SUMMARY OF

CONFERENCE ON TEXAS WATER PROBLEMS AND POSSIBLE SOLUTIONS

Held at

Southwest Texas State Teachers College

San Marcos, Texas,

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PREFACE

On July 20, 1954, more than five hundred farmers, ranchers, bankers, industrialists, members of the armed forces, teachers, and students gathered on the campus of Southwest Texas State Teachers College to hear leading authorities from private, state, and federal agencies discuss the increasingly acute Texas water problem and some of the possible solutions.

This conference was sponsored by Southwest Texas State Teachers College to meet two of its educational responsibilities: first, to insure that teachers and prospective teachers studying at this public institution be prepared to present the problem of conservation to the students in the Texas schools; second, to educate the lay public to the nature of the conservation problem.

This bulletin has been published in the belief that the addresses delivered to the conference are of such significance to the people of Texas that they should be given the widest dissemination both to teachers and the general public.

Southwest Texas State Teachers College
San Marcos, Texas
November 15, 1954

SPEECH BY MAX STARCKE

General Manager, Lower Colorado River Authority

Texas has plenty of water for everyone. I know that this statement will sound facetious to you—particularly as we are currently in a history-making drought. But let's stop and think a minute. The average amount of rainfall in Texas annually amounts to approximately 422 million acre feet of water. Between 80 and 85 per cent of the runoff of Texas rivers goes into the Gulf of Mexico unsaved and unused without any benefit to anyone. Therein lies the essence of this water conservation problem about which we are meeting today.

Personally, I prefer the term "water management" to go along with than that of "water conservation," because we must do more than just conserve our water supplies—that wasted 80 to 85 per cent which now is flowing into the Gulf; we must manage those supplies to the best advantage of all concerned.

When we consider our water problems as a problem of management, we can apply to the problem sound business judgment. Consider for a moment this proposition. Recently a cotton farmer in West Texas told me that without irrigation he could produce from a quarter to a half bale to an acre. But with irrigation, he could produce two or more bales per acre.

That difference represents a great economic advancement, even when you subtract the cost of pumping and distributing the water.

When you turn non-producing land into producing land, and the people who benefit from the economic returns from such production help to meet the costs of the water, then the great subsidies you hear so much about are not necessarily required in most cases.

While this problem of water conservation—of water management, if you will—is one common to all of Texas, many of the solutions today are dependent upon the actions of local people dealing with their local areas.

That was the situation on the Colorado River twenty years ago. And what has been done in solving the water management problems on the Lower Colorado River can be done over and over again in all parts of Texas.

As you know, the Colorado River is not located in the belt of heavy rainfall. In fact, our watershed is located in one of the more arid parts of Texas.

Naturally, we are proud of the accomplishments of the Lower Colorado

River Authority, and I would like to tell you briefly about them. But the purpose of what I have to say is not in the sense of bragging, but rather to the point that it can be done in other places just as well and just as efficiently as has been done in the LCRA area.

As long as there have been Anglo-American settlers in Texas, people have been working to improve the situation along the Colorado. Like most Texas rivers, it was one of "too much and too little"—of floods and droughts. As early as 1850, people along the river began working to bring the Colorado under control, but it was not until about 1930 that anything concrete was developed.

Private electric utility interests were contacted and became interested in building a large dam to produce electricity and to provide irrigating waters. A site was chosen and a corporation was organized under the financial leadership of the Insull interests. A dam (now Buchanan) was begun. But the nation was heading into a major depression. On April 20, 1932, work was stopped on the dam when the Insull companies failed.

Numerous efforts were made by the people of the Colorado River valley to resume work on the project through attracting additional investments of private capital, but during the depression such capital was not available.

But the people along the Colorado wanted protection from floods; they wanted an adequate water supply. They organized and fought for these advantages.

Their efforts reached a successful climax in 1934 when the 43rd Legislature created the Lower Colorado River Authority.

To complete the unfinished dam, the Authority made application for a loan from PWA on terms and conditions similar to loans granted municipalities such as San Antonio, Houston, Dallas, and others, both large and small. By these terms the borrowers agreed to pay the differences between the prevailing low wage scales and the amounts considered necessary to bring the nation out of the depression.

The PWA agreed to purchase revenue bonds from the Authority in amounts sufficient to complete the dam and to grant 30 per cent of the cost of labor and materials.

The original loan by PWA was paid in 1943, private investors refinancing the loan at a lower rate than the RFC required. No bonds held by State or Federal Agencies are now outstanding.

The last two dams, the Wirtz and Marble Falls Dams, were built at a cost of approximately eighteen million dollars; this money was raised by revenue bonds sold to private investors.

In creating the Authority the Legislature gave it no power ever to levy

any taxes, nor were any provisions made for the Authority to receive tax remissions. Since an original grant of state funds of approximately fifteen thousand dollars as an aid to research, the State of Texas has made no investment of its tax funds in the Authority.

The Authority has been authorized to issue revenue bonds to finance capital construction. However, none of its properties may ever be mortgaged.

The LCRA is a non-profit agency and may make only such charges for its services as are necessary to meet its operating expenses, repairs, depreciation, reasonable reserves for contingencies, fixed obligations, and for conducting its program of services for the benefit of the greatest number of people as provided for in the act creating the Authority. Today the Authority's properties are valued in excess of 150 million dollars.

The District, as established by the legislature, is composed of the lower ten watershed counties—San Saba, Llano, Burnet, Blanco, Travis, Bastrop, Fayette, Colorado, Wharton, and Matagorda.

Its governing body is a board of twelve directors selected by the governor subject to the appproval of the Senate. Directors are appointed for six year terms, with terms so alternating that at no time is a majority of the board subject to change at any one time.

In creating the Authority, the legislature gave it four major functions to perform.

First, is to control the devastating floods which occur periodically on the Colorado River.

From 1900 through 1938, these floods took a toll of a hundred human lives and caused property damage in excess of eighty-four million dollars. The Authority, with its six dams, today is capable of controlling floods equal to the greatest of record originating above Austin.

The September, 1952, flood provides a good example. The United States Geological Survey estimates that this flood would have reached a maximum height of forty-five feet at the Congress Avenue bridge in Austin with a peak discharge of six hundred cubic feet per second if there had been no dams on the river. This would have been a discharge nearly two hundred thousand cubic feet greater than the previously high flood of 1935.

Instead of having great damage to property, and probably to life, in Austin and downstream, the people of the city were peaceably unaware that a flood was even occurring. In fact, while the force of the flood was expending itself in Lake Travis behind Mansfield Dam, youngsters were water skiing on the placid, protected waters of Lake Austin immediately downstream.

All of the flood waters were controlled and stored in Lake Travis, which not only provided protection from flood damage but also provided a very greatly needed and valuable supply of water for the future years.

As a part of the flood control facilities, the Authority also has established in cooperation with the USGS, Weather Bureau, and the State Board of Water Engineers, 143 rainfall gauges and 12 river gauges over the watershed area.

Observers report to us any rainfall of as much as two inches in a twenty-four hour period and report again for each additional inch. As soon as the water begins to flow into the tributarial streams, river gauge reports are made. This provides a system of information regarding possible flood conditions throughout the watershed where no positive information was available previously.

The second major function of the Authority, to quote from the Act, is "to control, store and preserve . . . the waters of the Colorado River and its tributaries for any useful purpose . . . and to use, distribute and sell the same, within the boundaries of the District, for any such purposes."

The flood waters which once ran with so much destruction to the Gulf of Mexico now are stored for use.

The six dams of the Authority have a total storage capacity of 3,301,000 acre feet.

One filling of Lake Travis, behind Mansfield Dam, for example, would provide sufficient water to take care of the needs of a city the size of Houston for twenty-three years. And one filling of Buchanan could take care of the needs of Dallas for fifteen years.

This availability of stored waters for use all-year-around has meant much to the growth and development of Austin and of the area along the river.

Of the annual inflow into the Colorado River above Austin, none of the water is wasted, nor will it be unsaved or unused—except in the times of very extreme floods.

The conservation of the flood waters of the Colorado has saved the citizens of Austin many millions of dollars to assure an adequate water supply for a city which has been doubling in size on the average of every ten years.

For a typical example, during the 100 degree plus temperatures last week, Austin's water consumption soared approximately 51 million gallons daily.

During the same period, the inflow into the Authority's reservoirs was

negligible. Barton Springs, the only other source of water, provided only about one-sixth of the water required by Austin.

But the release of stored waters, through production of electricity, during this same period, averaged more than one billion gallons of water daily —twenty-four times the amount Austin required. That was during peak periods of both consumption and releases. But our minimum releases at Austin, through power production, on the average day is sufficient to take care of the average daily needs of Austin, Houston, Dallas, San Antonio, Fort Worth, and two hundred and fifty smaller communities.

Of equal importance is the value of these stored flood waters to agriculture. Immediately adjacent to the river, near the Gulf Coast in Colorado, Wharton and Matagorda counties, is Texas' largest rice producing area.

Prior to the building of the Authority's dams, an average of fifty thousand acres of rice was planted annually. And usually there was not sufficient water in the river to bring the crop to full harvest.

Today the number of acres planted annually has more than doubled, and production of the total acres planted is guaranteed annually by the availability of irrigating waters from the Authority's reservoirs.

By providing water not only for the increased acreage, but also by providing water in drought years for the entire planting, the Authority has provided the basis for a tremendous gain in income for the people of the rice belt.

During the fourteen years the Authority has provided irrigating waters (1940-1953) there have been only a few years when there would have been sufficient inflow into the river during the irrigation period to have brought even a portion of the original fifty thousand acres to harvest. In only a few years was there sufficient inflow even to approximate the total water requirements. As a result of this service of the Authority, it is estimated that there has been sixty million dollars worth of rice produced that could not have been produced otherwise.

The third function of the Authority is to assist in the prevention of the erosion of the watershed soils. To this end the Authority has a comprehensive soil conservation program which promotes the control of water where it falls on the land and which encourages development of the proper utilization of water by the farm and ranch people of the watershed.

In the interest of time, I am going to pass over the details of this program except for pointing out that it is an essential part of any water management program on any watershed.

The fourth major function of the Authority is the generation and sale of water power and electric energy. Since this is a whole topic in itself, I am not going to discuss this phase of our activities with you.

As I said at the outset, this is an important meeting. The more we know about the water problem—the more we understand the methods by which we can arrive at solutions—the closer we can come to having sufficient water to meet all our needs.

I want to congratulate the sponsors of this program for bringing to us the fine array of speakers who follow me. And I want to assure each of you that we will be more than pleased to provide you with more detailed information concerning what we have been able to accomplish on the Colorado River.

Again my principal reasons for outlining what has been done by the Lower Colorado River Authority is to show what has been done on a Texas river, particularly on one which rises in one of the most arid portions of the state. There is no good reason why it cannot be done again and again until our water problems are solved.

SPEECH BY DR. WALTER P. WEBB

Professor of History
The University of Texas

I want to say a few words to President Flowers and the members of his staff who are responsible for this conference, one of the first of its kind, dealing with the most serious economic problem facing the people of Texas. It is fitting that an educational institution should take the lead in calling attention to an impending crisis—rather a present crisis—of gigantic magnitude facing this state. And it is most appropriate for an institution engaged primarily with teachers who will go out immediately to instruct the children of Texas, citizens tomorrow who will have to deal with the crisis of too little water, to take this initiative. It is important for these teachers to see that for once they are not dealing with an academic or theoretical problem. They are dealing with stark reality, something that touches the farmer, the rancher, the merchant, the banker, the metropolitan centers and the rural areas. They are for once dealing with a non-controversial subject, for everybody at this time is favorably disposed towards water. Though religious denominations may differ as to its uses, they all want more water than they now have. Though Democrats and Republicans may differ on foreign policy, on domestic policy, on who should be in control in Washington, they agree so well on the water problem that they do not discuss it enough and are not doing enough about it. At the state level both of the perspiring candidates for governor have come out before the election in favor of water. What their attitude will be after election will depend in large measure on the force with which the people remind them of their present campaign promises.

My assignment today is difficult because I am not an expert on the technical phases of the subject. I do not know the answers. This was all right last week when I was talking to a group of students and teachers, speaking with that authority that the lecturer sometimes assume. I also realize that I am speaking in the presence of a large group of men who have devoted their lives to the water problem in Texas. There is not a man on this program besides myself who does not have every right to be classed as an expert. All of them hold some official position; most of them are trained engineers. Mr. Max Starcke is in charge of the Lower Colorado River Authority, in control of millions of acre feet of water. Mr. A. P. Rollins is a member of the Texas Board of Water Engineers, an understaffed organization which knows a lot about getting along with little water and a great deal about how to get along with hardly any money. Then

there is Mr. Harry P. Burleigh, representing the U. S. Bureau of Reclamation, an engineer who has spent practically his whole professional life in Texas. He reminds me a little of Johnny Appleseed, that fabulous and now legendary character who in colonial days went about the frontier planting apple seed so that the people could have apples instead of acorns to eat. Harry Burleigh is on call where people need water so that they and their stock can live on fruit, vegetables, and grain instead of on mesquite beans. Mr. Burleigh, like Johnny Appleseed, is a practical dreamer, often a grim realist who occasionally has to tell people that there is not enough water. He labors under the onus of being a federal employee. I suspect he has been called a bureaucrat, but I have found him to be quite human.

Then there is Judge Guy C. Jackson, President of the Texas Water Conservation Association. As a lawyer he understands the tangled skein of chaotic water law in this state, and the great need for a complete revamping of the law so that it will help and not hinder—as it now does—the practical solution of the critical water problems of this state. Mr. Stuart McGregor, though not an engineer, holds an official position, a double one, as editor of *The Texas Almanac* and an editor of the *Dallas News*. Through *The Almanac* he speaks objectively to all the people of Texas, and everywhere, on the subject of water and a thousand other topics; as editor of the *Dallas News* he represents the interest of the Dallas territory. Mr. E. B. Neiswanger is chairman of the Water Resources Committee of the South Texas Chamber of Commerce. Dr. Louis Koenig is an authority on desalting sea water.

So there they are, a galaxy of experts, most of them holding official positions, each possessing specialized knowledge, and some in position to purvey their point of view far and wide.

And here am I, the amateur, holding no official position, connected with no organization, having no sectional allegiance, without technical knowledge of either the physical or legal management of water. What role can I play in this drama? Whom do I represent?

I would like to think that I represent the sunburned farmer who looks out today on his devastated crops and knows that this fall his son will not go to college, that his daughter will not have a new dress, and that he can not have a new pickup truck. I would like to think that I speak for the busted ranchman who for want of grass and for want of water gathers his thin cattle from a sun-scorched range, delivers them to a falling market, wondering if the banker will tide him over another season. The banker himself is caught in the net of this disaster, torn between his desire to carry a man he knows to be worthy and his compulsion to guard the trusted funds that he loans. The merchant, the manufacturer, every-

body carries a share of the penalty. The one thing that all these people want is more water. I would like to think that I speak for them.

Professor James Taylor, who has worked so hard to make this San Marcos conference a success, showed me a partial list of the people who have come here from the Gulf Coast to North Texas to participate in this conference. I was struck with the character of those who responded to the invitation. Army men, soil conservation men, bankers, lawyers, representatives of the new heavy industries that have been recently attracted to Texas, and representatives of the chambers of commerce. They did not come here because of the climate or the pleasure of driving ninety miles in ninety degree temperature. They came in the hope that by counseling together we may discover some way to make a beginning in alleviating to some extent this enormous thirst from which we are all suffering. They came in the hope that these experts can tell them what, if anything, can be done to remedy the situation.

I like to think of these busy people—ranchmen, farmers, industrialists, financiers and lawyers—as laymen who have come with an intelligent interest to see what the experts say. I like to think of my role as that of a middle man who is anxious to bring the two groups together so that they can exchange ideas and then unite on a common program agreed upon by such a democratic process. Through the efforts of President J. G. Flowers and his assistants, the experts and the laymen are here together in a setting of drought and heat, good background for a discussion of all that pertains to water.

Since the experts are on the program, they will soon speak for themselves. My remarks from now on will be addressed primarily to those whose names do not appear on the program. It so happens that because of my amateur status, because I hold no official position I can say some things which either modesty or policy would preclude those with official connections from saying. Nobody can reprimand me for exceeding my authority because I have none. I am free to say what I think the state ought to do; I am free to say what the federal government may, under proper conditions, do; I am prepared to say what, in my opinion, the people of Texas ought to do to implement an effective state-wide water program.

The first thing I want to say is that the time has come when the water problems of Texas can no longer be ignored. Anyone with even the most superficial knowledge must realize that water is our most valuable resource, next to land, and that land without water is a desert. A very wise man, Major John Wesley Powell, said many years ago that in the east where water is bountiful, land is of primary value; but in the west where land is abundant in relation to moisture, water is paramount. We in this state

are prone to forget that Texas lies on the edge of the desert, partially in the desert. In the early days, down to about 1900 or 1920, the people distributed themselves over Texas somewhat as the plants and animals did, thickly in the well watered regions, thinly in the drier parts. About 1920 urbanization and industrialization got under way and have been going on at an accelerating rate down to the present, and added to that is increasing irrigation. Cities, industries, and irrigation projects are all consumers of vast amounts of water. The result is that every source of water available under present practices is being taxed to the limits, and in many instances beyond the limits. This is the situation today with a population of eight million. The population is growing and with it the demand for more water is accelerating, not just growing, but accelerating. The painful fact which we must face is that under present usage Texas is approaching very close to the edge of its economic potential, not because we are running out of resources as we ordinarily think of resources, but because we are running short of water. The future growth of Texas depends directly on the improvement of water use.

My second point is that we should not underrate the magnitude of the problem before us. Nor should we think for one moment that either kind providence or a rainmaker will solve the problem through compassion or for a fee. Nature, providence, or God set Texas down in a place where water has always been scarce in some parts and often scarce in all parts, and I for one seriously doubt that any water fakir can, to paraphrase Daniel Webster, rearrange a law of nature or reverse the will of God. The water supply of Texas is fixed, and has not varied perceptibly on a ten-year average since the weather bureau started keeping the record about three-quarters of a century ago. Since we have a fixed amount of water on average, and since we can not yet increase it, the only thing we can do is to capture more of it and make better use of it. When we tackle this problem on a state-wide basis, we are undertaking a task that stretches and staggers the imagination of even the most imaginative Texan. Those who formulate an adequate state-wide program must have long vision, great courage, abiding faith, and a willingness to be misunderstood, misjudged, and abused.

Since the water problem is exactly the size of Texas, it will be expensive in proportion to its magnitude. We might as well dismiss now any idea that any adequate water management plan can be a pinch-penny proposition, that it can be had cheaply. In the early days in Texas a man could obtain a homestead—160 acres or more of land—at a nominal cost. To obtain water, to sink a well cost him often more than the land, but he never hesitated at the cost for he knew that without water he could not

make a home. The case for Texas is much bigger, but it is just about as simple.

We need not be appalled at the stupendous sums of money that an adequate water conservation program will cost. I see in this audience Judge R. L. Bobbitt of San Antonio, a former member of the Texas Highway Commission. Had he and other men who first dreamed of a complete highway system for Texas, looked at the total cost, they must have wondered where that much money was coming from. Yet they had the courage to go on and project the system; they found ways in which it could be made to pay for itself. And so it will be with a comparable water supply system. It will pay for itself. It, like the highway system, can be built by sections, but the overall plan should be prepared to govern the whole operation.

Whoever undertakes a solution of the water problem, must realize that there are two kinds of water: fresh water and salt water, water on land and water in the sea. Dr. Louis Koenig is going to tell us of the progress that has been made and the prospect ahead of desalting sea water to increase the supply of fresh water. I trust that he will be able to say that before too long this inexhaustible source will become available at a price that agriculture, municipalities, and industry can pay.

In reference to fresh water, with which we must for the present be primarily concerned, we can deal only with the surplus, which amounts approximately to three inches of rainfall for the entire state. This surplus finds its way into the Teaxs rivers of which there are twelve or fifteen worthy of the name. This surplus amounts on average to about 53,000,000 acre feet annually, but since Texas must divide the water of certain rivers with neighboring states and Mexico, it has only about 40,000,000 acre feet on which to establish a surface water program. In addition to this there is an unknown quantity of ground water which would figure in the program. The two sources differ in character. The ground water is a relatively fixed amount with a preciously small annual surplus whereas the surface water has an annual surplus averaging some forty million acre feet. The main problem, then, involves the conservation of the exhaustible ground water and the capture and use of the annual surplus of surface water. Actually the ground water is almost static, a reservoir. There is little loss if it is not used. The surface water is running water, and if it is not captured, it wastes into the Gulf, an annual total loss. It is obvious that the major portion of the task ahead is the capture and use of water flowing in streams. The program is largely one of river development.

We have made a beginning in this river development, and Mr. Starcke has told us what has been accomplished by one of the many river authorities. Other river authorities have done comparable work.

If an adequate state-wide program of water conservation and management is to be launched, it will have to come through political channels, either through the state or through the national government or better through a combination of the two. It is my opinion that in such a movement the state of Texas should take the lead and should hold it throughout. Texas should undertake to help itself before it calls on others for help. But when we look back over what has been done in water conservation, we find that Texas at the state level has a very bad record. It has done up to now practically nothing. Had it not been for the federal government, Texas would not now have the vast water supply of which Mr. Starcke has told you. If it had not been for the federal government, the lower Rio Grande Valley would now be laid waste by the flood waters captured and saved by the Falcon Dam, water which will be used to guarantee valley crops for two years. The federal government has up to this time completed about twenty dams in Texas, and has projected or under way twenty more. And what have we, the people of Texas, acting at the state level done?

Well, Texas has set up a State Board of Water Engineers whose members have done excellent work in studying and mapping the water resources, and in advising the people. But Texas has given this board little authority. It has given it a pittance of money. Texas has gone through the motions of doing something, made a gesture of mild interest, but it has not increased materially the water supply of this state. I am told on good authority, and not by a member of any of these official organizations, that another state commission whose business it is to promote the pleasure of a limited number of leisure citizens has ten times the funds with which to work that the State Board of Water Engineers has. It is fine to say that Texas should take the lead, but the only way it can do this is to become a leader. It has not become a leader. Up to now it has not even been a good follower. I should think that unless Texas bestirs itself, the federal government could well become as indifferent to its welfare as some people want it to be. I am reasonably confident that by taking the lead Texas would merit and probably receive the supplementary assistance necessary to carry out a real program.

The first step in launching a program would be to set up the machinery with which to administer it. The State Board of Water Engineers should be elevated to a position with real power and provided with funds that would make its present budget look like petty change. It should have control over the water resources of this state comparable to the power the Railroad Commission has over oil or the power the Highway Commission has over roads, or the power the Game Commission has over deer. If the head is

appointed, as in the case of the Chief Engineer of the Highway Department, he should be chosen by, and work under the direction of, three or more citizen commissioners from different parts of the state. I would rather favor an appointed head over an elected commission.

A second need is for a complete study of the present conflicting and utterly confused and confusing water laws. Three distinct legal systems are fighting for supremacy in the state. Two of these are based on the English law of riparian rights and one is the arid region doctrine of prior appropriation. There is need for a complete new water code that might combine the desirable elements of the three systems and reduce the present chaos to some order.

With such a code in the hands of a State Board of Engineers endowed with power and supplied with funds, water could be prorated as oil is; waste could be eliminated; wells could be spaced; and a program of continuous construction could be carried on just as highway construction is. The people who use water should pay for it just as those who use the highways pay.

The question remains as to how such a program—any program—can be inaugurated. I doubt that we can depend too much on any one of these promising candidates to become on his own volition a delivering governor. They are promising everything but rain, promising so much that they will deliver only what they are reminded imperiously to deliver after election. I propose that the successful one be reminded in terms he can not ignore, reminded by people armed with a poll tax receipt. I would like to see conferences like this called in every community in the state for the purpose of informing and arousing the people. I would like to see every teacher carry the discussion of water into the schoolroom from the sixth grade through the colleges. Then, about the time the new governor takes office, just as soon as the honeymoon is over, I would like to see him call in the president of the Water Conservation Association and suggest a statewide conference in Austin which delegates from every county in the state would attend. The fact that Judge Guy C. Jackson, president of the Association, made the suggestion in the first place should be kept quite dark. Any governor of Texas, by turning his hand, could have several thousand people in to such a conference. The effect would not be lost on either the governor or the legislature.

I trust that in this discussion it has transpired that I believe the real power to do something about the water problem in Texas resides in the people. It is for that reason that I have discarded modesty and consideration of policy and directed my remarks to the lay audience. As an amateur,

I have outlined a program which I think the people of Texas deserve and would be willing to support. The program may have grave faults for the experts to point out, but at least it is a place of beginning.

SPEECH BY A. P. ROLLINS

Member of the Texas Board of Water Engineers

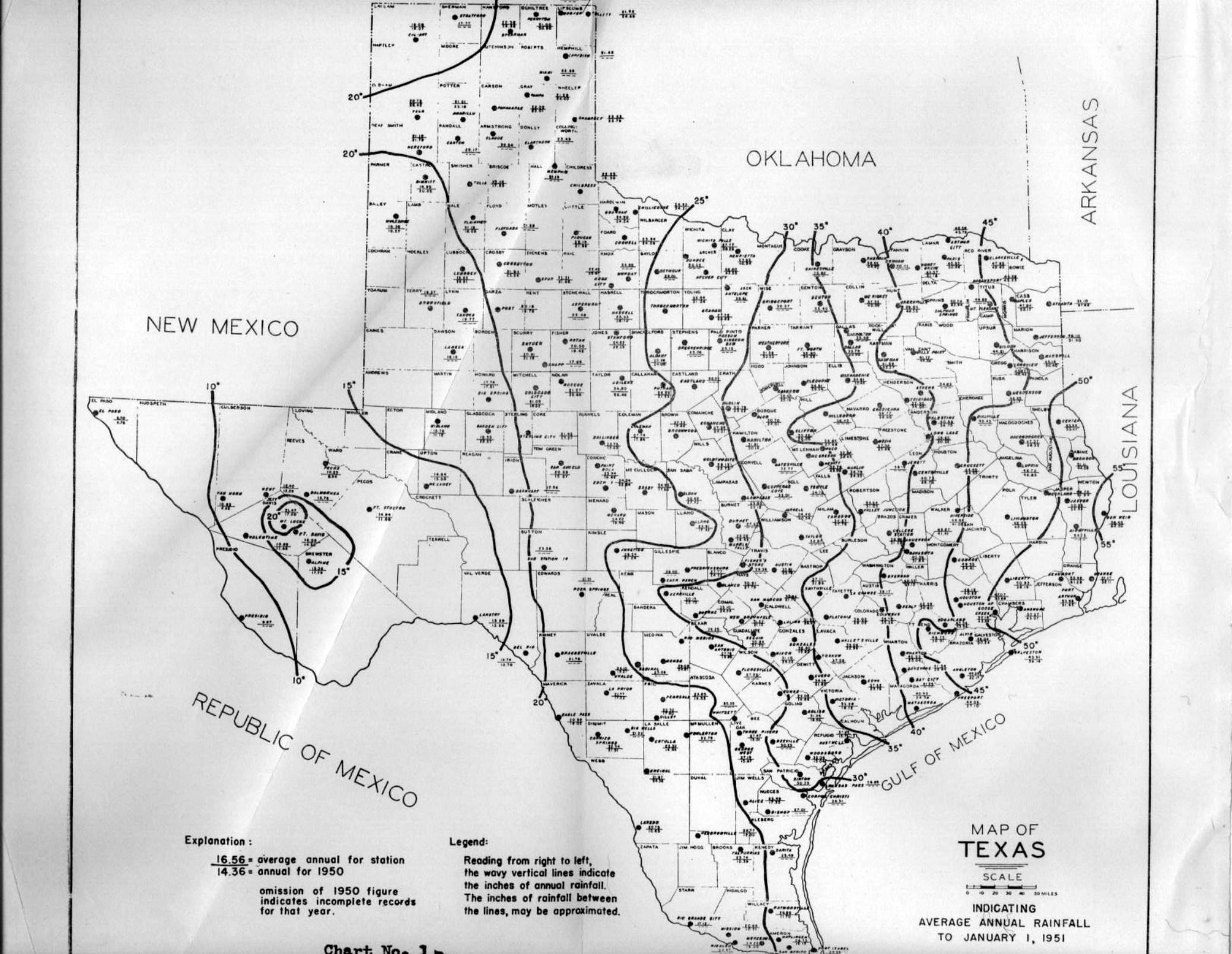
Texas is a state of large area, great distances, and extremes. The land area of Texas is 263,644 square miles or 168,732,160 acres. The longest straight-line distance in a general north-south direction is 801 miles from the southern tip near Brownsville to the northwest corner of the Panhandle. The greatest east-west distance is 773 miles from the Toledo bend of the Sabine River in Newton County to the extreme western point in El Paso County. In elevations above mean sea level, the state varies from sea level to 8,751 feet on the Guadalupe Mountain in Culberson County. Temperature variations range from a maximum of 112° F. to a minimum of —16° F.

During the recent years, because of the drouth and because of increased demands, water has become so important it is discussed in every household. Water is necessary for human and vegetable existence.

Rainfall is the source of all water. In Texas the mean annual rainfall varies from a maximum of 55 inches at the Texas-Louisiana line in Newton County to a minimum of 8 inches in El Paso. The *rainfall chart* (Chart No. 1) indicates the lines of equal rainfall, which you will note have a general north and south direction. It is generally assumed over the state that the Gulf of Mexico has a decided effect upon rainfall; the lines on the chart do not indicate such an effect. A study of the rainfall chart indicates that in the eastern part of the state the disposition of surface water is one of the problems. In the western part of the state, strictest conservation is necessary in order to have water to meet demands. A decrease of 47 inches from the eastern part of the state to the western part of the state means that as we travel west from the Sabine River we have an average loss of approximately one inch of rainfall for each 17 miles.

Rainfall when it hits the ground is surface water. After falling it either penetrates the soil to become ground water, or it remains surface runoff seeking its way back to the sea from which it came. Water penetrating into the soil finds its way into water-bearing formations or to an outlet, usually referred to as a spring. The unused runoff water is one of the greatest assets that Texas has, and a great portion can be impounded during flood times to be used during dry times.

The Board of Water Engineers entered into a cooperative agreement with the Ground Water Division of the United States Geological Survey in 1929, and a continuing program has been carried on since that date.



Explanation :

16.56 = average annual for station
14.36 = annual for 1950

omission of 1950 figure indicates incomplete records for that year.

Legend:

Reading from right to left, the wavy vertical lines indicate the inches of annual rainfall. The inches of rainfall between the lines, may be approximated.

MAP OF
TEXAS

SCALE
0 10 20 30 40 50 MILES

INDICATING
AVERAGE ANNUAL RAINFALL
TO JANUARY 1, 1951

Chart No. 1

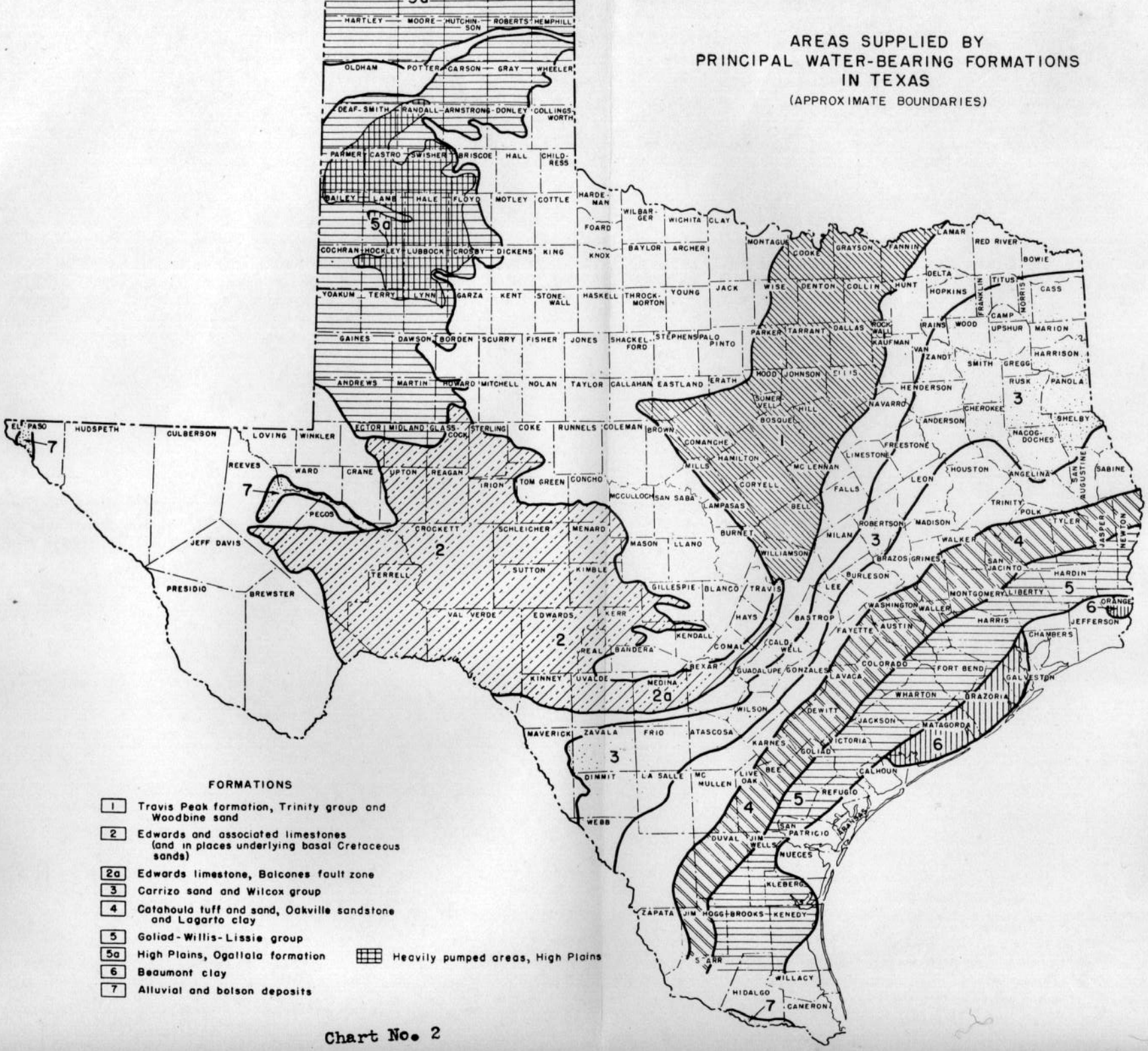
Chart No. 2, prepared from information compiled under that program, shows the Principal Water-Bearing Formations in Texas listed by numbers. Area Number 1, the Trinity group, is located in North-Central Texas. In this group we find the Woodbine, Paluxy, Glenrose and Trinity sands. Area Number 2, the Edwards Plateau, is a limestone formation which supplies the waters for the springs that outcrop along the escarpment from Del Rio to Austin. Area Number 3 consists of the Carrizo sands and the Wilcox group. This is a very prolific ground-water reservoir. The lower western end of the Carrizo sands is known as the Winter Garden District. The sands underlying this area supply considerable water for irrigation. Area Number 4, the Oakville sandstone, while not as prolific as some other ground-water reservoirs, supplies water to most of the cities in this area. Area Number 5, the Goliad-Willis-Lissie group, is a prolific ground-water reservoir; and it is from this reservoir that Houston and Harris County obtain their principal water supply. The Board of Water Engineers has records of as much as 250,000,000 gallons of water per day being removed from the Lissie sands in the vicinity of Houston. Area Number 5a, the High Plains District, is referred to geologically as the Ogallala formation. This underground reservoir contains enormous quantities of water and at this time there are probably twenty thousand wells drawing water from the South Plains part of the district. Area Number 6 in the vicinity of Galveston and Orange is known as the Beaumont clay. It is from this formation that Orange and Galveston obtain their water supply.

In 1951, the use of ground water in Texas totaled about 4,200,000 acre feet. This tremendous quantity of ground water was used to irrigate more than 2,500,000 acres of land, to supply 593 municipalities and to furnish about 80 percent of the rural, domestic, and stockraising requirements. Water pumped for irrigation amounted to nearly 3,000,000 acre feet. Of this amount, about 90 percent was used on the Texas High Plains. An inventory of the use of ground water for public supply (made in 1951) indicated that the 593 municipalities consumed about 350,000 acre feet during 1950. During the first nine months of 1951, the cities of Houston, San Antonio, Lubbock, Plainview, and Amarillo showed increases in pumping that averaged 21 percent more than during the corresponding months of 1950. The underground water supply is vast and varied. It is the supply most readily available to the people of Texas. These underground reservoirs however, are in many instances being depleted ten to twenty times faster than nature is replacing the supply; so some day the cistern will go dry unless the replacement of water is accelerated or the taking of water is reduced.

In 1915, the Board of Water Engineers entered into a cooperative agree-

AREAS SUPPLIED BY PRINCIPAL WATER-BEARING FORMATIONS IN TEXAS

(APPROXIMATE BOUNDARIES)



FORMATIONS

- 1 Travis Peak formation, Trinity group and Woodbine sand
- 2 Edwards and associated limestones (and in places underlying basal Cretaceous sands)
- 2a Edwards limestone, Balcones fault zone
- 3 Carrizo sand and Wilcox group
- 4 Catahoula tuff and sand, Oakville sandstone and Lagarto clay
- 5 Goliad-Willis-Lissie group
- 5a High Plains, Ogallala formation
- 6 Beaumont clay
- 7 Alluvial and bolson deposits

Heavily pumped areas, High Plains

Chart No. 2

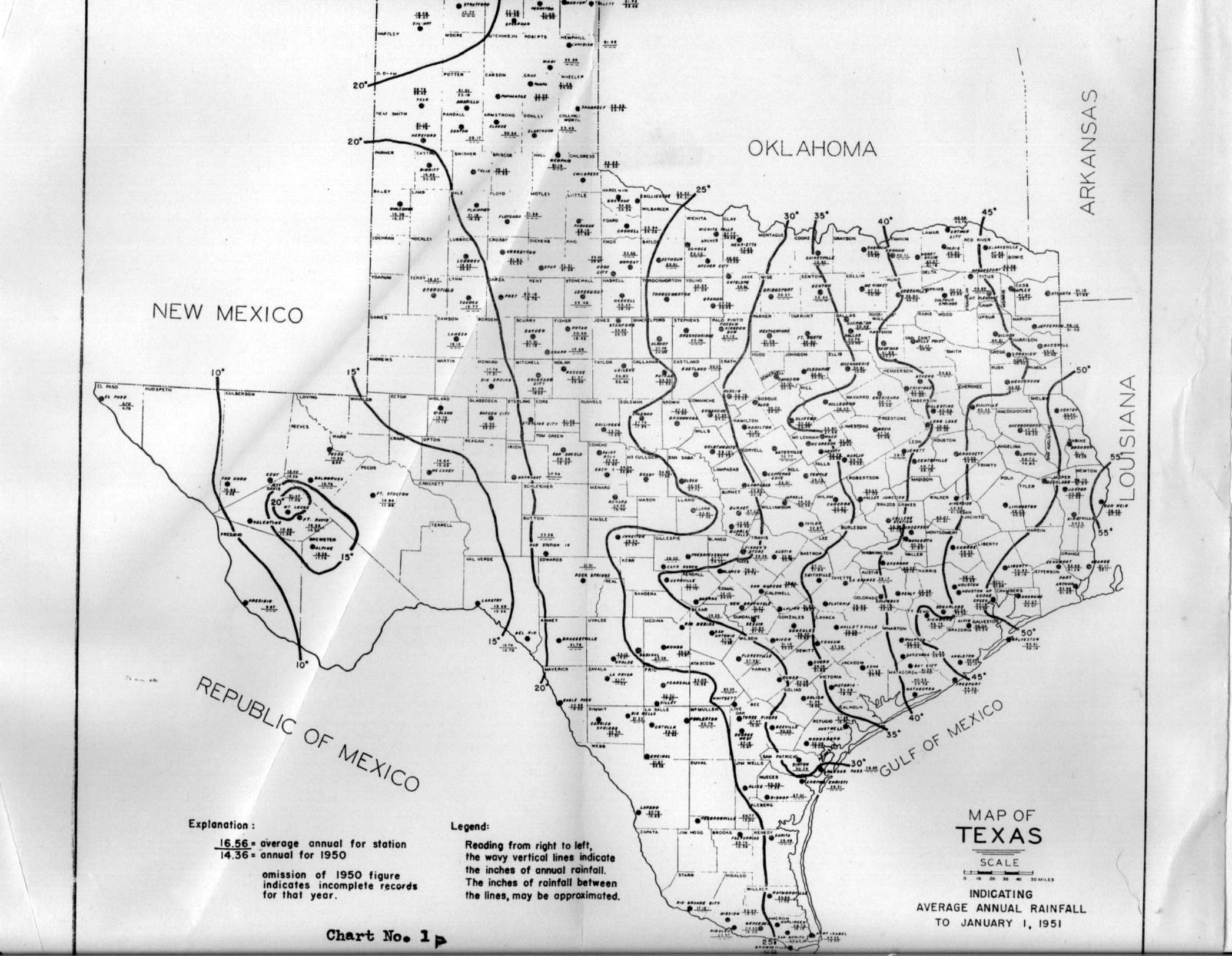
ment with the Surface Water Division of the United States Geological Survey to carry on a program of stream-flow and surface-runoff investigation. The program has been continuous since that time, and the following chart of Average Annual Runoff has been prepared from compiled data. This chart shows the average annual runoff in acre feet for the principal streams in Texas. Beginning up in the Panhandle and reading clockwise, we find the average annual runoff to be:

River	Acre Feet	River	Acre Feet
Canadian	501,700	Brazos	5,723,000
Red	8,875,000	Colorado	2,310,000
Sulphur	2,211,000	Lavaca	695,000
Cypress Creek	1,605,000	Guadalupe	1,872,000
Sabine	6,952,000	Mission	84,120
Neches	6,254,000	Nueces	640,000
Trinity	5,922,000	Rio Grande	4,783,000
San Jacinto	1,847,000		

The total average annual runoff of the state of Texas, as of August, 1952, amounted to 50,275,420 acre feet, a quantity of water sufficient to cover the entire land area of Texas approximately 4 inches deep.

Chart No. 3, prepared by the United States Geological Survey, in cooperation with the State Board of Water Engineers, shows the minimum recorded discharge of the principal Texas rivers prior to the construction of major reservoirs. This chart was prepared in 1948 and on the basis of conditions that existed prior to the most recent drouth. As you look at this map on which is indicated the minimum flow of the rivers of Texas, please bear in mind the chart you have just observed, which showed the average annual runoff of Texas streams. You will note from this chart that the Red River has had no flow as far down as Wichita Falls, Texas; the Sulphur River has been completely dry; Cypress Creek has had a period of no flow; the Sabine River has had no flow as far downstream as Gladewater. The Neches River has been dry as far downstream as the south line of Houston County. The Brazos River has had no flow as far downstream as Marlin, Texas. The Colorado River has been dry down to the mouth of the San Saba River. The Nueces River has been completely dry from the escarpment to Corpus Christi Bay, while the Rio Grande has had periods of no flow below Brownsville. This condition of low flow on the Rio Grande was changed during the last summer as there was a period of no flow from a point above Laredo to the Gulf.

It should be noted that while there is a mean annual available water supply of some 63,000,000 acre feet, in 1951 we had a consumptive use of only 8,465,000 acre feet, while we had appropriations of record in the amount of 34,818,725 acre feet. Strange as it may seem, the consumptive use of water in 1951 was approximately 25 percent of the amount of water



Explanation:

16.56 = average annual for station
14.36 = annual for 1950

omission of 1950 figure indicates incomplete records for that year.

Legend:

Reading from right to left, the wavy vertical lines indicate the inches of annual rainfall. The inches of rainfall between the lines, may be approximated.

MAP OF
TEXAS
SCALE
0 10 20 30 40 50 MILES

INDICATING
AVERAGE ANNUAL RAINFALL
TO JANUARY 1, 1951

Chart No. 1

appropriated. During the summer of 1952 with the exception of the Red River and the Sabine River, every stream in Texas ceased to flow. A dam was built across the Neches River at Beaumont to prevent salt water from reaching the pumping plants above Beaumont. The water users on the lower Trinity found it necessary to construct a dam across the Trinity River near Anahuac in order to prevent salt water intrusion up to their pumping plants. The Brazos River had a period of no flow at the Juliff gauging station for sixty days. The Lower Colorado River Authority was releasing only sufficient water from the reservoirs above Austin to supply irrigation demands. The Guadalupe River had salt water backing upstream almost to the intake of the Canal Company's pumping station. The Nueces River ceased to flow as did the Rio Grande.

We have arrived at the time when the ordinary flow of our Texas streams is insufficient to meet the heavy demands of summer irrigation and summer municipal and industrial supply. It is therefore evident that, if we are to expand and fulfill our destiny as a people, we must begin to plan immediately for the conservation of our flood waters in order that we may supply the demands of our increased growth, agriculturally and industrially. Conservation of the flood waters of our streams is not an insurmountable problem. The plan of conservation must be worked out on an intelligent basis, primarily by watersheds. First, we must have gauging stations on tributary streams, quality water stations on the main streams and tributaries and topographic maps of each watershed on which we can locate reservoir sites and determine the cost of capturing and storing water in these proposed reservoirs. As soon as the origin, quantity, and quality of water and the storage facilities of a watershed have been determined, then the potential demands of that watershed can also be determined. Only after such a plan has been worked out can we determine whether there is any surplus water available for trans-basin diversion.

The governor of Texas in a letter to me as his representative on the Arkansas-White-Red Basins Inter-Agency Committee made this statement:

> The formulation of projects for the comprehensive plan of development of the Arkansas-Red River basins in Texas should be on the basis of economic justification. Texas is not participating in this planning program for the purpose of seeking any form of subsidy. It is prepared, however, to encourage through State organizations or agencies the development of projects found to be economically sound. The existence of almost limitless opportunity in the State makes it unnecessary and unwise to promote unsound projects.
>
> As you participate in the deliberation of the Arkansas-White-Red Basins Inter Agency Committee, you will keep in mind and be guided by the provisions of the Constitution and laws of Teaxs, and will, in

all instances, attempt to make your decisions on the basis of and in accordance with such provisions.

The situation is not one to become alarmed over. There is water available and there is in Texas today sufficient human ingenuity and individual initiative to do those things we find necessary. When the shortage becomes acute enough or when it becomes economically feasible to impound and conserve flood waters for municipal, industrial, and agricultural uses, then those waters will be conserved and will be put to beneficial use. If I know the people of Texas, I am sure they will meet the situation squarely when it arises and will proceed, without seeking subsidy or without imploring the taxpayers of the nation to give them something, with the solution of their problems.

SPEECH BY H. P. BURLEIGH

Chief of the Austin Area Planning Office
of the Bureau of Reclamation,
U. S. Department of Interior

I note that I am the only Federal representative here today on this panel, and I wish to state at the outset that I and my Bureau are honored to have been included in the group to discuss the very important question of the Texas Water Problem—a problem whose solution must be evolved by Texans themselves.

Also, I think that the membership of this panel today, including, as it does, 1) A member of the Texas Board of Water Engineers, 2) A president of a public spirited water association, 3) A Federal water engineer, and 4) Distinguished representatives of our universities and colleges, marks well a recognition that the talents of all will be required to solve the Texas water problem—a problem that I think you will agree is certainly one of magnitude.

As the federal representative on the panel, I shall confine my remarks this morning largely to federal views on the water problem that faces Texas.

Let us understand clearly at the outset, that a federal engineer, with respect to decisions that Texas may make regarding its waters, has no power of decision—nor does he wish any. Texas is sovereign over its waters; it shall remain so.

Deeply imbedded in Reclamation Law is the proposition that the states are, and should remain, sovereign over their own waters.

There is, however, a deep and warranted federal interest in the water problems of this state. I wish this morning to examine among other things the nature and the degree of this interest.

Our panel topic this morning is: "The Texas Water Problem: Origin and Present Status." Let us first examine the components of a water problem:

Texas, like any other western state, faces a wide variety of water problems including, among others:

(1) Need for development of adequate water supplies for rapidly expanding industries and municipalities.

(2) Need for development of water supplies for large new irrigation projects.

(3) Future decline of presently operating, large scale irrigation enterprises through depletion of ground water supplies.

(4) Pollution of both surface and ground waters with industrial and municipal wastage.

(5) Need for drainage enterprises on both irrigated and non-irrigated lands.

(6) Need for aquatic refuges for fish and wildlife.

(7) Need for more power through hydro-production.

(8) Main channel flood control problems.

(9) Navigation improvement.

(10) Greater application of retention practices designed to retain moisture where it falls on the land.

(11) Extraction of higher recreational values from present and potential water projects.

(12) Absence of a firm state water code.

(13) Absence of a single responsible instrument to voice the views of the state with respect to water.

All of the above water problems are interrelated; all affect the economy of the State; none can be dealt with independently without affecting to some extent the solution of the others. Texas water plans should be based on an appraisal of all these problems, their interrelation, and the relative economic importance of each to the state.

It is the considered opinion of my Bureau that of all the above mentioned water problems, the problem of water supply for humans, municipalities, industry and irrigated agriculture now supersedes all other water problems in Texas because of its relative importance to the economy of the state and the nation. It is, in fact, controlling to the future development of the Texas economy. Solution to many of the other water problems will be incidental to, and often dependent upon, the character of solution provided for the water supply problem.

Before we proceed further, let me define precisely what constitutes a water supply problem. In my Bureau, we define a water supply problem as a present or potential need for additional water for municipal, industrial, irrigation, or any other beneficial water use, which can be met by converting presently unused water resources into a dependable water supply at an acceptable cost.

With this as a background, I believe we can review the origin and present status of the paramount Texas water problem—the problem of water supply.

It is our belief that the water supply problem of Texas has its roots—that it is inseparably linked to—the expanding national economy.

While many Texas water supply problems are purely local, and can be solved by local interests, the larger framework in which the Texas water use problem must be evaluated, reaches considerably beyond the borders of the state itself—reaching in fact, into the full panorama of the national economy. The framework, then, by which the problem must be viewed is the circumstance of a national economy expanding so swiftly that none—including the economists—can forecast with certainty the real magnitude of national needs of the decades ahead. The primary factors in this connection are:

(1) First, the American population already exceeds 160 million people. Past estimates have indicated that we must be prepared to feed, clothe, shelter and provide the attendant necessities for an additional 38 million more by 1975 and 75 million more by the end of the century—a matter of only 46 more years.

(2) Second, our living standards are increasing constantly. Year by year our dietary standards improve; per capita we buy more cars, television sets and air-conditioning units, etc. each year. Consequently our utilization of resources increases at a swifter rate than our population. This circumstance compounds the first point.

(3) Third, the attempts to satisfy fully increasing national wants (in the years ahead) will occur in a circumstance of a constantly narrowing national resource reserve whether that reserve be coal or water, arable lands, iron ores or natural gas.

(4) Quantitatively the preceding means that our demands of industry in 1975 will be almost four times that of the 1935-1939 average; and this affects Texas since Texas is rapidly becoming an industrialized state. Agriculturally, it means that the market for citrus and beef production—two typical Texas products—will be increased at least 50 per cent. The same general ratio applies to other Texas crops.

(5) The preceding figures, demonstrating mounting national population and need, were based upon data available in about 1950. In more recent estimates the Census Bureau states that there is every possibility that our population will be 175 to 180 millions by 1960—not 1975. This means that by 1975, five acres must be producing what six do today; that, by then, beef production alone will have to be increased by an amount equivalent to all present production of Texas, Oklahoma, and Minnesota; that as much new power capacity will be required in the next ten years as was established in the preceding seventy-five years.

The preceding relates to the water supply problem of the state. Texas is a true storehouse of under-developed resources both for industry and agriculture. It is one of the few remaining states in the nation presently operating far below its productive potential. The rate of national economic expansion brings to the doorstep of Texas a ready and profitable market for everything, and in any quantity the Texan can produce it. This presents to Texas an economic opportunity of unparalleled magnitude. But, increased production of anything in Texas from now on out will be a function of the rate at which water supplies are provided to industry, municipalities, and agriculture.

While the industrial economy of Texas is in strong ascendancy, irrigated agriculture, which produces 40 per cent of the gross Texas agricultural income from harvested lands, is reaching a peak that will inevitably decline in the future unless positive remedial steps are taken. Maximum development of water resources to provide for major growth of irrigation, combined with possible drainage improvements and other means to increased agricultural production, can lead to an expanding economy in Texas agriculture as well as in Texas industry.

The preceding described, I believe, the actual character of the national interest in a solution of the Texas water problem. We are in a nation that will shortly need goods from every category in great quantity. Texas is one of the last reserves of raw resources that can be processed into the products the nation will need. The needs for goods that can be produced in Texas warrants federal investment in the development of Texas water resources on a vast scale through projects of magnitude. Such federal investment, however, can only be intelligently channeled if the state will establish a water plan on a state-wide basis.

In connection with the federal interest, I would like to point out that this interest has manifested itself, to date, in an investment in Texas, water works of almost 400 million dollars and that at the moment Texas seeks additional federal funds for water projects to the amount of almost 350 million dollars. This, to me, is folding money.

Further, in this connection, I should like to point out that the water projects to come will of necessity have to be projects of magnitude. For example the Canadian River Project alone will cost 90 million dollars; Falcon Dam cost over 70 million dollars. Suggestions that my organization has made for a coastal water plan estimate a cost of over one billion dollars. Also we have concluded that such projects can pay their own way. Other western states have conceived projects of this magnitude. The projects now serve them well. If Texas is to utilize fully its water and profit from that utilization it will of necessity have to think of projects of the

magnitude I am describing. Also, I want to point out that no plan yet evolved in Texas for the state financing of water supply projects has begun to think in terms of the actual magnitude of sums that will be required if the water problem of this state is to be fully met.

That, as I see it, is the origin, the basis of the Texas water supply problem today and the nature of the federal interest in it.

SPEECH BY JUDGE GUY C. JACKSON

President of the Texas Water
Conservation Association

In considering water conservation for Texas, we must first determine the problem and then provide the solution. It appears that the problem is composed primarily of the following:

(1) Lack of basic data.

(2) Conflict between riparian rights and appropriative rights.

(3) Lack of authority and control by proper state agencies.

(4) Unused water escaping into the sea.

(5) Over-draw on the underground supply.

(6) Lack of finances.

To analyze the problem further we should take up each topic in the above list.

(1) Lack of basic data: The lack of basic data includes the deficiencies in topographic maps (only 15 per cent of the state being mapped); lack in stream flow information even on the main streams, let alone the tributaries thereto; insufficient information on the underground water supply; insufficient information on the quality of water.

(2) Conflict between riparian rights and appropriative rights: This is a matter about which we have been "kidding ourselves" for many years and this problem must be resolved before any competent and workable water laws can be enforced. Riparian rights to the use of waters for lands adjoining a stream are rights that have been established through the centuries. It is essential and necessary that riparian rights be specifically defined and limited before we can expect to place any values on the appropriative rights. It has been suggested that the riparian rights should be limited so as to include only "the use of water for household, livestock and household gardening and orchard purposes," and that all other rights to the use of water should come under the appropriative theory. In this connection, there are numerous persons or organizations throughout the state who have established an economy based upon the riparian use of water and in any change of laws, these rights should be protected and converted into recognized appropriative rights.

(3) Lack of authority and control by proper state agencies: The present State Board of Water Engineers does not have sufficient authority or control over the granting of use or the policing of such use of the waters

of this state. Such authority must be granted to some agency, whether it be the present Board of Water Engineers or some other which may be created by the wisdom of the legislature in order to assure those who have a right to the use of these waters that they can and will obtain same.

(4) Unused waters escaping into the sea: This is the problem upon which everyone gives wonderful lip service and few act. The recent report of the Board of Water Engineers shows the mean annual available water at 63 million acre feet, consumptive uses at 8 million acre feet, and the mean annual unused run off at 54 million acre feet. These are mean annual averages and do not represent the high and low flows as the records will show that the low flow is around 25 million acre feet and the high flow around 90 million acre feet. This matter of low flow of 25 million acre feet is important because that is the basic figure from which you must start when you go to planning your reservoirs or other impoundments of water.

(5) Over-draw on underground supply: This matter is becoming more acute in the state and underground supplies are being withdrawn anywhere from 10 to 30 times faster than nature is replacing this supply. It is fundamental that in time the underground supply of water will be depleted and economy based upon this supply of water must either wither and die or seek other sources of supply.

(6) Lack of finances: This problem has been approached from many angles, but still no sound policy has been reached. The various legislatures of the past have provided for the creation of state river authorities, reclamation districts, water conservation districts, navigation districts, water control and improvement districts and various other districts. All of this has apparently been brought about through various and sundry local urges or different political pressures, but the general trend has pointed in the direction of the creation of basin-wide, or partial basin-wide districts with the authority, not only to tax lands, but also to issue revenue bonds for the purpose of creating, operating, and distributing water. It is evident that Texas must recognize this problem and provide competent financial assistance whether it be in the form of a revolving fund, provided by appropriations, or state bonds, or provisions such as contained in the "Bell Amendment," submitted to the last regular session of the legislature.

All of this brings itself down to a two point matter, which is as follows: That Texas must have:

(1) A definite water policy.

(2) A definite water plan.

In connection with a definite water policy for the state, such policy should include:

(1) That the state assume primary responsibility for planning and financing dams to hold for beneficial use the escaping flood waters or assist its subdivisions to do so.

(2) That the state assume the primary responsibility for maintaining the purity of its waters, so that same may be used and reused many times from the headwaters of each stream to the Gulf of Mexico.

(3) That the state assume the policing of all surface waters, including riparian, except that which may be used for household, livestock, gardening and orchard use, under a modified riparian theory.

In connection with a definite water plan for the state, such plan should include:

(1) A clear-cut definition of riparian rights and the amount of water to be used under said rights.

(2) Full recognition of preferential priorities to the use of water for municipal purposes; similar to that expressed in the Woodward-Wagstaff Act of 1931.

(3) Create and adequately finance a state planning agency—this could be done through the present Board of Water Engineers, or a new agency along the lines of the State Highway Department.

(4) Provide ample finances for the construction of dams by the state or its subdivisions. This could be done along the lines suggested in the Bell Amendment, or through state bonds, or by appropriation.

In any plan it must be remembered that dam sites are limited; therefore, every dam site should be developed to its greatest logical capacity. With engineering skill and ability in selecting dam sites, flood waters can be held and made available for beneficial use and for some recharge of underground water.

SPEECH BY STUART McGREGOR

The Dallas Morning News

The people of Texas have been slow in coming to a realization that water is the really great limiting factor in their economic development. Water was adequate for the early settlers who lived along streams and tapped underground resources with shallow wells. Later, discovery of shallow and deep reservoirs produced an abundance of water for the development of many of Texas' great metropolitan areas. Something like three fourths of the urban population of Texas depends primarily upon ground waters.

The people of Texas fell into a way of accepting water as a matter of fact—something somewhat less free than air. Recently, because of the rapid population growth and the impact of one of the greatest drouths in the state's history, they have been startled into a realization of the seriousness of the problem. But they do not know how to go about solving the problem.

The following is suggested as the thought of a layman who has spent many years writing about the water problem.

1. We need a rewriting or codification of Texas laws in such a way as to make the state-wide water program possible. It should include underground and surface waters. There is already full authority for such legislation in Art. XVI, Sec. 59a of the State Constitution in which all uses of water are specifically mentioned in a declaration that the conservation of the natural resources of the state is one of "the rights and duties of the state." This section was added as an amendment in 1917. The last two legislatures have attempted to do something about our water laws and have made some progress, but much remains to be done before we have legal basis for a logical program.

2. In addition to a thoroughgoing surface and underground water code, the legislature should set up a reorganized Board of Water Engineers, Conservation Commission, or other agency of the sort. Without attempting to give the detail of such a new organization, I would say that it should be organized along the lines of the present State Highway Commission. Under any circumstances, it should have more definitely defined legal duties and it should have the financial support to maintain a technical staff much larger than possible under the present provisions for the State Board of Water Engineers.

The two foregoing paragraphs state the two essentials to a Texas water program—a comprehensive, consistent water code and the means of

administering it. The following needs should receive special attention under such an over-all program.

a. Clear definition of a law governing the use of surface waters along the course of a stream. It seems that there should be a new concept about midway between the theory of riparian rights and the theory of appropriative water rights. Because of the great engineering progress that has been made, it is possible to change the entire character of the flow of a stream. If the theory of riparian rights is adjusted to these engineering possibilities, it seems to me, we will come out with something that partakes of the best qualities of both theories. There is no need of any quarrel between the users of water in the upper and the lower reaches of a stream. A sensible program can make it a more useful stream to all residents of its basin.

b. Our state policy should be directed toward basin-wide projects. The laws in some respects should be amended to facilitate the organization of basin-wide districts. This is especially needful in view of the fact that current pressing defense needs and the mounting public debt put such a strain on the federal government that it is likely in the future to demand greater local participation in any big conservation program. All river valleys should logically be organized on a basin-wide scale. Where there are several organizations in one basin, they should ultimately be consolidated.

Recently, as a result of a survey by the United States Bureau of Reclamation, a plan for an inter-river canal, extending from the Sabine to the Nueces and beyond and lying about fifty miles from tidewater, has been proposed. This proposal should receive objective consideration by the people. The report, however, presents insufficient data as to exact location of the proposed storage reservoirs, location of canal and the means of obtaining flow in it, etc. Furthermore, this new project would cut across some long-established and fairly well matured river basin projects. If such a coastal plain inter-river canal is to be built, a more feasible plan would seem to be one extending a little farther east to the Atchafalaya which would be much more practicable. Because it taps the Sabine, the present proposed canal would call for interstate negotiation. So, why not tap a stream that is carrying a hundred million acre-feet of water a year contributed by the Mississippi and the Red? This is two and one-half times as much water as is carried to the Gulf by all Texas streams from the Sabine to the Nueces. Since there is a continuous struggle to control the flood waters from the Mississippi by levees and diversion, it probably would not be difficult to negotiate with Louisiana and the federal govern-

ment for a considerable part of this water, assuming that the coastal canal would be practicable otherwise.

c. Our state laws should be amended and improved to facilitate the coordination of all programs directed at the conservation and development of natural resources, including water, soils, forest and other native plant life, fish and game, and recreation.

d. We should strive, by statute and civil effort following up the statute, to reach a definite clarification of the relationship of federal and state governments in this work. I believe in maintenance of state authority as a principle on the side of keeping governmental affairs as close to the people as possible. Yet I realize that our ultimate sovereign authority is national, not state, and the basis of any state program must be a recognition of those areas of jurisdiction that logically belong to the federal government. Indeed, I think that Texas, because of its great size and diversity of resources, has a large measure of natural autonomy. It is in position to lead the way in such clarification. There has been too much dog-in-the-manger attitude in the conflict on both sides, too much striving to keep the other fellow out. There is work for everybody to do.

e. We should especially have a better policy embraced in new legislation for the conservation of our ground water resources. This is probably the most difficult problem before the state today. Under our law, the owner of any surface area is likewise owner of a prism extending to the center of the earth. This early concept seemed to embrace only the immovable subsurface resources. As it turns out, most of our subsurface resources are fluid and fugitive, including oil, gas, and water. We must arrive at some sort of compromise between the individual's rights to his subsurface resources while protecting his neighbor against exploitation and guarding the entire community against exhaustion of valuable resources. Hitherto this has been impossible for political reasons. In the oil industry, dire circumstances compelled the adoption of a cooperative program. The time is arriving when the sinking water tables of Texas' incalculably valuable water resources will force the recognition that we must have some plan of sensible cooperation.

f. Under effective state laws and administration thereof, we should aim especially at a better fact-finding program. We have made some progress in determining such factors as runoff and stream flow, erosion, and siltation. But we need still more information. Especially do we need more information about the exhaustion of our ground water resources.

We need more information about evaporation under widely varying weather conditions throughout the state and the losses through seepage

in our varying soils. Attention should be given also to the possibility of cheap chemical processing of some of our bad-quality waters. In view of the recent experiments with the so-called electric membrane process, it seems possible that the bad-quality waters (gypsum, iron and others) in many parts of the state might be processed into cheap, potable water at low cost.

In conclusion we need, as stated above, a better water code and a better state administrative system. And, beyond that, we need, through proper education, a better public understanding of the water problem.

Let me congratulate Dr. J. G. Flowers and Dr. James Taylor of Southwest Texas State Teachers College, Dr. Walter P. Webb of the University of Texas, and others for their leadership in bringing this conference together.

SPEECH BY E. B. NEISWANGER

Chairman, Water Resources Committee,
South Texas Chamber of Commerce

I feel greatly honored in being given the opportunity to participate in this important conference and the suggestion has been made, that I develop some lines of reasoning that were used in an article I prepared for the *South Texan*, in September, 1953.

In recognizing the difficult water problems faced in many sections of this state, one could easily be misunderstood if his views of a well publicized project should appear to be critical.

My invitation and the program, refer to me as chairman of the Water Resources Committee of the South Texas Chamber of Commerce, the regional organization for this area. Since I have not had the opportunity to ascertain the views of the membership of that organization regarding the questions I shall raise, I must request that such views and opinions be attributed to me as an independent engineer and economist who is concerned with the future of Texas. I believe my continued studies and exploration of Texas water development since 1927, justify my participation in this conference.

My primary interest is in South Texas and since the allocation of time would not permit a discussion of state-wide water problems, I will confine my remarks to comments relative to the "Appraisal of the Texas Water Problem" prepared by the U. S. Department of Interior and Bureau of Reclamation, which presents a plan of development for Upper Gulf Coast Basin streams and involves construction of a master canal to serve the Lower Nueces and Corpus Christi area and the Rio Grande Valley particularly.

Research is necessary and desirable for every important undertaking, and we are not questioning the value of any research work which may be done to appraise the people of Texas of the possibilities for future development work in the field of water conservation, but it is also important that our people are not diverted from developing present emergency projects that can and will serve the areas involved, for the foreseeable future.

Corpus Christi and other area towns will be best served from a storage dam on the Lower Nueces River, for which projects revenue bond financing in the amount of $15,000,000 has been arranged. This water storage project should serve the Corpus Christi area for twenty years or longer.

We must be concerned, then, when some of our people wonder if we

should not wait for the government to provide us with a billion dollar project. Of course, they may not realize that the fruition of such project may be beyond the life span of the most of those in attendance here today, but it does make trouble for those who know our salvation depends on action today.

Since Corpus Christi is one of the prospective beneficiaries of the proposed master canal plan, it is well to remember that the average flow of the Nueces River is 640,000 acre feet of water per annum while the water needs of Corpus Christi in the foreseeable future, are only 137,000 acre feet per annum. Hence it would be economic suicide for this area to assume its share of a billion dollar canal system until all of the available flood waters of the Nueces were fully utilized.

As an example of what this highly publicized plan has done to certain individuals, we now have a candidate for congress from Corpus Christi, who is running on the platform that he wants to go to Washington to get this Bureau job done. I must confess I did not think congressmen were rated such life expectancy.

As for the wisdom of Rio Grande Valley water users assuming the responsibility for a substantial share of a billion dollar canal project, to secure supplemental water for irrigation, convincing figures as to the cost of such water per acre foot delivered would be enlightening and perhaps sobering.

It is rather difficult to understand a situation where one branch of the government is endeavoring to interest water users in a plan to conduct water 450 miles, at what it appears would entail prohibitive cost for the users, while the executive branch of our government has committed this nation, by treaty with Mexico, to construct two or three dams, if necessary, to contain and store the waters of the Rio Grande for the protection of the people along this river and to provide irrigation water for the lands which now have insufficient water to insure the crops.

In fairness to all concerned, I would remind you that this Document 57, "Appraisal of Texas Water Problem," was not initiated by the present administration, but by Interior and Bureau heads who no longer direct the policies of these governmental agencies.

The United States-Mexican treaty, providing for dams on the Rio Grande was approved by the president in 1944 and ratified in 1945, thus indicating the lapse of nine years to complete one dam.

After the loss of life and destruction of property in the terrible flood the last week of June this year, the government and our members of congress should awaken to the need of immediate action toward the further

fulfillment of our treaty obligations on the Rio Grande, by speeding the construction of a dam in Diablo Canyon above Del Rio. This dam would not only have avoided the catastrophe which has overtaken us, but would provide additional water storage needed for the irrigation of crop lands in the Valley and in the state of Tamaulipas, Mexico.

Every river valley in the upper Texas gulf coast area has been and is now being studied by the authorities that have been set up for each river basin, to plan the future development of the rivers involved. In the majority of cases these Authorities now know where dams should be constructed to effect the most desirable and maximum conservation storage.

The industrial, irrigation and population development and expansion in each of these river basins will ultimately determine the timing of construction and the storage capacity needed to meet the demands in each area. Until each river basin has been assured of water for its own use and purpose, would it be reasonable to assume that waters would be optioned for the benefit of either the Corpus Christi area or the Rio Grande Valley?

Obviously the industrial cities of these river valleys do not know today what their water requirements may be in ten, twenty, or thirty years and so the question of yielding waters for transfer to distant areas wholly unrelated, could encounter serious opposition because our laws prohibit such transfers except by consent.

Finally: Waters delivered to the Corpus Christi area would presumably be utilized largely by industrial customers and we would need to know just what the city's share of the billion dollar canal investment would be, in order to fix the cost of water per thousand gallons delivered. An excessive rate for such water could increase the cost and defeat the purpose because rates for industrial waters must be competitive with rates that are applied in the upper gulf coast industrial areas.

Water delivered to the Rio Grande Valley raises the same question because the Valley would have to bear a substantial share of the billion dollar canal investment and until a dependable estimate could be made, as to the cost per acre foot of water so delivered, the Valley irrigators would have no idea whether the cost of water would make its use either practical or possible.

Prospective water uses and increased income to the entire area have been projected to the year 2000 and time will record the accuracy of these forecasts. We must be concerned, however, with the inherited financial responsibilities which must be assumed with a project of such magnitude, while awaiting our ultimate development.

The project report, in its forecasts of revenues needed to support the project, allocates substantial income from irrigation, but unless or until the Interior Department and Bureau of Reclamation are ready to coop-ate with Congress in amending the 1902 law which carries the land limitation provision, the whole revenue forecast will fall by its own inconsistencies.

There can be no question but that a project of the magnitude embraced by the Gulf Coast Canal plan, would of necessity require federal financing and it follows that a government agency would expect to retain control of the project until all borrowed funds had been repaid. In any event, revenues sufficient to liquidate the indebtedness and operate the complicated system would be required, and such contract would of necessity provide that the federal agency advancing the money would also have the power to fix the rates to protect its loans.

These are matters of importance that should be given further consideration before the prospective water users can properly reach a decision regarding the practicability of this proposed plan, for the two areas in question. I have raised these vital points because someone who is informed should do so and for the sole purpose of guarding against any creeping complacency that may divert us from the emergency projects which must go forward today for our self protection.

SPEECH BY LOUIS KOENIG

Associate Director,
Southwest Research Institute

My remarks will constitute a progress report on the development of saline water conversion methods, which are a possible solution to the Texas water problem. In view of the other possible sources of fresh water for Texas which have been discussed this morning, saline water conversion cannot at present be taken as a major possibility but should as my remarks will show, have some consideration for special situations.

Much of my discussion will center around costs, and accordingly for your orientation Table I shows representative costs for bulk raw water.

TABLE I. REPRESENTATIVE BULK RAW WATER COSTS DOLLARS PER ACRE FOOT

	Municipal	Bureau of Reclamation Irrigation	Private Irrigation Companies
Range	$1.00-$120	-$25	$3-$40
Usual	$49 -$82	$1.64-$6.00	

From it, for example, we see that usual costs for municipal water are $50 to $80 per acre foot and for irrigation water from Bureau of Reclamation projects $1.60 to $6.00 per acre foot. As a specific example, Colorado River water transported 273 miles to Los Angeles for municipal uses costs $30 per acre foot.

Most of the work going on in this country today in saline water conversion is under the guidance and sponsorship of the Saline Water Conversion Program of the Interior Department which has a small appropriation of $400,000 per year to sponsor research and development on the problem. The program has been in operation for about two years, and last year I reported to the public on the progress made up to that time.

Since then two careful engineering studies have been carried out to determine the probable cost of the plant and of water produced by solar evaporation. In the one study directed to simple solar stills, it was estimated that the water cost would be $775 per acre foot. In the second study in which solar heating was used for multiple effect evaporation, a more complicated procedure, the most optimistic cost for present practice would be about $1,000 per acre foot.

The investment cost of the plants per acre foot per year of capacity

would be some ten to fifty times the investment cost of the normal method of water supply, namely aqueducts. Furthermore, the engineers estimated that under the very best conditions which could be hoped for, the cost would be no less than $700 per acre foot. These figures indicate that water by solar distillation would cost twenty to one hundred times per acre foot as much as we now pay for irrigation water. The goal of the Saline Water Program calls for irrigation water for at least as low as $40 per acre foot, and thus it is rather clearly indicated by these careful studies that the use of solar energy does not constitute a likely solution.

The second development has been made under the program by Dr. Hickman who has made some important fundamental contributions to the practice of vacuum distillation. He has shown from fundamental discoveries of the nature of boiling that there are some spots on the surface of boiling water from which water is evaporating at a rate up to 400 times as great as the average rate. By asking the fundamental question, "Why does water boil faster in some spots than in others?" he has been able to develop an hypothesis which when reduced to practice shows important promise of greatly increasing the rate at which water can be distilled. Since a costly part of the distillation apparatus is the surface through which the heat is transferred, this discovery means that such surface area can be greatly reduced and therefore we may hope to reduce greatly the cost of distillation. The same total amount of heat must still be supplied, however, which means that the cost of fuel would not be significantly reduced. This development is still far back in the research stage.

The third item of progress to report on the Saline Water Conversion Program concerns the work being done by an industrial corporation, Ionics, Incorporated, in Cambridge, Massachusetts, which for many years has been attempting to develop the electrolytic membrane method of water purification. This company has recently had some support from the program, and under it during the past year has operated a 100 gallon per hour pilot plant. From the results of this pilot plant they have made some cost studies which are very favorable for that method of water purification.

It should be noted that the previous two methods of which we have been speaking involved the removal of the water from the salt, by distillation. The cost of these methods does not depend very greatly on the concentration of the salt in the water. The electrolytic membrane method, however, involves separation of the salt from the water and therefore is quite dependent upon the concentration of the saline water. The pilot plant was run on brackish waters having concentrations typical of the Dakotas, of Arizona and of Texas, namely 885, 4,635, and 10,000 parts per million respectively. The estimated purified water cost for a plant which would

produce 87,600 acre feet per year was $4, $20, and $40 respectively per acre foot of product water containing 350 parts per million salts. These costs are actually within the range of present prices for municipal and irrigation water. Sea water contains 36,000 parts per million; so that the $40 figure applies to a water which is already one-third as contaminated as sea water. The plant has not yet been run on sea water and no estimate of that cost is available.

The investment cost for an electrolytic membrane plant is also within the range of feasibility. For your orientation, Table II shows investment costs per acre foot per year capacity and water costs per acre foot for a number of methods of water production. Among those listed are some of the suggested saline water conversion processes, as well as some of the conventional aqueduct methods of water supply. All the investment and operating cost figures have been corrected to represent what the installation would have cost in 1952. Most of the figures in this table are taken from a compilation made by Dean Everett Howe of the University of California, who is an energetic and prolific worker in the field of saline water conversion.

From this table we see that some of the recognized methods of water production, namely the aqueducts, cost $500 to $1200 and up per acre foot per year. The electrolytic membrane plant, however, is estimated to cost only $240 per acre foot per year for operation on typical Texas brackish water.

The Saline Water Conversion Program has now asked Ionics, Inc., to prepare two mobile trailers containing demineralization plants. These trailers will be moved around the country to various sites in order to demine the operating characteristics on various types of brackish waters. There are still a number of unanswered questions concerning the process —the most important being the cost of maintenance and the life of the membrane. But the picture looks very encouraging for this method of water purification; certainly in special situations.

Despite these encouraging costs, the magnitude of water production by saline water conversion is staggering. Recently I was at Landa Park with a colleague who is quite experienced in industrial chemistry. In walking across the dam at the swimming pool, which is discharging 10 second feet, my colleague remarked that this discharge would represent the output of a very large chemical plant, and a saline water conversion plant is a chemical plant. This started us calculating in these terms and we found that this 10 second feet, which is 8000 acre feet per year, would represent the output not of one but of ten 3,000 ton per day chemical plants. My first industrial job was with a company which had the largest soda ash plant

in the world. It then produced 1,800 tons per day; during the years I was there the capacity was increased to 2,300 tons per day, and they may possibly have it up to 3,000 tons per day now. It is still the world's largest in a field noted for the size of its production and the size of its production units. How many of these chemical plants would be required to supply the 12.3 million acre feet per year for the Gulf Coast? The staggering figure of 15,000 plants would be required of the size of our largest chemical plants; one plant every 150 feet from the Sabine to the Rio Grande, wall to wall for 450 miles!

A great deal of further research is needed. The amount of money being spent on saline water conversion research and development in this country is practically limited to that of the program, which at $400,000 per year is a very small amount compared to the importance of the results. The research effort going into this work is only 1/12,000 of the research effort of the country which now stands at three billion dollars per year. In my last year's report I gave the opinion that it would require five years to show the feasibility of a saline water conversion process, and ten more years to have a process in established commercial operation. Progress has been a little better than I anticipated, but in general it will still be three to four years from the present before feasibility is shown.

During the past year some resource studies and some market studies have been made on saline water. Surveys have been made of the saline water resources of South Dakota. Something like 93 per cent of the water resources of South Dakota are brackish. I understand that the U. S. Geological Survey is about to engage in an underground water study in North Texas which should result in some inventories of underground saline waters. At Texas A. & M. Paul Weaver, former chief geophysicist for Gulf Oil Corporation, has started a program to locate, sample, and analyze all underground and surface water resources of Texas. This information will disclose the location of the water, its quality, and the amount and direction of flow. The information will be placed on IBM punch cards so that it may be withdrawn in various categories.

In market studies, since purified water should be a cheap commodity, the marketing area is limited to the vicinity of the production area. In order to determine the extent of such markets, work has been done under the Saline Water Conversion Program to show that in the Gulf Coast strip within 50 miles of the ocean, and at elevations of less than 500 feet that is, within reasonable pumping distance and height from a sea water source, there is a potential market for over 5,000,000 acre feet per year of water for irrigation and municipal and industrial use.

It is this same area slightly expanded which constitutes the market for

the proposed Gulf Coast Canal water, which we have just heard discussed by Mr. Burleigh. This canal costing 1.1 billion dollars will have a capacity of 12.3 million acre feet per year. This computes to $89 per acre foot per year which is about 1/6 of the investment cost for some of the conventional aqueducts. Possibly Mr. Burleigh could later explain to us whether this much lower unit cost reflects a cheaper method of construction than was possible in the aqueducts, or whether his investment cost figures are not comparable with those of the other installations.

One final word on water re-use: that is the utilization with or without purification of effluents which have already been used for another purpose. At Southwest Research Institute we are strong advocates of water re-use and successive use. A calculation of the water use patterns in Texas, both present and estimated for the future, shows, however, that the municipal and industrial water which is by far the most feasible source of re-usable water constitutes only about 15 per cent of the total. This means that the supply could be augmented by only 15 per cent by one re-use. Thus water re-use is not a major factor in water supply for Texas.

TABLE II. COST OF WATER SOURCE INVESTMENT AND WATER PRODUCTION

Location	Type	Date Installed or Estimated	Investment Cost* 1952 $/a.f. per year	Water Cost* 1952 $/a.f.	Remarks
Los Angeles	Owens Aqueduct	1904	$ 485		
Los Angeles	Colorado Aqueduct	1924	535	$ 30	
Philadelphia	Delaware Aqueduct	1950	562		
Contra Costa County, Calif.	Reservoir, pumps and pipeline	1932	1220		
San Francisco	Hetch Hetchy reservoir and aqueduct	1925	3840		
	Triple effect distillation	1952	450	700	Estimated
	Vapor compression distillation	1949	1300-3600	429	Estimated
Abidjan Africa	Vacuum distillation using marine thermal gradients	1950	690		Estimated
	Vacuum distillation using waste heat from diesel power	1952		528	Estimated
	Simple solar evaporation	1952	3,600	775	Estimated
	Multiple effect distillation using solar energy	1953	15,000	1069	Estimated
	Electrolytic membrane	1953			
	885 ppm feed		20	4	Estimated
	4,635 ppm feed		115	20	Estimated
	10,000 ppm feed		240	40	Estimated
Texas	Gulf Coast Canal	1952	89	8**	Estimated

*Corrected to 1952 dollars by application of Engineering News Record Cost Index.

**Computed from conference discussion statements: $15/acre for 20 inches, using 50 year amortization and zero interest.