The department has had $400,000 a year available for that program and under the direction of Congress, the research has been handled largely by the method of grants to colleges and scientific and industrial organizations, in an endeavor to put to work some of the best scientific brains of the country.

Much progress has been made. The original goals have already been exceeded and though the costs are far too high for a competitive industry or for agricultural use, they are coming at least within sight of limited domestic use. The initial cost of energy in the process is about 12¢ per thousand gallons and investment and operational costs will prob-

ably double that figure to a total of 25 or 30¢ per 1,000 gallons. But the studies in possible use of solar energy as well as conventional electric power, may reduce that cost. The groups involved are continuing to work, and if the past achievements of American scientists and industrialists are any indication, they may yet evolve a process which will solve the problem.

3. Using Water Sources at Our Command

There is one source of water supply which is often overlooked which I would like to bring to your attention and that is the large quantities of water in the underground storage reservoirs of nature.

A member of the United States Geological Survey made a recent statement that the underground reservoirs of water comprises the largest storage of fresh water in the nation—far more than the capacity of all surface reservoirs and lakes, including the Great Lakes.

The State of Missouri is unusually fortunate in its share of ground water storage and the fact that two-thirds of the municipal supplies in Missouri are well supplies, exemplifies this good fortune. But are we using this underground storage to its full advantage? *Definitely, we are not.* One under-ground storage basin which is not fully utilized and which is vital to this audience, is the Missouri River Valley.

The Missouri River enters the State of Missouri in the northwest corner and flows south to Kansas City where it picks up the Kansas River and then turns east to flow across the state to St. Louis, where it empties into the Mississippi River. The quantity of ground water stored in this Missouri Valley, which spreads out to a width of 15 miles at some points, and has a depth of alluvial fill of 50′ to 175′, is beyond our comprehension.

In fact, in the State of Nebraska where a similar condition exists, and the Platte River winds its way across the central part of the State, the Nebraska Geologist declares, "We are currently utilizing about 1,500,000 acre feet of ground water in the state. This is less than 20% of the estimated annual recharge to ground water in Nebraska under normal rainfall conditions." The State of Nebraska at the present time, has approximately 15,000 wells which are being used for irrigation purposes.

Turning again to Missouri, it is noteworthy that many of the cities along the Missouri River obtain their municipal supplies from this underground storage basin provided by the Missouri River. The industries in St. Joseph and Kansas City take approximately 100 million gallons per day from this source without signs of depletion.

Last spring, the Missouri Water Company of Independence, Missouri drilled a series of wells in the Missouri River Valley and installed a water plant having a capacity of 15 million gallons per day. Previous to this time their water supply was taken from the Kansas City, Missouri municipal system. Now, Independence will use or have available 15 million gallons of water per day that heretofore was going to waste.

Some ten years ago, the Weldon Springs Ordnance Plant put in a well supply in the Missouri River underflow and recovered from this little used source, 45 million gallons per day.

Where Was The Water Before Weldon Springs?

This 45 million gallons per day was stored underground and was slowly finding its way into the river and thence into the ocean where it eventually became sea water. Why then, if there is so much water lying dormant underground, and there are drouth areas adjacent to and at the most, 50 miles from this source, isn't there some way to get the water to the location where it is needed? That is the $64,000 question and the answer of course, is that it is physically possible to construct a project of this magnitude but large sums of money would have to be expended to accomplish it.

Pipelines of the size needed would probably cost $50,000 a mile and yet, in comparison to our new super highways, which cost a million dollars a mile, perhaps it is not so much. Years ago, an expenditure of $25,000 a mile for a public highway was considered a reasonable estimate, but the traffic load in our fast developing era has stepped up our financial thinking into the realm of one million dollars a mile. Perhaps our thinking in water problems will someday approach and parallel our progress in the development of our highways.

Can you visualize what it would mean to the Northwest Section of Missouri where the drouth is most severe at this time, to have a series of pipelines filled with cold, fresh water running through this area. The water would come from wells and pumps, each capable of pumping 2,000,000 gallons of water per day, installed at stated intervals and starting at the northwest corner of the state and coming south to St. Joseph and to other strategic locations.

To each well and pump would be connected a pipeline which would be piped 5 to 50 miles inland, depending upon circumstances, through the

drouth ridden area. City reservoirs could be filled, farmer's ponds replenished, dry cisterns filled and and with a pipe outlet discharging at a high point, or elevation in the area, the water could run down road ditches by gravity to aid in the watering of stock and of beneficial use in general.

Perhaps the above sounds like a wild dream but here is a case in point. A few years ago at Tuscola, Illinois, a large chemical plant was built by the National Petroleum Chemical Company. Several millions of gallons of water per day were needed to run the plant and the closest source of a dependable water was an underground reservoir similar to the one we are talking about, 26 miles away near Champaign, Illinois. The pipeline from the well field to the plant was estimated to cost 1 ½ million dollars which was almost prohibitive.

But the problem was solved in this way. A creek bed, which was dry most of the time, was discovered which ran alongside the chemical plant and originated several miles to the north of the plant and adjacent to the well storage field. Two wells and pumps of 5 million gallons per day capacity were installed 26 miles to the north of the plant and the water emptied into the creek bed and thence flowed to the plant site 26 miles below. It was then a simple operation to recover from the creek the well water for the plant use—the water supplied which had originated from the wells 26 miles away.

Therefore, in the case of wells versus drouth, if from each of several pipelines a supply of 2 million gallons per day of cold, fresh well water could be spilled on a high point for gravity distribution during the dry period of rainfall deficiency, it would be of immeasurable aid and benefit. Yes, the cost would be high and the thoughts presented are from an engineering standpoint and not from a monetary point of view. But here is what has been done in other parts of the country.

A few weeks ago in Kansas City, it was announced that Jackson County—just one county in Missouri—would vote on a $75,000,000 bond issue to improve its highway system over the next ten years. The State of Missouri will spend millions and our Federal Government will spend 33 billion dollars for highways which are certainly needed, but water is likewise important and needed badly.

In conclusion, if this program seems a little bold and perhaps impractical, may I recall for you the words of General Summerville who replied when called upon to perform an almost insurmountable task, "We do the impossible immediately and the miraculous takes a little longer."

ECONOMIC SIGNIFICANCE OF WATER in Crop Production

George E. Smith

PROFESSOR OF SOILS
UNIVERSITY OF MISSOURI

AGRICULTURE is rapidly changing from an art to a science—becoming a business. The mere exploiting of natural conditions found on a particular tract of land can no longer suffice to maintain a satisfactory standard of living in this period of rapid technical development.

Machines and chemicals, produced by industry account for an ever increasing overhead in crop production. Yields that would return a satisfactory labor income 10 to 15 years ago may only meet the cost of production today. Good farm managers, utilizing technical developments, have made obsolete many past concepts of so-called land capabilities.

Many who are still following pre-war practices are having difficulty in maintaining standards of living, are farming more acres with low yields, without materially affecting profits.

The increased use of fertilizer in Missouri during the past ten years has been phenomenal. A deficiency of nutrients has been the first limiting factor on many Missouri farms. More vigorous plants require additional water and exhaust moisture to greater depths, increasing the problems of recharging subsoil reserves. Although a large percentage of fertilizer nutrients may be recovered following years of drouth most other production costs are a total loss, and the entire farm economic structure may be jeopardized when a shortage of moisture seriously reduces yield. We are reaching a stage where soil moisture is the limiting factor in crop production. Even in Missouri with from 30 to 50 inches of annual rainfall there are few seasons when a moisture deficit does not limit yields.

Water Required to Produce a Pound of Dry Matter

Crop	Pounds Water	Variation
Wheat	453	102
Oats	552	194
Corn	349	119
Sorghum	277	61
Alfalfa	853	411

Most people do not appreciate the amount of water required in crop production and have erroneous concepts concerning the rate of loss or the amount required. This means that the large amounts of water required to grow these various crops (500 pounds of water to produce 1 pound of dry matter) would be over 20 acre inches, or 600,000 gallons for a 5 ton crop. The variation in amounts of water

required becomes the function of other growth factors—soil fertility level, for example. A thick growth of lespedeza on a lime-deficient and low-fertility soil, would remove almost as much water as lespedeza growing 2 feet high and producing 2 to 3 tons of hay per acre.

The amount of water lost by a land surface is primarily determined by the amount of energy (heat from sun) reaching a soil surface. For example, the "evapotranspiration" rate (this is a long word that will soon be common-place to most farmers vocabulary—refers to the total moisture lost through leaves of plants and from the surface of soil) is essentially the same for a given period with live cover from a good bluegrass pasture three inches high, from a cornfield with plants 8 feet tall or a forest 100 feet tall. Other factors, such as humidity and wind velocity, have only minor influence.

Water Needed by Corn

Our measurements indicate that the average moisture requirements of a corn crop will be about .15 inches per day, or about an inch per week. This would be about 17 inches annual requirement for a 120 day hybrid. Many of our better corn soils can store an inch of available water in 6 inches of soil. If roots can exhaust the moisture to a depth of 4 feet, then this is a storage reserve that would require an additional 8 to 10 inches absorption from rainfall for optimum yields.

We do not know all the relationships between crop moisture requirements and climate, but measurements made in years like 1954 indicate that the evapotranspiration figure for corn may be nearer .2 inches per day in central Missouri instead of .15 inch (much higher on individual days). This would raise the water requirement to 1.5 inches per week or nearly 25 inches for a maximum corn crop.

Results of Irrigating Corn at McCredie Field

Year	No Water	Water	Increase	
1948	95 bu.	101 bu.	6 bu.	
1949	99	129	30	
1950	77	85	8	
1951	Not irrigated			
1952	75	101	26	
1953	51	79	28	Avg. 16 Bu.
1954	2	74	72	
1955	79	150	71	
1956	118	141	23	--- 55 Bu.
	9 year average		30	

Much is yet to be learned regarding the most efficient use of irrigation water in Missouri. In the past we have used as a guide the addition of water when the moisture level drops to 50% of field capacity in the surface 2 feet. Through 1953 this gave us an average increase of only 15.3 bushels of corn at the McCredie field—probably not sufficient to pay the cost of putting the water on the land with some irrigation systems. Since 1954 when additional water has been used, the yield increases have been much greater.

Cotton has been the crop (one of high value per acre) that has shown the greatest return from supplemental irrigation water. It is grown in an area of unlimited water supply.

These results show that water alone is not sufficient. There is no point in making these moisture additions unless there is a good stand, soil fertility is ample, insects are controlled, and other production practices are optimum.

Response of Cotton to Supplemental Irrigation and Soil Treatment
Sitner Farm - Average 1953-54
Pounds of Lint Cotton

Soil Treatment	No Water	Irrigated
None	502	663
Full	697	1070

When one considers that lint cotton is worth about 35 cents per pound, this kind of response becomes most attractive.

Response of small grains to supplemental irrigation has been small. The soybean is a crop that is frustrating to the investigator—both from the standpoint of plant nutrient requirements and water use. Apparently there are other factors that have not been isolated that are limiting yield more than is a shortage of moisture.

Pasture Irrigation Important

Irrigation of pastures offers much opportunity, particularly for dairymen. However, adding water to grass increases many problems. On irrigated, and heavily fertilized pastures we have increased the number of animals until we were carrying eight per acre. This did not increase gain per acre over the grazings of a smaller number of animals. The additional tramping and droppings actually reduced feed intake and a reduction in rate of gain.

Some systems of farming must be changed to higher value crops to justify such investments. We can't just put water on our present crops. Changes must be in kinds of crops grown as well as in alteration of farming methods. We should not be completely carried away by interest in irrigation systems. Remember, we are still in an area where annual precipitation exceeds crop needs. Certainly the people in the Missouri Valley between St. Louis and Kansas

City, have not forgotten 1951. And the ditches in Southeast Missouri were not dug for irrigation to carry water *from* the Mississippi River. Actually we are doing a very poor job of utilizing the water that falls as rain. Too frequently the creeks are out of their banks, yet two weeks later crops need moisture, and four to six weeks later stock water is being hauled from town.

Save Rain Where it Falls

We must give more attention to saving and utilizing rainfall—where it falls. Illinois has reported a 96 bushel yield of corn from moisture stored during the winter, and no rain during the growing season—the ground was covered. Fall plowing to leave the surface rough, contour tillage, sub-soiling and other management practices can reduce runoff and store water in the soil for later use. Adding organic matter is important, but it will only increase the rate that water penetrates. Organic matter has little effect on water-holding capacity as is commonly believed.

It is also necessary that we break with some other soil and crop management practices that are almost sacred. Legumes are good livestock feed, but inefficient producers of nitrogen. Nitrogen can be purchased in a bag much cheaper than it can be grown. The legumes also utilize moisture that is critical in the production of the following high value cash crop.

We have long emphasized the merits of growing cover crops to prevent erosion and leaching. We now know that the moisture used by these cover crops may be of greater detriment than the benefits. With heavier fertilization, and deeper rooting, more water is used by the high value crops, they return more residues, and a growing cover is of less importance.

Missouri farmers need to awaken to the possibilities of irrigated agriculture in this state. This does not mean that all farmers should use intensive irrigation. We have much land where an extensive system will be most profitable. This does not mean that all that is necessary is to put water on the crops we are now growing. Many farms will require entirely new crops (probably specialty crops) to make irrigation profitable. Careful analyses of costs of water and returns should be made before an investment is made in an irrigation system.

LEGAL ASPECTS

Willard L. Eckhardt

PROFESSOR OF LAW
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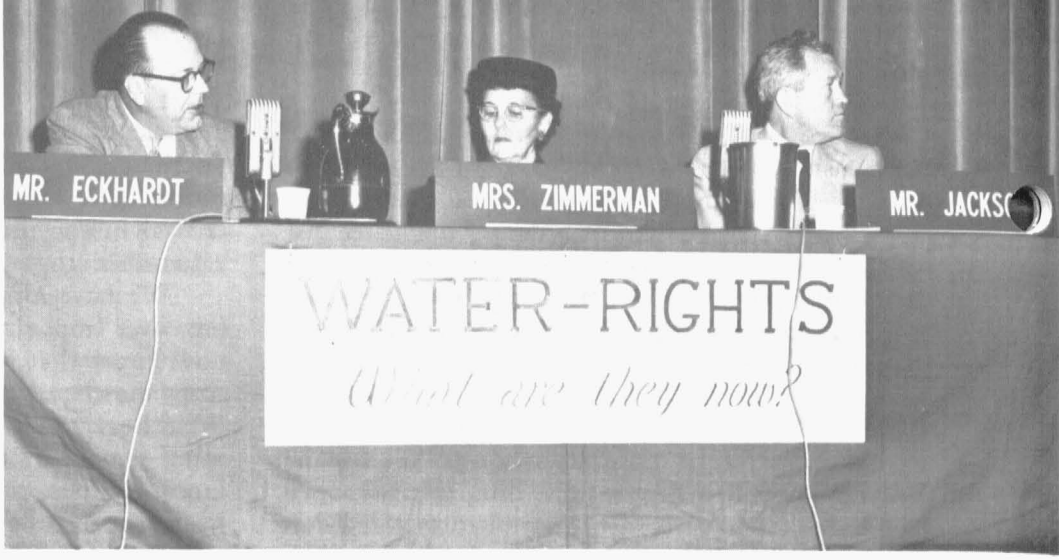


Legal Aspects of Water Rights in Missouri were handled by panel discussion. Pictured above in this phase of the Farm Forum discussions are, Willard Eckhardt, Professor of Law, University of Missouri; Katharyn Zimmerman, State Leader, Missouri Home Economics Extension work, and Jack Jackson, Director of Agriculture, Radio Station KCMO, Kansas City, Mo.

I WOULD like to talk for just a few minutes about "What is this thing we call law"? To most of us, law means that part of the law that in some personal way we come in contact with. To the public generally, law means criminal law. The contact may be nothing more serious than a speeding ticket or something of that type. But criminal law—the phase of law that is in the newspapers—is the bulk of law to most people. Criminal law is very important, but it is the least part of the law and not the bulk of the law.

So far as farmers are concerned, their touch with the law has changed over the years. I was a youth in the 1920's, and I think the chief agricultural contact with the law at that time was in the field of bankruptcy. Since then, fortunately, the typical farmer has a good deal of immediate contact with the law with reference to the law of taxation. He is now in the income tax brackets. The farmer also has immediate contact with that field of the law we call administrative law, through all of the government agencies that in one way or the other affect agriculture at the present time.

Now when one thinks of the law in Missouri, one is most apt to think of the statutes of Missouri, now published in two fat volumes. Those statutes have somewhere around 6,000 pages in the two volumes and they run into about 4,000,000 words. While that looks like a lot of law, that again is the smallest part of the law that we have in Missouri. Law that we have today came basically from an 1816 statute that adopted all of the English statutes, starting out with Magna Charta in 1215 and coming down to the year 1607. We also adopted all of the English case law—thousands and thousands of English cases that antedated 1607. In one fell swoop we adopted basically the English system of law. Since then, of course, we have had our own statutes as I indicated that now run into some 4 million words.

But beyond that, the bulk of our law in Missouri is found in the reports of decisions of the Missouri Supreme Court and the Court of Appeals in Missouri. Those decisions arise from controversies, some of them have to do with statutory problems, others(I would say most of them) have to do with problems for which there is no statute that applies. So the lawyer has to deal with the problem not only as applicable statutes, but also with this tremendous volume and bulk of case law.

For example, the reports of the Supreme Court now constitute about 365 volumes with about 1,400 pages of fine print to the volume.

I want to emphasize that the law is more than the most of us have any immediate contact with. There is a tremendous bulk, not only of statutes, but also of case law.

Problem Must First Arise

Now secondly, a general characteristic of our law and our approach to law is that the legislature

# of Water Rights In Missouri

and the courts ordinarily do not handle a problem until the problem actually arises—until we have an actual case. The courts themselves ordinarily will not declare what rights are in advance of an actual controversy. The result is that quite often problems creep up on us and the problems become quite acute before we have any declaration of what the law actually is in the particular type of case.

We do have anticipatory legislation occasionally. The best example, I think of that is zoning law. Zoning laws in cities are well accepted now. Zones are set up to preserve the general character of the city—residential zones, light business, light industrial, industrial, etc. There we anticipate problems. Currently, we are expanding into county zoning; some persons are advocating state-wide zoning; some national zoning; and some who are men of great vision, or are crackpots, depending upon your point of view, are advocating international zoning regulations. In zoning we, to some extent, anticipate the problem and set up the rules in advance, but with other problems, generally, we do not do that.

One other difficulty that I might notice on anticipatory legislation, is that ideas change and public policy changes. There is a problem of knowing what is going to be the best thing for us twenty-five or fifty years hence. Land drainage affords an example. This problem came to the courts in the period of 1910-1920. It looked then as if we would need lots of food. We wanted to bring more land into cultivation. So the court answered the question, "Can I drain my swamp, and throw my swamp water on the man down below me, and let him do the same thing with the man below him, to bring more land into cultivation?" by saying "Yes, it is desirable to drain land. The upper owner can throw his swamp water on the man below him."

Then in the 1920's the picture changed considerably. We had too much land under cultivation. It appeared that it would have been much better if not so much land had been brought under cultivation.

We always have that problem of a declaration in advance, either by a court or a legislature—What is going to be good five, ten, or fifteen years hence?

Water Rights in Missouri

With reference to the present water rights in Missouri, I must state to you quite frankly that most of the problems, I do not know. Nobody knows what the water rights are in Missouri today. We simply do not have the cases, or the legislation that clearly sets forth a man's rights with reference to water. Water rights are part of the law of property. Water rights are classed as rights in land; they are rights that are incidental to the ownership of land. If I own Black Acre, (a term we lawyers always apply to a piece of land) as an incident of my ownership, I have certain property rights in water.

That is the source of one of our problems—water rights are tied up with the ownership of property. Water rights presumably are property rights, and that raises the problem of the constitutional protection of property rights. They cannot be confiscated or taken without due process of law. These water rights then are tied in very directly with the ownership of land. If you own the land, you have water rights. If you do not own the land, you do not have any water rights.

We classify the water rights—I don't say this is the ideal classification but this is a classification we find in the law—according to the source of the water and the place where we find it.

First we will deal with the broad term "surface water". I notice that in your conference here, you use the term surface water to cover any water of the surface, not only the water in streams and lakes, but also the runoff. In law, we break down that classification and our first classification is what we call "water courses". Water courses includes streams, rivers, a good many branches, lakes, great ponds (whatever they are), the great springs, and underground rivers if the course of the underground river can be traced. We have one set of rules that is applicable to the surface water that we classify under "water courses". It is in that area that we do have a certain amount of case law and statute law in Missouri.

I will talk about rivers being typical of all water courses. There have been three principal doctrines developed as to the right of user. The right of user is limited. It is tied in with the ownership of land, and it is limited to the so-called riparian owner. In a few minutes, I will discuss what we mean by a riparian owner, but essentially he is the man who owns land along the stream. There was no law on this subject up to about 1800. Apparently there was plenty of water for everybody to use. There was no occasion to have any statute law or decisions, any common law on the use of rivers.

Starting in 1800 and for a period of thirty-three years, England had what we call a *prior appropriation doctrine,* a doctrine that provides essentially that the first man to use water has a right to continue to use the same quantity of water.

Then England shifted over to what is known as

the *natural flow doctrine.* That doctrine essentially is this: that a man may not sensibly change or diminish the flow of a stream or water course. You may not sensibly diminish the flow by extracting water for irrigation. You may not sensibly change the flow by damming the stream and thereby decreasing the flow of water to the man below. Under that natural flow doctrine in its extreme and literal form, practically no use could be made of water out of a smaller stream.

On the Missouri or Mississippi, I suppose a large quantity could be taken without sensibly affecting the flow. But when you come to the smaller river, the creek, and the branch, then almost any use would visibly affect the flow of water. That is the basic English doctrine that has been maintained for many years, and it is a doctrine that we find announced by many states, and it is a doctrine that our Supreme Court and one of our statutes has recognized a good many times over the years.

Reasonable User Doctrine

Another doctrine that grew up in this country is what we call the *reasonable user doctrine.* That is a doctrine to the effect that any riparian owner can make use of the water in a reasonable manner considering the rights of every other person who is interested in using water out of the same stream. That is, at least considering the reciprocal rights of all other riparian owners. Now that reasonable user doctrine has had a good many statements in its favor in cases decided by the Missouri courts.

So we find ourselves in the position. In many cases the court has stated this natural flow rule that you cannot appreciably change the flow of water in quantity. You find many statements of the reasonable user doctrine. You can use a considerable quantity considering the reciprocal rights of others. Two years ago the Attorney General issued an opinion which reflected both the natural flow theory and reasonable user theory, and nobody knows which theory will really be applied in the showdown. I suspect the reasonable user theory will be applied. That is, a man can take as much water out of the stream as is reasonable in view of the reciprocal rights of others situated on that same stream.

I might say, incidentally, that the right to take water out of a stream for domestic uses is unlimited. The common law recognizes the highest priority in that area.

The second distinct area of water rights law is with reference to what we lawyers call surface water. We use that term in the limited sense of the ordinary runoff. That is, the water that hasn't yet gotten into a well defined channel or stream. Again the courts in different jurisdictions have different theories. The one doctrine is known as the *common enemy doctrine.* That is, this runoff—this surface water—is the common enemy of the land owner, and he may prevent the water from coming on his land in any way that he can. In its extreme form, that would mean that if I wanted to prevent water from coming on my land, I could build a dyke or embankment on the upper side of my farm and back that water up on the land above me.

The other law is a *civil law rule.* It is sort of a natural law rule that water ought to run where it has been accustomed to run in the past. In other words, you cannot block up the water and back it up on the man behind you. Missouri has worked out a fair compromise on that. We seem to apply the civil law rule in the country. In the country, you cannot block this surface water from coming onto your land. You cannot create a slough, or a pond on the farm immediately above you. That is a reasonable doctrine for the country. In the city, we adopt the common enemy rule. In the city you have the possibility of storm sewers, artificial drainage, etc. In the city with this common enemy rule you can keep the water from coming onto your land.

We do have other problems with surface water. In addition to the problem of warding off unwanted surface water, we also have the problem of appropriation. You have this surface water running over your land, either the water that falls on your land, or water that falls on the land of the man above you and comes down over your land. You may appropriate all of that by a system of embankments or ponds and keep that water for short times. As far as we know in Missouri, there is no law, there is no limitation on appropriating surface water. You can build as many ponds as you want to catch the water that falls on your land or that runs down on your land so long as this water has not gotten into a stream. Once it has gotten into a stream, its character has changed completely.

Problem of Flood Water

A somewhat related problem is that of flood waters. We have one set of rules on water courses and streams, another set of rules on ordinary surface water. But what about flood waters? This falls into an in-between category. Flood waters are treated to considerable extent like surface waters in that you can impound as much of these flood waters as you wish and hold them. On the other hand we apply

the common enemy rule in that you can build a dyke to keep the flood waters from coming on to your land even though that levee is going to throw more water, or water at a greater velocity, on the man below you. So flood waters are a sort of in-between category.

The fourth area wherein the state rules on water is what we call underground percolating waters. We presume that all underground waters fall into this category, unless there is clear proof that we are dealing with an underground stream. The ordinary waters that you reach either by an artesian well or by a drilled or dug well are underground, percolating waters.

There are two problems here. One is the problem of pollution of underground waters. The typical case is where an oil company has a leak in its gasoline or oil tank and oil seeps into the underground strata and spoils the water for drinking purposes. We do have a few cases on that in Missouri. That is the liability of the oil company that pollutes the water and makes it unfit for drinking purposes.

Our chief concern today is with the right to use this underground water. Here again, different courts have had different theories, and neither theory has been clearly expressed in Missouri. The earliest doctrine we find is an *absolute ownership doctrine.* You own the surface and you are the absolute owner of all the water that lies beneath the surface of that land. You are the absolute owner whether that water is initially under your land or whether, by reason of pumping, the water flows under your land from adjoining lands. This is the *absolute ownership* doctrine. If you are the absolute owner, you are privileged to pump as much as you can use on your own land, you can pump as much as you want to use on other land, or you can pump it for the sheer fun of pumping it. You can do anything with it you wish. A number of our early American cases adopted that theory, when there seemed to be an unlimited supply of underground water.

Reasonable Use Doctrine

The other doctrine that is receiving current attention from the courts is the *reasonable user doctrine.* The current trend is that the owner of the surface has the right to pump as much from beneath his land and he can reasonably use on his own land. Under that doctrine he can be limited in using that water off his land or in selling it to the owner of other lands.

On this particular problem, I do not know what the law is in Missouri. We just do not have any case on the problem. I could guess that when litigation arises our court will probably apply some sort of a reasonable user doctrine. But up to the present moment, we do not know what doctrine our courts may adopt.

We have the practical problem of what you are to do if you are contemplating an irrigation system, extracting water from a stream, drilling wells, getting underground waters. You have a potential investment of anywhere from $30 to $100 an acre, and your investment, of course, could run into a very, very substantial amount. What should you do? I would say, that in any event, you ought to talk to the lawyer that is handling your tax problems and other problems. Talk to him about that problem with reference to the particular stream that you are drawing water out of or with reference to drilling wells.

Your own lawyer may not be able to give you a definite answer on all of this, but he is a man who can look up what little law we do have in Missouri on the problem. Your own lawyer is on the ground; he has a sense of the feeling of the community, how much danger there is of getting into litigation. He can give you not only some legal advice but, I think, some good, sound, practical advice as to whether it is a reasonably safe course for you to proceed with the particular program that you have in mind.

In addition to that, of course, you ought to get all the information you can from other sources. The state geological survey may give information on the probably quantity of underground waters, etc. With all this information at hand, and where the law is not definite, you simply have to make your own best estimate as to what your chance is of having enough water available, and also what your chance is of not getting into litigation with other persons over the water.

Yesterday, Professor Penn talked about this very interesting controversy between the city of Fond du Lac and the adjoining farm areas. There you have not only the problem between one farmer and another farmer that lives on a stream and wants to use the water, but you have the problem of competing uses between the city and the country. We do have some legislation on that type of case in Missouri. The city is in a position to go out and get the water that it needs.

The right of the city is recognized, and again that is right at least for domestic purposes. The people must have the water to live. But in Missouri, although a city has the right to go out and take the

water it needs, it has to condemn the right, and it has to pay for that right. And that again I think is only fair, that the farmer or other riparian owner who is injured, while he may have to suffer that injury, at least he ought to be fairly compensated for the injury that is done to him.

Who is a "Riparian?"

Who is a "riparian"? If you have land on a stream, you are a riparian owner. Beyond that, in Missouri, we do not know how far riparian rights extend. Quite generally they will not extend beyond the watershed of the particular stream—that is the extreme limit. But various states have adopted various rules. Quite generally the riparian rights are limited to the man who is immediately adjacent to the stream. The rights are in the land he owns. Some states limit riparian rights to the original government survey sections that were surveyed along a stream.

That would mean that the water could not be used beyond that particular group of sections of land. So in irrigation, we have the problem not only in the man immediately adjacent to the stream using the water, but can the water be pumped for the man who lives back of him who would also want to use the water. The problem is to whether the cooperative group could go together and pump water for all members of the particular cooperative group.

I have tried to talk to you very briefly about: first, what law is generally, secondly, how law approaches problems in advance of actual litigation. I have tried to indicate the reason why we do not have more laws in Missouri today than we do. Simply, it is because up to this point, problems have not arisen in such form that brought the problems to the courts. Then, I tried to indicate in a very broad way, what the rights probably are in the various categories of water in Missouri today.

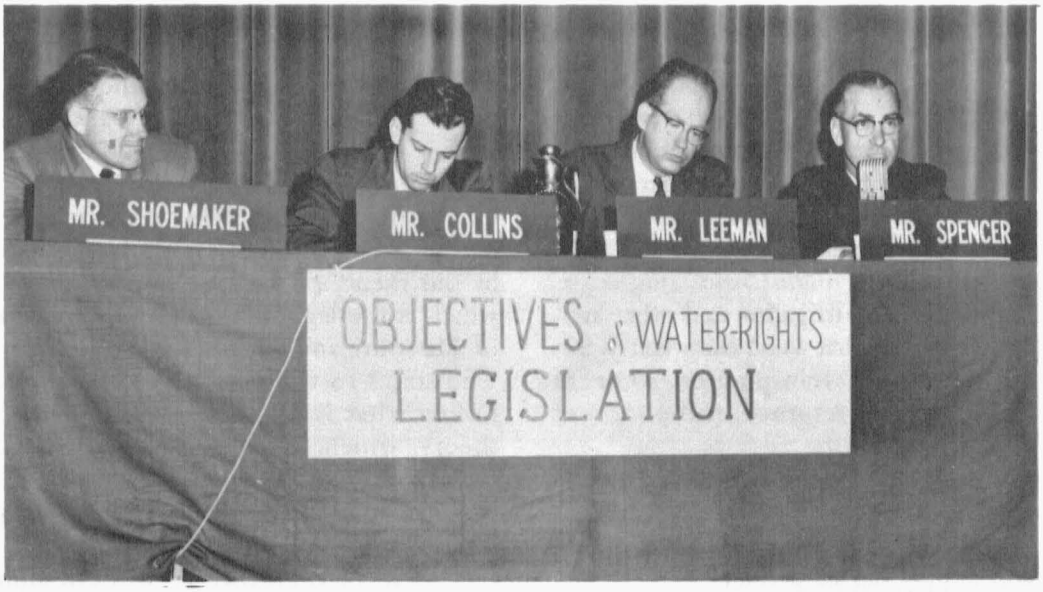
Objectives of . . . WATER-RIGHTS LEGISLATION

George Spencer

STATE SENATOR
MISSOURI GENERAL ASSEMBLY

WATER, or the lack of it, is a much greater problem than the general public realizes.

The city dweller thinks of water as it comes through his water faucet for personal and domestic uses. The industrialist thinks of water as it relates to his need in industry. The city official thinks of water as it relates to prevention of fires, the cleaning of streets, etc. The sportsman thinks of water as it relates to the production of fish and wildlife. The farmer thinks of water as it relates to his personal use, the needs of his livestock, and its necessity in the production of crops. Some people think of water and its problems only in case of heavy rains or the lack of rain, but we have not only the problem of surface water, we have the problem of underground water.



Objectives of Water Rights Legislation were discussed by the panel shown above, consisting of Dr. Karl Shoemaker, left, Chief, General Economics and Sociology Branch, Federal Extension Service, Washington, D. C.; Richard Collins, Associate Editor, Missouri Farmer, Columbia, Mo; Wayne Leeman, Staff Writer, St. Louis Post-Dispatch and George Spencer, State Senator, Missouri General Assembly, Columbia, Mo.

When we stop to think that in 1900, 40 billion gallons of water were used per day, while in 1955, 262 billions of gallons were used per day, and in 1975 it is anticipated that 453 billion gallons of water will be used per day, we readily see that a problem exists to assure adequate supply. In the last 55 years, the daily use of water increased by 252 billion gallons, and in the next 20 years it is expected that it will rise another 191 billion gallons per day.

Consequently, it appears that our problem is the conservation of water resources so that the fixed supply can meet progressively increasing agricultural, industrial and domestic demands. We must start thinking about utilizing the available supply of surface water for maximum economic benefit. Thus, the objectives of any water rights legislation should tend to solve this problem.

Harvest Water Like Crops

It is a recognized fact that there is sufficient water at the present time to supply our present and contemplated needs. The problem is that this supply does not come at the regular and required intervals. We have sufficient rainfall, but, as we have observed this year, it does not come always at times needed. For this reason, we must learn to harvest our water like a crop and not mine it like coal. As pointed out above, and as you have heard on this forum, one of the factors to be considered is the extent to which the use of water is increasing.

Another factor is the varying effect of different uses of water. Municipal and industrial uses are largely non-consumptive. Approximately 90% or more of the water withdrawn for these uses is ultimately returned, and the problem connected with these uses has to do with their effect on water quality rather than quantity.

On the other hand, in irrigation and other agricultural uses it is evident that ⅔ of the water is lost through evaporation and transpiration, some of which, of course, will be returned in the form of rainfall.

The other main factor deals with the legal rules governing water rights, which cannot of themselves increase the supply of water but can only determine how the water supply can be divided at places and times when there is an insufficient quantity to meet the demands of all. This is the problem of legislation.

In my opinion, this cannot be solved by an anti-water-pollution piece of legislation, and I am a firm believer that the only way to attack the problem is by an over-all water policy. Here again, it is not as simple as it may sound, as any legislation seldom is, because the real conflicts and basic problems are caused by conflict of public interest which arises from honest difference and sometimes from selfish interests.

It might be pointed out that in the upper portion of the Missouri River Basin the people honestly and naturally feel that the Missouri's water should be developed primarily for irrigation and hydropower, while in the lower part of the river they need water equally badly for navigation and water supply. That is a perfectly honest difference, and the problem is to reconcile that difference, as it is the problem to reconcile all other differences with legislation.

Even among people interested in farming alone there are various and sundry problems and conflicting interests. Could a farmer impound all the water that falls upon his farm by innumerable ponds and large reservoirs? Should he be entitled to impound all spring water on his farm? Should he have the right to use all the water he desires for irrigation purposes? Should he be permitted to straighten out the natural streams to speed the flow of water to the farmer below him? Should he be permitted to build levees to keep the water within the banks and speedily move the water on to his neighbor, or should he be prohibited from constructing levees and let the water spread out and leave more naturally? Should he be permitted to drill all the large and deep wells—bearing in mind the falling water level —that he might need for any and all agricultural pursuits?

You have heard Professor Eckhardt discuss the legal problems connected with some of these matters in the state of Missouri as they are governed by our theory of the law known as riparian rights, which is the legal philosophy followed in the state of Missouri and in most states to the east of us. The states to the west of us, however, generally follow what is known as the prior appropriation theory, which generally means "first come, first served." It is generally considered that 31 states have followed the old English rule of the riparian doctrine.

Eight of the other 17 western states felt that the riparian doctrine was not a suitable method of insuring the most beneficial use of water resources, so Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah and Wyoming set up their own system based upon custom and usage. This result was accomplished by constitutional provisions making it clear that the English rule of decision would

not be binding in those states. The remaining 9 approached the appropriation doctrine by some conversion method in one way or another.

I want to emphasize that it is my thinking that an over-all water policy must be set up by legislation, and it cannot be done through decisions of the courts.

We Know When Creek Goes Dry!

Professor Eckhardt has set forth many problems dealing with riparian rights, and if we waited for each of them to be decided by the Supreme Court, it would be an endless task. This is exemplified by a statement of a Chief Justice of the Supreme Court of one of our neighboring states wherein he told of an opinion he had written, and within six months after it was handed down, he was convinced that his opinion was wrong, but it took 9 years to find an opportunity to set it right again. When we discuss this matter from a legislative viewpoint, however, it is certain that most of us do not know much it is certain that most of us do not know much about prior appropriations or riparian rights, but one thing we do know for sure is when the creek goes dry!

There has been no legislation proposed in the state of Missouri covering this over-all problem. At the last session of the legislature, a bill on stream pollution was introduced but failed of passage. A resolution was introduced by Senator Jack Jones of Carrollton and myself, to set up an interim committee of the Senate to study this problem.

We proposed in the broad phases of study by this committee a study of existing water resources, existing and future needs and uses of water, and the means of conserving water resources. The subjects which we proposed to include were surface water, ground water, water supplies for domestic and municipal use, irrigation and drainage of agricultural land, water for recreational and scenic attraction, farm ponds and storage of water, fish and wild life propagation, water for fire protection, pollution abatement, power development and related subjects.

The Attorney General ruled that our committee was without legal authority, and we did not carry on our study as previously anticipated. We propose to initiate another resolution at the next general assembly to properly set up such a study committee.

Passage of legislation dealing with this over-all subject is not simple, and since this is not a problem local to the state of Missouri, we might review some of the problems and progress made by other states.

The Wisconsin permit system was set up in 1935. It apparently requires a permit to be obtained from the Public Service Commission for the diversion of water from any stream for agricultural or irrigation purposes, and the quantity and time are controlled by the Commission and subject to not diverting water which would injure the public rights, and only "surplus water"—water which is not being beneficially used—may be used by other riparians located along the stream.

In 1951, a rule was adopted that the permits be granted in cases where the percentage of water diverted would be so low that no injury to public or private rights could be anticipated and where any required consents of riparian owners are obtained.

The Minnesota permit system was set up in 1937 and reenacted in 1947, making public water subject to the control of the state, and a permit was required except for the use of water for domestic purposes serving less than 25 persons. All of this was subject to existing rights and the "public water" was the water in excess of existing rights in all waters and in streams and lakes. There are practically no guideposts or standards with respect to granting or denial of permits, other than permits are not to be granted if the proposed use is wasteful, dangerous, impractical or against the public interest, or in the case of irrigation, would deprive another of his rightful share of such waters, which he has requested.

The North Carolina permit system was enacted in 1951, which requires that permits be obtained from the Director of Conservation and Development before utilizing waters in a stream or lake for "purposes of irrigation" in such an amount to "substantially reduce the flow or volume thereof". The applicants must submit a proposed irrigation plan and survey and the Director is authorized to investigate such plans and to issue permits, and no standards or regulations have been promulgated in aid of the administration.

None of these statutes above mentioned says anything concerning what effect, if any, priority in time of application would have, and it appears it would have little, if any, significance.

Existing Legislation Inadequate

It will be noted that the existing legislation is very inadequate, and certainly does not appear to be the solution to the problem. A number of states have within the last few years proposed bills. South Carolina has been working on a water policy plan for many years.

A bill was introduced in 1954 to declare the state's policy to promote the attainment of the fullest beneficial use of its water resources and the prevention of waste or unreasonable use. It purported to establish the doctrine of prior appropriation of water in surface water courses, except for certain domestic use, and such waters as are actually being put to some other beneficial use when the law goes into effect or within 3 years prior thereto, which are defined as vested rights.

Subject to these domestic uses and vested rights appropriations of different quantities of water in surface water courses at specific times, places and rates of diversion could be granted by the State Board of Water Commissioners created by the bill.

Presumably appropriations could be granted for an indefinite length of time, although the appropriative right would be forfeited by failing to use the water for the specific purposes for a period of three consecutive years, and no legally acquired appropriation could be declared forfeited except by a court.

It will be noted that this eastern state invokes the principle of priority in time of appropriation, and it appears that in times of shortage senior appropriators would be entitled to the available waters over junior appropriators from the same source. The bill also provided that where further appropriations of water for different purposes conflict, they shall take precedence in this order: domestic, municipal, irrigation, industrial, recreational, and water power uses.

Although the bill allows non-riparian to obtain appropriations, it provided no way to help the appropriators obtain access to the stream. The bill provided for administration, determination, and the establishment of rights of all riparian owners who on the effective date of the act were making beneficial use of the water, and various provisions relating to its enforcement, including obtaining an injunction and criminal prosecution.

I hasten to say that the bill did not pass. But in 1955 it was tried again with changed provisions by eliminating the preference by type of use, except domestic use was given top priority, and the Board given general instructions to reject grant or modify applications, and provision was added which would authorize the Board to establish the "average minimum flow" for any given point of any stream when reasonably required for purposes of the act, and appropriations could be granted only for the excess of this average flow.

Other provisions were added to narrow the type of watercourses to which the act would apply and the instances in which construction of dams would be subject to it, and prohibited interference with relations established between legal water users by contract.

Even with these many amendments, objection was raised as to the possibility of granting appropriations of definite amounts to anyone in perpetuity. It might be added that this act failed to pass, but further work is being done to limit the granting of a right in perpetuity and limit it to a certain number of years, and the renewal would depend on existing circumstances when such renewal was sought.

The North Carolina legislature considered a bill in 1955 similar to the South Carolina bill, but it failed to even get out of the Committee on Conservation and Development. The main difference between the North Carolina bill and the South Carolina bill is the preference given where future appropriations of water for different purposes conflict, and the North Carolina bill provided for water for human consumption; water for agriculture and industrial production, and third, for water for other beneficial purposes.

It might be noted that North Carolina already has some legislation requiring permits for irrigation purposes, and North Carolina did pass a bill to create a Board of Water Commissioners to study the water resources situation and problems and make recommendations and with certain powers to act in emergency situations when so declared by the Governor.

The Arkansas Legislation in 1955 proposed another appropriation doctrine bill discarding the old riparian theory except for domestic riparian uses, and providing a fair and equitable division of water supplies as a practical means of providing a quantitative rule of guidance for apportionment of water. The bill expressly provided that priority in time would give the superior right, and the earlier priorities could use to the full extent of their rights. A State Water Control Commission would have been established to pass on applications and administer the act.

The proposed bill would provide that persons having actually applied water to "reasonable beneficial" use prior to its effective date would be given vested rights to continue to use such amount if it had not been abandoned. This provision was later abandoned in a later draft of the bill, and abandonment of only a portion of one's appropriation would not invalidate the whole. This bill failed of passage. Some of the objections were that the state would

control the use of water in local areas where such control might not be wanted and under the prior appropriation doctrine many small farmers might be excluded.

It might be added that another bill was passed in 1955 which simply stated the state's policy to control the use of water for all beneficial purposes and establish a commission to study the manner and recommend ways of implementing such policy, particularly as to natural streams and lake waters.

The Michigan Legislature in 1954 gave consideration to another proposed appropriation doctrine statute providing that the holder of any tract of land that conforms to the definition of riparian land included in the act would have a "Class A vested right" to the "reasonable use" of the stream or body of water to which his land is riparian, for purposes of domestic use, power, recreation or fishing on or in connection with such land.

Actual application of water to any "reasonable beneficial use" other than the type consisting of Class A vested rights prior to the effective date of the act, would be deemed to create "Class B vested rights" in such users to the extent of their actual application of the water for these purposes.

Water in any stream in excess of the needs for Class A and Class B rights could be appropriated on application to the Michigan Water Resources Commission for use on designated lands "riparian or non-riparian". Only Class A users could divert or impound any water required to satisfy the rights of Class B or appropriation rights with earlier dates of priority, and there are no provisions establishing preferences as between different types of uses.

The fate of this bill is uncertain, because of constitutional objections. However, it might be added that existing Michigan legislation authorizes county commissions and/or the State Conservation Commission under prescribed circumstances to establish and maintain the "normal" level of various public and private inland lakes with powers of condemnation.

A proposed bill was prepared for Wisconsin which would adopt the prior appropriation doctrine to apply to both surface water courses and underground waters, and which would permit diversions for any beneficial purposes without consent of riparian owners and which resembled other proposed legislation discussed above, but its application would be expressly limited to diversions or removal of stream or ground waters, and diversions were defined to include withdrawals whereby the water is not readily returned to the stream, and each appropriation right granted would be subject to the limitation of use for a "reasonable beneficial purpose."

Domestic and municipal uses were preferred to others, and the commission established would have power to designate the type of use granted.

Wide Study Made in Ohio

Ohio has made a wide study on the supply of water available in that state, and although there is sufficient water, the study indicates the need for the construction of additional reservoirs and pipelines to distribute the available water in periods of the year when not sufficient water is available. Comment might be made on other states, but time does not permit here. It might be observed that none of the states following the prior appropriation theory have changed to the riparian theory, while the proposed acts of the riparian doctrine states propose at least a modification toward the prior appropriation theory.

However, it might be noted in the states that follow the prior appropriation theory the holders of rights with highest priority may be provided a real dependable water supply, while others may experience a shortage; also one's use of water must be "beneficial", but it need not necessarily be "reasonable" in relation to the rights or needs of others in the sense required by the riparian doctrine of reasonable use.

Appropriated rights may be lost in whole or in part by failing to use the water for a beneficial purpose for a period of time; such rights are not lost by riparian users. Also under the appropriation doctrine land need not necessarily lie adjacent to a watercourse in order for the owner to have use of water therein. In most instances the appropriation system is accompanied by a state administrative control over the allocation of appropriative rights and the distribution and use of water, although in many of the western states the courts now tend to require a senior appropriator's use to be reasonable, particularly with respect to the prevention of waste considering the rights and needs of a junior appropriator.

The weaknesses of the riparian law seem to be the lack of reasonable legal protection for those who have invested their capital in irrigation systems, industry and other projects requiring use of quantities of water. It fails to recognize any system of priority of use, conservation and prevention of waste. It lacks administrative guidance to assure that development and use may follow a course which protects existing rights and to assure full utilization of water

resources in accordance with their inherent capabilities. The riparian doctrine was adopted when there was an excess of water and is not adapted to the complex agricultural, industrial and economic situation of today.

In the first place, it will be noted from the above, and it has been stated here on this forum at numerous times, that the problem of water and water rights is much greater than even those who have considered it contemplated, that the passage of legislation to solve the problem will be difficult, that the confusion in the whole field of water law demonstrates the need for the declaration of legislative policy for the over-all problem and for some solution to the problem of assuring that the available water supply shall be put to the greatest economic use, that no model statute suitable to a large number of states can be drafted, that the problem cannot be solved by developing the law through court decisions, where the problems generally involve damage by water or flow of water, rather than by use of water, and which do not provide workable rules for the maximum economic utilization of available water supplies, and that certainly such maximum economic utilization cannot be accomplished under the current common law as has been followed in Missouri and other riparian states.

Grave constitutional problems face all legislators where the courts have declared that the riparian owner has a vested right to use of water from a stream so long as that use is reasonable in relation to all other riparian owners.

In considering the matter of legislation, the role of the Federal government must be considered, because of the inter-state aspect of water in some regions. Being a great believer in states' rights, I think that the role of the Federal government should be limited to research and technical consulting, enforcement on interstate pollution situations, and perhaps financial aid.

No Need to Act in Haste

The task before Missouri and all other states similarly situated is not an easy one to determine a water resources policy, and it has far-reaching ramifications. The crisis is not so severe that we must act in haste. In my opinion, what is needed now is study, research and much more data than is so far available concerning water supplies, probable future needs, and the relative economic values of competing uses, which information must be supplied by economists, agronomists, engineers, and hydrologists, to provide the basis for legislation to serve the needs of future generations.

It seems to me that we need a water policy supplied by a modified type of the prior appropriations doctrine based on beneficial use, and then an individual, a municipality or an industry would know, barring an act of God, how much water it would count on and the way in which water can be legally used, which should be defined so clearly that waste would be eliminated and excess water conserved.

Considerations for Agriculture in WATER RIGHTS LEGISLATION

Fred A. Clarenbach

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MOST of the important considerations that leaders in agriculture must properly take into account when weighing alternative proposals for water rights legislation are not wholly peculiar to the agricultural industry. The central fact of our emerging situation is that virtually all groups of water users are making increasing demands on available physical supplies of water and that, at some times and places, some of these demands must go unsatisfied.

The central need is for more water—at the right times and places—and for better "rules of the game" in allocating both the present supply and prospective increases among the various users.

Such a statement of the situation and the needs sounds fairly simple, but the problems generated are in reality appallingly extensive and complex. What are the amounts and locations and qualities of present and potentially available supplies of water? What are the physical interrelations of surface streams and groundwaters? How do the various land-treatment practices for conserving soil and water, and the various water storing and conveying facilities, actually affect the behavior and availability of water at particular times and places? Adequate answers, in quantitative terms, to these and similar questions of hydrology are to be found in few areas of the country.

When engineers and hydrologists leave many questions unanswered, economists must do likewise. And even if the physical questions were answered, economists would still find it exceedingly difficult or impossible to answer many of the questions that are put to them. For example: What are the highest and best and most profitable uses, from a long-range public viewpoint, to which our water resources can be put? To answer a question of this kind, even for a limited geographic area, requires detailed projections and interrelated assumptions concerning population size and distribution, technological developments, shifting needs and demands of the people, and changing relative prices and costs.

Moreover, because significant human values are not satisfactorily reflected in the market system of an enterprise economy, these extra-market values would have to be brought into the picture in some

way before an acceptable answer to the question could be formulated. And how can the economist objectively and unambiguously give just the proper weight to each of the competing interests and the human values involved in each alternative pattern of water use?

The answer is, he cannot; for he has no common denominator for measuring these often vague, conflicting, important values. With respect to these extra-market values, however, he can use the same processes of judgment that are open to legislators or editorial writers or any thoughtful citizen. The worth of judgments concerning public policy, by economists, engineers, editors, judges, or farmers, or anyone else, will depend in large measure on the extent of knowledge and the degree of insight and integrity of the person giving the judgment. At the same time, non-economists may be able to arrive at better judgments by considering broadly some of the underlying economic factors in the situation.

What I have been leading up to, with respect to the water problem, is the suggestion that it is first and foremost a matter for extended and thorough debate as a set of far-reaching issues of public policy. The question of what kind of water-rights legislation, if any, a State should have cannot be settled intelligently and democratically in the absence of careful and unhurried public discussion. This Farm Forum is a recognition of the need for such discussion and is potentially a valuable contribution to the larger debate of the issues that is almost certain to develop.

Policy Decisions Should Come First

The first important consideration, then, is that the question of water-rights legislation is only one part of a much larger complex of questions that bear on the water problem. Any broad statute on water rights should follow, not precede, the emergence of a reasonable consensus regarding basic questions of State water policy. A legislative enactment should implement part of a State water policy and should be in harmony with other parts of the policy.

Unless there has been a real "thinking-through" of the complexities of the total problem, and an agreement as to the major aspects of a general State water program before a water-rights statute is passed, there is danger of serious error and a compounding of difficulties for the future. This does not mean that all elements of policy must be spelled out in one comprehensive law. Action can be by steps, but the successive steps should be pretty well thought out in advance and should add up to a meaningful program, the various parts of which will fit together.

I do not suggest that water policy can be decided on some given day once and for all. On the contrary, as times and conditions change, the old decisions will need to be reconsidered. Nevertheless, the fundamentals of policies wisely chosen can be stable even while these policies are evolving on response to changing needs and circumstances. "The law must be stable but it cannot stand still."

Nor do I suggest that State government policy alone can or should cover the whole field of water use and control. Certainly, there is a degree of national (and even international) public interest, as evidenced by Federal statutes and treaties and by substantial federal expenditures in water-resource programs. We must recognize also that many kinds of decisions can best be made locally—by local units of government (including special water districts of various types), by private contractual arrangements, and by individual landowners and holders of water rights.

I do suggest that the potential and proper role of State governments in setting policies is of key significance in improving and stabilizing the "rules of the game" of water use, including the development of additional waters. In most States of the Middlewest and the East, the water problems of the past have not been acute enough to persuade many people that broad action by the state was needed.

Piecemeal or occasional state attention to matters of drainage, flood control, pollution abatement, municipal water supplies, irrigation, or the like met the need in some way. Missouri State law, for example, enabled local districts to undertake drainage work, and the Federal Government took most of the responsibility in flood-control and navigation projects.

Now we are faced with the growing need to do much more than fight against too much water at some times and in some places. Unless the state establishes at least the firm outlines of a policy that covers not only water disposal and reduction of flood damage but also beneficial use, future conflict as to water and the confusion and waste of human energy and of water resources will be far greater than necessary. In the absence of adequate state action, it is likely that the Federal Government will be drawn more fully into the partial vacuum.

The pressing needs of water users could lead to a system of local-Federal relations that would largely bypass state governments. Such an evolu-

tion would spell the sacrifice of many potential values that flow from wise and realistic state planning and action in developing and allocating water resources.

Issues Concerning Agriculture

Now, more particularly with respect to agriculture, what are the issues and considerations? A commentator from another state said recently that what the farmers there need and want is a fair share of the water—that is, all they can get plus 10 percent, and that the only real question is how to go about getting as much as possible.

At times, it may seem that other interests may have a little of the same kind of feeling about their own needs and wants. But obviously such a facetious formulation is inadequate. It avoids the heart of the matter, which is the question of an equitable and efficient basis for sharing scarce water among the many who need and want it.

As the debate has shaped up in some states, it has tended to center around two considerations: (1) How to promote the public interest in achieving the best all-around use of water, over time; and (2) how to protect the holders of water rights (and those who have investments that depend heavily on water) from unjust losses when significant shifts in water uses become necessary in the public interest.

An important facet of the debate has stemmed from the contention that existing riparian law of watercourses in the Eastern states, including Missouri, does not give water users a sufficiently definite and secure right to continued use of water to justify the heavy investment that is often associated with water utilization. It has been contended especially that potential irrigators are deterred from investing in equipment for supplemental irrigation because the water-rights situation is so obscure and uncertain. In some states, in fact, it is apparently an open question whether irrigation from surface streams and lakes is a legally permissible beneficial use.

The remedy that is frequently proposed is statutory restatement and change of the law of water allocation in the direction of some version of western "prior appropriation" doctrine. Some supporters of this proposal speak as though "prior appropriation" were a panacea and the only alternative to an alleged weak and crotchety riparian system. In fact, we have a wide range of alternatives. Western water law itself embraces not only many distinct variations of appropriative rights, but also (in 9 of the 17 Western states) the more or less significant elements of the older riparian systems.

Moreover, some features of western systems, such as the usually important role of State administrative agencies, are adaptable in the East without going over to a prior appropriation rule. The western law is by no means a unified, consistent, and wholly satisfactory system. It is in process of change in the direction of greater flexibility while some of the riparian systems are showing signs of greater orderliness and definiteness. In other words, there is an apparent tendency for the two broad classes of systems to move toward each other and possibly to meet on a middle ground.

Perhaps, then, it would be wise for a riparian state to consider what would be involved in moving forward to a better middle ground, as an alternative to either standing still or jumping "all the way over" to prior appropriation and then having to work back toward the better middle ground.

In Indiana, for example, there is a feeling that neither traditional riparianism nor prior appropriation is the answer to the present and future needs of a humid, mid-continent state.

A policy and doctrine that centers directly on the idea of maximum or optimum use is being developed. As an early step, the drafting of a legal framework to encourage the building up of larger available supplies is being undertaken. Certainly, it is clear that new laws alone cannot produce more water, but proper laws can promote the storage and development of water for best use at the times and places needed.

Whether irrigation is the best use of water is a question that cannot be answered categorically—in fact in that form it is an almost meaningless question. There is no doubt that in some localities, at some times, for some crops, the best use for some quantity of water is irrigation. The place, crop, and quantity depend on many particular circumstantial factors such as production costs and returns with and without water, alternative crops and land uses, and competing non-agricultural needs and demands for water in the area.

Moreover, these factors are likely to change through time, and the best use today may not be the best 4 or 5 years hence. Today, it may seem unjustifiable from a national viewpoint to use valuable water and costly equipment to irrigate subsidized cotton to swell the surplus in Government storage. Possibly some years from now this situation will change, but the outlook in 1956 appears to cast

doubt as to the overall economy of extensive acreages of some irrigated crops, including cotton.

How to Fit National Policy

All this points to the difficult question of how to fit national policy considerations into the regional and state and local determinations of how water may best be used. From a local agricultural viewpoint, the heavily consumptive use of water for irrigation will frequently prove to be profitable. In some such situations, this use will pretty clearly be in the interest not only of the irrigators themselves but also of surrounding local and regional economies and the country as a whole.

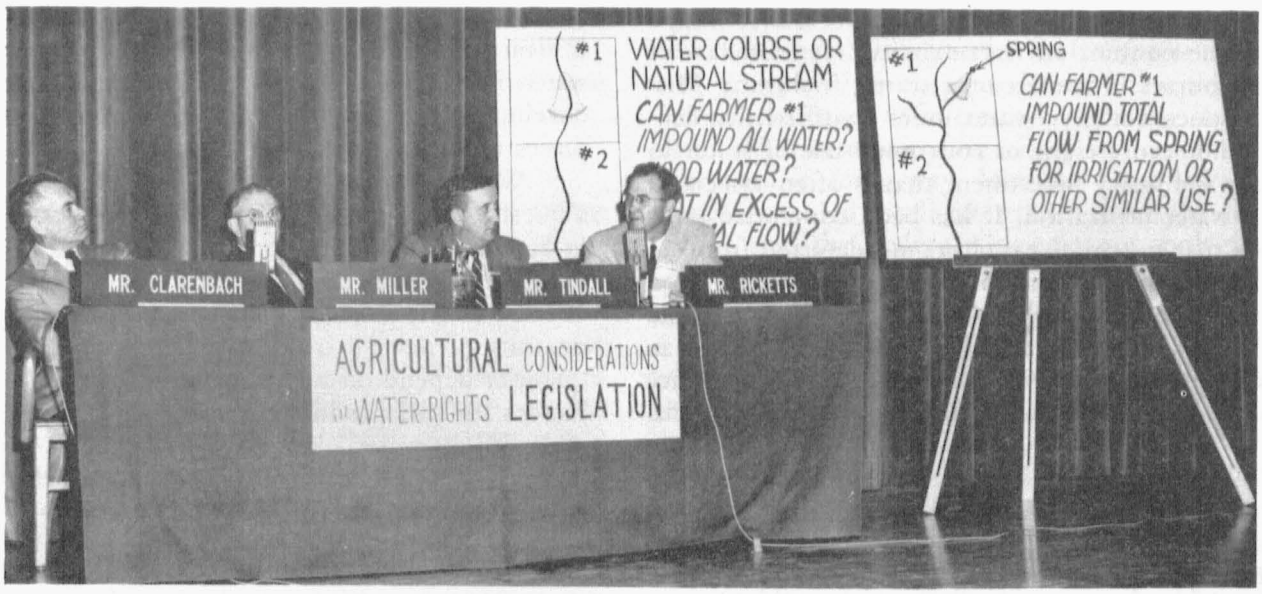
In other instances serious conflict of interest will develop. Not only will non-agricultural users (municipalities, industries, and recreation interests) sometimes object to irrigation, but other farmers also will be adversely affected at times. Non-irrigating farmers may find their water sources for domestic and livestock uses seriously depleted; and other irrigators, both those in the neighborhood and others more distant, might be claimants for the same water. Riparians and non-riparians are not likely to see eye-to-eye.

"Agriculture", in short, does not have a single, unified interest in all aspects of water legislation. It should be recognized that within a state there may be great differences among basins and localities, both within agriculture and as between agricultural and non-agricultural uses.

So far as feasible, state policies should permit action to be tailored to the particular needs of the basin and locality, with full regard for nonlocal private and public interests. This consideration would appear to argue against establishing by law any statewide fixed system of use preferences (except for domestic uses) such as is sometimes associated with the appropriation systems of Western states.

Permanent or Temporary Rights?

The prospect of important shifts in water needs also argues for caution in allowing heavy low-return uses to grow up and acquire prior, "permanent" property rights in water. Other major public (and private) users may soon have a choice only between developing water at high or prohibitive cost, or buying out existing rights holders, also at high cost, in order to make water available for more important uses. If an ordinary prior appropriation doctrine were adopted, probably substantial unearned gains would soon accrue to many fortunate speculators in water rights and irrigable lands as well as to some farm operators.



Agricultural Considerations in Water Rights Legislation were discussed by a panel group, shown above, consisting of Dr. Fred A. Clarenbach, left, Agricultural Economist, Agricultural Research Service, U. S. Department of Agriculture, Washington, D. C.; Dr. Frank Miller, Professor of Agricultural Economics, University of Missouri; Cordell Tindall, Editor, Missouri Ruralist, Fayette, Mo., and Ralph Ricketts, Extension Professor of Agricultural Engineering, Missouri Extension Service, Columbia, Mo.

Under either a modified riparianism or a modified appropriation system (or some other label), it might be well to consider the alternative of granting temporary permits that would carry a right of water use for a specified period, such as 10, 15, or 20 years. In this way, optimum short-run use of water could be approximated without giving away valuable permanent vested rights to a relatively few persons. A legitimate extension of this idea is the sale of temporary water rights by the state.

Another device that is used increasingly in the West in connection with publicly and privately developed waters is the water delivery contract, under which water is sold and supplied on a utility-contract basis. Probably, development of some kind of market system for water and water rights would focus attention on and would help to clarify the question of cost-sharing and subsidies for government-sponsored water projects.

Small Watersheds Need Study

In this connection, it is appropriate to point out that the amendments this year to the Watershed Protection and Flood Prevention Act have substantially broadened the effective scope of the Federal cooperative program for protection and development of small watersheds. One aspect of this program is the encouraging of local watershed organizations to assume an essential and responsible share in the planning, construction, and operation of water storage and conservation facilities. It is a potentially vital local-state-Federal joint enterprise, and its proper place in the broad scheme of water policy and administration in Missouri might well be an item for serious and thorough study.

Steps Toward Action

Although immediate broad legislative action on the substantive law of water rights would appear to be premature and risky, this consideration does not mean that nothing should be done. The necessity for laying a solid foundation for action is plain.

I am not about to suggest simply another "study commission" to look into and make recommendations for changing the law of waters. The influence of law on water use is overemphasized. As a Tennessee lawyer said recently: in the Southeast, farmers will put pumps on streams and *use* water, rights or no rights, until somebody sees water getting awfully short and then either goes into court or shoots the excessive user. The first water case in the history of Montana involved a homicide, and the defense plea was, "He stole my water." The most recent homicide in a water dispute in Montana occurred just last year. East and West, sometimes they're just in too much of a hurry to wait for the law to operate.

Studies are essential as a firm foundation for action, but a temporary study commission is likely to be inadequate for the kind of studies needed. What is necessary is a well-financed and well-staffed state agency to develop long-range studies as the basis of a continually evolving state water plan. This evolving water plan would be underpinned by a growing practical and detailed knowledge of the occurrence and behavior of water in the state, including the interrelations of surface water and ground waters. The state agency should have a broad program for accurately inventorying water uses and for making comprehensive and continuing studies of the problems of water development as well as water allocation.

In providing funds for a state agency to accomplish these difficult tasks, a state legislature would need also to provide for formal recording of all water uses or withdrawals. In addition, in order to lay a legal basis for the recording statute and for whatever subsequent regulation that may be decided on, it would be prudent to have an early legislative declaration of public interest in the reasonable and beneficial use of waters in the state.

An important study task of the State agency staff would be a careful consideration of the role of relatively large multiple-purpose watershed districts or basin-conservancy districts in the state's scheme of things.

As the nature of the longer range water problems and issues becomes clearer and more widely understood, changes in substantive law and provision for a permanent water-administration agency may be crystallized more surely and safely. If it is decided to follow the road of evolutionary riparianism, consideration might be given to redefining riparian land in terms, for example, of any land in the watershed that had access by easement or otherwise to a surface watercourse.

Some provision for interwatershed transfers would also need to be considered. Or if it were decided that unused riparian rights should be acquired by a public agency, the question of compensation would need to be decided as a matter of ethics and of political policy, whether or not a constitutional requirement were held to apply.

If the significance of the law is at times overemphasized, the significance of administrative arrangements in the field of water cannot be stressed

too much. Certainly, it is true that substantive legal provisions are no more important than the procedures for putting them into effect. It would be naive to expect new and different water laws to be self-enforcing. Unless a strong and vigorous administrative agency is developed and given the support of an alert and enlightened public opinion, the laws may be mere words in the books.

In conclusion, I would suggest that most Eastern and Midwest states need a basic water policy far more than they need any quick shift to a different legal doctrine of water rights. If a fundamental shift is needed, such a determination can reasonably come only after thorough study and public discussion of alternatives in each state. Then the water rights statute should fit into and implement the state's broad evolving policies for the development, use, and control of water.

MAKING WATER A NON-LIMITING PRODUCTION ASSET

Arnold W. Klemme

ASSISTANT DIRECTOR
MISSOURI AGRICULTURAL EXPERIMENT STATION

THE HIGHER overhead cost of operating farms makes it more economically difficult to withstand flood and drouth damage which occurs only too frequently in Missouri. The necessity of removing all known factors limiting production of high acre yields and quality crops year in and year out and lowering production cost, brings water to the forefront. Likewise, the cities and towns with their growing population need more water and ultimately will compete with agriculture for this vital necessity.

Since 1952 water deficiencies in Missouri have re-emphasized the importance of water for farms and cities. Farmers are deepening their wells and ponds. Industries carefully inspect and check water supplies before locating new plants. The water supply frequently is the determining factor in where they locate. Cities have resorted to expensive means to supply their citizens with water. No longer is water a free good. It is now beginning to get the consideration it merits, namely: "It is a vital asset usually renewed annually by precipitation." Its annual use is increasing at about 3.4 percent per year or nearly twice that of the annual gain in population.

While the average individual uses directly five to six pints daily, the per capita daily use for all purposes is estimated at 1200 gallons (7). In 1950 it was estimated that the total daily use for homes, business establishments, farm homes, and irrigation was 170 to 180 billion. By 1975 it is estimated that this already tremendous total will be doubled.

For the potential increases in food production needed up to 1975, Black and Maas estimated that with normal acceptance and application of technology to present-day agriculture, there will be ample wheat, corn, potatoes, and cotton, the crops now in over-supply. Not even a complete acceptance and application of technology to present agricultural resources can produce enough fruit, vegetables, and the protein foods such as milk, meat, and eggs (5).

Potential Protein Shortage

The potential shortage of these proteins and health foods is good news for Missouri farmers located almost in the population and geographical center of the United States, where the resources are abundantly available for rapid population growth, and also for the production of these foods. It provides an opportunity for many Missouri farmers with small farms now using extensive farming enterprises and low return per acre, tolerated economically only on large acreages, to shift to intensive farming with high returns per acre.

Missouri does have relatively small farms. According to the 1954 United States Agricultural Census, the average size was only 169.9 acres (6). The following data show that there were only 1,472

farms of 1000 acres or over; 37,444 from 50 to 99 acres; 60,584, 100 to 179 acres; 29,437, 180 to 259 acres; 29,174, 260 to 499 acres; and 7,210, 500 to 999 acres.

That the extensive systems of farming practices and enterprises used give low returns per acre is indicated by the following. Of the 201,695 farms, only 140,322 sold $1200 or more of farm products and were classed as commercial farms. Of this number 36,605 reported sales of $1200 to $2499 and 37,059 from $2500 to $4999, and 12,000 from $10,000 to $24,999. Intensive enterprises that can be economically operated on these relatively small farms are: dairying, truck and fruit growing, swine and poultry production, raising hogs for market on concrete, large poultry flocks in confinement (5000 hens or more per unit), and pen feeding or beef cattle and lambs.

These enterprises, as well as others now considered extensive can be operated intensively and give high gross and net income per acre and per farm unit. In the future for either extensive or intensive farming to be successful, there must be full use of technical information, professional services, adequate operating capital, full mechanization, and all known factors influencing production, such as soil fertility, moisture deficiencies, and management, must be removed.

It is assumed that agriculture is to remain a competitive business. Different sections of the United States producing the same or similar products will compete with each other for the consumer's dollar, and the individual farmer, large or small in operation, highly efficient or inefficient, will not be hampered by production controls and will sell on a free open market.

The storage in the soil and reservoirs of the runoff water from excessive rainfall, along with the development, use, and conservation of the underground water is suggested as a flood and drouth relief measure and also as a source of extra water for agriculture, the cities and towns, and for industry.

A Complete Program is Needed

To assure an adequate water supply in the future for a rapid growing population and their continued increase in use of water, an expanding industry using great quantities of water, and a highly scientific, efficient, competitive agriculture using water for irrigation to remove moisture as a limiting factor to high production, a carefully planned water development and conservation program, broader in scope than the soil and water program now existing, must be formulated and developed. Such a program should provide for:

1. Orderly development, use and recharge of underground water supplies.
2. Storage of a sufficient amount of the surplus runoff rain water in reservoirs ranging from small to large in size, to meet the full domestic, industrial, recreational, and agricultural needs during periods of drouth.
3. Flood control.
4. The elimination of pollution of streams and water courses.
5. Coordination of soil and water conservation.
6. Additional research needed on physical and economical phases of water use.

Irrigation Supplements Other Practices.

Making water an unlimiting production asset in agriculture must start where the raindrop hits the soil. Essential practices of soil conservation, such as the correction of soil fertility deficiencies, the growing of more vegetative cover, and a high turnover of organic residue to the soil, along with the construction of terraces and waterways to slow up the movement of runoff rainwater and increase its intake into the soil, need to be further accelerated. These practices aid materially in providing extra water for plant growth.

Even with the full installation of these soil and water conservation practices, because of the torrential nature of our rains (12 inches may fall in a 24-hour period) (18), sloping topography of our land area, and the high content of montomorillinite clay (swelling and shrinking clay) in our soils, 10 to 20 per cent of the rainfall escapes as runoff water (4) (15) (18). Thousands of reservoirs and lakes are needed to store this runoff water from rainfall for use for irrigation and industry.

By impounding this runoff water in reservoirs and using it and underground water to supplement rainfall during periods of moisture deficiency, when coordinated with other soil and water conservation practices, it can be expected to give high acre yields and quality of products year after year.

Some of the factors to be considered in making water a non-limiting production asset under Missouri conditions are:

1. Frequency in which extra water is needed
2. Availability of water for irrigation

3. Does it pay?
4. Organization and finance

How Often is Supplementary Irrigation Needed?

An examination of the rainfall data and the water than can be stored in the root feeding zone of crops shows that supplementary irrigation is needed nearly every year to remove moisture as a limiting factor to plant growth for one or more crops. Decker* (9) reports that one-fourth of the time during July and August there are 2 inches of rain or less during each of these months, and 50 percent of the time there are 3 inches or less.

If at the beginning of July the soil is at field capacity in moisture holding capacity, the following approximate amounts of stored water per foot of soil would be available for plant growth: sandy soil, 0.75 inch; silt loam, 1.75 inches; clay loam, 2.0 inches. As indicated by the studies of Willit and Erickson, the top 9 inches supply more than half the moisture for alfalfa, clovers, and grasses, and the top 18 inches two-thirds to nine-tenths or more for the legumes (23). When a sandy loam is at field capacity in moisture holding capacity at the beginning of July, it could deliver to a growing crop from the zone occupied by plant roots about 1½ inches of water, a silt loam 3½, and a clay loam 4 inches.

Thornthwaite (20) has given the term "evapotranspiration" to the amount of water lost from a moist soil surface completely covered with vegetation. It is the evaporation of water from the soil and transpiration of water from plants and the earth.

The formula used by Thornthwaite in calculating the evapotranspiration of crops (moisture needed) is based on monthly temperature and percentage of sunshine and other factors. All plants under these conditions use the same amount of daily moisture.

According to these calculations, the peak in daily moisture requirement during July and August is 0.2 to 0.3 inch of water per day or 6 to 9 inches per month for maximum growth of such crops as alfalfa, corn, sorghums, and pastures.

These data, along with data showing the evapotranspiration for Columbia, Missouri, as calculated by Decker (9), indicate that it is not the severe drouth years alone but every year when rainfall in July and August drops to or below average, moisture is in short supply for crops. (Table I, following).

These moisture deficiencies range from a minimum of 4.5 to 7.5 inches on a sandy soil and 3 to 6 inches on silt loams. Frequently there is a moisture shortage even during the preceding months, causing a deficiency in subsoil moisture, thus accelerating drouth damage. Usually deep-rooted crops such as alfalfa are able to obtain sufficient moisture to survive, but fail to make growth. Fruit and vegetable crops may remain alive and then, when rains come start growth and often crack open, reducing quality and increasing susceptibility to disease.

While during the present summer, there was enough of moisture to grow a corn crop, the prevailing drouth this fall has delayed the germination and emergence of small grain and the normal growth of pastures. One supplementary irrigation of 3 inches of water would have been sufficient to start much of the small grain and also to significantly increase the livestock carrying capacity of pastures.

Except in seasons of severe drouth, only 3 to 7 acre inches of water would be needed to remove moisture as a limiting factor of production and significantly lessen the farming risk. Even in seasons of severe drouth there would be ample water for domestic use, livestock, and some for irrigation.

TABLE 1
AVERAGE DAILY EVAPOTRANSPIRATION IN INCHES PER DAY FOR COLUMBIA, MISSOURI

Month	Average Evapotranspiration Inches per Day
March	.02
April	.07
May	.12
June	.18
July	.19
August	.18
September	.13

Data supplied by Wayne L. Decker, Associate Professor of Climatology, University of Missouri.

Ample Water Available

A large quantity of water is required for irrigation. To supply an acre inch requires 27,154 gallons and to irrigate a 40-acre field with 3 inches requires over 3¼ million gallons. Fortunately Missouri is blessed with an abundance of underground and surface water. The Missouri and Mississippi Rivers, their tributaries, along with many springs, provide a good supply of surface water.

The Missouri Geological Division of Resources and Development reports unlimited yields of underground water at 600 to 1000 gallons per minute from wells at 100 to 120 feet in Southeast Missouri lowlands and in the Missouri and Mississippi River flood plains. The Ozark area also has suitable underground water for irrigation at much greater depths. In Northwest Missouri the underground water is limited to the glacial channels, and in west Central Missouri up to depths of 500 feet.

At greater depths, salty or sulphurous water unsuited for irrigation is encountered. The land available for irrigation for which there is reported ample underground water is equal to about one-third the irrigated acreage in California, which ranks first in the United States in this respect (10).

The estimates of Springer and Scrivner (21) show that of the 8,836,800 acres alluvial soil in Missouri, 7,279,730 acres are available for irrigation. More work is needed to determine suitability. The acreage of this soil by regions is given in Table II.

TABLE II
ACRES OF ALLUVIAL SOIL IN MISSOURI

Region	Total Acres of Bottomland	Available for Irrigation %	Available for Irrigation Acres
Southeast Missouri Lowlands	2,298,000	85	2,053,000
Missouri River Flood Plain	713,000	85	606,050
Mississippi River Flood Plain	206,800	85	175,780
North Missouri (exclusive of Missouri and Mississippi River Flood Plains)	2,750,000	80	2,200,000
Southwest Prairies	900,000	75	675,000
South Missouri (exclusive of Mississippi River Flood Plains and Southeast Missouri	2,480,000	80	1,984,000
TOTAL	9,347,800		7,693,830

There is underground water for the 2.8 million acres of land available for irrigation in the Southeast Missouri lowlands, the Missouri and Mississippi River Flood Plains, and for a considerable acreage in North and South Missouri.

Streams and Springs Supply Water

There are a number of flowing streams and springs in Missouri which have a sufficient flow to supply irrigation water for a few bottom farms which border them. In general, when irrigation water is needed in midsummer, many of these streams are at low flow and unable to furnish water for irrigation.

Consequently, adequate stream flow cannot be expected to supply water for irrigation for any appreciable number of farms. However, the high flow at flood stage of many of the small streams can often be impounded in reservoirs to supplement the runoff water from rainfall, and springs aid significantly in supplying water for storage for irrigation and other purposes.

Irrigation Water for Uplands

Runoff water impounded in reservoirs offers a source of good water for irrigation of uplands. Estimates of runoff water range from 10 to 20 percent of the rainfall or approximately one-third to two-

Making Water A Non-Limiting Production Asset was discussed by the panel pictured above, consisting of Dr. Arnold W. Klemme, Assistant Director, Missouri Agricultural Experiment Station, Columbia, Mo.; Karl Shoemaker, Federal Extension Service; Uel Blank, Extension Associate Professor of Agricultural Economics, Missouri Extension Service, Columbia, Mo., and Dr. Fred A. Clarenbach, U. S. Department of Agriculture, Washington, D. C.

thirds of an acre foot from each acre in Missouri (4) (15) (18). Runoff from forty-four million acres of crops and pasture and forest lands would give the staggering total of 14.6 to 29.2 million acre feet of water annually.

Rolling Lands Favorable for Reservoirs

The irregular topography of much of the upland lends itself to the economical construction of reservoirs to impound runoff water. Land that is now waste can be used for such reservoirs. Wells and springs equipped with pumps can also be used to pump water to supplement the runoff water into the reservoirs.

Many farms in the Ozark and other rolling areas have sufficient drainage area and excellent sites for the construction of these reservoirs of sufficient size to store water in adequate quantities. Several land owners could construct reservoirs cooperatively and use the water from them as their land provides drainage area into the reservoir.

Large reservoirs with thousands of acres in the drainage area can be used to supply adequate water to municipalities for domestic use and also for industry. The latter would in turn furnish employment for surplus labor in the rural areas. With more employment and more people in the rural areas, an enlarged market could be developed locally for fruit, vegetables, milk, eggs, meat, and other foods. With sufficient volume, processing of these could be done, thus bringing new industries and an additional payroll to the rural areas.

Aid in Flood Control

Reservoirs would give multiple benefits by impounding runoff rainwater in the area where it falls for irrigation, recreation, and industrial use as well as aid in flood control for those in the immediate area, as well as for those downstream.

The ten new large government dams proposed for Missouri, if constructed, should be multipurpose dams. That is, provide water for towns and cities for domestic use, industry, recreation, irrigation, and power where needed, as well as for flood control.

Reliable estimates indicate that the cost of constructing reservoirs ranges from $25 to as much as $70 per acre foot of impounded water. With the improved equipment and information now available this cost can be reduced. The smaller reservoirs usually cost more per acre foot of impounded water than the large ones, but they are worth more to the farmers, as they impound the water near where it falls, making its use available for irrigation and other uses on the farms.

Many 170-acre farms, the average in Missouri, could have reservoirs impounding 100 acre feet of water or more. To construct this size reservoir would cost, depending on the site, from $3000 to $7000, about the cost of one or two farm tractors or a barn. On the farm acre basis it would be $17.64 to $41.18 per acre and remove about ten acres of land from its present use.

A 170-acre farm has 66 to 133 acre feet of water runoff. Assuming that 12 percent of this impounded water escapes by evaporation (1) there would be left about 58 to 116 feet for irrigation and other purposes. If all the impounded water were used, two 3-inch applications could be applied in each of the months of July and August on 58 to 116 acres. Should as much as one-half of the water be lost by evaporation, there would still be sufficient water left to irrigate 33 to 66.5 acres with 3 inches of water during each of these months.

The importance of moisture at this period was well demonstrated in 1956 when about 3 inches of rain fell in July on a moisture deficient surface and sub-soil. The highest yield of corn on record is being harvested even though the total rainfall is about one-third below normal, or about 10 inches less than in 1954 when corn yielded but 9 bushels per acre. California experiments show that the timely application of water at the flowering period of cotton increased both the length of staple and yield.

Reduction of Evaporation

Estimates of annual losses of water from reservoirs vary widely. All studies show that a large part of the annual losses occur during the hot summer months of June, July and August. Water for irrigation is used in these months before all of this evaporation occurs. There are numerous ways of reducing evaporation. Recent investigations in Australia indicate that the use of monolecular surface films of either of four alkanols, dothecanol, tetradecanol, hexadecanol, and octadecanol, will reduce evaporation about 50 percent (16). These alkanols are long chain carbon compounds with 12 to 18 carbons. Applications as low as 1 pound per acre were effective.

Proper Irrigation Pays

Numerous experiments and experiences of present-day farmers indicate that supplementary irrigation, properly used with ample soil fertility, is now

profitable on corn and cotton, pastures, and fruit and truck crops, when extra moisture is needed, which is nearly every year on one or more of these crops. The recent trends in the use of irrigation in Missouri according to the 1954 U. S. Census of Agriculture are as follows: In 1950 142 farmers irrigated 2,089 acres, while in 1954, 752 farmers irrigated 32,998 acres (6). Apples, fruit and truck crops which give high returns per acre, rank first in acreage irrigated.

During recent years farmers using supplementary irrigation in Southwest Missouri have produced two hundred or more crates of high quality strawberries per acre as compared to near failures where no irrigation was used. In 1956 an increase of 15 bushels of soybeans per acre was obtained with an application of 3 inches of water in the Missouri River bottom in Ray County. Numerous farmers report acre yield increases of 25 to 50 bushels per acre of corn with applications of 2 to 3 inches of water at the critical tasseling and silking stage.

J. W. Bennet of Marble Hill, Missouri, working with his County Agents and others produced 196.7 bushels of corn per acre with 5 inches of irrigation water on a 30-acre field in 1955. The unirrigated field yielded but 99 bushels per acre. There are experiments where irrigation did not significantly increase crop yields. In such cases, factors other than water were the limiting factors and irrigation was not needed.

The Missouri Experiment Station reports an average increase of 34 bushels per acre of corn on a claypan soil at McCredie in Callaway County over the period 1948-1955. The average of the non-irrigated plots was 72 bushels and the irrigated 106 bushels per acre. Only in 1951 did irrigation fail to increase the yield. The last two years, 1954-55, the yield increases were 73 and 80 bushels, respectively. In a two-year study in 1953-1954 in Southeast Missouri, irrigation with full soil treatments increased lint cotton production from 697 to 1,027 pounds per acre. Without soil treatment and without irrigation the yield went from 502 pounds to 664 pounds of lint per acre.

The University of Illinois increased the acreage yield of pasture from 6,800 pounds on non-irrigated land to 9,600 pounds on irrigated land in the four-year period, 1949-1952, at Dixon Springs, in Southern Illinois. In drouthy 1952, for example, the yield on irrigated pasture was 9,221 pounds as compared to 4,508 on non-irrigated lands. Whereas, in wet 1950, irrigation brought a yield of 10,443 pounds as compared with 7,118 pounds on non-irrigated pasture.

Supplementary irrigation is highly essential for making double cropping work. Soybeans or grain sorghum can follow small grain or clover, alfalfa or corn can be established in small grain regularly, and good crops of forage or seed harvested the year of seeding.

More Research Needed

Although the hydraulics of irrigation are well established, additional integrated research is needed on the economics and physical aspects, such as (1) infiltration of water into the various types of soil; (2) evaporation; (3) amount of runoff water from farm watersheds; (4) different kinds of vegetative cover on the amount of runoff; (5) response of the different crop varieties under irrigation; (6) effect of irrigation on soil fertility; (7) influence of irrigation on plant composition, insects, and diseases.

Developing Water Resources

Early development of irrigation was done largely by individual farmers and small groups of farmers. Although in the west there are now large federal reclamation projects, commercial irrigation districts, single farm enterprises comprise 90 percent of the irrigation development and 49 percent of all the irrigated acres.

Supplementary irrigation in Missouri can be done most economically by individual farmers or cooperatively by small groups of farmers. There are a number of ways of financing supplementary irrigation. Many individual farmers can finance the program through banks and other credit agencies.

Organization

To guide in the initiation and development of this vital water program for our growing economy, it is suggested that a legal body be legislatively created, representing the various segments of our society, such as agriculture, municipalities, industry, and labor. This body would initiate investigations on the development, use, and conservation of water, and make recommendations to the Legislature on the necessary legislation, and through their representatives administer the program on a state level.

In a complete water program, some legislation would be needed to protect individual water rights and the public interest. Such legislation should include an enabling act which would permit a small number of farmers to form an organization to pro-

vide water for irrigation. Texas has an enabling act which provides that five or more landholders may organize a water conservancy district.

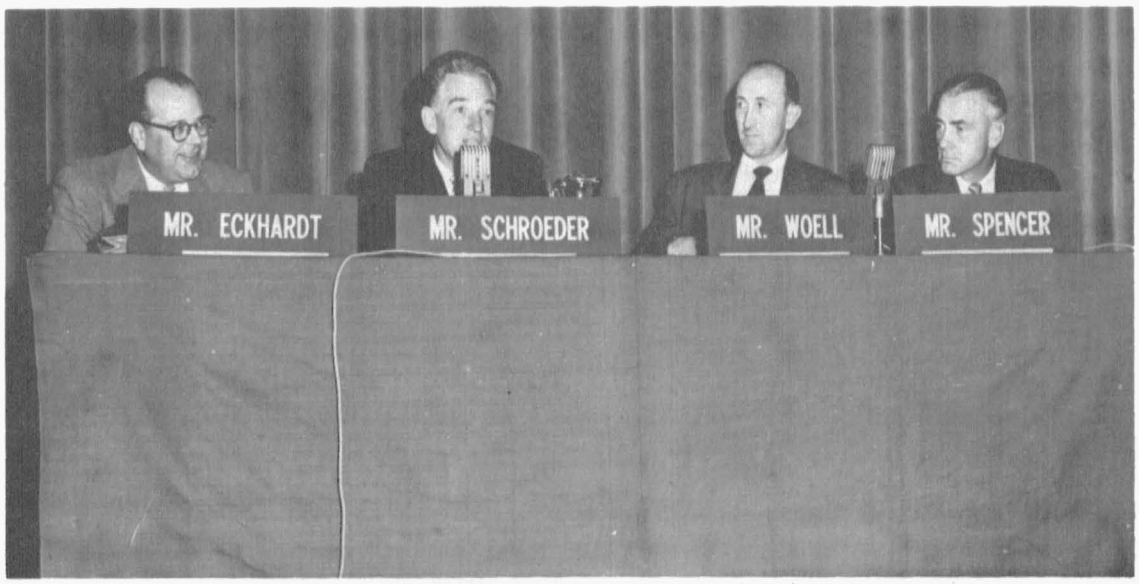
Such a district has the legal right to issue bonds to finance the drilling of wells, construction of reservoirs to provide water and to purchase equipment for irrigation. These bonds bear 5 percent interest and run twenty years or more. The returns from such bonds are tax exempt and like any other tax are a first lien against the land—making them attractive for investors.

A legally organized group could no doubt develop and use other methods of financing. Technical information and equipment is available in private enterprise to do this work. Such a water conservancy program could be carried out without federal aid. It would be self-liquidating and would be administered locally by the people financially interested, which usually leads to a greater degree of efficiency.

The development and conservation of the water resources of the state and making water non-limiting asset to agricultural production will lessen risk, permit the relatively small farmer and larger farm operator as well, to select and use production enterprises on a community basis. By so doing, adequate volume is produced to attract volume purchasers or for processing and up-grading near the point of production.* This activity would require local labor which along with the increased income of the farm family, would add to the cash income of the community and put them in the market for more of the other goods of industry and labor.

For the towns and small cities the development of a complete water program would provide an abundance of water for domestic use and also for local industrial plants, which in turn would furnish many jobs for local people and make unnecessary their migration to the large cities for employment. Thus, some of the expected population gain could remain in the rural area where born and add to the demand for locally grown food products and other goods. As the result, the development of a complete water program would be economically sound for the urban dweller as well as the farmer.

Only a few years ago, raging floods from excessive rainfall swept over the alluvial flood plains of the rivers and streams, causing hundreds of millions of dollars damage to crops and property. Much more disastrous economically are the short and long drouths such as now occur from uneven distribution



Summing up the discussions of the Eighth Annual Missouri Farm Forum at the conclusion of the two-day meeting were the above panelists, consisting of Willard Eckhardt, Professor of Law and Dr. Raymond A. Schroeder, Professor of Horticulture, both of the University of Missouri; Melvin Woell, Director of Information, Missouri Farm Bureau Federation, Jefferson City, Mo., and George Spencer, State Senator, Columbia, Mo.

and/or shortage of rainfall.

Much of this economic loss, the human disappointment and discouragement that result therefrom, can be prevented by the development and installation of a well-coordinated and integrated soil and water program.

As a permanent corrective measure for these disasters and in addition to the soil and water program now used, a more complete program is suggested, namely, the construction by farmers and municipalities of thousands of small reservoirs on individual farms, as well as large ones, to store excessive runoff rainwater for later use and to lessen flood damage; to meet the increasing water needs for municipalities; for domestic use; for industry; for recreation; and to supply water for irrigation for thousands of farms in midsummer when extra moisture is usually needed; and thus make water an unlimited production asset. The water stored in reservoirs would also aid in recharging the underground water supply, permitting the use of underground water for irrigation and other purposes.

The technology and the resources are available in Missouri for this gigantic and vital undertaking.

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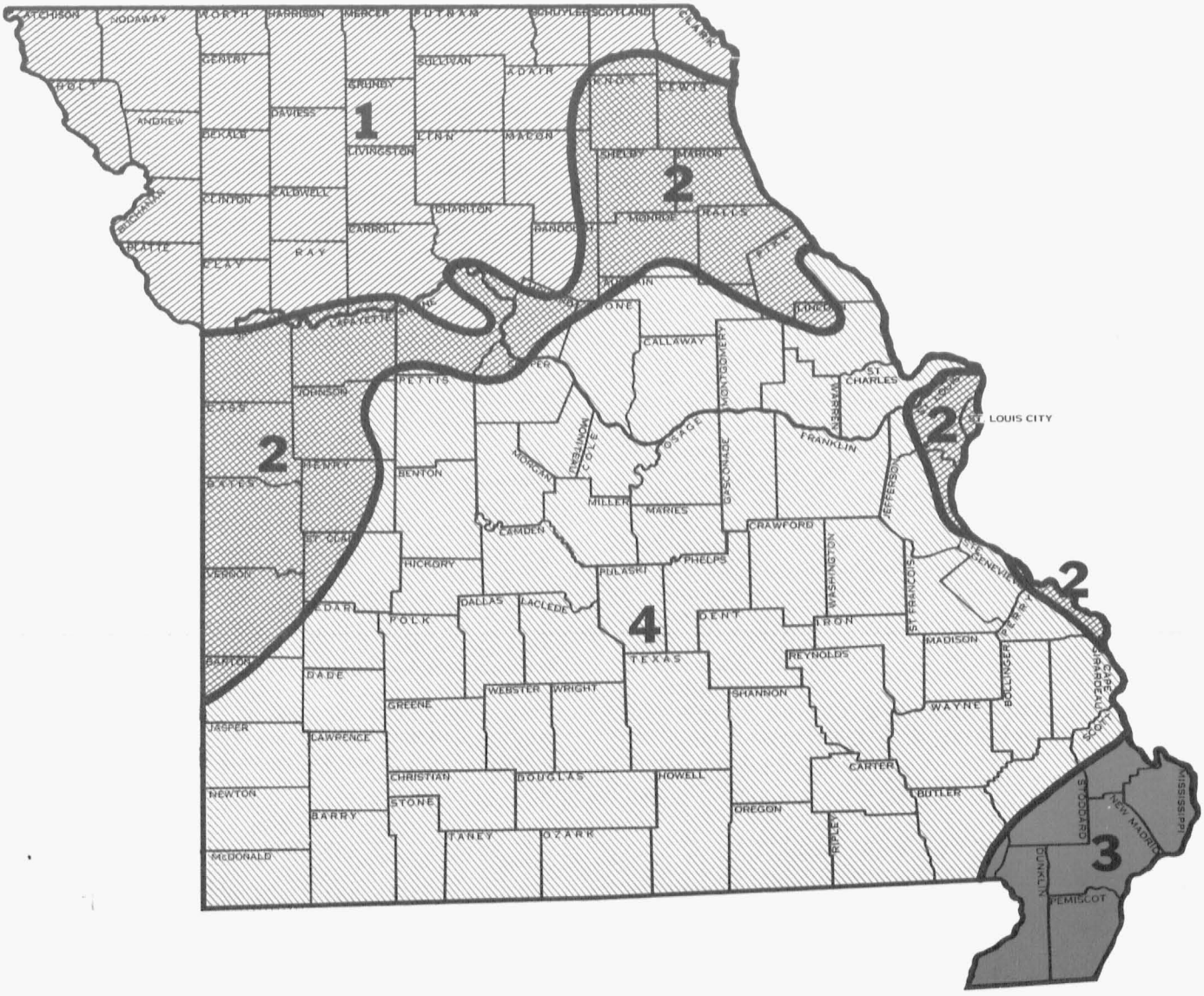

*Groundwater Provinces of Missouri.

*See Page 3 for Article, "The Water Resources of Missouri" By Thomas R. Beveridge, State Geologist.