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MEETING ON HYDROLOGY

IN

MARICOPA COUNTY

June 13, 1961

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HYDROLOGY MEETING

June 13th, 1961, 9:30 a.m.

Meeting on hydrology in Maricopa County was held June 13th, 1961, in the County Health Department auditorium, 1825 East Roosevelt, 9:30 a.m. Those attending were:

Soil Conservation Service	J. J. Turner Marvin Sheldon George Watt J.H.Dorroh, Jr.
U.S.Geological Survey	Douglas D. Lewis James J. Ligner Al Wilson James E. Bowie
U.S.Bureau of Reclamation	Jack C. Jorgensen Paul C. Brabham Don L. Sieckman
U.S.Corps of Engineers,Los Angeles	Fred E. Tatum
U.S.Weather Bureau	Louis R. Jurwitz
Johannessen and Girand	Jack Phelps Jake T. Doss
Benham Engineering Co.,Inc.	Chandler McCoy Wilson D. Charles
Yost and Gardner, Engineers	John E. Schaefer Leigh O. Gardner
Arizona State University	Robert D. Kersten
Flood Control District of Maricopa County	Robert E. Cron, Jr. Tom R. Neiswander

The meeting was opened at 9:00 a.m. by Mr. Cron. Mr. Cron pointed out that there are three governmental agencies making studies

connected with flood control in the county and three consulting firms doing the same thing. Mr. Cron stated he was fully aware of the fact that we cannot hope to have a uniform hydrology throughout the County because hydrological conditions throughout the County are not uniform. Also in the case of Federal agencies, each one may have its own criteria. Nevertheless, in an effort to assure equal treatment to all parts of the County it seemed only fair that we have this meeting for the purpose of exchanging information, asking one another questions, commenting, and contributing towards one another's knowledge of the hydrological conditions within the County. Since most of the people here have a good basic knowledge of hydrology, elementary principles of hydrology need not be covered, but the approach you are taking toward the solution of your own problems in the County is very important. Mr. Cron hoped everyone would feel free to ask questions, it is not a formal meeting, you are not expected to make formal presentations. The meeting will be recorded for the purpose of keeping a permanent record of the useful information which will come from this meeting.

As there is no formal agenda for the meeting, the scheme Mr. Cron felt might be effective would be to first have the gentlemen who provide the basic data on hydrology say whatever they have to say. This would be Louis Jurwitz of the U.S.Weather Bureau and Douglas Lewis of the U.S.G.S., then call on the agencies working in certain areas to make their presentation.

Mr. Douglas Lewis of the U.S.G.S. was called upon. His comments are summarized as follows:

Mr. Lewis introduced members of his organization present - Jim Ligner, who is Mr. Lewis's assistant, Al Wilson in charge of hydrological special study section, Jim Bowie in charge of the Phoenix sub-district office. The U.S.G.S. has worked quite closely with the agencies represented here for quite a number of years; they have also worked closely with the consultants. Recently, some of our policy statements indicated that the objective of the survey was an appraisal of the water resources of the United States. Broadly speaking that would include providing the basic information and some interpretation of that information for the agencies, all of the acting agencies, and that is including the Federal agencies, State agencies and the consulting engineers. It is a pleasure to be able to talk to this group and express some of our ideas.

Mr. Lewis remarked it seemed to him that it was only a few years ago that all the basic information that was needed was primarily stream flow records, water level records and that sort of thing. There have been some tremendous changes in the America of today. These changes have been brought on by population, economics and social pressures and accordingly they have contributed immensely to the water problems that we have. Let us just consider for instance a few of those that have developed within the last years or have become more critical during the past few years. Here in the arid southwest, the demands for water

have caused a mining or a depletion process of ground water. I suspect that within a few years that is going to create problems that are much more complex than the solution to the present water shortage. There has been a change in hydrological environment of plants; we have to consider that. There has been the organization of large areas of agricultural and waste lands; they have changed the problems. We have an interstate system of highways across the country that has developed drainage problems. We need to know a lot more about the repetitive processes of the hydrologic cycle than we have in the past. The concept of flood plain zoning, as an alleviation of flood damages has increased the need for knowledge of flood frequencies, and so right on down through the list. Problems of pollution and the disposal of atomic waste -- all of these enter into it. I think that if we had the basic data that the problem we are confronted with would be fairly easy. Actually here in Maricopa County, we have very little basic data; some of that that we do have is not germane to the problems confronting us. The Survey itself, has published, in two of its water supply papers, a number of parts of what we call our hydrologic by-laws. In just a few minutes I will give Jim Bowie the opportunity to explain the way the Survey attacks some of these problems and a little later I want to provide Jim Ligner with the opportunity of explaining what our program is here in cooperation with the Flood Control District of Maricopa County. We are faced with a problem. I think we all realize that there is a lack of basic data and yet I think we would be derelict

if we even suggested we put off flood control until we have all the information that we need. We are going to have to make out with what we have. We do have some tools that we can use. The Survey normally does not favor empirical formulas or some of the standard processes that are used elsewhere. We have such tools as the unit hydrograph, flood routing processess, rain-fall run off relationships can be developed, conveyance slope methods. Actually I don't believe we should be dogmatic about where a particular method should be used. We try to fit the particular method of attack with the data that we have on hand and that in turn throws/much greater burden of responsibility upon the individual engineer who does the work. That, perhaps, is confusing to some of you but we believe that it has worked. In some 30 states we have cooperative agreements with the state highway departments providing information that will permit them to develope a closer design on their drainage structures. It has worked out very successfully. At the present time we are about ready to complete a program of flood plain zoning for the city of Boulder, Colorado. There was very little more data available at Boulder than there is in Maricopa County at the present time. In addition to these hydrologic tools I want to mention one other tool. We are attempting to get into what we call systems analysis, which will take an entire drainage basin and make it possible to predict what would happen in any given spot of the drainage basin if something else happens, perhaps upstream or downstream. The mass of computations required for that type of analysis have been just too large for any

agency to get very deeply into it. However, we are working on analog computer methods to solve some of these problems. Frankly, the analog computer is in an experimental stage but we do believe we can develop it to the point where it will cut out a lot of the menial labor connected with this type of work. Now I want to get down to a few specific cases for awhile. I think that even with a wealth of data the computations that we make are going to define a rather wide band of error. Without actual data to work on that band is going to be somewhat wider. I might give one or two specific examples. I do not want to point the finger at any one or any agency but there is one that comes particularly to my mind. I think that many of you have heard here and there that the Corps of Engineers, for instance, may overdesign on hydrology. In 1950, the Omaha Division Office sent into the Chief's office a survey report on the little Neemah River in Nebraska. I don't recall what the actual design flood was but it was somewhere in the neighborhood of 100,000 cfs. On May 30 the Little Neemah River crested at 225,000 cfs. It looks to me that any accusations that the Corps of Engineers overdesign on these things is pretty well refuted by that, because here is a flood 2¼ times their design figure. Sure, it is one of these special events but you find them all over the country and even a matter of three years earlier the Bureau of Reclamation had to make a redesign of Medicine Creek Reservoir because of one outstanding flood that occurred on Medicine Creek. So, as I say, with our empirical formulae, even when we have a wealth of data, the best

we can hope for is a rather wide band of errors. Now I would like to have Jim Bowie talk for just a minute on some of the methods that are used by the survey.

Mr. Bowie: Mr. Lewis mentioned the basic stream gaging network that we have proposed and are operating for the Flood Control District of Maricopa County. This program should be much larger except for economic reasons we cannot expand it any further at this time. Theoretically, a network of stream gaging stations such as we have proposed should be a number of data collection points distributed spaciously and physiographically so that the data collection may be combined and used to yield results within limits from ungaged areas. Mr. Ligner will later on show how we attempted to go into the area and space these gages, reason for each particular gage, etc. We have given quite a bit of thought in the planning of this stream gaging network and also have attempted to take into consideration any critical areas that might exist. There was a progress report submitted to the Flood Control District several months ago that listed some possible fields that the Geological Survey might help or be of assistance to the Flood Control District. The first of these was the development of flood hydrographs, durations, rate of travel, velocity distribution and related hydraulic studies. The unit hydrograph furnishes the apparent solution to these problems and, simply stated, the unit hydrograph is a hydrograph of direct run off resulting from one inch precipitation excess occurring in unit time. There are a number of definitions out but they

all say the same thing basically. From this unit hydrograph, the time of occurrence of peak run off could be determined, also the rate of run off at other times and your complete hydrograph can be estimated. The unit hydrograph is a time distribution study, does not furnish any key to the amount of precipitation we can expect over a given area or the amount of run off that can be expected. Our computation procedures will be based on a report by W. P. Mitchell, the District Engineer in the State of Illinois. He has a set of procedures in his book that we will follow. Another suggestion in this progress report was the effects of urbanization upon flood peaks, volumes and times of concentration. This will also be primarily a unit hydrograph study. But the effect, magnitude and frequency of floods may be used to evaluate the urbanization effectd since the two factors controlling the magnitude and timing of flood are the infiltration rate and the installation of storm sewers and channel improvements. The infiltration rate is decreased by the paving, roof tops, etc. and your channel improvements and storm sewers are used to get the water to the run-off point in a shorter given time. The second suggestion was the relationship between rainfall and run-off. When the additional gages are installed we will have a lot of comprehensive rain fall data that can be correlated with the run-off information accumulated from our stream gaging stations. One of the simplest correlations would be the direct correlation between rain fall and run-off. Further studies can be made in time trend analyses, per cent of urbanization and any other

measureable factors that can be put into the correlations. The prediction of run-off and rain fall is usually unreliable because run-off is controlled by physiographic factors in the area, such as your drainage areas, channels, slopes, elevations, geology, etc. Records of the rain fall are from gages that the survey will operate, will be computed and tablulated by the Survey, and will be turned over to the Weather Bureau to become a part of their files; these records will be available from them. Another suggestion that was listed in the progress report was a flood frequency analysis. From the flood frequency analysis we may determine the magnitude and frequency of momentary peak discharges, peak stages and flood volumes. The knowledge of magnitude and frequency of peak discharges are essential to flood control structures design as well as in the fields of flood zoning and flood insurance. The use of flood frequency methods has been abused and subject to a lot of criticism but properly computed and conservatively interpreted is a very valuable tool. In general we will make our analyses if possible, on a regional basis - an area that is hydrologically homogeneous rather than making them at a particular point. We can make three types: (1) Discharge (2) Stage (3) Volume-frequency, the most common being the discharge-frequency curve. This applies to general areas. The stage-frequency will apply only to a gage which determines the frequency and will be regionalized. You have to use extreme caution in handling that. Two methods used in making flood-frequency analyses are by using the annual flood or by

the partial duration series. The Survey attempts to stick with the methods of the annual flood because it seems a little simpler to handle it that way. Another item mentioned in the progress report was the making of inundation maps. These can be very valuable in flood control work, flood control zoning and planning. Such maps can be prepared by using slopes, profiles, and some of those things that are available to us. One of the most important need is for topographic maps and since the height of a major flood, the variation in height, is very small, you need your maps on a very small contour interval. Good maps are essential in that. We have installed a system of crest stage gages which Mr. Ligner will talk on, that should provide the basic stage profiles and high water marks upon which to base these maps. The last suggestion made in this progress report was the salvage of water that would otherwise be lost by evaporation. The diminishing surface water supply is a major problem in this area. It may not be a problem of flood control but the responsibility of utilizing any water that flood control channels or retention reservoirs capture is a responsibility of all people interested in the development of water in our area. The possibility of recharging the ground water table from flood waters, etc. should be investigated as well as any other losses should be investigated.

Mr. Ligner: Gentlemen, we can perhaps analyze the problems of a given area, we can understand in some general way what we are faced with, in the way of problems, we can do as Jim Bowie says. We have

at our fingertips, all of us as hydrologists and engineers, certain tools, methods that we all know about, that we can use to perhaps come up with some answers for this area. We can't always wait around until somebody else comes up with the kind of data that we would like to have in our design; we have to go ahead and use what is available. This means then that it does perhaps fall on the shoulders of the individual making the study as to just how good an answer he comes out with. We don't want to lose sight of the fact that even though we have to go ahead at the present time and do some of these things, we have to look to the future, to the time we will need more data. No matter how good an analyst you are you can do a better job if you have better data. What we are attempting to do in cooperation with the county flood control program, is to design within the limits of the funds available the type of system that will give us and you, the data that you need in the future. We hope that as time goes on it will become greater and greater and we will get more and better data for all of us to use in solving these problems. As for the elements of a collection program, we might start out with the top of the hydrologic cycle, and that is the element of rain fall. In Maricopa County we are faced with a rather large problem in that it is a very large area. There are more than 90,000 square miles in the county. To get a very complete coverage in an area this size will cost a lot of money. We can't do everything we would like to do but we have to design then on the basis of what is available in the way of funds. There are rather a large number of

existing rain gages in the area. The green dots shown on the map (pointing to U.S.G.S. map) are Weather Bureau and Corps of Engineer rain gages that are already in the area. There are 37 of the non-recording gages and 10 recording gages. Most of the recording gages are in this area (pointing to map). Even though we have a fairly fine network we don't get complete coverage that we need for studies that we would like to make and that you would like to make. We have installed a number of rain gages of our own. We have at the present time a little more than 60 non-recording gages that have been installed, observers have been secured for them and everything is all set to go when we get some rain as far as the non-recording gages are concerned. This presented a number of problems. The man we had going up to the houses trying to get people to participate in the program was many times thought to be a salesman of some kind. We have had some fair success however in that field. We are in the process now of installing recording rain gages. We are going to install 12 of these, placed strategically we feel, in connection with our stream gaging program so as to obtain rain fall amount correlations for the most part. In fiscal year 1962, we propose to install an additional 12 gages which will give us a total then of 24 recording gages that we will be operating, along with the 10 recording gages that are presently in operation. We feel it should give us a pretty good coverage. With the non-recording gages to supplement this it should be pretty good. The recording gages are going to give us not only the volume but the duration which is very important

in the rainfall studies. In fiscal year 1962, we hope to install an additional 40 non-recording gages. This pretty well covers then, what we have and hope to have in the way of rain gages. The next element in our basic data program is the stream-gaging stations. We have, at the present time, 9 stream gaging stations that we have installed in connection with this particular program and one that is yet to be installed. We are waiting for the completion of one of the highways. I would like to briefly go over for you each of these stations, their location and what they have been placed there for. First of all let me say that all ten of these stations provide certain basic data and we hope data that may be used to solve certain problems and be used with certain techniques. They can all be used for flood frequency studies, they can all be used for volume studies, they can all give us some indication, at that point, of the velocity distribution in a stream. When I say velocity distribution - the gage itself won't do this, but the fact that we take measurements there will. There are any number of items of rainfall - runoff relationships; they all basically work for any of these things, but each of them has been placed strategically to answer some particular problem in the county. The first station that we have is in the Sycamore Creek drainage basin. This is a gage that is on the only large uncontrolled stream above the Granite Reef Diversion Dam. We hope that it is going to provide sedimentation data that can be used for the proposed new dam just above the present Granite Reef Diversion Dam. We feel also that it is going to be very valuable in

that it will provide rainfall-runoff data from the mountain type drainage area which lies north of Phoenix.

The second station is the one on Indian Bend Wash near Scottsdale. This, we think, is a very interesting and perhaps, if not unique, a little unusual. This particular station is just upstream from the Arizona Canal and will furnish records on one of the worst problems that apparently faces the Flood Control District, the Paradise Valley area. The property values in that area are extremely high and the station will measure a drainage area of about 223 square miles. It is believed from the flood history that is available that the run off can be particularly high - as much as 15,000 second feet runoff in the report of the Flood Protection Improvement Committee. In this area there are no definite channels, the sheet flow that comes down through this area is one of the problems we are faced with. It is a tremendously interesting problem and one that is going to be very useful to the Flood Control District and to the county.

Gage No. 3 is located near New River. It is placed to give total flow figures in the proposed detention reservoir located on New River just before it enters the Salt River valley proper. It is hoped that some record will be collected in the very near future so as to aid in the design of the proposed structure. The drainage area above this station is probably undisturbed and that is another reason why this gage was placed there. It will give us some good data on undisturbed areas.

Gage No. 4 is on an unnamed wash near South Mountain Park. This particular station is located on a small steep mountain drainage area and we hope will provide runoff data for use in the design of flood control features on this type of area. I understand there are a number of those types of areas in the Phoenix area.

Gage No. 5 is located in Apache Junction, also on an unnamed wash. It is a small desert lowland range area and it offers the possibility of the study of effect on runoff from the development of this area, since I understand the Apache Junction area is having explosive population increases and is changing very rapidly. With the rain fall and run off studies and the change in the area, this station will give us some answers that are very sorely needed.

Gage No. 6, is also on an unnamed wash in Tempe. It was placed in that particular spot to answer a problem that I think all of us are aware of and that is what is happening in the industrial areas where we have large areas of pavement and practically no infiltration of rainfall at all. It is a small area in there suited for this particular type of study. We hope it will give us some answers as to what takes place in relationship of rainfall to runoff in the highly industrialized areas. This is the gage that we have to wait to locate until the road is finished there.

Gage No. 7 is at Youngtown in an unnamed wash. This is on a very small 160 acre residential development at Youngtown and we hope will give data for us all to use on these small, well-kept urban areas of homes, lawns and that type of situation.

Gage No. 8 is on the Hassayampa River near Hassayampa. It and also Gage No. 9, which is on Centennial Wash near Arlington, will furnish, we hope, the total flow from these streams and give data for the flood protection plans when they are developed further in this particular area. Of course it will be utilized and will furnish information for all the other types of studies that are open to us.

Gage No. 10 is on lower Rainbow Wash. This is located at a syphon where it goes under the Gila Bend Canal. This is a hydrologic station to furnish data from an arid mountainous area.

From low land desert to high mountains, to urbanized, to industrialized areas we try to get all of the elements in here that we can possibly get with the amount of money that we have to spend.

In addition to our stream gaging stations and the recording rain gages, we have installed 14 crest stage gages in the area. These will be used primarily to give us flood profiles on a particular stream. We can go in and do additional things in getting those flood profiles but these are going to be of tremendous assistance in getting that information.

Gentlemen, this is pretty much what we have in the way of instrumentation, what we have and hope will allow us to get the kind of data that we can use and you can use to give us better answers to the problems of the Maricopa County Flood Control District.

Mr. Gardner inquired if the U.S.G.S. stated in their report to the county that you suggested some additional studies. Are these being made or were these subject to appropriation?

Mr. Lewis stated they were not being made at the present time, it is hoped that to get into the program next year, it is largely a question of funds. It has not been funded as yet, but things are looking good.

Mr. Cron pointed out that the map in the front of the room breaks down the various drainage areas in Maricopa County. Most of them point towards the Salt and Gila Rivers. Approximate areas of drainage basins are indicated on the map. This map may be useful in the discussions that follow. The next agency represented here that is in the business of providing basic data is the Weather Bureau.

Louis Jurwitz: Mr. Lewis has mentioned a good portion of the background of the development of basic data and rainfall stations. His office and our office work quite closely together to spot these various stations and originally the recording rainfall stations were ones that we had primary interest in so we can get some ideas of intensity, duration, etc. With regard to the other stations we probably are uniquely fortunate, from the standpoint that we have some very long records, both on the non-recording as well as the recording stations. The Weather Bureau office, itself has almost 60 years of recording rain fall records, a tremendous record for this young area. Some of the other recording gages that already have been installed have records back to about 1940. We also don't want to lose sight of the fact that we have some bucket surveys in the area that the Corps of Engineers developed and have reports on. We have a good basic foundation of what can be done. These that we now propose or already have are a beginning of amplification of

what we hope, ultimately, funds will permit. In order to be able to get across-the-board ideas of what actually takes place from a rainfall standpoint, records have to be in existence for quite a long time, so let's never lose sight of the stations that we already have. We can take, for instance, the Phoenix recording set up, which has been in existence long enough to have actually sampled some of our major storms. Just recalling the 1911 storm, better than 4", we have the duration and time set-up on that, so that you have a nucleus of what already has been recorded. With some of these others that are spaced around the county, I might say that we are fortunate, from the standpoint of the number of records we do have of comparatively long durations, in that this has been a metropolitan worry. The climalogical stations grouped around Phoenix are much more dense than any other place in the state. When I first came here in 1948 I had a campaign on where those that were interested in weather, and most everyone is, were invited to join in what I called the metropolitan network. These are not published records, these are records given by citizens that have standard equipment and we have in the metropolitan area about 25 of those. Don't lose sight of those, they are on record and available. I do want to say that one reason the Weather Bureau has not been able to participate directly in this program is that we do not have enabling legislation which permits the Weather Bureau to accept funds from any other agency. That is the reason it is worked through the Geological Survey. We do work very closely together, and, as mentioned, the records will

be on file at the Weather Bureau available for anyone that wants to use them for research. The Weather Bureau is more than willing to do anything we can to help in the analysis and provision of what records we do have.

Mr. Lewis wanted to point out that the relationship of these two agencies has been very cordial; the U.S.G.S. has relied to a large extent on the advice of the Weather Bureau in spotting these stations. They are weather records and are the property of the Weather Bureau. As soon as the Survey does a little processing they are happy to turn them over to the Weather Bureau.

Mr. Cron pointed out that Mr. Jurwitz, in addition to providing technical help for the Flood Control District, also helps to advise with policy guidance and polititcal guidance because he is a member of the Citizens' Flood Control Advisory Board and is extremely helpful in that capacity.

Before the Flood Control District was ever formed or organized, the Corps of Engineers had been requested to initiate a study as to measures needed for protection of the metropolitan Phoenix area. They held their first hearing in December, 1959, here in Phoenix, so their studies have been underway formally for that period of time. They are studying the area primarily lying east of the Agua Fria basin, will possibly include the Agua Fria basin, over to the other side of Paradise Valley. The gentleman in charge of the hydrological studies of the Los Angeles District is Mr. Fred Tatum who is here with us today and may point out the problems that sometimes come up in the

reputation of the Corps being over-conservative, as Mr. Lewis mentioned.

Fred Tatum: One thing everyone might be interested in is the criteria for a design flood, and for what we refer to as our standard project flood or design flood for levees - this is a flood that will occur from the maximum storm of record in an area that can be transposed over the project area we are working on. For example in the Phoenix area, working on the Indian Bend Wash problem which is going out as a separate report, we take the largest storm - perhaps we compare two or three to see which is the largest - and compare runoff conditions, transpose it over the area and get our largest flood from that. On this, where there is not a dam in the project, it is most generally the peak flood and we can have two standard project floods or two design floods. One is the peak and one is the volume depending on the structure that we are designing. For dams, the criteria is the probable maximum precipitation for an area, and that is determined for us by the hydrographic section of the Weather Bureau. The most rain that they expect to occur in the area we are studying, is sometimes a local storm or a general storm, depending on the size of the area. We take their precip figures and apply our information on loss rates, figure the minimum loss rates and maximum base flow, if there is any base flow, and this gives us quite an extreme flood but it is one we hope will never be exceeded so the dam will never be overtopped. That is the only place this approach is used. We also have some surface water recorders and a non-recording gaging station on McMicken Dam and Trilby Wash.

I don't believe any of this data is being published but we have copies of it in our office and Mr. Raymond of the Maricopa County Water District has copies.

Mr. Jurvitz remarked that Mr. Raymond furnishes the Weather Bureau with photostats.

Mr. Tatum: So far we haven't had any flow into McMicken Dam, that is of any size, that we could use for determination of runoff characteristics. Normally, in survey reports we don't go into detail, until it comes up for actual design. We do try to go over the area with the hydrologist that is making the study to observe the type of ground conditions and relate those to other areas where we already have studies for comparison of loss rates, what type of stream bed there is, etc. Indian Bend Wash is very interesting and we hope to get some data from that gaging station there. We have no records of flow out of that type of an area. That is sheet flow and according to our estimate will spread out from our standard project flood over a considerable part of the area. We feel this is quite different from our normal studies. In making our study we take, if there are records in an area, the records and make reproductions of them to determine our unit hydrograph. Probably the other agencies do that too. Where there are no records we relate the basic characteristics to these and apply as a more or less average condition, develop our unit hydrograph and develop our storm and runoff based on that.

Mr. Cron asked if Mr. Tatum could tell those present what their

design storm flood is that they are using in the metropolitan Phoenix area studies.

Mr. Tatum stated he believed that so far the storm that has been most severe is what we refer to as the Queen Creek storm of August, 1954. That had over 5" of rainfall over 100 square miles. The Whitlow Dam project had a discharge of about 45,000 cfs from that storm. It was one of the most severe storms and covers a larger area than others that we do have records of. There were other storms with approximately 5", but not covering so large an area.

Mr. Jurwitz stated that he believed the general set up for the project storm is pretty close to 6".

Mr. Tatum stated they had been using a little over 5" for this area. The only place we might use some other storm is when we get into a larger area such as New River.

Mr. Cron said that he understood that Trilby Wash, designed and built by the Corps, was designed after a heavy flood in 1951. Did you use that storm as your project storm for the Trilby Wash reservoir? Where is your dividing line to be, when you approach that area in studies for metropolitan Phoenix? Where will you change your hydrology?

Mr. Tatum remarked that it is unfortunate that we don't have all these storms when we make a study. The Queen Creek storm occurred since then. It might not be the most severe storm over the Trilby Wash area anyway. If we were to make a restudy of the Trilby Wash area we would try our Queen Creek storm over the area to see how it

compared with the other. The more data we get, we do sometimes revise figures.

Mr. Jurwitz reported that the 1951 storm resulted in 20 new records of total rainfall in that area so it was an outstanding storm.

Mr. Tatum stated the dam was a military project, mostly for the protection of Luke Airforce Base but of course it gives protection to the farm land down below.

Mr. Wells asked if the Corps computed design floods on the basis of frequency studies?/ Mr. Tatum: Design floods are not based on frequency studies. Where it does come in is with our section that works on the benefits. They work on a flood frequency curve that, in areas where you don't have any records are hard to come by, but most of our standard project floods around this area range somewhere between 200 and 500 years. That doesn't mean that they have to be in that range. I have heard of some areas where they go over that.

Mr. Cron stated he believed the project storm for the Salt River Channel is frequency of .6 per hundred years.

Mr. Tatum stated that was based on the 1916 storm shifted over the area to give a more severe condition. In case of a general storm, we don't take the isohyets, bodily, and move them because we feel there is a lot of topographic influence on those so we would use a procedure of transferring by mean seasonal.

Mr. Gardner asked if they had assigned frequency intervals to the Queen Creek Storm?

Mr. Tatum replied that they had not on the storm itself. With regard to frequency of flooding, we are trying to work out a relationship between rainfall-frequency and flood-frequency. There isn't any real definite relationship but we are trying to work up some factors that we can possibly apply to rain-fall frequency and flood-frequency. It depends on your ground conditions. That is something I think needs to be worked on.

Mr. Cron asked if the determination of flood frequencies down the Salt River is complicated by the location of upstream reclamation reservoirs which have no flood control storage in them, but which at the same time might be almost empty when a big storm occurred. Could you tell us about how you determined the flood frequencies in the Salt and Gila in view of that complicating factor.

Mr. Tatum: I don't remember right now but will use another example, Painted Rock Reservoir. On that, our frequency was based on dams being in and having the effect that they would have on floods. On floods that occurred before the dams were in we made a study, more or less of a yield study, assuming conditions that would have been at these dams had the flood occurred. Sometimes it would be empty and other times partly full. This approach was used for flood frequencies at Painted Rock and I am sure the Salt was based on the same thing. We made corrections so that the frequency indicates there were dams in. We believe the approach that works best now is to work on data available prior to the dams coming in, in relationship to conditions as they are now.

Mr. Cron: One other Federal agency that has a very important flood control function for the metropolitan Phoenix area is the Bureau of Reclamation, which is making a study, or will make a study of the multi-purpose reservoir at the confluence of the Verde and the Salt Rivers. They are represented here to-day and I would appreciate it if you would tell us what the problems are in connection with that study.

Jack Jorgensen: I am in charge of the engineering division of our staff here in the Phoenix office. For those of you who have not been acquainted with the Bureau of Reclamation's activities in the area, the office here has been rather small until just a couple of months ago. Since that time the office has been expanding due primarily to the anticipated study here on the Salt in connection with the Maxwell site, as well as additional studies in connection with the Central Arizona project which are being financed through the State Stream Commission for an appraisal of the old Central Arizona Project report which possibly by next January when they anticipate the Supreme Court Decision will be handed down, will put the State in a position to go forward and try to seek an authorization of the project at that time. Through these early studies that we are conducting now we hope to update and weed out some of the obvious differences and changes that have occurred due to a lot of things that have happened during the past 15 years. We are one of the agencies, of course, that rely on the other agencies for our basic data and hydrologic studies. We have

very little data collection type activity and the only collection that we do is in connection with specific problems that are related to operating reservoirs or some very short type of special study designed for a special purpose. We are cooperating all the time with the U.S.G.S. in setting up programs that will meet both agencies needs, as well as all Federal agencies in connection with our over all objective of multi-purpose types of project, such as flood control, recreation, conservation and the like. Our present study on the Maxwell site is a continuation or taking up where the Corps left off in the 1958-59 study of what they then called the McDowell site. That report studied the Macwell site in connection with channel clearing and channelization downstream. In the channelziation project which was authorized the Maxwell site was not considered at that particular time. Since then, looking toward the Central Arizona Project, again, and toward the need in our aqueduct system from the Colorado of the requirement for terminal storage, as well as further conservation that is possible on the Salt, we succeeded in initiating a feasibility type study on the Maxwell site which will begin in July. In that connection we will be relying on the Corps of Engineers to furnish us with the basic data for large storms and channel capacity and the like down the stream so that we can incorporate these into the possible design of the structure. In that connection we met with the Corps in Los Angeles a month or six weeks ago and there are some questions in their minds as to whether their previous predictions of a channel capacity of 82,000 csf is actually

there now due to the encroachments that have been made and conditions on the stream. It appears that the channel capacity that they predicted just a few years ago possibly isn't there and there is a requirement for additional study and that will be taken up during the course of our study in order to resolve just exactly what the capacity is so that we can design our outlet works and flood control storage in the structure to meet the conditions that may exist when the project is built.

Basically it will be a structure similar, perhaps, to what the Corps proposed - a rock fill or earth fill type of structure, which we hope to operate with the other dams as a unit of this whole Verde-Salt system of storages. We can perhaps work out some operation that will incorporate all of the reservoirs to get the maximum total bulwark of development there. Other items in our study will incorporate the large aqueduct from the Colorado River across Maricopa County and other areas, with large canals. In that connection we will have a need to study - perhaps your highway people have the same type of problem - of what the concentration of washes along the route will concentrate, what type of water to expect, how much water, what type of structure we will have to provide and whether to pass it over the canal or under the canal. Those are a very important part of our overall program. Our current study on this is what we call a reconnaissance study looking towards authorization of the project or future studies which we have planned on the project. We will go into this in much

greater detail before the construction. I am deeply encouraged by your proposed program here of obtaining additional data, which will certainly be of great help to us before we finally get all the structures designed. This canal can also cause some measure of changes that could affect flood control in the reaches below the canal. It is bound to concentrate flows in certain areas that have not been concentrated, or that will have greater intensity than they have had in the past. However, our objective in this particular type of structure that we are building is a large concrete lined canal which would be required by necessity to operate almost on a 12 month uniform type pattern with little opportunity to de-water, clean, and generally maintain the system in a normal fashion as in a canal system. Therefore, we are going to be very critical, or look very critically, in trying to keep the water in the canal as clean as possible, free from any silt or anything that will drop out and decrease the capacity or flowing area. Therefore, wherever possible, one of our criteria will be that we will try to pass over or under any local drainage type water that comes from upstream area above the canal. That is something to think about in your future project planning. We will be looking toward you people for help along those lines also in trying to get our plans worked out. Certainly we are in a very preliminary stage, at present we are just sort of feeling our way. In this six months period we are working with State funds and we won't be able to answer all these questions. We don't have plans developed that will give sufficient accuracy to go on in design planning.

We have in our future year's program monies programmed for a more detailed study that we hope to begin a year from now. Another flood control aspect of our program, of course, is the proposed Buttes development on the Gila and that report has been finished and has been forwarded now by the Secretary of the Interior, who has recommended it in his future program. Those reports are now being distributed, I believe, for their 90 day review period by State, local and Federal agencies and there has been some progress made in connection with that report. However, there still is a little problem, as always on any of these projects, in trying to get the two main interests together so they can operate the reservoir to the satisfaction of both of them. We hope that the upper and lower valley will come to some kind of agreement very soon so that project can be authorized and under construction within a short period of time. We will also be looking toward more storage in the upper Gila. That was proposed in the old report and we are going to go into those in more detail in future studies. We are very new in this area. I have been in Arizona for only 2½ months. Mr. Seaton, who is in charge of our hydrology branch, just arrived yesterday. Mr. Braham has been here a little less than a year. We also in our overall program have a soil and moisture program which goes toward phreatophyte clearing and its effect on salvage. We also have our betterment program in the Salt River Project designed to reduce seepage and leakage in the canals, reduce evaporation in reservoirs and promote general overall conservation of water.

Mr. Cron: Among the consulting firms working in this area is Yost and Gardner who rather recently were awarded the contract for preparing our flood control survey that the law requires us to prepare, for the metropolitan Phoenix area. As a matter of fact, their contract covers the whole northeastern end of the county and includes the run-off from South Mountain toward the Salt River and a report on the Salt River channel itself. Mr. Gardner.

Leigh Gardner: We are very happy, of course, to see the gaging stations going in by the U.S.G.S., because all of our records so far are stage records - our recording records are in Tom Neiswander's head, Tom is a wonderful source of information. We should get the records because in the future we will be able to design a little better. We do have to carry forward with our design but ultimately the record of rain fall and run offs, associated with each other, will prove very valuable. Everytime we have a record or estimate of run-off we have the rainfall over on some other watershed, not on the one we want. This has been our problem so we will be happy to get this correlation. I think all the remarks today are most appropriate and in agreement with the things we think about local flood problems. Of most interest to me, individually, is this problem of flood plain zoning. One that I think we can do, one that Mr. Cron is pushing very hard now in the river and other places because it affords a means of keeping the water in channel where it belongs without requiring dams, diversion structures or other structures. Keeping

the water where it belongs and reducing the damage. I think Hayes said 50 years ago that our trouble comes from people occupying the flood zone and it is more pronounced today. I know nobody likes an empirical formula, but of necessity without having the capability or the calculating equipment, we have some 50 or 60 little zones for which we have to estimate the run off, in the North Mountains, and as many in the South Mountains, thousands of different combinations in the street system of the city of Phoenix. We have to make some sensible or reasonable estimate of what run-off might be expected at different occurrence intervals. We know that scientifically our background isn't so good but we do use the empirical statement in our flood control report made to the City, some time ago, and we will continue to use it, let us say just to give us a basis of estimate, a basis of design. Whether it is as appropriate as it should be we don't know. We will know when we get through. For example, Youngtown will be an exact demonstration of a small urban area and will confirm some of these things, if all the facts of rainfall, infiltration and rain fall intensity and run-off occur/are associated properly then we will know how to check out. We do use a statement, I won't go into it, it is in our report, that we think gives a reasonably good estimate of what flow can be expected from any area, by knowing the rainfall intensity, estimating the infiltration or base loss in some fashion and thereby calculating run-off, also knowing the characteristics of the watershed as to its topography. Unfortunately the report even though a few years old, is wrong. The Weather Bureau's

Technical Paper #28 has changed the type of rain fall data that we used in the report and has upped it to some degree. Mr. Schaefer has spent considerable time in the last month working on Technical Paper #28 and all the storms in the area, towards a better chart of rain fall intensity duration curves and some estimate of how those rains might be distributed across the area, so that we have that information or will have it. We will give it to Mr. Cron, we will be happy to show you what our ideas are on those factors. Let me say one other thing, just for fun I made an estimate of the Indian Bend Wash, this is a subject that has been slightly reported on by the U.S.G.S., I know that the Army has their project design flood for the area. I used a formula for the area, just used an empirical formula, to try to arrive at these occurrences - run-off associated with some kind of occurrence period. This is very rough but I have this type of figure. Every 5 years we would get this minor amount of rain fall, about 1,000 cfs - the USGS says 5,600 - the Army estimates at 7 years, 8,000; we estimated 10 years, 8,000 and the USGS, 8,000. Now the figures begin to come together. The USGS estimates 10,000 and then we do begin to separate. At 25 years we have 20,000, 33 years the Army has 20,000, 50 years we have 30,000, 100 years 37,000. We can't reach the 60,000 of the Army's, except it would be an extreme storm. Actually though those figures seem to vary, they are for estimating purposes and the Army's figures in the higher reaches would be very close to what we would obtain. Our estimate of flow was made

by reconnoitering the valley with Carl Harris who is skilled in soils infiltration, who made a few sample tests and tried to place some value on the infiltration that could be experienced in the valley by utilizing the Weather Bureau's curves for rain fall, by making this estimate of infiltration or base loss and by using the formula that we set up in this Phoenix Storm Drainage Report and I think it gives us at least a talking figure and certainly it is not too much different than the Army's figures nor the USGS. The USGS hesitated to estimate this across the great range of years, their basis was on the more frequent reoccurrence intervals. The information that we have is available to others. We appreciate all the past help we have had.

Mr. Tatum asked what velocity was used in Indian Bend.

Mr. Gardner replied 43/100 on an average approximately a 2½ hour period of collection time.

Mr. Tatum reported that they had used 35/100 in the upper part, 2/10 in the valley. They also were spread out over so much a bigger area. They also put in a percolation rate which would raise the loss rate.

Mr. Gardner: My reconnaissance wasn't scientific at all. We made a few infiltration tests, it was averaged out to a figure. This didn't agree too well with the actual tests. We had a fine infiltration rate. I went by one other thing there is no occurrence of run-off up to 1 year, 2 year, 3 year or 5 year periods - some place in there, as Tom can tell you, there must be a base loss. Its too bad that

it doesn't average out the way it should. It is not that we want to do it, it is something that we almost have to do. We are asked to make some estimates coming out of the South Mountains. We cannot, we don't have the information and I don't think we can go through the mechanics of constructing a hydrograph range for those small areas so we empirically say it should be about this rate.

Mr. Dorroh pointed out that from their experience in experimenting with the watersheds the really significant run-off periods came about once in five years.

Mr. Gardner: In this particular case we have a fine estimate that we are going to try to run down through the Water Users, fine estimates of the '43 storm. If we could do a little better job of associating the rainfall in Paradise Valley with that storm we might have the base loss or infiltration down a little closer. We have a reasonably good estimate made by Tom Neiswander of the flow at that time, about 15,000 sf. We associate that with a fairly good storm.

Mr. Gardner introduced Mr. Schaefer who has done some fine work with reconstructing Technical Paper #28 in a little more useable form, not that it isn't in useable form, but useable in our office so that we can quickly take off duration, whatever time of concentration in an area we are using and what rainfall and what occurrence interval.

Mr. Schaefer: I just wanted to say on this infiltration matter,

which is very important from our standpoint and makes a tremendous difference in the results, we are trying to approach it from the relationship between runoff and rain fall. For instance, storms that occurred in '59 - there were no gaging stations on Queen Creek before that. In September of '59 about 8% of the rainfall went through the gaging station at Queen Creek dam. There were two Weather Bureau stations in that area and I hope we can get some data on that particular storm from observers up there. The other thing is this area-depth relationship.

Mr. Garuner: John has a great number of the storms plotted where we have good records to try to get this area-depth relation versus point-intensity that the rainfall intensity duration curves represents, how that rainfall drops off on an average over a large area. The Army curve was constructed for an entirely different type of thing. I used an area-depth relation that bears no significance or no relationship to what occurs around here but we will plot that up and have something that is a little more representative of the area-depth relations in this area.

Mr. Dorroh asked if they were getting a very sharp drop.

Mr. Gardner: We have a very sharp drop. We are getting 80% over 180 square miles. This curve that I have incorporated in the book would use something less than 50%. We now think it is more on the order of 80% for about 200 square miles. Two hundred square miles is pretty good coverage, which the Queen Creek storm would bear out.

As a matter of fact, the Queen Creek storm stays up at the 95% level indefinitely. Before, of course, we were working on small watersheds, we didn't have a maximum over 4 or 5 square miles, so that whether the area in that relationship curve dropped off rapidly or not made little difference. They were still only a few per cent apart. But now we find that we were greatly in error in that choice so we will reconstruct that.

Mr. Dorroh asked if they find this from the low lying strips, not in the mountains.

Mr. Gardner: The best indication that we have, I think, is the 1943 storm which caused all this trouble and it stands up there. The Queen Creek storm is well above it.

Mr. Schaefer said that he believed the storm in September of '59 was worse than the Queen Creek storm, just not over so large an area.

Mr. Gardner asked if this included the mountainous area.

Mr. Schaefer said that they had Crown King in there, the row of stations in the northern end of Maricopa County. Center of that storm was at Horseshoe Dam. It was a three day storm that was over 10".

Mr. Gardner stated that Mr. Schaefer has plotted the isohyetals on those and we will try to arrive at what we think is an average for the Phoenix area for our purposes. Our rainfall intensity-duration curves that we have are for the Phoenix Weather Bureau Station and

Technical Paper 28 has to be gone back to for the change in two year, one hour, and the relationship of the 100 year to the two year is a function of 3.7; those vary depending upon the location.

Mr. Dorroh asked if they were finding a pretty good relationship shown in Technical Paper #28.

Mr. Gardner: We just accept 28. What information we have, and what we have done before, is we took Technical Paper #24 and #25 and accepted something very close to them. Paper #28 varies this, but we agree that it is the best source of rainfall information that we have.

Mr. Tatum: In our Queen Creek Storm/the curve stays up to about 5" up to a 100 square miles. There is a lot of data missing up there. We had two high points. You could have two centers or it could be done with one center. Whether we are right or wrong I don't know but the curve does stay up there.

Mr. Gardner: We understand that the data had to be sketched in. In some of these other storms we have had to make a few hypotheses too as to what might have happened depending on at what elevation we have the gage reading or we may be missing a gage reading but we are working with something a little variable so we don't object to this kind of use.

Mr. Cron: In addition to the Corps of Engineers and the Bureau of Reclamation, we also have the Soil Conservation Service making flood control studies in Maricopa County. At the present time the SCS

is studying the problems resulting from waters originating in the Usery-Superstition Mountains. Actually this water originates primarily in Pinal County but most of the damage occurs in Maricopa County. They already have that project approved and they have started their survey. In addition we have given them a request to make a study into the Buckeye Valley Watershed to handle the flows coming out of the south end of the White Tank Mountain. I think within the next month they will get requests for projects in the Centennial Wash because of the fact that there have been such tremendous development of irrigated farming in this area within the past few years. There is a total of about 50,000 acres of irrigated farm land in that area right now so the SCS knows that they get these requests. Representing that Bureau here today are a number of very competent gentlemen. I will call on Mr. Bill Turner the representative of the State Soil Conservation Office and ask him to run the presentation on behalf of the SCS.

Bill Turner: I feel you are to be commended here today for having the foresight to get all your "hired hands" together and see that they are all thinking along the same lines. As mentioned by the others we are indebted to the Weather Bureau and to the USGS for all our basic data. Some 25 years ago we recognized this same situation that everytime we consider runoff on a particular watershed we found that the rains had occurred on some other watershed. In connection with the flood control work on the upper Gila some 25 years ago we set up a number of observation stations in the Safford

area, instrumented them with recording rain gages and also run-off recording stations. For a period along in the 40's we found it a little bit touch and go to keep those going, but we did keep them going and have records on them now. Some five or six years ago we turned them over to the Agricultural Research Service and they have continued those studies, so on small watersheds we do have some actual records not only on precipitation but on run-off on the different areas. We also at Walnut Creek Watershed, in the Tombstone area, established a yield study. That has also been turned over to the Agricultural Service. They have got in the last few years some very interesting data, not only on size and intensity of these summer storms but the actual run-off yield from that particular storm. Those records are also available. Through the years our hydrologists have worked very closely with other governmental agencies. In fact back in 1953 and '54 when the Corps held its hearing here on Trilby Wash Project at Litchfield Park we had previously made studies on that. As I recall the storm we used was the Las Cruces storm of 1935. These studies were made prior to 1951. We subsequently compared them with the storm of 1951 and found a rather close relationship. At that hearing at Litchfield Park the Corps announced that while they had changed our design - making one dam rather than the two structures we had proposed - they had accepted our hydrology and our sedimentation. This is merely to show you here that the two agencies, I believe, are and have been working hand in hand.

We have made some other hydrologic studies in the state. As an example, take the flood control job at Safford, the first item of which was due to be advertised for bids this week. All other governmental agencies agreed with our hydrology on that. The same thing is true of the plans prepared for a drainage area in the vicinity of Doublas for the Magma area, which is right here (pointing to map), just over the line in Pinal County. We are now completing a study of Florence. I would like to give you the responsibilities of the other people with me from the SCS - Marv Sheldon has been with us about three months, several years prior to that was hydrologist with the State Highway Department, came to them from the State Engineer's office in North Dakota. George Watt, has for the past four or five years, headed up our within-the-state hydrology studies, Jack Dorroh not only has been acting as our consultant on the hydrology of desert areas but has been showing the boys up in the northwest how to handle their work in the country up there. I don't know what comments our hydrologists have to make but possibly Jack Dorroh would like to make a few comments.

Jack Dorroh: I didn't come down here with the idea of trying to expound anything but primarily with the idea of participating in any discussion we might have, problems we might have and particularly the hydrology of the Soil Conservation Service, generally speaking on the basis of agriculture, since we, up until recent years, have not been shooting toward PMP. The Corps, of course, has done that for years, and in certain types of structures we are going into that field.

We are going toward this PMP. We financed Technical Paper #28 and 38 that the Weather Bureau prepared. We are getting closer and closer together. On the other hand I still feel that when we are concerned with agricultural areas, unless there is a real likelihood for improvement, we will probably fall back to say the 100 year event or something on that order. I feel like we are on rather sound ground there. You are all familar with Technical Paper #28, our hydrology guide, and I might better acquaint you with how we go about working this job of developing hydrology for projects and particularly hope we can assist you in getting this information into your hands so that we will have a good understanding of what you are doing and we are doing. TP 28 gives a number of methods of working out problems on hydrology.

Mr. Cron asked if this was printed by the U.S.Government Printing Office. He felt that if anyone was interested in getting these publications they might write to the U.S.Government Printing Office.

Mr. Wilson of the USGS asked if by basing your computations on PMP you can place statistical limits on your answer; is there any way of doing that?

Mr. Dorroh replied that there was not. It is one of these things that can happen; we've had some great discussions with the Weather Bureau on how PMP was developed.

Mr. Turner: I believe I neglected to mention that our hydrologists have been in discussions with hydrologists from these consulting

engineers and it has been a pleasure to exchange ideas with them and we would be happy to continue doing so.

Mr. Watts: We might mention that at Walnut Gulch there is an experiment by the ARS to get data for this area on distribution and precipitation. They have got about 60 gages on about 60 square miles. They only have five (5) years of record.

Mr. Cron: There are two consulting firms who have been or will be working with the Soil Conservation Service in the county. Johannessen and Girand started last fall and they are studying the western end of the county beginning with the Hassayampa River Basin and also south of the Gila River. They are represented here today by Jack Phelps who is in charge of this study.

Mr. Phelps: In our area covering roughly the western end of the county, we have spot gages and some places where there are rather short records. It has been necessary for us, in many cases to move these gage records over to areas that we are concerned with. The gage at Wickenburg did not give us sufficient data so we came up to Stanton which we believed was more representative of the area as far as we were concerned. We had computed two or three areas but could not come up with the water we believed had flown down there. In Wickenburg there has been much building down in the bottom of the washes and buildings are in the path of any water that might come down. Several methods have been tried, such as inverted streets to handle the water but this cannot handle the drainage.

1 Another wash on the east side is Powder House Wash. This is a short but steep wash and the area from which we would get the run off is comparable to the area around Stanton. We just eliminated the Wickenburg gage from consideration. Over in Centennial Wash we have the rain gage at Tonopah. That is of very short record so we have used the gage at Aguila because it is more representative of the area. In the Gila Bend area there is discharge from waters which flow in the Sand Tank and Bender Washes. The gage in Gila Bend did not furnish us adequate information so we had to go down to the Ajo rain gage to determine run-off because again this was more representative of the area than was the Gila Bend gage.

I would like to take this opportunity to thank the Federal agencies we have dealt with for the information furnished us, they have been most courteous and cooperative.

Mr. Phelps introduced Jake Doss of Johannessen and Girand.

Jake Doss: In general the methods described in the Soil Conservation Service/Handbook HYDROLOGY, Supplement A, Section 4 was used in utilizing existing rainfall records to obtain probability curves, and in preparing hydrographs for individual basins for a 100 year 24 hour projected storm. The resulting hydrographs were used to prepare graphs showing the effect of runoff on selected sites for storm water retention.

Engineering

For the Wickenburg area it was felt that the recording gage at Stanton, Arizona was more representative of rainfall than the gage

within Wickenburg itself. Stanton recorded greater precipitation, and past records indicated runoff through Wickenburg larger than could be expected from the rainfall recorded in the City. Orographically Stanton is located in higher more hilly terrain, typical of that at the head of washes flowing through Wickenburg. Probability curves were prepared from recordings at Wickenburg (50 year record) and Stanton (17 year record). Stanton lacked two years of record to give a satisfactory length of record for projection. Still from the higher rainfall recordings at Stanton it was felt that this station and its projection would indicate more closely the rainfall in the basins around Wickenburg than the recordings in Wickenburg itself.

For the basins of Bender Wash and Sand Tank Wash lying south of Gila Bend the Ajo rain gage was selected as most closely representing the Basins. Ajo has a long length of record, 43 years, and it is in a higher more mountainous region than Gila Bend.

The maximum 24 hour rainfall per year was compiled and listed in sequence of greatest inches recorded to the least. Each rain's percent of probability was computed from the formula

$$Fa = \frac{100\ (2n-1)}{2y}$$

Fa = the plotting position in %
n = the rank number
y = the number of years of record

The plotting position in % versus the rainfall for its rank number was plotted on 3 cycle probability paper. A straight line through this series of points resulted in a frequency curve

used to project the 100 year storm. This curve was derived by a computed method also and the two curves coincided favorably.

Now with a 100 year - 24 hour point rainfall the areal rainfall was found by figure 3.4-1 of S.C.S. Supplement A.

The projected storm was broken into 1/2 hour increments for the first 6 hours, 2 hour increments for the second 6 hours, and two 6 hour increments for the last twelve hours. The factors for this were taken from Table 3.21-2 from the first 6 hours on. The Factors for the first 6 hours was taken from curve B figure 3.21-5 of S.C.S. Supplement A.

The antecedent moisture condition and soil classification for the area was then estimated.

Condition II, the average condition for annual flood was used in all cases. This is the second worst condition of the 3 broad classifications.

The Soil Group, A through D, most fitting the type of soil in the region was determined.

The land use was classified as rangeland in poor condition in all cases. With these points established, Table 3.9-1 was used to obtain a curve number for hydrologic soil-cover complexes.

The curve is then used to obtain runoff quantities given the rainfall. This curve figure 3.10-1 was used to obtain runoff for each increment of time that the projected storm was divided into. A minimum of 0.05 inches per hour was considered lost to

infiltration for soil group B, but no minimum loss was considered for soil group D.

Next the time of concentration for the basin was estimated by the formula

$$T_c = \left[\frac{11.9\ L^3}{H}\right]^{0.385}$$

T_c = Time of Concentration
L = Length of water course in mi.
H = Height in feet from upper to lower reach

With the time of concentration, unit Hydrographs for durations of 1/2 hour, 2 hours, and 6 hours were computed from the following formulas:

$$T_p = D/2 + 0.6\ T_c$$

$$T_b = 2.67\ T_p$$

$$q_p = \frac{484\ A.Q.}{T_p}$$

D = Duration
T_c = Time of Concentration
T_p = Time of Peak
T_b = Total Time
q_p = Peak runoff (c f s)
A = Area Basin (sq.Miles)
Q = Runoff (inches, 1")

The runoff as previously found times Peak runoff for Q=1" gave the runoff in cfs for each unit hydrograph. These were plotted and graphically added to obtain the composite storm hydrograph.

The accumulative runoff was then plotted and a safe discharge deducted and that accumulation plotted. Also area (acres) and storage capacity (acre feet) was plotted versus depth of reservoir on the same graph. This indicates the height of dam required to adequately retain the flood runoff.

Mr. Cron stated that the District will employ a consulting firm for a flood control survey and report in southeastern Maricopa County, to cooperate with the Soil Conservation Service studies. The problem in this area results from flows originating in the Usery-Superstition Mountains and a major drainage problem exists in connection with disposal of storm water in the Mesa, Chandler, Gilbert and Tempe areas. The flat areas in between these cities are rapidly becoming urbanized. Presently all or part of the storm water is dumped into drainage ditches of the Salt River Valley Water Users Association. In the past, the Association was able to accept this storm water without serious difficulty since it could be disposed of on vacant land. However, because of the rapid development of this land the Association will no longer be able to accept the water into their irrigation ditches. Benham Engineering Company, Inc. has been selected to make this survey. The contract has been approved by the Board of Directors and it is now a matter of getting it signed and the Notice to Proceed issued. Benham Engineering Company is represented today by Mr. Chandler McCoy. One feature of this study that will prove of interest to everyone is the introduction of this water into the underground.

Mr. Cron also introduced Dr. Bob Kirsten, head of the Engineering Department, Arizona State University, Tempe. Dr. Kirsten spoke briefly on engineering study. He stated that their goal was to learn the cause and the effect.

The meeting was adjourned at 12:15 a.m.