

CENTRAL ARIZONA PROJECT

HEARINGS BEFORE THE SUBCOMMITTEE ON IRRIGATION AND RECLAMATION OF THE COMMITTEE ON INTERIOR AND INSULAR AFFAIRS UNITED STATES SENATE EIGHTY-EIGHTH CONGRESS FIRST SESSION

ON

S. 1658

A BILL TO AUTHORIZE, CONSTRUCT, AND MAINTAIN THE
CENTRAL ARIZONA PROJECT, ARIZONA-NEW MEXICO, AND
FOR OTHER PURPOSES

AUGUST 27, 28, OCTOBER 1 AND 2, 1963

PART 1

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CENTRAL ARIZONA PROJECT

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STUDY BY SAMUEL

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ally, the attached report of the division of water resources deals with matters
of water supply, water requirements and utilization, and feasibility of the central
Arizona project.

In conclusion, I respectfully request that this letter and the concluding com-
ments and recommendations set forth in the report of the division of water
resources, as approved by the director of public works, be considered as express-
ing the views and recommendations of the State of California on your proposed
report on the central Arizona project, and further request that both the report
and this letter be transmitted to the President and the Congress.

Sincerely,

EARL WARREN, Governor

Senator KUCHEL. I think that is a good letter and I think the sen-
tence that my friend, Barry Goldwater, has just read is precisely
the philosophy that would guide any representative of California
here today.

Senator HAYDEN. The next witness is Mr. Samuel F. Turner, a con-
sulting engineer, subject: dendrochronology as an aid in the ascer-
tainment of wet and dry cycles. That is tree rings.

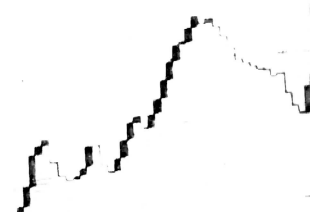
STATEMENT OF SAMUEL F. TURNER, CONSULTING GEOLOGIST AND ENGINEER, PHOENIX, ARIZ.

Mr. TURNER. Mr. Chairman and members of the committee, my
name is Samuel F. Turner. I am a consulting engineer and geologist
specializing in hydrology. I was raised on an irrigated farm in New
Mexico. I attended the Colorado Agricultural and Mechanical Col-
lege, at Fort Collins, Colo., and graduated with a degree of bachelor
of science in civil and irrigation engineering in 1926. I received a
master's degree in geology from the George Washington University
in 1929. From September of 1929 to June of 1952, I was with the
U.S. Geological Survey. I have been a consulting engineer with of-
fices in Phoenix, Ariz., since June of 1952.

I have done extensive work in hydrology where long term flow
records were of greatest importance. Our streamflow and weather
records both are of comparatively short duration, with the earliest
weather records going back to about 1855 and the earliest streamflow
records to just before 1900. Thus, the existing data in Arizona
records just one long wet spell followed by a long drought.

To increase this period of record so that we may better determine
what we can expect in the future we have dendrochronology, the
science of tree rings. The science of dendrochronology proves that
there is a direct correlation between the annual growth of rings of
trees and the amount of soil moisture available in any given year.
Thus we are able to deduce the relative amounts of soil moisture
available from year to year historically for the life of specific tree
specimens, and from that establish relative precipitation in the life
span of the specimen trees measured. By various scientific means
the period in which a tree specimen was a growing tree can be deter-
mined. That applies to archeological specimens.

Dr. A. E. Douglass of the McDonald Observatory at the University
of Arizona was the originator of the study of tree rings. He de-
cided their value in a search for the relationship between sunspot
cycles and weather cycles on the earth. His work was continued by
his assistant, Dr. Edmund Schulman. Among the publications I have
used in my studies are those entitled "Tree Ring Hydrology of the



10 YEARS

Colorado River Basin" by Edmund Schulman, "University of Arizona, Laboratory of Tree-Ring Research," Bulletin No. 2, October 1, 1945, and "Dendro-Climatic Changes in Semiarid America" also written by Dr. Schulman in 1950. Plate 3 of the Colorado River Basin report gave the tree-ring indices in the Colorado River Basin as a whole and for its principal divisions. The record for the Colorado River Basin above Lee's Ferry began in the year 1250 and continued through 1944. This was brought up through 1950 by using the Colorado River in Lees Ferry from figure 8 on page 50 of the report on semiarid America. On this graph Dr. Schulman compares the variation in tree-ring growth with the runoff of the Colorado at Lees Ferry.

For many years I have maintained a graph showing the accumulated departure from average of the precipitation for the State of Arizona. This has proven to be such an effective method of showing what was happening that I have adapted it to tree-ring growth. I have prepared a graph comparing the average Arizona precipitation with the available tree-ring records in Arizona. These correlated very well but the Arizona tree-ring records went back only to the year 1600. The longest record in the Colorado River Basin area was that for the Colorado Basin above Lee's Ferry which dates back to 1250. This was graphed in the search for long-term cycles. This illustration is given in the back of the report which you have.

Dr. Schulman's tree-ring graphs indicated the variation from the average growth rate for the period of record. I converted the material to my cumulative graph by measuring the variation from average with a metric scale and plotting these changes on my graph using a scale which gave variations approximately equal to the weather variations. A copy of this graph is attached to this statement.

On the right hand side of the graph there appears the cumulative departure from the average flow of the Colorado River at Lee's Ferry as set forth in the *Arizona v. California* exhibit No. 201A and as derived from Arizona exhibits 197 and 77-B. The figures graphed varied from those in the exhibits named due to the fact I brought the runoff data through 1961 and used a new average of 15,002,000 acre-feet per year and the deviations were recomputed.

The graphic record of the cumulative variation from average flow at Lee's Ferry bears a remarkable resemblance to the tree-ring record for the area above Lee's Ferry. This close comparison of the two curves justifies the conclusion that the runoff of the Colorado River in previous years, back through the year 1250, would have been similar to the tree-ring records as shown on the graph.

The tree-ring record starts with the record of the great drought which drove the Hohokam Indians from this area. This was the greatest drought shown by the record. The present drought will be equal to that if it continues for another 20 years.

I have indicated the major wet cycles and major droughts on the graph. My study accentuated the wet cycles and I have darkened in the years in which the growth was above normal. One thing that stands out is that every major drought was followed by a major wet cycle, and minor droughts seem to be followed by minor wet cycles.

The period from 1622 to 1824 was characterized by minor wet cycles and minor droughts, but on the whole during this 200-year period

there was a gradual increase in the accumulated departure from normal. A major wet cycle began in 1825 and was followed by a minor drought and a minor wet cycle and then by a major drought which started in 1869 and ended in 1904, with only one very minor wet cycle to relieve the distress. The wet cycle which started in 1905 and continued through 1929 was contemporaneous with most of the Colorado River flow record that was available when the Santa Fe compact was signed in 1922. The drought which started in 1930 and has continued to 1963 has countered the effect of the wet cycle and we have had below normal runoff during this period.

In my study the start of each major wet cycle was marked on the graph. The average number of years separating these periods was 57 with the minimum being 41 and the maximum being 77 years. Thus, we note that according to the averages, 1963 would well mark the beginning of another major wet cycle. If we go to the maximum time, it could be another 20 years and would give us another drought equal to the one which drove the Hohokam from their homes.

I believe that my graph shows that we will have wet cycles occurring which will give flows in the Colorado River at Lee's Ferry which will approximately equal those which occurred during the wet cycles 1905-29, inclusive. (Although our streamflow record covers only one wet cycle and one dry cycle it is believed that the average flow from these two cycles of 15 million acre-feet per year is a reasonable average for the Colorado River in the future not considering upstream storage dams and other manmade factors which influence this flow.) The tree-rings indicate that two of the previous weather cycles were greater than the wet cycle of record, 1905-29. These were the wet cycles starting in 1365 and ending in 1396 and the one starting in 1603 and ending in 1627. (This would indicate that the average might actually be somewhat higher than 15 million acre-feet.)

31 yrs

Bad statement

If the year 1963 turns out to be the start of another wet cycle, we should have about 20 years of somewhat above average precipitation and runoff. (This will give time to pursue other means of increasing the runoff to the Colorado River and saving more of this water for beneficial use.)

Senator HAYDEN. Any questions?

Senator KUCHEL. That is a most interesting paper, Mr. Turner. I listened to you with great interest.

You said in part, quoting from your statement on page 4:

The figures vary from those in the exhibits named due to the fact that I brought the runoff data through 1961 and used a new average of 15,002,000 acre-feet per year, and the deviations were recomputed.

That would be the average in the Colorado River over what period of time?

Mr. TURNER. The average in the Colorado River from the start of the flow record, which was 1896.

Senator KUCHEL. And you forthrightly suggested that the storage dams now under construction and those authorized in the upper basin would, of course, affect that amount?

Mr. TURNER. Yes.

Senator KUCHEL. As they are built.

Mr. TURNER. I did not attempt to estimate any effect.