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SAFETY PANEL OF CONSULTANTS MEETING ON RULISON

(HARVEY GAP DAM)

NEVADA OPERATIONS OFFICE

COPY

MAY 1, 1969

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I N D E X

Opening Remarks . . . . .	Mr. Edwards . . . . .	3
Spring and Well Inventory . . . . .	Mr. Johnson . . . . .	3
Area Inventory . . . . .	Mr. Conwell . . . . .	6
Harvey Gap Dam Field Investigations . . . . .	Dr. Sherard . . . . .	16
Slide Presentation . . . . .	Mr. Compton . . . . .	17
History of Construction . . . . .	Dr. Sherard . . . . .	26
Test Holes Samples . . . . .	Dr. Sherard . . . . .	32
Summarization . . . . .	Dr. Seed . . . . .	42
Downstream Area . . . . .	Mr. Conwell . . . . .	56
Assumptions . . . . .	Mr. Skjei . . . . .	58
Report of State Engineer. . . . .	Mr. Paddock . . . . .	67
Lowering of Reservoirs . . . . .	Mr. Conwell . . . . .	73
Recommendations . . . . .	Chairman Wilson . . . . .	87
Panel Discussion of Presentations . . . . .	Chairman Wilson . . . . .	94

SAFETY PANEL OF CONSULTANTS MEETING ON "RULISON"

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MAY 1, 1969

8:45 A.M.

MR. EDWARDS: If we can, we'd like to get started. We have, what we hope, is not the longest agenda but nevertheless, we would like to get started on it and move along as rapidly as possible, because of the importance of what it is. We again have visitors here today that not all of us know, so I would like to take time out for the first couple of minutes just for a few introductions.

(At this time, Mr. Edwards introduced the members of the Panel and various people in the audience.)

We're short circuiting our little introductory procedure this morning, we usually give the Panel the opportunity to argue amongst themselves as to who is going to be the Chairman, but we have asked Stanley D. Wilson to volunteer and I think he has been volunteered and without further ado, I'll turn this meeting over to you, Stanley.

DR. MAXEY: Just because he's Chairman he isn't going to tell us what to do.

(Laughter.)

CHAIRMAN WILSON: Shall we proceed with the agenda?

Item I then is the Spring and Well Inventory--who is going to present that?

MR. JOHNSON: I'm Dick Johnson of the AEC/NVOO and I hope to make this very brief--this is just to iron out a few things that were not completely clear or complete as of the last meeting on April 11th. The Spring and Well Inventory is one of those items that is still not completed,

it is ninety percent complete. Because of the snowpack, it has not been able to be completed, we hope the USGS offices will be able to complete this after May 15th when they hope that the snowpack will be melted such that they can begin this inventory. They'll do so at the best of their ability at that time, obviously, if the snowpack does not melt, they cannot complete this but it is only a documentary effort to do so in these areas. It has no effect on the safety of the shot per se.

We have identified in more detail the rock fall areas and the Test Manager has arranged to take care of this by some operational procedures.

DR. MAXEY: What is he going to do, hold them up?

MR. JOHNSON: He's going to hold them up--he will have some people out there controlling traffic.

I don't think--unless there are any questions that there is any need to say anymore about that subject. They were identified generally before and we have just been a little more speculative and know the hazard exists.

Structural bracing recommendations have been identified by the Blume people. This is solely within, what would it be about six miles, Lloyd?

MR. LEE: 10 kilometers.

MR. JOHNSON: Within about six miles is the only bracing that has been recommended which mainly consists of either the removing of chimneys and replacing brick chimneys with metal flues or some other treatment for chimneys. Unless you have some discussion you would like to have on this subject, I think I'll leave that briefly since it's just a refinement of what was presented last time and we are identifying some

specific locations at this time.

One thing that is not on the agenda today that I would like to bring up and that is that we, in presenting the ground motion prediction last time, were assuming that Rifle, Grand Valley, and the area around the community of Rulison would respond as a hardrock station location. This was just based on incomplete information. We had no reason to believe different at that time but we felt that it was quite worthwhile to go out and do some geophysical work and refraction work to determine the compression of velocity of the underlying medium in order to be assured that we knew whether or not any amplification of the ground motion might occur. This work has been completed at most of the locations and we now believe that, in fact, there would be some amplification of the ground motion in certain frequencies. These frequencies at Rifle, Grand Valley, and Rulison area happen to be at the frequency of most of the one-story structures around there and consequently, it is necessary to increase our statement of damage from the \$130,000 we currently have in the report upward of \$300,000.

If you have any questions--if not, I'll just leave it at that.

CHAIRMAN WILSON: Do any of the Board have any questions? (No response.)

MR. JOHNSON: I'm through sir.

CHAIRMAN WILSON: Thank you very much. Are there any comments anyone wants to make on this particular subject?

DR. MAXEY: Would you ask if any of the Press is here?

CHAIRMAN WILSON: No.

DR. MAXEY: This is not a classified meeting.

MR. EDWARDS: The question has been asked if we have the Press here, I said no and I think that is correct. I saw Dave Miller walk in,

is he here?

MR. MILLER: I'm right here.

MR. EDWARDS: Is that a correct statement?

MR. MILLER: None of the Press have contacted me to come, so I don't believe--let's ask.

MR. EDWARDS: This was intended to be an in-house working meeting, it has to remain unclassified because of the non-Q cleared participants because all people either are or aren't potential participants of the RULISON event.

CHAIRMAN WILSON: If there is no further discussion, we'll move onto the next item then.

MR. SKJEI: I'll make the introductions for our presentation. Our firm has been responsible for the structural inventory in the area, prediction of structural response and damage, hazard evaluation for surface earth structures and discussion of the safety measures in this. Mr. Conwell has been in charge of the area inventory, he's going to discuss his work in the field, his preliminary evaluation of the surface earth structures and hazards and identification of Harvey Gap Dam and the potential hazards and the reason then that Harvey Gap Dam receives a special study. We will then turn the meeting over to Doctor Seed for discussion of the analysis that he and Doctor Sherard and Mr. Johnson have been involved in for Harvey Gap Dam. Following that, the Blume people will be prepared to discuss recommendations for some preventive measures, those that aren't covered by Doctor's Seed and Sherard in their discussions.

The principles that are represented by John Blume Associates are Lloyd Lee, who is responsible for structural basin evaluation-- structural surveys. Fred Conwell is an engineering geologist by profession.

so his field is in engineering geology. With that, I'll turn it over to Fred to discuss the work he did in the field and identification of Harvey Gap Dam.

MR. CONWELL: Part of the inventory involved the identification of the potential earth hazards for future evaluation. Part of these results were presented at the last meeting, and this is namely a continuation of some of the things we uncovered at that time. In addition, to a few new potential problems and I emphasize the potential aspect because the evaluation that went along with these has not been completed. There are within 25 or 30 kilometers of ground zero a whole host of dams, reservoirs, lakes and stock watering ponds very few of which are over 4,000 acre feet. Several of which are new such as Vega and Rifle Gap Dam which are fairly new--Bureau of Reclamation Dams, well designed and constructed under moderate means. One of these dams we first came across was Harvey Gap Dam. It was known to be an earth-filled dam, it was also covered with snow to quite a great extent and has a very small spillway and piping was noted behind one of the walls of the spillway--it wasn't severe. The dam itself had appearances of being in generally poor disrepair. It was also full--the time we first saw it, it was within about one-foot of spilling, then it appeared if it did spill, the spillway couldn't handle any sort of sustain flow. This is in March.

CHAIRMAN WILSON: Would you describe what you mean by piping, what you saw as piping?

MR. CONWELL: One wall of the spillway had, at that time, a gap between this concrete that had been caked out and quite a hole in behind it that had appeared to have been sluiced--it could have been an

enlarged rodent hole or something like that or it could have been as a result of the seepage out of the spillway itself.

DR. THOMPSON: Pardon me, isn't this an old dam--because haven't you mentioned this before?

MR. CONWELL: Yes, it is because this dam was originally built, I believe in the early 1880's, it failed the first time in 1895, was reconstructed about 1909 and has had some modifications since which I think Doctor Sherard and Seed can amplify on.

Because of its general appearance, it had all the earmarks of a possible problem, we ran from preliminary analysis on facts of safety based on assumed properties on the material itself. Its factor of safety was slightly over unity based on these assumed properties and it was definitely something that should be looked into and it was at about this point we turned the evaluation over to Doctors Seed and Sherard.

DR. MAXEY: Excuse me, it had been established what the size of the output is, through the drainage pipe?

MR. CONWELL: Yes it has.

DR. MAXEY: What is it?

MR. LEE: Two foot.

DR. MAXEY: Any piping around the drain pipe?

MR. LEE: The only tubing we could see in that rock--

DR. MAXEY: Any piping around there?

MR. LEE: Haven't noticed any there.

DR. MAXEY: That hasn't been examined?

DR. SEED: There is no indication of trouble down there.

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5-1-69

MR. CONWELL: In conjunction with the outlet works at this point, we talked to the Bureau of Reclamation people out at the Grand Junction office and they have taken under their jurisdiction quite a number of these old dams in developing some of the bureau projects-- seepage around the outlet work seems to be a pretty common thing in the older dams. A lot of these outlet works were wood stave pipe buried in fill stations that weren't too well compacted to start with and some of these are seeping now and have been for a number of years. They are watching a lot of them very close where the seepage is not in large amounts in the area of 10 cubic feet for the worse one and it does not seem to change, it's very steady.

JAT2B1  
RSPC  
5/1/69

DR. THOMPSON: That sounds like quite a bit of water to me.

DR. MAXEY: Ten cubic feet per second--lake acres.

MR. CONWELL: Well, this is not all combined, this is what they're picking up at the toe of the dam. Most of the dams that were built--

DR. MAXEY: --this is not Harvey Gap Dam?

MR. CONWELL: No, these are older dams in the area. There are quite a few dams built around the turn of the century during the depression, none of which received the benefit of the engineering field or even very much in the way of design. Other problems we have run into in the area is the general saturated condition of the slopes. At this time of the year they have had above normal rainfall and also precipitation, the snow pack contains a little better than 200 percent, its normal amount of moisture, it is extremely wet snow. This is leading to a resumption of rockfalls, landslides in and around the railroads, highways and canals. This is a chronic problem in the area and it is aggravated by wet years and this happens to be part of the busy season for this sort of thing. During the course of the investigation there were two sub-rockfalls on Interstate Highway 80 which crosses the main area and one large one which did not interfere with the Denver and Rio Grande but they removed it as a precautionary measure. In addition, the Bureau of Reclamation people, on both of the Cobra and Silt Projects, put in their feeder system which is out of the Vega reservoir, which was completed about 1960, and in many areas crosses silted and silt materials, many of which are glacier deposits. These have a tendency to both slow and sloop and slide.

JAT2B2  
RSPC  
5/1/69

The canals have had repeated failures in the past two years of operation and they're expecting a bad season this year from this. They have identified for me several thousand feet of both canal lines and gun stop feeder lines for the Molina Power Plant that are currently saturated and some of which are currently alluvium. The waste way works for the Vegas Reservoir Canal system is also slighted. The listing has already been taken once and replaced. The stilling basin on the Molina gun stop collection works which comes out of this series of small dams--these old small dams failed last year in this type of an operation. They are anticipating a great deal of operational difficulty with this whole network of canals.

DR. MAXEY: How far is this network?

MR. CONWELL: In the neighborhood of 20 to 30 kilometers. It is to the south of the ground zero, closest point within 20 kilometers and extends on out to 30.

DR. MAXEY: Apparently a lot of this silt is in a quick condition right now?

MR. CONWELL: Yes, it is, that is basically the observation of the Bureau Field Engineer who has about 10 or 12 years on the project and evidently had a lot of practical experience trying to keep these open, in fact it's his chief headache to try to keep these things going. He tells me that since he's been on the job which is some 12 years, this is the worst condition for saturation that he ever seen and the earliest in the season. Its been work back there and they had unprecedented thaw in the sense that it set on very fast rather than slowly and then stopped. The one reservoir at 10,000 foot level raised to an inch and the next 24 hours it came up

JAT2B3  
RSPC  
5/1/69

13 inches. It is not a large reservoir but it certainly indicates the impact of this warming trend on this area.

DR. THOMPSON: Do you have a map that you could point out-- this is something that wasn't brought up the last time.

MR. CONWELL: I believe this one right up here--the shot is about here (indicating), Vega Dam would be here (indicating), Grand Mesa here (indicating), and Molina Power Plant is right here (indicating). This Molina Power Plant receives water which is collected by a series of pipelines in about 22 reservoirs some of which were formerly lakes. They have just been raised a few feet--over 30 to 40 feet. It's brought down the hill across these inner-bedded gravels, silt, and in some cases bouldery conglomerate derived from lava flow into the area--in some cases across the lava. For all particular purposes very high flat lines. This section of this line crosses the silty areas which appears to inner-bedded these glacial deposits silt but also silt layers in the Wasatch formation. That appears to be the problem with this collection work comes across to the Molina Power Plant and also where the canal outlet and sections from the Vega Reservoir which brings water to these mesa areas in here (indicating) for irrigation purposes. The same material are affecting the performance of both this collection system--pipeline collection system in stock--

DR. THOMPSON: --well, who operates this power system?

MR. CONWELL: The power system is operated by the Bureau. The canal works are operated by a conservancy of the local people and the dams are under the jurisdiction of the Bureau and the Bureau has operation and maintenance responsibility.

JAT2E4  
RSPC  
5/1/69

DR. MAXEY: Is there a Bureau man here Ross?

MR. KINNAMAN: George Rouse was expected.

MR. JOHNSON: He is due here at 10:30.

MR. KINNAMAN: He is not here yet.

DR. MAXEY: Is there some reason to bring this in before we talk about the Harvey Gap Dam, is this the time to ask detailed questions about this problem?

DR. THOMPSON: I don't even recall this being mentioned last time.

DR. MAXEY: No, this was not brought up last time. I have some concern that we were primed for something else but I see some questions that need to be asked here.

MR. CONWELL: I did not come across this particular situation until last week.

MR. MAXEY: Is this a good sequence, is all I'm asking.

MR. KINNAMAN: In view of the fact that we don't have a Bureau representative here, I would suggest that we sort of train the trend down to the Harvey Gap then you can raise that.

CHAIRMAN WILSON: Right, I think that is a good idea.

DR. MAXEY: I don't think we should forget this.

DR. THOMPSON: It sounds like a rather complicated arrangement a number of dams and conduits and sluices and penstorks and silt.

DR. MAXEY: Could someone review former earthquake experience with this problem?--not now but sometime today.

MR. CONWELL: Yes, I can handle that.

One of the problems we have looked at, here again this is not a problem, we thought that it might be--would be the tailings ponds

JATB5  
RSPC  
5/1/69

at the Union Carbide Plant at Rifle. This is a uranium ore processing plant and their mill pulp is carried out of the plant and stacked up sort of behind dikes. Part of the material is generally silt dikes which carried out, pumped out in a fluid. They had built out from the plant--they have built this thing out from the plant in 50 foot increments above the general level of the ground by a series of dikes. The pond extends these things out across the gravel bed to within about 7 to 900 feet of the Colorado River. Parts of it are a pile of water saturated material.

CHAIRMAN WILSON: What is the maximum depth of that?

MR. CONWELL: The part that seems to be saturated right now is about 20 feet, but the older portion which has its feet wet, so to speak, is about 50 feet.

DR. MAXEY: Can you show us any pictures?

MR. CONWELL: I do have sketches and I do have some extra photographs here. There are copies if you care to see them.

DR. MAXEY: Again, should we segregate this from the Harvey Gap problem?

CHAIRMAN WILSON: Yeah, I think we're getting a little disorganized.

MR. CONWELL: Well, it was my purpose to present the general hazard picture here. I believe Dr. Sherard and Dr. Seed have evaluated the Harvey Gap--the dam itself and I also have information to present at the proper time on other measures.

CHAIRMAN WILSON: Yes, is someone going to evaluate the hazard here and give us their opinion of it or what?

MR. CONWELL: This situation has not been evaluated. This is an inventory of the potential hazards here--this is one of the others

JAT2B6  
RSPC  
5/1/69

that we have encountered.

DR. MAXEY: Mr. Chairman, could we have the material that we were primed for first and get that off our mind and then go into this new material?

CHAIRMAN WILSON: Lets see, how many hazards are there that we're going to look at? We're going to have Harvey Gap, and we're going to have something more on the conduit system and the collection system, and the pipes and sluices and we're going to have something more on this--or is this all there is?

MR. CONWELL: This is all except photographs and I do have some more data on the rockfalls and landslides that are affecting the railroads and highways.

CHAIRMAN WILSON: Yes, these are the four or five areas that we will have to take a detailed look at.

DR. SHERARD: How about Vega Dam, is that full by the way?

MR. CONWELL: Yes, well no, I'll retract that. They are releasing water into the canal--it is filling very rapidly and it is estimated that it will be full by shot time.

DR. SHERARD: Vega Dam, I know some facts about it, was not built by the Bureau, it was taken over by the Bureau about 30 years ago. It has a steel upstream facing. At some time they had some problem, there was a slide on the abutment that was wrinkling the facing.

DR. WILSON: Well, I think we have a little of the overall picture of what we have to cover, and if it's all right with you, let's get right into the Harvey Gap Dam and let's concentrate only on Harvey Gap for the next hour or whatever it takes.

JAT2B7  
RSPC  
5/1/69

(A presentation was given at this time by Dr. H.B. Seed, concerning the Harvey Gap Dam, during which the following comments were made:)

DR. SEED: Harvey Gap Dam. About two weeks ago I received a phone call asking me if I would evaluate "as far as you can," possible affects of our shot on Harvey Gap Dam." My question was, what do we know about Harvey Gap Dam and the answer was almost nothing. There are three steps involved in this type of program. The first is to find out how it was built and what it consists of, then to determine something about the properties of the material involved and finally how it might respond to the kind of ground motion that would be induced by our shot. Because of the impossibility of doing all this work myself, in two weeks time, I enlisted the cooperation of Dr. Sherard and Mr. Johnson from Woodward and Clyde to go out in the field and see what it was all about, what it actually consisted of and do some soil testings and boring. I'm going to ask Dr. Sherard to describe the results of his field investigations of this dam, that is the biggest part of this problem at the moment, and that will take quite a little while. I will turn the meeting first over to Dr. Sherard who will describe the dam, what it consists of and then I'll finish off by summarizing what I think will happen to the dam as a result of the shot about to be set off.

DR. SHERARD: I have some drawings and I was wondering if we would want to spread them out--shall we lay them out in front of the Panel Group.

MR. KINNAMAN: I would suggest that sir. We have a projector now if there is any need to show any slides.

JAT2B8  
RSPC  
5/1/69

DR. SHERARD: Joe Compton, of the Army Engineers, was out at the site at the same time and took a few slides from various abutments and perhaps just some overall views of the dam might be handy at first. Joe, would you narrate what you took?

(A presentation was given at this time by Mr. J. R. Compton, on the Harvey Gap Dam, during which the following comments were made:)

MR. COMPTON: Gentlemen, these slides were taken in the afternoon of the 18th of April, or the 17th and then on the 19th when I visited it when Dr. Sherard was there and Mr. Johnson of Woodward and Clyde and Associates. I'll apologize, some of them are extraneous and some of them are not in the exact order.

SLIDE:

This is the downstream slope of the dam.

DR. THOMPSON: Where is the crest of the dam?

MR. COMPTON: The crest of the dam is here (indicating). Here is the drill rig (indicating) putting in a hole on the top crest of the dam. This is an inspection trench (indicating) which was brought down with the backhoe about four and a half feet deep.

I believe that we have got this reversed.

There was a little red shack there, that was a sale house for the coal mine, and the direct abutment which was operated between about 1930 and 1953 according to one of the older residents there. This coal mine was in the left abutment and there was another one in the right abutment down below the spillway.

DR. SHERARD: The first shot was looking at the drill rig and that was up here. The trench was shown here (indicating). This is a tower which is on the center line, it runs like this (indicating), there

JAT2B9  
RSPC  
5/1/69

is a pipe to here (indicating)--from here to here (indicating).

DR. THOMPSON: Rock tunnel that goes through the dead rock?

DR. SHERARD: Yes. The rock abutment is more or less here (indicating).

MR. COMPTON: You see the tower is sunk in here (indicating).

DR. SHERARD: It is in across the tank but it is in good shape.

DR. MAXEY: Where are the coal mines?

DR. SHERARD: Here, and one over there sir (indicating).

DR. WILSON: I think we're ready with the slides now.

SLIDE:

MR. COMPTON: Well, we're looking now at the right perspective. There is the little coal house (indicating). This is a road on the downstream slope (indicating). One of the older residents said that this represented about right here (indicating) the top of a sluice filled dam that had been placed about 1908--finished about 1908. The dam itself was largely built in 1910.

SLIDE:

Now, we're looking at the left abutment, the east abutment. This is the coal shaft, this is waste pile here (indicating). Here, that little red-topped sale house (indicating) where they sold coal. This is a local road that goes along the left abutment here (indicating). A slight amount of seepage was noted right at the intersection here (indicating) and it appeared to be coming out of the abutment. It was pretty difficult to tell because it was masked off by coal waste.

SLIDE:

Here is some of the coal waste, this is in the lower part of the valley at the junction of the left abutment and the dam.

JAT2B10  
RSPC  
5/1/69

SLIDE:

Now, we are looking from the crest of the dam downstream, this is the coal waste (indicating), here is the red roofed shack-- this is a quarry here for road material (indicating) for road surfacing it does not represent any slide, the coal mine was right up here (indicating).

DR. WILSON: Are those sand and gravel, Joe?

MR. COMPTON: Sand and gravel--I didn't actually get up there.

DR. WILSON: Well, is that typical of both abutments all the way down?

MR. COMPTON: I'll show you some of the rock--

DR. SHERARD: --basically the rock is on the surface. This is a place where they could get some soil.

MR. COMPTON: Next slide.

SLIDE:

Downstream is now to our left, we're looking, however, at the east abutment--the left abutment, and this shows the bedding of the rock-- they're finding shale and coal, it seems, in here. I'm not a geologist, I didn't identify the rock, perhaps somebody else can. The next slide is a closer shot.

SLIDE:

Now this is oriented correctly, downstream is to your right, and this shows that the bedding lies at this angle (indicating) relative to the down axis looking toward the left abutment. You can tell about the size of this bedding here by my field notebook. You can see the shale seams in here (indicating). Next slide.

SLIDE:

JAT2B11  
RSPC  
5/1/69

Now, we're looking at the dam at the downstream toe, this is an area of slight seeping, I believe Dr. Sherard said later, or about at the center of the dam lake. Dr. Sherard put a backhoe trench in here and traced this seepage out to the outlet tunnels. Is that correct? Through about a three foot sand layer or gravel layer that was not found in any of the borings in the dam itself.

DR. THOMPSON: Is this water coming out of the outlet tunnel or through the dam?

DR. SHERARD: This water is water that came through the tunnel, discharged through a canal and seeped into the canal.

DR. WILSON: Apparently a local condition.

DR. SHERARD: Yes, I don't think it has anything to do with under seepage or through seepage.

MR. COMPTON: Next slide.

SLIDE:

Now, this is a view from the left abutment--this is the right abutment. Here is the tower (indicating), here is the drill rig (indicating), and we have got about a four and a half to five feet freeboard. I want to point out here, however, with this restricted spillway that this is the regulated reservoir and there is no drainage basin except a little off of these slopes. The land upstream slopes away from the reservoir and the reservoir is filled by controlled water flow from the canal from east Rifle Creek, next slide please.

SLIDE:

This is looking from about where the drill rig was operating about the center of the dam and it is looking northeast and this is high

JAT2E12  
RSPC  
5/1/69

ground here (indicating). And this is rim (indicating), and the ground drops off from there. So you can see there is very little drainage basin. Next slide.

SLIDE:

This isn't to advertise Dr. Sherard, but to show the right abutment and you can see here again, you have the same bedding angle downstream. This is Mr. Tibbets, a local resident who was quite familiar with the construction of the dam and from whom we got quite a bit of information. We were standing right near where the spillway is. The spillway is right through here (indicating). Next slide.

SLIDE:

Now, this is a spillway, you can see it here (indicating). We were given to understand, and Jim I don't know whether you checked this out, that the spillway was originally cut in rock and was some 80 feet wide and 1946, Mr. Vajarro, who is Manager of the District-- (reporter unable to hear speaker)--because it is a regulated reservoir and there is presumably a concrete wall across the gap--the original gap that ties into the eighth embankment from this training wall here (indicating). Next slide.

SLIDE:

Now, we are downstream looking at the present spillway. The original crest of the spillway was here (indicating) and permission was obtained according to Mr. Vajarro, in 1946 to raise it five feet and increase the crest of the dam several feet to obtain five foot free board, I believe. There must have been more at the time.

DR. THOMPSON: What is the filling in the spillway there,

JAT2B13  
RSPC  
5/1/69

is that slash board at the top or concrete or what is it?

MR. COMPTON: Right here (indicating), this is wood--two boards. But this concrete wall (indicating) was a filler.

DR. SHERARD: That is a permanent concrete wall.

DR. THOMPSON: This is the amount they raised it?

DR. SHERARD: It was raised twice--it is a concrete wall that is wet--it's rotten concrete.

MR. COMPTON: Well, it's just not carefully poured concrete.  
Next slide.

SLIDE:

Now, we are looking from about the same position where I took the spillway--back of the spillway down--I presume this is where some of the leakage was coming from that was going down in there. This is why they call it Rifle Gap. You can see it's quite a gap. This valley is very narrow, V shaped valley and this narrowness persists on up to about the entrance about a mile or mile and a half on up. Next slide.

SLIDE:

Now, we are looking at the exit of the Alfred Tunnel, this was carved in rock--Jim can probably tell you how competent the rock looked, I believe he went in there.

MR. THOMPSON: Where is this with respect to the dam? Is this underneath the dam or in one of the abutments?

MR. COMPTON: This is through the rock outcrop of the right abutment which levels out somewhat at the spillway and goes on out into the valley somewhere.

DR. MAKEY: Is it on the opposite side of the spillway?

JAT2B14  
RSPC  
5/1/69

DR. SHERARD: No, no same side.

DR. WILSON: What elevation is this, I mean, how far can you pull the reservoir down with the outlet?

MR. COMPTON: Well, from the intake, which is in the lake, I think is 52 feet from the spillway crest.

DR. WILSON: In elevation down?

MR. COMPTON: I understand that they pull it down every year that much and fill it back up in the winter time.

DR. THOMPSON: How much dead storage is there--what is the total height of the pool--the depth of the pool?

MR. COMPTON: I would say 50 or 55 feet.

DR. SHERARD: Very small dead storage. It may be a number of feet, but in volume it is very small. We can look on the topo here.

MR. COMPTON: The crest length of this dam was, I think, 660 feet and its greatest height above this lowest point in the valley is about 80 feet, I believe.

DR. SHERARD: I don't believe it exceeds 71 or 72.

MR. COMPTON: 64 at the bottom and 62 at the crest.

DR. SHERARD: Oh yes, that's right.

MR. COMPTON: This is a very narrow portion generally it will run 60 or 65 feet, something like that. Next slide.

SLIDE:

We are looking at this dam spot--we must be back to the original.

DR. WILSON: Okay--no, that is not the original.

MR. COMPTON: This is not the first one--next slide.

SLIDE:

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RSPC  
5/1/69

Here we are simply looking at the material out of the back of trench on the downstream slope and this is the little road (indicating) that I pointed out earlier, which is somewhat considerably higher than the lowest part of the valley. Next slide.

SLIDE:

We are looking now at the bottom of the east abutment and they are making an auger boring here and also at this point is where an auger rig put in a much deeper hole. This one went down about 20 feet. Next slide.

SLIDE:

This is a test bit that was dug when a hand auger couldn't penetrate it. It was about 15 feet on down the downstream slope below the crest and they had a number of rocks in there and they simply couldn't get through with a hand auger. So this was dug out with the hopes that perhaps we could put in an auger at some depth. We still weren't able to--we made a number of tries.

DR. THOMPSON: Do I understand that the earliest dam was the hydraulic fill?

MR. COMPTON: One of the earlier ones. According to this older resident, it formed a part of the downstream slope. The road I showed on there represented about the crest of that old sluiced dam.

DR. WILSON: Maybe we could discuss that after we get the cross section.

MR. COMPTON: Next slide please.

SLIDE:

This just shows some of the seepage out of the left abutment

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5/1/69

in this coal waste. And that's all I have.

DR. WILSON: Thank you.

Let's take about a ten minute coffee break.

(At this time a recess was taken.)

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CHAIRMAN WILSON: Will you proceed?

DR. SHERARD: Well gentlemen, I think first I'll take just-- I'm not prepared to give a lecture in the sense of having my agenda well laid out. Mr. Wilson has suggested that I stick to the essentials, so I'm going to speed through it very quickly.

First, one of the things that we are interested in is how is the dam built. I found some things in quite detail. First, there was an old dam at the site in the 1890's--I don't know very much about it, I couldn't find anything reliable about how it was constructed or when, but it failed in 1895--in March. That was pretty well known, but how it failed or why it failed or how high it was, I didn't get a very good idea.

The next stage, as far as I was able to learn, was some work done by the local farmers in the years between 1904 and 1908 or 9. In those years the construction was described to me secondhand as being a hydraulic filling type operation. In those years there was already a canal bringing water into the area that had been used for the 1890 dam-- the canal being about eight miles long from the adjacent creek--East Rifle Creek. They used the water in that canal to sluice the material on the right valley wall above the dam down into the valley of the dam. In secondhand description it was described as a type of construction that would be useless. As far as I know, in several dams in Colorado, about those years, of building up a dike around the periphery of the dam to a height of several feet with horse drawn equipment and making a pond in between and filling the pond with sluice material.

CHAIRMAN WILSON: The material was not dumped into the pond, it was just carried in to--

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DR. SHERARD: --carried in by water and dropped into the pond.

CHAIRMAN WILSON: You don't know whether there were pipes along each side, or on one end?

DR. SHERARD: By secondhand picture I have a picture of a wooden flume being brought to the construction surface and the water being dropped from the end of the flume into the pond.

DR. THOMPSON: Where did they pick up the material, in the abutments?

DR. SHERARD: Yes, on the right abutment, somewhere in this general area here (indicating).

DR. MAXEY: This was valley fill material?

DR. SHERARD: Yes, slope wash. After that time we have a much better record of what happened.

In 1909, a set of drawings which were deposited in the State Engineer's office, eight drawings, quite good drawings, showing the present dam, essentially. This present dam is setting on top of this sluice fill. I have here the eight drawings of 1809--they show a topographic map of the valley at that time, including the old dam and cross sections through the dam. Cross sections are shown here on this sheet (indicating). But, in general, the natural ground may have been something like this (indicating), and this sluice dam actually something like that (indicating). It mentions that this is the old map system--elevation 30, and this about 65 (indicating), and this 6014 (indicating) and this 59. So, the total height, as Mr. Compton said, from the lowest point in the valley, is about 84 feet and this thing was up to about 35 feet in the lower half or two-thirds of the dam.

DR. THOMPSON: Do they have a fair idea of what the medium of the sluice material was?

DR. SHERARD: Yes, we see it here on these profiles, it is more or less flat on the top at this elevation (indicating), it has slopes of two and a half or three to one here (indicating).

DR. MAXEY: The maximum, essentially, is the same as the present dam?

DR. SHERARD: Yes, essentially, the drawings show two and a half to one and three to one up here (indicating). But, as it turns out, this slope here (indicating) is two and a half to one.

Now, the new dam was built by a company from Colorado Springs that came down and, evidently, made an arrangement with the farmers to obtain half of the water rights to build the dam. They built it completely in the summer of 1910. And that old gentleman that you saw the picture of in the photograph, was 14 years old at the time the dam was built. His father had been an employee of the Farmers Irrigation Company in the role of maintaining the ditch. So, each day he visited, or several times a week, the construction to bring his father's lunch, so he told the story. But, to make a long story short, I gained the impression that he was a reliable witness of what happened. He is essentially the main source of the information about the construction. He said that the dam was built relatively carefully in horizontal layers about six inches in thickness. There were two barrow pits located in the valley just upstream from the dam, one on the right side and one on the left side and perhaps a thousand feet upstream. At one of the barrow pits there was a steam power shovel and at the other a horse drawn elevator grader and they had

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about 50 horse-drawn wagons. The wagons were drawn with two horses carrying something between one and two cubic yards. The wagons made a round trip to one of the barrow pits to the dam and to the other barrow pit and to the dam. They would come under the construction surface, they were bottom dump--they dumped it into a pile--the material in the pile was spread out by a horse-drawn grader to a layer of six inches or less in thickness. That layer was then sprinkled with a hose--one man working on the construction surface with a hose approximately two inches in diameter, connected to a two-inch pipe head, came down from the irrigation ditch on the abutment. Relatively little pressure.

The barrow pits were extremely dry, characterized by a cloud of dust, particularly in the one where the horses were excavating continuously.

DR. THOMPSON: How did they compact this stuff?

DR. SHERARD: Yes, they had a steam roller on the job that was continuously in operation, running around the construction surface. Evidently the construction surface was kept completely horizontal all the time and they were quite concerned about that. They were quite concerned about putting large rocks in the fill, even though the barrow pits did not have a large amount of rocks--they had a horse drawn wagon and a crew of laborers picking rocks about three inches over in size off the construction surface and hauling them to the upstream and downstream side.

As I said, they completed it wholely in the summer of 1910 and the next interesting aspect, which I feel we can rely upon, is, they raised the reservoir for the first years in increments slowly. There

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1-69

had been a lot of trouble in Colorado in those years compacting homogenous dams of clay too dry and having the dam, when the reservoir filled the first time, crack and water break through the crack. So, they were quite cognizant of that, according to Mr. Tibitts, and insisted, and they could do it because the water was brought in through the reservoir through a canal, that they raised the reservoir slowly, and I feel that it was probable, they didn't fill the reservoir for the first time until about eight years. In 1918 or 17, something like that. When the reservoir was pulled down for the first time, about 1918, there was a slight slump on the upstream slope, this is described as being like a scarp of a slide with the high point about two-thirds of the way from the upstream tow to the crest, and with a vertical component of a slump of about two feet. Evidently nothing was done about that except to observe it for a while and it stabilized, and when the reservoir is low it is said that it can be seen now, although we didn't see it since the reservoir was full.

35

From the history of this, the next piece of information we have is a single drawing in the State Engineer's Office repository dated 1920 by a consulting engineer named S. O. Harper, which some of you may know, he subsequently became Chief Engineer of the Bureau of Reclamation. This drawing shows that, and we have a drawing here to show you, that the crest had slumped in a uniform slump to a maximum of about three and a half feet in 1920. They say just uniform settlement. It also showed a scheme for raising a reservoir level. The original design, the distance between the fixed crest and the spillway at the top of the dam was 16 feet from elevation 5998 to 6014. It showed

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-1-69.

raising it up five feet. I found no record as to whether or not that thing was raised at that time or whether the crest was brought up to grade at that time but I suspect that it was.

In 1947--and the information now comes from the present administration of the reservoir, the spillway was raised again up to a point where supposedly there was five feet of free board. It was also closed in from 80 feet of width for about 14 feet and probably brought up to grade again at that time--the crest brought up to grade.

The operation of the reservoir, the water is all brought in with the canal--it started to be brought in--it's not uniform, the operation from year to year, and they have plenty of water to fill the reservoir. They start filling the reservoir about September 1st and they continue to fill it with the ditch until it is full about March 15th. And then sometime toward the latter part of April or the first part of May they start to use it for irrigation and they draw down gradually with the outlet works and drain from 10 to 50 cubic feet per second. In different years, depending on the crops that had been irrigated until the reservoir is empty late in the fall, in September, and evidently that has been used that way more or less consistently for a number of years.

Well, so much for the way it was constructed.

CHAIRMAN WILSON: I might make it clear Jim that the sprinkling was more to control the dust than it was really to wet the material. It must have been put in--

DR. SHERARD: Yes, I don't think there was any question about it. The Dam is homogeneous and there is no zoning in it. I didn't make that point very well, I suppose.

DR. THOMPSON: Is there riprap on the inside?

DR. SHERARD: Yes, there is one of the best looking blankets of riprap one could ever have seen. It is made out of this flat sandstone and laid flat--hand placed riprap--very good shape except at the surface, there is a lot of trees growing out of it at the present time. The Dam was undoubtedly very dry because they undoubtedly just didn't have enough water to put on it, whether or not it was an attempt to keep the dust down or whether or not it was an attempt to wet it, I think it probably was some of both. Surely they had some knowledge that it was desirable to wet it also. But dust undoubtedly was a problem, and in those days they had a lot of trouble with horses dying because of the dust. But we also had evidence of a great settlement that it was compacted dry and also evidence from the trench which we made on the downstream slope of the dam which you saw in the photo, which probably represents the condition very close to that which it was placed as dry and loose.

So, let us talk then about the exploration and I won't go into that hole by hole unless you wish.

CHAIRMAN WILSON: No.

DR. SHERARD: We have borings by two different rigs and the backhoe trenches and in summary, we found as follows--

CHAIRMAN WILSON: Just give us an idea of the number of borings you had--you had expressed about 9 or 10 borings--not the locations.

DR. SHERARD: Yes, I guess we had a total of 13 or 14 borings and 7 pits and 2 longitudinal trenches down the slope.

CHAIRMAN WILSON: I just wanted to bring out that it has been

pretty thoroughly explored.

DR. SHERARD: Yes, we first started working on the 15th of April and we had one or two drill rigs and the backhoe working almost continuously for ten days or so.

DR. MAXEY: Will it stay there now?

CHAIRMAN WILSON: That comes later.

DR. MAXEY: I just thought you removed enough of it.

(Laughter.)

CHAIRMAN WILSON: Let's see, we have a couple of people from the State. Can you add anything?

MR. KUIPER: I think he's covered it very well.

MR. PADDOCK: He has pretty well covered it. Apparently, there were two pretty substantial failures--I can't find the date of the second failure but the first one is 1895.

DR. SHERARD: You mean it failed after 1895?

MR. PADDOCK: Yes.

DR. SHERARD: I found no knowledge of that from the local people.

MR. PADDOCK: Mr. Harper made a report and recommendation that he wanted in the second phase.

DR. SHERARD: That must have been then of this thing (indicating)?

MR. PADDOCK: 1920 was when he made, I think, his analysis.

DR. SHERARD: Is there a report of Mr. Harper in your office?

MR. PADDOCK: Yes, I have a copy of it with me if you would like to see it.

CHAIRMAN WILSON: We would very much like to see that. Did he

say that it was in the foundation or in the embankment itself?

MR. PADDOCK: He was just like we are today some forty years later, there wasn't very much information. But there were some borings made at that time. According to him, they went down about 82 feet and hit solid rock.

CHAIRMAN WILSON: I know Mr. Harper personally, I'd like to see his report.

DR. SHERARD: You say he made borings in 1920?

MR. PADDOCK: He doesn't exactly tell what happened there but I think one of those sheets which I turned over to you has a copy of this.

DR. SHERARD: There are two borings shown in 1920.

MR. PADDOCK: Well, you've got me now.

CHAIRMAN WILSON: Well, let's go on anyway, we'd like to see the report later though.

DR. SHERARD: Well, I think the best way to find what we found in the Dam is to make a little sketch of the profile. In a very rough sketch, the maximum section of the Dam looks something like that because we couldn't see anything below the water (indicating). This slope is about two and a half to one (indicating). The original national crown is probably something like this (indicating) and the bedrock surface down here (indicating). The Dam itself as far as we were able to tell is a homogeneous embankment of clay of medium stiff-to-stiff. There is no indication that there is any layering of pervious materials, any layering of soft materials or that the water is seeping through it anywhere. The trench on the downstream slope is here (indicating)

and another one here (indicating), were largely dry to trickles, well below standard posture optimum, very porous and not well compacted. The material in the holes and at the crest was saturated, stiff to medium stiff, a clay with a liquid limit--from 30 or a little lower 26 to 33, in general, well above the A line. Typical inorganic clay, low plasticity but fairly high tuffness--very good material.

DR. THOMPSON: Where did your boring go? Did you go all the way down to the old rock line?

DR. SHERARD: We have one main boring that went down here (indicating) and stopped short. And we had one boring that hit the bedrock here (indicating) and then closer to the end of the hole at the downstream, we hit bedrock about here (indicating). The depth to the bedrock is about 80 feet.

DR. THOMPSON: Did they excavate out the overburden before they built the dam or did they just build it on top of the overburden?

DR. SHERARD: We didn't have any knowledge of that.

CHAIRMAN WILSON: --in the water tables.

DR. THOMPSON: The water table would generally look something like this (indicating) from the deep hole. We had a hole here (indicating) that was 20 feet deep and was dry, and the water level here is about 27 feet (indicating). At the downstream and at the end of the crest, it's roughly 14 or 15 feet. At the center line about 8 feet down--

DR. MAXEY: The implication is that it is saturated below there?

DR. SHERARD: Yes.

CHAIRMAN WILSON: Yes, and we checked on that and the degree of saturation is 100 percent.

DR. SHERARD: So, the embankment itself is a typical homogeneous embankment of clay with sufficient drainage in the foundation, or at

least control of the seepage so that the water surface is never reaching the downstream surface--the downstream slope. Because this material here (indicating) is quite dry, I don't believe it has ever been wet. If the water had ever reached the downstream phase, it would still be moist and it's not moist so I don't think that it ever reached the downstream slope.

The foundation material is essentially the same material in its basic properties, that is the embankment, that is to say that the clay is of about the same plasticity. The gradation is such that about 70 to 80 percent and passes the 200--very little variation in 15 or 20 percent. And in clay sizes in about 20 or 30 percent finer than 0002 millimeters, about 20 or 30 percent finer than that. Now the foundation, as we expected, is less uniform than the embankment. In general, I find stiff to medium stiff brown clay, particularly for me in the upper part here (indicating). In the upper third here, the color is mottled with black and sometimes very organic samples are obtained but in general with an undefined presence of strength of 3,000 pounds per square foot. Some of the samples were more sandy than others, all we saw was sandy clay, but in an overall view of the foundation, a medium to stiff to stiff clay with horizontal stratification, probably quite erratic and some thin layers of material that could be very pervious relative to the clay.

DR. THOMPSON: Well, what is the material--is there a pervious material at all in the foundation?

DR. SHERARD: I found one sample that we got in the hole we put down here (indicating) at a depth that would be shown schematically about here, 4 inches long in the Shelby till of clean, fine gravel, pea gravel from about a quarter to a half-inch.

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5-1-69

Now, one other interesting detail is one of the test bits which we put down in the valley floor, here (indicating). This is a low point of the valley which is right down here (indicating) and that is this elevation 30 and we put one test bit down here 10 feet and in that we found about 7 feet of stiff clay and then I ran into a very clean, very coarse cobble area. The water was at a depth of 7 feet and it ran in very fast in this cobble area, so at least the one test bit in the lowest part of the valley, we had a very pervious material. With the backhoes, I investigated these two small leaks which I described here earlier and convinced myself quite clearly that they were not the manifestation of water coming from underneath the dam but were coming through the rock abutments and running out on the surface and saturating the area around there.

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DR. MAXEY: You say through the rock abutment?

DR. SHERARD: Yes, I postulate, and the main reason being that in the particular bit that I would put down, I would find the water flowing at that surface sometimes two or three feet horizontally but as I came down deeper I came into the clay again and the clay having no water in it. Particularly, the several bits over here near the outlet works, it was quite clear that the water was running from the canal in a shallow seepage.

DR. THOMPSON: In this pre-adit line there, you would gather there must be something down below that has some permeability otherwise it would come out in the slope of the dam.

DR. SHERARD: Hypothetically of course we have a very pervious foundation, no matter how pervious the dam is, it should come out in this

slope and I think that is the main reason that it is down because there is something pervious in the foundation particularly right at the low point, there must be a bit of gravel running under the dam. But, also this dry material on the downstream slope is rather pervious, you can dig it with a shovel very easily just because it was not compacted. So, very probably, the difference between the center portions of the dam (reporter unable to hear speaker)--the difference between the permeability here (indicating) and this part here (indicating) is that if any water that seeps through this relatively pervious portion finds the pervious zone in the dam, relatively speaking, and essentially speaking from the seepage standpoint is the zoned dam.

MR. COMPTON: Jim, the other point is that that reservoir just stays at the highest peak for a short period. It's brought up to there about the first of March and then about the first of May they start drawing it down. And it may mean that the pre-adit line doesn't have a chance to get out.

CHAIRMAN WILSON: I think it's more likely that the drainage from the upper surface layer that controls it prevents it from coming out.

DR. MAXEY: You don't believe that the movement of water is between the clay material and the abutments?

DR. SHERARD: It could be--seepage back there.

CHAIRMAN WILSON: I would doubt that. I think it's more likely in the rock.

DR. MAXEY: In the rock?

CHAIRMAN WILSON: Yes, this is a good quality clay.

DR. SHERARD: The other point that I did skip over is the construction. Mr. Tibbits was quite clear. There was a concrete cutoff placed on the left abutment, more or less similar to the ones we place now but with rather large dimensions. He estimated that it might be six feet wide and twenty feet protruding into the dam--he may have been a little hazy on the dimensions.

DR. THOMPSON: Just on one abutment?

DR. SHERARD: Just on one abutment, yes. So there may have been something there that lead him to believe that they needed a cutoff to make it seal. Also, there is, from my point of view a rumor, that there was a drainage pipe at the contact here that never flooded.

DR. MAXEY: Like a bleeder pipe?

DR. SHERARD: A bleeder pipe, yes.

DR. MAXEY: There are no bleeder pipes at the foot of the dam?

DR. SHERARD: No, none whatsoever and the lower part of the dam is completely dry. On one test bit that we had as I said in the deepest part had 7-foot of stiff clay and hit water at a very pervious gravel and the water immediately stabilized.

In order to avoid another round of details, I think I'll just summarize by saying, the way I see it, it's an old dam, relatively well constructed in those days, that has a relatively good history and certainly has a very large margin of safety. The normal conditions, in my point of view, is something that in no way we have need to be

concerned over at the present time. And it certainly is much safer than many of its colleagues of similar age.

DR. THOMPSON: Do you mean of this area?

DR. SHERARD: I mean in the western part of the United States.

So, I think I will stop there unless you have specific questions and then we can talk later, I guess.

CHAIRMAN WILSON: I might make one or two comments. I did have the opportunity to look at these samples yesterday in Oakland and reviewed the history. In such a density as these--of the embankment material itself, is about 90 percent of standard posture so it is not a high density, it is a low density, but despite that, the appearance of the material itself is good, of the dam material itself.

DR. SHERARD: Well, that is the central portion?

CHAIRMAN WILSON: Yes.

DR. SHERARD: We took some field density tests and it's 10 percent lower. It's 70 to 80.

DR. THOMPSON: Would you identify the hydraulic fill or separate that from the later fill?

DR. SHERARD: It is very difficult except visually on the scope but right here (indicating) was a top which had something much less than cobble in it. We could use the hand auger here but we could not use the hand auger to dig holes on the slope. So, except for that, the hydraulic fill was not what you think of if you are thinking about a puddle core of a hydraulic fill in California where it remains a

soup for decades. This material is very similar to a very stiff-like deposit.

DR. MAXEY: So really it wasn't wet down very much?

DR. SHERARD: No, I think it must have been deposited underwater but because of the fact that it developed low liquid limits, it was able to consolidate in a time that elapsed between now and then. When they built this 1910 dam, they moved upstream a bit and the rumor has it that they were a little bit afraid it must have been a little bit soft at that time--to put the dam right on top.

CHAIRMAN WILSON: Jim, you described the foundation material as being stiff to medium stiff. I think that my evaluation was not quite that good, a little less homogeneous, if there is a problem here it is in the foundation and not in the embankment itself.

DR. SHERARD: I reflected quite a bit yesterday after we talked Stan, and I concluded that the samples that you saw were softened somewhat by repetitive handling and where you would have had a somewhat different view if you would have seen those when they were first cut open. Mr. Wilson has seen samples that were extracted from Shelby tills and cut longitudinally in half and put in plastic bags several days before he arrived. In the interim period, they had been handled by several people and they were just low enough plasticity that they bled a little bit. There was a little bit of sensitivity in them.

CHAIRMAN WILSON: But embankment materials would not do that, Jim. The foundation was less competent than the embankment.

DR. SHERARD: The foundation is less competent than the embankment but on the other hand, I feel that the view that you had yesterday would not have been quite the same view if you had two days earlier.

Shall I then stop?

CHAIRMAN WILSON: Yes. Thank you very much, Jim.

DR. SEED: Well, now we know what the dam consists of, what are the other parts of the step? First of all, let us review what could happen to the dam. We assume, from previous knowledge of these shots, the rock motion of this site would be at maximum acceleration point of 0.25g and the predominant frequency would be about 3 or 4 cycles per second. This is to be something like this sort of thing that comes out of the shots that came before. The next question is to analyze the response to the system that we deal with, first of all the foundation and secondly, the foundation dam system. We made a short study to determine what might happen in the foundation if the dam were not there, to get a free field response and our estimation was that there would be an amplification of the rock motion by a factor of about two and that the ground surface around the dam for a 70 or 80 foot foundation layer, of the kind of material we have here, the freefield accelerations might be of the order of about .05g. Putting the dam on that, we then determined that the trash response might be about .08g. These are very crude estimates because the amount of information available is very spotty. The samples taken in the dam and in the foundation are quite variable. Sometimes we find pressure strength at 8,000 psf and sometimes it's down as low as 1,500 psf which is an

enormous variation and just what the average strength of this material in this embankment would be is very hard to determine with the information available. We can back figure the stability of this, if we do that, then the average strength of the dam and its foundation would have to be about 1,400--average shear strength would have to be about 1,400 psf to give a factor of safety of one. That is an unconfined pressure strength of at least 2,800 to give a factor of safety of one and we know it is more than that, so the average strength must be somewhere upwards, I would guess, 3,000 pounds per square foot, at the present time. Knowing something about this kind of material, our estimates are about 505g for the free field ground surface response and .08g at the crest of the dam. I might add here that the period conditions are not too favorable if the incoming motion is about .25 per second in a predominant period--the foundation system alone has about .3 seconds and this is a very unfavorable match of incoming period of base motion and frequency of system. That tends to amplify very strongly of course. Then the dam itself might have a period of about a quarter of a second or so, so that the entire dam foundation system would be 0.5 to 0.6 seconds which is still reasonably close to the predominant period of the incoming motions, which is not a very favorable thing from a response point of view.

We computed the maximum shear strength increase of the dam and estimated this at about 230 psf. Having done that, we determined that we might like to see some material in the body of the dam. For that purpose, we took a sample of soil which was representative of the elements of the soil in the dam, which might find itself perhaps about

here (indicating) in the cross-sections which would have a major principle stress in this direction (indicating) and a minor principle stress in this direction (indicating)--took that out and did a special triaxial test in which we took a sample of clay from the body of the dam and consolidated the sample under 1,200 psf laterally and about 2,500 psf, it might have been a little bit more than that, vertically to give a principle stress ratio of about two and a quarter. Then, on top of that, a cycle stress, up and down to represent the effect of the shear stresses of everything going up and down to an increase of about 230 psf so we cycled 500 psf actually which would give a shear stress of about 230. We did this to observe the effect of cycling loading on the pore pressures induced in the soil in the body of the dam. The effect of this--this was plus or minus 500. The effect of this was virtually nothing, there was no pore pressure increase in the sample that we tested. We could only do this just on one sample and it seemed to be reasonably representative of the material of the body of the dam. It is my conclusion from this and looking at the material and based on other tests that we have done on other materials was that the material in the body of the dam does not tend to get increases of pore pressure as a result of the cycling loading that might be induced by the level of motions that we are talking about in our particular case. So, I don't look for any significant loss of strength in the material of the body of the dam.

I conclude therefore that the material of the body of the dam should not present a problem from the stability point of view it would not lose strength significantly and it should be able to withstand

the stresses and stress increases caused by our shot. I estimated that the shock that we are talking about would be about 12 percent which would be a net decrease in a factor of safety, if the soil strength did not change of about 10 to 15 percent as a result of the transient motions induced by the shock we're talking about.

DR. THOMPSON: So one of them cancels out the other--your strength increase--

DR. SEED: No, the strength did not increase--did not change. Now, we can't really determine what the factor of safety would be with this because we don't know what the strength is before it. My guess however is that the factor of safety at the present time must be at least one and a quarter, just by looking at the condition of the dam, I can't imagine that it would be less than that. If it were one and a quarter right now, we would have a factor of safety drop of 15 percent and it would still be 1.1 which is not an unacceptable value for a transient phenomenon, that is assuming no strength loss in any of the materials. So the interesting question here is what is the possibility of a strength loss. We have reasonably satisfied ourselves, based on experience and tests, one test, that there would be no strength loss in the body of the embankment, this doesn't say anything about what might happen in the body of the foundation of the dam. And I would agree that the real problem here seems to be in the foundation of the dam. The material down there seems to be weaker and the material in the embankment itself, because of its sandy nature is more vulnerable to a pore pressure increase as a result of the cycling bloating being induced in the structure by what we're doing.

Now, what do we have on the credit side, we can look at a lot of other dam behavior and shots like this. A good example of this might be the Arby Tehachapi Earthquake, and that particular earthquake in Southern California, there was something like 64 dams that were affected in the area, small dams something like this, some may have been well built, some not so well built in the area where the modified Mercalli intensity was about seven. If we would convert this roughly will it be at the hydraulic acceleration level at about .1g and then recognizing that this conversion is very pore--nevertheless it still seems that in this area where the modified

intensity was reported to be seven, the ground motions would be somewhat comparable or perhaps a little bit larger than the motions at our site. In that area there were 64 dams, varying heights, varying quality--three out of 64 dams were damaged in this particular earthquake. One of the dams that was damaged was the Dry Canyon Dam, which surprisingly enough was built in 1910 to 1912, it is very similar to our dam, it's a rolled fill, built over a hydraulic fill which is very similar to the one that we're talking about--it is 70 feet high and our dam is 80 feet high. This dam had a crack in the crest, it settled three inches and moved laterally three inches as a result of the ground motions that were induced. There was some cracking of the crest for a variety of reasons because the hydraulic fill of the body of the dam and the possibility of much stronger earthquakes than the one that affected it at the time, the dam was subsequently rebuilt.

South Highwe Dam was damaged, this was built in 1908 to 1913 and it's a hydraulic fill construction, 81 feet high and the cracking

at the crest indicated incipient failure at the time of the earthquake. On the other hand, 61 out of the 64 dams had no damage at all, so it is well to keep this in mind, it is to the credit side that motions of this intensity had not characteristically caused failures of dams, they have occasionally caused minor damage to dams.

Now, the material most likely to lose strength in our system is the sandy material in the foundation. This we think is cause for little concern. The other material in the foundation-- the clay I don't think will lose strength by the intensity of the motions that we're talking about. There are sandy lenses or seams or whatever they may be, we don't have enough information to know how continuous they are that might lead to a minor problem.

What about the debit side? First of all, I understand that this is purely psychological I'm sure. In 1895, the dam at this site failed five days, failed one day five days following an earthquake 100 miles away. I'm sure that effect is highly psychological, it doesn't seem conceivable that an earthquake with the intensity of five in the epicentral region 100 miles away could possibly have affected this but nevertheless, it is a remarkable coincidence that five days following that was the time that the very first dam failed.

Secondly, rock motions at .025g are not a thing to be casually dismissed as not being important. Our best estimates are that the rock motions in Carracas in July of '67 were also about .025g's. Most of us will note perhaps that four apartment buildings collapsed in Carracas killing 300 people in that earthquake so that motions of this intensity are severe enough to cause damage. And again the problem

following Carracas was largely a problem of the soil conditions responded quite strongly to the motions that were coming in to amplify the motions to produce a significant condition.

Thirdly, there is a problem with the Proesser Creek Dam. The Proesser Creek Dam is a small dam 100 feet high, near Truckee which was affected by an earthquake about three years ago. They had a magnitude of five and a half and we can convert that to rock motions in the epicentral region, it would be about .03g which is not unlike the rock motions we're talking about. It is a rather well built dam, built by the Bureau of Reclamation and the affect of the earthquake was to have caused cracking of the crest.

Fourthly, the soils of our dam are clay materials, these kind of materials tend to have low damping characteristics and that is not good from a response point of view. There are many other kinds of materials, sandy gravels and sand which have a much higher damping factors than the kind of materials from here. So, from the damping point of view, the response might be strengthened by the fact that we have this kind of material and of course, we have this rather unfavorable matching of a predominant period of incoming motion and predominant periods or fundamental periods of the system that we are dealing with.

Now, putting all this together, it enables one to draw some conclusions about the dam that we're dealing with. To summarize, I would say that the problem materials in our dam are the dry soil above the water level, I say this because if the dam would crack this material as I see it would be reasonably easily erodible. It hasn't been stiffened and bonded together by water previously in the soil so it

might be quite erodible in the event of the cracking of the crest of the dam which seems to have occurred in a number of earthquakes and this I think, is the most likely affect of the shock that we're applying to the dam on this dam. Secondly, we have the sand lenses in the foundation that presents something of a problem. It is very hard for us to ascertain just how serious a problem these are because opinions obviously vary about the prevalence of the lenses, Doctor Sherard doesn't think that they are so common as Mr. Wilson and myself would be inclined to think. It's a matter of opinion. You can only look at a few samples and try to guess what might be done.

I don't think there is any serious danger of a major slide produced by the ground motions we are anticipating. I would say that there is very little danger of this at all, but nevertheless there is a finite possibility which should not be completely ruled out. It is one of these incredible events, very unlikely. The major effects of the shock on the dam are likely to be some minor slumping of the crest and some cracking of the crest.

Finally, if we are going to get some cracking and slumping of the crest, I think that a number of precautions should be taken if this shot is to be set off. First of all, I would like to see the people downstream of the dam evacuated while the shot is going on. Secondly, I think it would be prudent to draw down the water level in the reservoir so in the event we get cracking of the crest, the water would not be readily available to move into the crack and perhaps cause erosion downstream. I think it would be prudent to draw down the water level to about 10 feet of free board or something along that line. Thirdly, I think it would be prudent to have some system available readily to seal any cracks that might develop in the crest

of the dam as a result of the shot. This sort of thing might be the availability of some cheap pile lengths of about 15 feet long which could be quickly hammered in at cross cracks if they should develop and secondly, the availability of a stockpile of sand and gravel to toss into the cracks to seal them up if they develop. Finally, I think it would be wise to carefully observe the performance of the dam for some period of time following the shot to see that there is no instability development as a function of time following the shot.

That is the consensus of the survey as I see it and I should be glad to answer any questions that you have.

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DR. THOMPSON: Are there any unstable landslide areas within the reservoir that might come in as a result of the shot?

DR. SEED: Jim, can you answer that question?

DR. SHERARD: Well, we didn't, Mr. Thompson, look specifically. The ground surface is not at all high and I would say categorically there is no risk of slide, causing a wave on the surface. It is just not the kind of situation that even made me want to look carefully. The topography is too low.

MR. THALGOTT: Doctor Seed, did I understand you correctly, to say that your calculations were based on fundamental frequency at this point on four cycles per second?

DR. SEED: Yes, at the rock level.

CHAIRMAN WILSON: That was based on some records from GASBUGGY, was it not?

DR. SHERARD: We looked particularly at GASBUGGY instrument No. 10 which is thirty yards away--(reporter unable to hear speaker.)

MR. THALGOTT: No, I will take your word for it. I'm a little surprised. I thought it was a little shorter.

CHAIRMAN WILSON: Four cycles per second lasting for about 10 or 15 seconds and then tapering off for another 10 or 15 seconds. So, there are about 50 uniform shocks during the first interval.

Are there any other questions? I would like to say that I had the opportunity to review this and I am very much impressed, Mr. Edwards, with the thoroughness with which the gentlemen have done this survey. I think that they have done an excellent job, in the short time available, and I don't think that very much more would be left by additional explorations at this time. Non-homogeneous and exploration and the foundation which we can never fully hope to resolve and I think we know now about it as much as we ever will know about this dam and I think it is sufficient to draw some conclusions.

DR. THOMPSON: You mentioned evacuation downstream, just what does this consist of? The downstream could be all the way to the Pacific Ocean.

DR. SEED: I think that Roger will talk about that.

I think it's 75 families temporarily.

(At this time, Mr. Edwards introduced some visitors in the audience who had not been previously introduced.)

CHAIRMAN WILSON: This last topic of course is extremely important and if there is anyone in the audience who would like to ask questions or add something, now is the time to do it.

MR. HELLER: I would like to ask one question. If you draw

down the reservoir, does this have any effect on the stability of the upstream slope?

CHAIRMAN WILSON: Would you like to answer that? I think it's safe enough myself.

DR. SEED: I think it's safe enough to draw it down (reporter unable to hear speaker.)

DR. THOMPSON: This draw down would never get down to the point where you would never get involved in the failure in the dam?

CHAIRMAN WILSON: Oh no, that was about a third of the way down and what we have contemplated is about ten feet of draw down.

DR. SEED: It's just enough to get below the depth of the cracks.

CHAIRMAN WILSON: And to avoid saturating that upper downstream flow over the cracks.

DR. MAXEY: Have you an estimated timing? How long will it take you to draw this down?

CHAIRMAN WILSON: I hope we will have some input on it a little later.

MR. LOUX: I'm Peter Loux from ERC. There is a certain amount of evidence that the peak acceleration input in the bedrock might be about half of the value that you used on this--

DR. SEED: That is always good. I might add that we used .025g because all the people I talked to seemed to give me this number-- it's the one that's been--

MR. LOUX: There is a considerable amount of evidence from

the GASBUGGY data. All of the running analysis show you our average at NTS today that it would experience a likely value at that distance--this shot--and you would have that.

CHAIRMAN WILSON: But we are here in a different environment and a different geological condition.

DR. MAXEY: In effect, what you're saying is that this is very conservative.

MR. LOUX: I can say that the evidence indicates that this is conservative.

MR. THALGOTT: Out of sheer ignorance, if this cracking does take place, how long does it take for you to get a catastrophic failure at this stage?

CHAIRMAN WILSON: I would say in this case the worse thing would be the erosion of the downstream slope--that loose dry material on the downstream of the dam. The material itself in the dam is cohesive. It holds together, I think that the erosion through the cracks would proceed quite slowly--I think there's time enough to stop it.

MR. THALGOTT: Well, let me put my problem to you real simple. I'm quite concerned about pressing these people, I think that if this is something that takes sometime, there is no reason why we can't make preparations to be sure that there is transportation and communication and everything else with the people concerned so that in the time that it takes to drive out of that valley, we can evacuate after the shot. I think we would be much better off public relationwise to wait.

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CHAIRMAN WILSON: That may be true but my concern is the possible liquefaction of the foundation which could result in a catastrophic failure itself--not just traffic, I think there is an incredible possibility. I don't think it's going to happen but there is a incredible possibility and that would occur too fast to evacuate after the shot.

DR. MAXEY: Bob, I think we've had so many examples of this type of cracking. Doctor Seed mentioned a few, I have observed at least three of the examples that he mentioned and particularly Proesser which was the worst cracked dam that I have ever seen as a result of earthquakes. These cracks are really superficial--this is not our concern. We probably wouldn't feel so confident about this if we didn't have so many examples in front of us--this is no Baldwin Dam failure.

MR. PADDOCK: Mr. Chairman, have there been any studies made about damage that might occur if the water level were lowered and then a failure occurred? In other words, we pull the top 10 feet and we still have a failure. Have any studies been made about the consequences--

CHAIRMAN WILSON: Well, the only type of catastrophic failure is these liquefaction of the foundation material which the whole shell of the dam would move downstream and open up a major breach either at the bottom or through the center of the dam and whether the water was within 10 feet or at the top it doesn't really make any difference. Pulling it down 10 feet helps with respect to the cracking that is involved and this is much more of a probability that

something like this would happen. The possibility of a deep seeded liquefaction failure is just a remote and an incredible event.

MR. PADDOCK: Well, in that respect of the gentleman's question, there is about 2,000 acre feet in that top 10 feet and it would take about three weeks according to our data.

CHAIRMAN WILSON: We're talking about 10 feet of free board now from the top of the dam and we're already down five.

DR. MAXEY: Well, we're going down five feet instead of ten.

MR. PADDOCK: Well, the first order of business when I get back to my office in the morning, will be to order those flash boards out of the spillway so you can forget the first foot or two.

CHAIRMAN WILSON: Yes. Well, I think we want to get a report from the legal effects of drawing down the reservoir and that is on the agenda which will be coming up later.

MR. PADDOCK: If you draw down 10 feet of free board, then you will have approximately 1,200 acre feet of storage. That will take about 10 days.

CHAIRMAN WILSON: So there is time enough for that.

MR. THALGOTT: Have they begun to use that water yet?

(Reporter unable to hear speaker.)

CHAIRMAN WILSON: The Board has not yet agreed upon a fixed number.

MR. PADDOCK: Well, if the number has to be bought, the going price in that area is approximately 20 to 25 dollars an acre foot. So far as I know, that is the Grand Mesa.

DR. MAXEY: Is that what the farmers pay for it?

MR. PADDOCK: Yes, they buy it by the second foot--they pay about 40 or 50 dollars a second foot for 24 hours, so it figures out to 20 to 25 an acre foot.

DR. MAXEY: Boy, that's high.

MR. PADDOCK: They only buy in July and August at that rate.

CHAIRMAN WILSON: If there's no further discussion, I wonder if we can go on then, Roger.

MR. SKJEI: Okay, we have looked at two things, we have looked at the downstream area in the field trying to make some judgment type of evaluation as to the area that would flood, taking into account the kinds of debris problems that would be approached with a downstream flood--diversion that may occur and this sort of thing. Another study was made on the basis of some assumptions that were made about the mode of failure in the kind of flow that would come out in using open channel flow calculations for what sort of channel the flow might follow, following the topographic contours. We'll proceed with both of these and there are some differences and I'd like Dick Conwell to go first with his field evaluation of the areas that might be involved.

MR. CONWELL: Gentlemen, here are a couple of tabulations and plus a photograph of the map involved.

CHAIRMAN WILSON: Where is the dam?

MR. CONWELL: The dam is right here (indicating).

First of all, we covered the ground using a judgment approach to which direction the water might take in the event of a

failure. This is the Harvey Gap Dam (indicating). I believe you have the maps and also tabulations of all of the family units and what we consider by family units, was a location with possibly a couple and maybe two children--a house that was lived in plus its outhouse structures, there is a couple of copies there (indicating).

DR. MAXEY: And, that's what these numbers are?

MR. CONWELL: The numbers there correspond to the inventory there (indicating).

We have visualized the water going completely through the gap and coming out through an entrance here (indicating) before it could possibly start spreading--moving across the flats spread out and being baffled somewhat by a buried outlier, underground humpback and then this point bifurcating--there is also some evidence that the stream itself that normally flows through Harvey Gap has progressively abandoned channels from east to west. The radiant-- here is a broad jump--the distance from this buried bridge here to the southeast, so we visualize a worst possible condition which was spreading in the orange indicates the spreading that we predicted it will take. The drop in velocity on the other side of this ridge, there are these channels that are rather deeply in size which possibly were involved with the earlier failures and they may have had their incision at that time. Now, these are through silt, glacier or old lake beds which form a vertical slope 20 to 25 feet deep channels and several of them cross there and they will be a collective pond for the water in the areas of the volume involved. We feel that once it gets past this ridge, it probably will have a tendency to reform into the

channels. It looks like it might go through the very western end of Silt. Now this is based on field observations alone and Roger has the open end calculations that he can amend to this somewhat. I'll leave this for your reference, I do have a few small photographs if you need to look at detail.

MR. SKJEI: Most of these are assumptions but they have been most conservative assumptions. The mode of dam failure and the kind of failure is something but I can't get much feel for. Doctor Sherard suggested that I talk to Mr. Cartwright, Division Engineer for the Division of Dam Safety, State of California, he says this is a tough problem. They have looked into it following the Baldwin Hills failure. They have had people who offered to do these studies for them but they don't have any confidence in any rigorous analysis. So, what I did was assume that the dam was going to fail and the whole thing was going to empty in twenty minutes. Now, what I have been able to look at in terms of other failures, this isn't a bad assumption. There is a very well documented study on the Rubicon River following the failure of the Helbrow Dam, it was under construction at the time and there was a heavy rainfall area, it's a bigger dam than the Harvey Gap, the water was 150 feet in depth at the time of the failure. The dam eroded very rapidly. It let go with something like 24,000 acre feet, four times as much water as we have here. And the average flow was around 250,000 cubic feet per second, peaked up to about 300,000 cubic feet per second. After I had that to make an assumption, it seems to me to verify a fairly a very conservative assumption as to the failure in the downstream flow.

So, using this assumption I did some channel calculations and using the Chezy Mannion equation, and the roughness numbers that I had gotten from Mr. Conwell. I checked the numbers with experience with downstream flows from the Rubicon River and from stations below St. Francis and where my velocity seems too high and the flow consequently too low, from these calculations I went back to experience, and used some of the velocities which were observed which gave me deeper flow and I used those deeper flows. This of course would me a wider flooded area. The first section down from the dam I took at about the bottom of the canyon and from this I got a flow depth from the Chezy Mannion equation of about 40 feet, the velocity was too high. So, I went back to the dam experience flow rate and got a flow depth of about 60 feet. Now, after I get through with these, I'll show you the kinds of channels, purported channels to compare with what Fred gave you.

#### VIEWGRAPH

The second section below the canyon you had a flood plane where the flow would widen out quite a bit and now here is the Chezy Mannion equation and experience with flows seems to check very well. This is a very broad channel topographically and the total channel width is on the order of 2,000 feet.

#### VIEWGRAPH

Coming down to the ridge that Fred showed you earlier, is the next section down on the map where you see the town of Silt on the Colorado River on the bottom of the map. My first section there

is up on the ridge and here I get a little increase in flow because the channel is constricted. Chezy Mannion equations and the experience checked fairly well. I got a little more depth from experience so I used it.

VIEWGRAPH

Now, the fourth section down, again I had trouble with the Chezy Mannion equation but I used 20 feet per second flow which seems to be fairly well verified by experience--downflow. Here for the first time, I began to get some overtopping of the channel bank. I got a depth of flow of about 60 feet. The flow was pretty well constricted here. I picked the channel, looked at it, to see whether or not it would overtop the banks or flood out toward Silt, which is the real regional concern. Now, looking at the same region, in order to keep the flow inside that channel not overtopping the bank, using a velocity of 20 feet per second, I have to have a flow rate of 150,000 second feet or less. Now, using the same mode of failure of the dam, 20 minute emptying, that gives me a total volume supplying this flow of 4,400 acre feet. I did this to see what would have to be done to the reservoir to keep the flow inside the channel on the basis of the assumptions I had made.

DR. MAXEY: Your figures are based on 6,000 acre feet?

MR. SKJEI: That's right.

VIEWGRAPH

Now, here is the upper section of the dam down to the ridge at the bottom and I show you the heavy line, the flooded areas

that I get from my calculations and the dash lines, you'll see the field judgment area that Fred achieved, and you see I have a wide flow--they have a wide flow there, my constriction goes all through this channel to the west in the ridge and Fred has his spreading out and going out to the channel through that ridge down to the southeast.

#### VIEWGRAPH

Here, you see that I have my flow coming all through this little gap at the left-hand edge of that ridge, he has his spreading out--his comes into the two channels pretty satisfactory and it still runs into the western edge of the town of Silt. Mine, this is based on the 6,000 acre foot capacity, mine spreads out in this area and also tends to have some problem in the western edge of the town of Silt. Now, I would also say that reducing the capacity to about 4,500 acre feet, would avoid this problem with Silt than the flow would all come down the channel to the west.

Other than Silt, we're talking about generally the same evacuation area upstream, he's got a few more people over to the east there that would have to be evacuated, according to his scheme than I would have in mine, but I don't think there is much involved there in the terms of the total number of people.

DR. MAXEY: When you're talking evacuation, you're talking about bodies and not furniture?

CHAIRMAN WILSON: Oh, no just people.

MR. SKJEI: I have done something like this for the Battlement Mesa Reservoir.

CHAIRMAN WILSON: Let's confine it to this.

MR. SKJEI: We have not really looked at the problem in Colorado but my impression is that there is adequate capacity there to handle the flow without any serious problem. We concentrated our attention to getting it through the populated areas and to see what kind of problems we had there. I presume with this kind of failure, you would have a hell of a lot of debris and junk and dirt coming down which would mud up a lot of farm land probably the Colorado too. That seems to be the picture of this Rubicon River thing; A very large transport of boulders and debris.

DR. JACOBSEN: I'd like to ask a question to the underlying assumption. Am I right in understanding that you have assumed that the entire volume of the reservoir passes the cross-section there in 20 minutes?

MR. SKJEI: Yes, sir.

DR. JACOBSEN: That of course is an assumption?

MR. SKJEI: Yes, sir.

DR. JACOBSEN: And that does that regardless of the length of the cross-section and upland?

MR. SKJEI: That's correct.

DR. JACOBSEN: So that is simply an assumption and I'm not criticizing your assumption at all. I know how complicated that thing is.

Now, there is a second question. If, for instance, you have a 2,000 foot wide channel that you start out with and you assume that that volume passes it in 20 seconds--20 minutes and the height therefore

has to be, let's say 10 feet, do you then go back and see what an additional height of 10 feet would do to the width of the channel?

MR. SKJEI: In most of these cases, there is so much more capacity in the channel that doubling the height wouldn't really make any difference on it except in section 4 down here. Here I flooded the channel and my flow therefore spreads out over broader areas so it would be even wider than showed by my assumption.

DR. JACOBSEN: So, the width of the channel is not effected very much by the height?

MR. SKJEI: No in the upstream area, no.

DR. JACOBSEN: Well, I could see up in the canyon, it won't be, but down in the flatlands, I should think there would be.

MR. SKJEI: There are tremendous capacities in those channels. Those are 40 foot contours and I again tried to be conservative. It generally amounts to a fairly broad wash and in many cases and in sized channels in the middle of it. I used an equivalent rectangular section which was really about 50 percent of the channels capacity.

DR. JACOBSEN: That 20 minute emptying is regardless of the gradient of the channel?

MR. SKJEI: Yes.

DR. JACOBSEN: It's certainly a complicated problem and the only way it could be done I think is by models of some sort.

MR. SKJEI: Yes, I did go to Mr. Cartwright and to Doctor Sherard and a few other people that I thought would be knowledgeable

and asked them if there were rigorous techniques for solving this problem. I was pretty sure that there weren't but they said there aren't any.

DR. MAXEY: There are some people who did this during World War II on large dams who are with the USGS, I believe Herb Raubraw-- Mr. West, I'm not sure.

DR. MAXEY: But of course, these were very large dams.

MR. SKJEI: I did use the Rubison River study, which is a good one by the way, which had good data on flow which I checked and found out afterwards. Mr. Cartwright gave me some flow rates on the St. Francis Dam which helped, of course, considerably, more storage, deeper water, and the flow rate for the first half hour or so, well it went up fairly rapidly from small flows to a total flow at that time to about 400,000 per second feet. So my assumptions still didn't bother me too much, since this is still a much smaller dam.

CHAIRMAN WILSON: That 20-minute assumption seems unrealistic and short to me. How do you feel about it?

DR. DOUTHETT: Seems fast.

CHAIRMAN WILSON: Well I really hope it was fast. I would be inclined to make this at least twice that long.

DR. SHERARD: Well, frankly, in order for the dam to fail, under the worst circumstances--

CHAIRMAN WILSON: If a concrete dam fails it opens up a wide frequency, but if this fails, you still have all of the run off from the other dams, and I think 20 minutes is too short.

MR. SKJEI: I have assumed uniform closeups on this for that yield, but actually you would get actually a slow buildup which I don't know whether it would approach this or not, but if it did then we would have the same problem.

DR. MAXEY: Is it possible that the Colorado River channel might be obstructed by the debris and sediment? You get quite a change in grade right at the Colorado junction--does the carrying power of the stream, in other words, drop off where you might

get some obstruction flow into the Colorado that might be damaging?

MR. COMPTON: I don't think so because the channel at that point is very wide and the river is moving very fast, and I would say there is sufficient capacity in the river channel to begin with and it might hit it in.

MR. SKJEI: The whole discussion seems pretty onimous now, this is for the purpose of evacuating people and finding out how wide--

(Due to the multiplicity of voices the reporter was unable to hear or understand the speaker.)

MR. SKJEI: The thing that concerns us is that we have looked at the evacuation up there, we haven't looked at the evacuation in Silt, and that would be a problem of an order of magnitude.

CHAIRMAN WILSON: Yes, but you reach the conclusion even with the distinct accumption that Silt does not have to be evacuated.

MR. SKJEI: No, I didn't reach that, with a 6,000 foot flow I see some problems in the western edge of Silt, particularly in the western boundaries if you will accept my line as being good. In order to keep the combined flow in the channel over there you have got to take the capacity, still using the 20 minute emptying, you have to get the capacity down to 150,000--4,400 acre feet from 150,000 second-feet flow--

DR. MAXEY: And that number approximately represents what is going to be recommended anyway?

MR. SKJEI: Yes.

CHAIRMAN WILSON: I think Silt is a different problem. We have a possibility of a catastrophe being much less here, you have these

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extreme assumptions and you have more time involved--you have got one in there.

DR. MAXEY: What is your timing that the crest will reach the Colorado River?

MR. SKJEI: Let's see, that must be about three miles, four miles--15 miles per hour would seem to be a fair number--over an hour.

MR. THALGOTT: What is the distance from Silt to that dam?

MR. COMPTON: About three or four miles.

DR. MAXEY: But that speeding is going to cut the velocity at the crest.

DR. SHERARD: The crest comes down at an informal rate--it goes in and out, even though it crests.

DR. THOMPSON: You don't have a hell of a lot of time.

MR. SKJEI: The thing that you do have is the flow probably won't be that fast, and I think the whole thing is debatable--well, that concludes my presentation. That is all I have on Harvey Gap Dam.

CHAIRMAN WILSON: I understand the State Engineer would like to make a short presentation.

MR. KUIPER: Mr. Paddock made this map and I think he might want to explain this a little--Frank, do you want to take a crack at that?

MR. PADDOCK: I made a field trip from the dam down to the highway, and there are about six farmsteads on the west channel as it's shown. And, it looks like to me that the ridge up there is pretty low and if you've got a flood as big as has been computed 240,000 feet it will jump that ridge. If it's a lesser flood it will go down the

14  
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-69

west side. If it goes down both sides, then it will involve more people than the half a dozen that I counted.

The history of our Department has been that a 50-foot dam goes out over a four-hour or longer period--this is based on about 60 years of statistics.

DR. THOMPSON: You have a number of these things happen?

MR. PADDOCK: Not a lot of them, but enough that has been used to make our history.

DR. VON LOSSBERG: There are some Dutch papers on this subject--dikes--release the water--it makes a difference by the amount of water.

MR. KUIPER: Of course, this thing is different than any type of thing that we have experienced in Colorado too.

MR. PADDOCK: You see, most of our failures have come about--the facilities have been filled with sand bags to the flashboards--we haven't lost very many by just overtopping or shear failure from earthquake or anything like that. They have been lost because people--they were caught in time to prevent the water coming over top of the crest.

DR. MAXEY: Is this topping at the dam as a result of plugging up the spill rate to get more height on it?

MR. PADDOCK: The majority of them failed on overtopping because the spillway has been crested.

DR. MAXEY: It is not an erosion thing, it is just the reloading.

CHAIRMAN WILSON: Well, I think somewhere in between these two seams is where we're talking about.

MR. KUIPER: A foundation failure would be in another ball game.

entirely.

DR. THOMPSON: That would be something similar to St. Francis.

DR. MAXEY: With a foundation failure the thing would move more or less as a body so that it wouldn't be immediate release.

MR. KUIPER: I would envision a collapse if the thing was a foundation failure.

DR. MAXEY: It would slip downstream.

DR. SEEDS: I don't think the foundation would fail like the Sheffield Dam failure. There is not a continuity as I could see it with the sand seams to make this possible--sand seems to be discontinuous. So, you have sliding through some sand and some clay, and this would not allow complete failure like Sheffield Dam. If anything happens causing some degree of movement or flooding of the embankment, then there would be a release of water slowly overtopping the embankment and it would come out much more slowly than the time we're talking about here.

CHAIRMAN WILSON: I think I may have overstated that--

MR. KUIPER: Of course, you will have a shear plane in there which would erode much faster--just over top of the embankment.

CHAIRMAN WILSON: You might get some fracturing of the surface which would loosen up the surface material.

DR. SEEDS: I think that it would be in the foundation--

MR. KUIPER: No, in the embankment itself.

DR. SEEDS: I still think it would slump down to a mass and overtop.

CHAIRMAN WILSON: Yes, I think that is a more reasonable assumption.

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69

DR. SEEDS: Furthermore, we are talking about a very compatible area at the moment. The motions are, even at .025 g, this is very unlikely, certainly at 0.15 g, it is much less likely than it was before and the motions are indeed, so small, the possibility of this happening is very, very remote.

CHAIRMAN WILSON: I think that Mr. Banister has a few comments which might throw a little light on this here.

DR. BANISTER: I wanted to point out that there is really very little energy available for liquefaction or other processes because the characteristic maximum displacement which we're expecting at this site of the ground motion without amplification on the order of one millimeter, and we're talking about the duration of characteristics previously of about four cycles. So I wanted to emphasize that and be that these displacements are very small and they do not persist very long and I thought this point should be brought up.

CHAIRMAN WILSON: You say four cycles per second is the frequency--

DR. BANISTER: The characteristic of any one frequency is only about four cycles also. If you look at a characteristic frequency in the BCF analysis, preparatory in the sphere of velocity--you find its characteristic duration of a particular frequency four cycles.

CHAIRMAN WILSON: The record we saw wasn't like that--the one we were looking at.

DR. BANISTER: I'm saying at a particular frequency--characteristics previously--

DR. SHERARD: This is GASBUGGY 10 that we have been looking at

'7B7  
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-1-69

as kind of a guide--this is 30 kilometers.

DR. BANISTER: I would say that this is a--

DR. SHERARD: Acceleration displacement--

DR. BANISTER: Right, you're correct. The frequency train is more like seven cycles. If you talk about equivalent energy at the peak it would be true.

CHAIRMAN WILSON: In any event, the amplification of motion is quite small. We're talking about amplification of two or three millimeters.

DR. SEEDS: It is the amplitude that is more significant. Frequency of five or six cycles a second--San Francisco '57 is a good example, but the amplitudes is the one that makes it very, very unlikely.

DR. MAXEY: Is it possible that these numbers are so conservative that they are facetious? Is that what we're talking about? I get the feeling that we're building up a strawman and he's getting bigger and bigger.

CHAIRMAN WILSON: I think we're overstating it some, but you can't discount it because of the possibility of the residents condition and the presence of these critical materials in the foundation--it just can't be ignored.

DR. SHERARD: I agree that it cannot be ignored, but on the other hand, I think we can sit around the table like this and look at maps like this, you can put yourself in an emotional position that is really not realistic. For me, all of our experience in dams and earthquakes indicates, to me, that there is no chance of failure. It's just that we cannot, because we are poor technicians in the field that we don't have a complete assurance we cannot rule out the possibilities

7B8  
JCR  
-1-69

and you can only state so much.

MR. HELLER: What is the possibility of this shot triggering, say, aftershocks, some sort of false system that might be closer to the dam than the actual shot itself containing some energy?

CHAIRMAN WILSON: That is something that we could talk about for the rest of the day, I guess.

MR. HELLER: Has it been looked into at all?

DR. MAXEY: Our experience with aftershock is that they are so minute that we didn't even observe them for a long time. The energy produced by this shot is going to be several orders of magnitude greater than any energy release from an aftershock, in our experience.

MR. HELLER: What area of the country is that, primarily NTS?

DR. MAXEY: We have to take NTS and STS.

DR. THOMPSON: You had an experience up at SHOAL, you had a seismic in an inactive area up there and nothing was turned loose.

DR. MAXEY: SHOAL was a good example of an active area. I don't know how active this area is, but the impression is, I guess, that it is not very active.

DR. JACOBSEN: I understand that about 300 earthquakes have occurred and none of them within 50 miles--

MR. ROUSE: The major earthquakes in that area are down in Cimarron on the other side of Montrose and they have had earthquakes down there with magnitudes close to six in 1960. I suspect that this particular area may be not over near Rifle, but on the other side of the river, may be subjected to a magnitude of, say, three to four.

MR. KUIPER: While we're on the subject of emotion, you might say that many people in Denver are concerned about the fault running

through Denver. I imagine that this is rather remote, but there is emotion on this shot and you can't ignore it.

DR. MAXEY: Have they looked, without emotion, at the fact that we're within a hundred miles of the San Andres and this has never slipped for us yet--we've been wanting it to.

MR. KUIPER: As we say, we don't think that there is any further need for concern, but these things do get around.

CHAIRMAN WILSON: Our time is getting short, gentlemen, and I would like to continue if we may. If we can get into a discussion of the legal aspects of lowering the reservoirs--who is going to present that?

MR. JOHNSON: I think that there is one item that is of interest and that is what Roger is going to present as to, if you do lower the reservoir, what is the possibility in the incoming weeks and months of being able to fill it up again, which is a prelude to some degree to the legal aspects.

MR. CONWELL: I was in contact this morning with the Bureau at Grand Junction, their office, and the resident for the Silt project was in contact with the Farmer's Irrigation District last night. Now, the present flow, at least of Rifle Creek is now being diverted to Rifle Gap Dam because the reservoir is full, but the Farmer's Irrigation Company has proprietary rights. The flow on May 22nd is estimated to be around 90 cubic feet per second. Under normal operating conditions, the Farmer's Irrigation Company is willing to do this if they continue to divert water into Rifle Gap Dam they can pick up about five additional feet of drawdown which would make it pretty close to the ten feet or so that we are thinking about at about shot time. Without cutting the water

7B10  
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5-1-69

requirements in the district short, anything in addition to that would start chopping into what normally would be used for irrigation. The peak flow is estimated to take place on East Rifle Creek sometime between May 10th and May 20th at 100 cubic feet per second. There possibly could be, because of this proprietary right, there is no way to transfer water from Harvey Gap to the Rifle Gap and back. It has to come from East Rifle Creek and be diverted directly into the Harvey Gap Reservoir. Its pluses, anyway, for the reason of the water level at shot time and also they're willing to forgo where they would normally keep it at and leave it at that until that time.

MR. AAMODT: You're saying that the water is really not the Rifle Gap Dam though, are you not?

MR. CONWELL: Pardon?

MR. AAMODT: Rifle would be the actual loser of this amount of water?

MR. CONWELL: Yes, it will, because of the proprietary rights. Now, this Rifle Creek is a remarkable, as I understand it, because of the fact that it has an average sustain flow of about 30 cubic feet per second throughout the year. It is one of the higher flowing and it doesn't respond seasonably to the same degree that other lakes do. It captures over about half the flow of Rifle Creek.

MR. KUIPER: Are we talking about six more feet of drawdown in Harvey Gap?

MR. CONWELL: Five feet if they did not have any additional water between now and shot time.

MR. KUIPER: How many acre feet does that amount to?

CHAIRMAN WILSON: 1,200, I believe.

'B11  
JCR  
1-69

MR. CONWELL: We actually feel that this could be diverted into Rifle Gap Dam during this interim about 4,500 acre feet of their water, which would normally be their water.

DR. MAXEY: When you say "they," you are talking about the people at Harvey Gap Dam?

MR. CONWELL: Yes, the Farmer's Irrigation Company.

DR. MAXEY: In other words, they are flowing the water into Rifle Gap and will then pick it up later?

MR. CONWELL: Yes, and the water that goes into Rifle Gap, I think the Bureau has some jurisdiction on it. So, there wouldn't be the legal complications; the Farmer's Irrigation Company is willing to go along with this sort of arrangement. This has all been verbally arranged between their representatives and the Bureau of Mines who took it on themselves to see what the possibilities were to get some consideration.

DR. JACOBSEN: That is a concession on the part of the Farmer's, is it not?

MR. CONWELL: Yes, sir.

DR. JACOBSEN: What makes them give that concession--just out of the goodness of their hearts?

MR. CONWELL: Well, no, sir, I think they believe that there is enough water this year so that it won't cut into their crop requirements. Anything beyond this they said they could probably raise a flat curtain.

MR. KUIPER: I would suggest very strongly that you check with the Division of Engineers--the legal office--of the legality.

MR. CONWELL: There is no legality--this was simply explored

B12  
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69

as to the possibility. There has been no agreements here, or even firm commitments.

CHAIRMAN WILSON: Well, we will discontinue this conversation of this particular item. It wasn't really a part of the business, actually. I would suggest that we go on into the other areas of concern, which are the Battlement Mesa and the Bureau of Reclamation.

DR. MAXEY: I think what we need is a little geographic instruction here. We don't know where these places are, or we may be talking about something that we may have no concern of. Can you point out on that map, Fred?

MR. CONWELL: Do you want the Battlement Mesa first?

CHAIRMAN WILSON: I don't really care but let's take one topic at a time and pursue it all the way through.

MR. CONWELL: First of all, Harvey Gap Dam is here (indicating), Rifle Gap Dam here (indicating), the scale of this map is approximately four miles to the inch, one to two hundred and fifty thousandths. The shot point is here (indicating) at Battlement Creek, this basically is Grand Hogback and Harvey Gap Dam is located there (indicating), Vega Dam is in the plateau area--that point (indicating) and this is the Grand Mesa area in here (indicating) and the Pontin Dam--reservoir is here (indicating). The reason I mention this is it is part of the collection system for the southwest canal. The Battlement Mesa reservoirs are southeast of the shot point right there (indicating).

CHAIRMAN WILSON: Is that at a higher elevation?

MR. CONWELL: Yes, sir.

CHAIRMAN WILSON: All right, let's take them one at a time,

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5-1-69

shall we take Battlement Mesa?

MR. CONWELL: All right, the Battlement Mesa reservoirs were also built around the turn of the century. There were seven. We were not able to get to this area at all, that is the week before last because there was still six inches of snow there. We had talked to a person that had been in there two days before and I also talked to the area supervisor ranger who had been in there shortly before.

CHAIRMAN WILSON: How tall are these dams?

MR. CONWELL: As far as we can determine, the tallest one is 20 feet, of the seven original ones left--these are a series of interconnecting reservoirs used to regulate the flow on down to Battlement Creek.

CHAIRMAN WILSON: Built with horses?

MR. CONWELL: Yes sir, built apparently between 1896 and 1900.

DR. MAXEY: They are all of this vintage?

MR. CONWELL: Yes.

CHAIRMAN WILSON: Any idea of what the slopes are?

MR. CONWELL: No. Two of these dams have been breached, several others are full of rodent holes, the Forest Services, as I understand it, the soil conservation centers are involved with the State Engineer's Office, have been trying to get the owners to update these dams, as I understand it, since 1941.

CHAIRMAN WILSON: Through spillways or control elevation or what?

MR. CONWELL: The spillways, the last one was made as I saw it,

in '67, it listed the spillways as being filled with trash and overgrown and the dam themselves being full of rodent holes. The outlet works on none of them were operable. We're not talking about a large amount of water even when these are full.

DR. MAXEY: What would be the total available water if it was all added together?

MR. CONWELL: If it was all added together, as near as I can determine based on some of these old reports, it is around a thousand acre feet--of the five operable ones left. But, this was based somewhat on surveys that were made at the time the dams were constructed and I'm not sure whether this volume includes the capacity that could be reached--

CHAIRMAN WILSON: This water would flow where?

MR. CONWELL: It would come down Battlement Creek in a fairly deep channel, which we can, since we couldn't get into this area, if we would consider this the worst possible failure and that was a failure.

DR. THOMPSON: All of the things failing at once?

MR. CONWELL: Actually, it's like a string of dominoes, the biggest one if it fails would flow into one of the smaller ones which is the final outlets of the whole system.

DR. THOMPSON: They are stacked up like a chain?

MR. CONWELL: Well, not end to end. They are kind of--a couple over here flowing into a little one and one over here flowing into a little one which regulates the flow out.

DR. MAXEY: How close are these to Silt?

MR. CONWELL: Eight kilometers--six to eight kilometers.

We have really made a feel of judgment. The probable consequences of the failure here and there is, by the way, only one house in the way. And he is the Commissioner for the Water Company.

(Laughter.)

This is a reservoir system here (indicating), the shot point is here (indicating), and the control point is in this area right here (indicating). The channel is very highly entrenched-- a lot of trees but a beautiful trout stream. The channel backedges averages down, on this lower end (indicating), around 40 feet high and failure under the worst conditions would pick up a lot of debris but I still feel it would hang up in the channel and break out into the Colorado here (indicating).

DR. MAXEY: Let's see, the shot point is where?

MR. CONWELL: Here (indicating).

DR. MAXEY: And the reservoir is up on top?

MR. CONWELL: Yes, sir.

DR. MAXEY: Well, that is less than four miles.

MR. CONWELL: I have the exact figure on those. About three and a half to four miles.

DR. MAXEY: That is what I was thinking.

DR. JACOBSEN: Would this mean that only one house would have to be evacuated?

MR. CONWELL: Yes, that is based on this concept with a failure, which I think has got quite a lot of conservatism in it

because of the assumptions that were made, first of all. It is estimated that the reservoirs at that time would still be iced up-- not be full and this is also taking into consideration that you have a whole lot of failures simultaneously in order to get high enough body to come out of the channel and I don't think the volume is there.

DR. MAXEY: But if the big one hits the small one, then the small one is going to fail.

MR. CONWELL: A good point, yes sir.

MR. MILLER: Are these dams normally dry or low, as well as Harvey Gap Dam?

MR. CONWELL: They are low in the fall--the dams are not being operated. You can't regulate the flow out because you can't get the outlets to work. The water from Battlement Creek is diverted off down below this gauging station here (indicating) and the two canals that irrigate Morris Mesa and one of the other sections of Grand Valley.

DR. MAXEY: That is not the Mesa Dam, that is the irrigation water.

MR. CONWELL: It's also used for irrigation but it is also used domestically--it's a very good quality water.

DR. MAXEY: Well, where is it used?

MR. CONWELL: I understand that it's sold out in the Mesa area.

DR. THOMPSON: You say there is no means of controlling the flow out of the reservoir?

MR. CONWELL: That is my information, yes.

MR. AAMODT: What is the mechanism for their draw down if they slope and fall?

MR. CONWELL: Seepage, they leak.

DR. MAXEY: What are these--fruit trees?

MR. CONWELL: Orchards.

The small black squares are basically houses.

DR. MAXEY: Most of these people use this water supply out of the ditch, is that what you're saying?

MR. CONWELL: No, I don't know who uses it for domestic supply, I'm just told that it is used for domestic supply, it might be used in Grand Valley, I'm not sure.

MR. KINNAMAN: I understand those people use this to fill cisterns--they use it all during the summer and they have to refill for the winter.

DR. MAXEY: The idea is not to drink water in Silt.

MR. KINNAMAN: The idea is not to drink silt in water.

CHAIRMAN WILSON: Do you people have a specific recommendation on this?

MR. SKJEI: All I can say is we have gone through some of the things on the hydraulic calculations and similar catastrophic failures and I get the same pattern that he does--everything the same within the channel, there's been no stability analysis and damage data of any kind. Since there is only one family to be evacuated, I don't see why we just don't evacuate the house and let it go at that.

CHAIRMAN WILSON: Does the State have any particular comments?

MR. PADDOCK: One deep channel area which is about 1,900 feet. Part of these dams do go out. I've never been able to get into these particular dams but as a result of what I hear today, I will be there this summer, as soon as it's open.

DR. MAXEY: This may clear out a nice path for you.

MR. KUIPER: Without an assay of each dam I would determine the damage that you would be liable for--I can see all kinds of claims coming in for damage.

DR. THOMPSON: You mean damage to the dams?

MR. KUIPER: Yes.

DR. MAXEY: You're talking about a before and after type?

MR. KUIPER: Yes.

MR. EDWARDS: I think to clarify a point here, this Panel, around the table, is to discuss the hazards of the dam and we're not asking these people to worry about the price--financial prices of the consequences--that falls within the purview of another area. I might also state too, that prior to shot time there will be a thorough preshot investigation of all facilities subject to whatever snow limitations but everything available will be inspected thoroughly even those that have already been looked at will be looked at again prior to the shot so we will have a pre and postshot comparison.

DR. MAXEY: Will you take them in with a chopper?

MR. EDWARDS: If necessary.

MR. PADDOCK: I might add one point. The problem of rodents which we heard mentioned. We have a record of, out of eighty failures,

only two of them were caused by rodents. Rodents hardly ever, unless they're beavers, go under the water. One failure was because of a beaver--they went into the dam and then went up into the material of the water and then went on through, of course.

CHAIRMAN WILSON: Was there any further discussion?

MR. MUDRA: I would like to mention one thing. I overflowed the area on Monday and all of the reservoirs were filled. All of the roads are closed but there are a lot of snowmobile tracks on the surface of the reservoir. The only open water that I could see was the outflow.

CHAIRMAN WILSON: --the indication is that they are all closed in that area.

MR. MUDRA: Yes, as of Monday.

CHAIRMAN WILSON: Well, then all right let's go onto the next problem area.

MR. SKJEI: I would like to make a little summary statement to sort of follow up Fred's discussion this morning. I'm afraid we left you with some reservations about this thing. I would like to read you what we're going to say in our report, essentially what we're going to say in our report. We have discussed the Harvey Gap Dam and its area and the reason we're real concerned about it--and, we say, "An initial evaluation indicated that the dam could be a potential hazard in its present structural and hydraulic condition subsequently a separate investigation was begun conducted largely by Doctor J. R. Sherard under the technical direction of Doctor H. B. Seed and the results indicated that the dam did not experience any serious damage as of the consequence of the RULISON ground motion. Therefore, this

hazard according to Doctor Sherard and Doctor Seed does not exist." Now, that is a very strong statement, a little too strong perhaps, and I have qualified that a little bit to suggest--and I go on "that a particular study has also been directed in the problems of stability of Rifle Gap data, Bonham Dam and small Battlement Mesa reservoirs. Also, some attention was directed to the many problems of the many canals in the area. A current consensus of those concerned were dam and canal stability which indicate that these failures are not a serious hazard. Rifle Gap, Vega, and Bonham Dam would appear to be of unquestionable stability. The Battlement Mesa reservoirs are largely an unknown quantity because of the current inaccessibility and the deep snow cover, however, the available data indicates that because of the dams deep maintenance the materials in the dam are essentially sand and gravel with cobbles and boulders and not particularly sensitive to seismic motion. Water levels are minimum. Precautionary measures to remove any hazards to persons would be unlikely in the event of any failure or plan. Other problems of minor nature to persons include the possibility of canal bank failure and a slight problem of injury downstream to outer works below Vega Dam. Damage to these structures may occur as a consequence of present instability and failures triggered by the seismic motion and superimposed on seismic existing study portions." Now, perhaps again, that is a rather strong statement that we want to qualify a little better.

And finally, we say, "some published data as well as discussions with appropriate agencies and individuals we are aware of the presence of numerous small dams and reservoirs in the area. Many high elevations are not accessible because of snow coverage of these

roads. These reservoirs are of various sizes and have unknown conditions as far as repairs or as far as we can determine these do not constitute hazards to persons."

So, in summary, we are mentioning a number of places that we have looked at dams and we have seen dams and we have great confidence in the Bureau of Reclamation dam and our evaluation suggests that there are no problems there. I am sure that the Bureau will have things to say about that.

We are a little concerned about the stability of some canal banks. We have brought up the question of the mine shavings pond and I don't feel that we're very concerned about that. The older banks or the higher banks are pretty dry and the lower ones are a little wet, any failure might drop some material down toward the river. So, as far as I'm concerned, I'm not very concerned about it either. I wanted to make that summary statement to bring things back a little bit more toward center. I'm speaking for Fred in some respects and I invite him to contradict me if he cares to because he has spent a lot of time in the area. But his initial statement was largely to summarize the areas that he looked at, the things that he thought might be potential hazards and now I wanted to say that our evaluation generally, short of the stability analysis, we generally feel that there aren't any serious problems. Particularly, there aren't any hazards to persons that haven't been discussed. There are holes in our surveys of course--upper dams and reservoirs at upper levels, old dams and reservoirs but again I don't think they constitute any hazards to persons. So, with that, what point shall we take up next?

CHAIRMAN WILSON: Let's go into the analysis of the various parts--

DR. MAXEY: Well, if there is no hazard to persons, why are we concerned--we're not concerned with liabilities, except to safety in people.

CHAIRMAN WILSON: Does that statement apply to the canal banks?

MR. SKJEI: Of course, there could always be somebody standing on the canal bank and the bank slip out from under him, short of this, I know of no hazard.

MR. EDWARDS: As far as people are concerned, it has been mentioned briefly a minute ago and to reiterate, there will be evacuation of all persons out to the limit of about five mile radius regardless of today's problem but for other reasons, they will be evacuated.

DR. MAXEY: Are these silty ditches within five miles of the shot?

MR. CONWELL: No, they're between twenty and thirty kilometers of the shot point.

DR. MAXEY: Like 7 to 10 miles?

MR. SKJEI: I'd like to remind you about Doctor Seeds statements about dam failures and areas of strong clay motion.

CHAIRMAN WILSON: With regard to the landslides and the canal slopes and so forth, we assume that this can be ironed out between the Bureau then and the parties concerned--then we don't have to discuss it.

MR. EDWARDS: Would you state that again.

CHAIRMAN WILSON: Well, do we have to consider this problem if there is no hazard to human life?

MR. EDWARDS: Not as a hazard statement--I think--speaking in those areas where we might do some damage to property in itself but the damage to this property as such proposes no hazard to the surrounding territory and its people. I think this is something that we can leave in the purview of the operations office and its liability procedures and its shot time operation plan.

MR. MILLER: Let me add one thing to that. I think that we should be brief particularly with respect to the conditions you are associated with and that the material be saturated with the likelihood or unlikelihood of slides. Whether or not that constitutes a problem with respect to human life and whether it constitutes a problem to property damage, that should be implied.

MR. CONWELL: Two things to amplify that. The best information that I have been able to get from the field engineer of the Bureau of Reclamation itself. These slides would interfere with the functional operation canal of the power line--there was no mention potentially any damage to people--just to property. Also, the other implications was that he found out that the canal systems in this area are the main source of economy in the ranching that goes on. So, it is a functional interference.

CHAIRMAN WILSON: The question has been raised and I think we ought to, at least, hear a brief on what the problem is--what the system is we're talking about--some idea of what the potential damage

might be--who could give that presentation?

MR. CONWELL: The whole facility is known as COLBRAN Project. The observed areas of both the canal and feeder line instability, here is the feeder lines (indicating) in stocks (indicating) for the Molina Power Plant here (indicating) and here is the canal system generally coming out of Vega Dam (indicating). These have been outlined in red. These are a problem area generally speaking but not always, the are saturated silts.

CHAIRMAN WILSON: Where is the shot point again?

MR. CONWELL: The shot point is off to this direction (indicating). Now here is a list of the stations both on the canals and the ditches that were given to me by them that they have had past problems with. And these numbers correspond to the areas marked out.

DR. MAXEY: There is actually instability in some of these dams right now?

MR. CONWELL: I have checked one myself--the Vega Dam and it is going.

(At this time, Mr. Conwell showed some pictures.)

MR. AAMODT: Excuse me, are we to understand that this is not a function of the time of year, this particular hazard?

MR. CONWELL: No, it very definitely is a function of the time of the year, in that it is worse this time of year. When the canals are operating this sort of thing does take place, but these instances pick up during the spring thaw.

CHAIRMAN WILSON: Mr. Rouse, are you personally acquainted with this problem, would you like to comment on it?

MR. ROUSE: We expect to have slides along the canal as a result of this, and I expect that what the Bureau will do is to repair the canals and charge AEC for the cost.

MR. MILLER: Would you say that again?

MR. ROUSE: We do expect slides along the canal from RULISON and it is our opinion that the Bureau will move in and repair these canals and charge AEC for the cost.

MR. MILLER: All right, let me ask a question in that connection, if I may. Does the time of the year have any influence upon the sliding, in your opinion?

MR. ROUSE: The time of the year does, but whether or not they'll determine whether the slide was produced by the seismic vibrations as a result of RULISON or other natural causes is something I don't know.

MR. MILLER: Let me ask you the question in a different way. Is there a greater susceptibility of slides in any time of the year than at other times of the year, from something like RULISON--does the time of year, for example, from the conditions that you have observed in the RULISON area now, May and June primarily, would these be any different than conditions that you predict in the August/September time frame?

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5-1-69

MR. ROUSE: I think it would be less effective in September.

CHAIRMAN WILSON: The Bureau, I gather, is not really raising a red flag?

MR. ROUSE: No.

CHAIRMAN WILSON: They learn to live with these things?

MR. ROUSE: We're going to have to live with it. You people are putting these shots off pretty close to our dams and we're going to have to get used to it.

DR. MAXEY: All we hope is that the dams get used to it.

MR. ROUSE: Oh, I think our dams are all right.

CHAIRMAN WILSON: All right, then I think that will cover that aspect.

DR. MAXEY: Unless there are other areas--are there other areas?

MR. CONWELL: I don't know of anything else, but I also know that there are a lot of things that I haven't seen out there. The hydraulic systems at a distance have not been observed in the same detail that they have been in close.

MR. SKJEI: I think we can safely say that we have identified any major hazards and have given them some sort of treatment.

MR. CONWELL: Within 20 or 25 kilometers, yes.

CHAIRMAN WILSON: We are, of course, learning as much as we can from this initial shock and in that regard I wonder if you could outline briefly what instrumentation is planned for Harvey Gap Dam.

MR. CONWELL: Well, currently we have both channels of instrumentation. The Coast and Geodetic Survey is going to place this. They are L-7's. Our tentative plan is to place three of the components at the base and at the crest and possibly at the intermediate point to

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-1-69

one abutment. This is not a hard-fast plan, and we could possibly make some other recommendations to the Coast and Geodetic Survey in this regard after Dr. Seeds' work here.

CHAIRMAN WILSON: Well, is anyone going to put a station across the top of the dam and get elevations forward and afterward, after alignment and this sort of thing? It's an excellent opportunity. What about the Waterways Experiment Station? Are you taking any recordings?

MR. COMPTON: We're at Rifle Gap Dam, Lyman, you can tell them about that.

MR. HELLER: We're going to put some meters on Rifle Gap at approximately the same locations that you described for Harvey Gap.

CHAIRMAN WILSON: Some bench marks, et cetra?

MR. HELLER: Yes, bench marks and we are going to monitor them.

MR. ROUSE: They're going to be read immediately before and after.

CHAIRMAN WILSON: Does that apply to any other project?

MR. ROUSE: It will apply to Rifle Gap Dam.

CHAIRMAN WILSON: And you have the performance records of these?

MR. ROUSE: Oh, yes.

CHAIRMAN WILSON: Certainly Harvey Gap Dam should be pretty thoroughly instrumented, I should say, especially if we start talking about additional shots up there in that area. The more we can find out from this one about problems in that area, the better.

DR. MAXEY: Sam, do you have any new hot information, supplementary information that the Panel should be aware of before

B4  
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-1-69

we start to wind up this meeting--if there are facts we are to know, we should have them.

MR. WEST: I don't think there has been any additional data developed in the ground water area since the last time we reviewed it for the Panel. I might just briefly review though, that all the water wells in that area are quite shallow, the deepest being 300 feet. Most all of the wells are under 200 feet, and almost all of them get their water from superficial material and from along the Colorado River. We have registered about wells within that ten kilometer area. We have records also on about 38 or 40 springs, now, we have not been able to get to the high altitude springs to get any background information on them. If the snow melts, sure, then we can get in to the higher elevations and we will then take a look at some of these. Their irrigation station has been established at the same point that it was in previous years, and we are getting a record on that. Chemical analysis of some of the water samples are receding and we have some other samples--(Due to the multiplicity of voices, the reporter was unable to hear the speaker.)

DR. MAXEY: In essence, we're making our decisions on the information that we already have?

MR. WEST: That's right.

DR. MAXEY: Isotopes?

MR. NORK: We did do something recently that was based on purely assumptions, but we didn't know anything about rate and direction or flow of water, or significance of any continuous flow, but we made some very conservative estimates and based on these, we felt there was

9B5  
JCR  
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no ground water hazards of any significance. Recently however, we took some stream samples in one exploration hole and transmitted these into, at least the transmissibility of the rocks, and although we're not certain what the possibility of the water throw off along the rocks may be, the rocks do have a reasonable transitive quality so that water could be transferred, at least in the Morrisania Mesa rock, which is up to about a mile at those rates, if they were fully saturated. What the transition rates and the distance would be in shallower activity, I don't know. In the alluvium I really don't know what the transitive rates would be. I think the likelihood that anything would get to the alluvium of significant condensation would be reasonably low. I think the summary, as is given in there is correct.

CHAIRMAN WILSON: Any additional information that anybody would like?

DR. JACOBSEN: What about the legal aspects? Are we going to cover that?

CHAIRMAN WILSON: No, we're not going to get into that.

(At this time the meeting adjourned for lunch.)

T10B1  
SPOCR  
-1-69

SAFETY PANEL OF CONSULTANTS MEETING ON "RULISON"

HARVEY GAP DAM

NEVADA OPERATIONS OFFICE

AFTERNOON SESSION

MAY 1, 1969

1:40 P.M.

MR. EDWARDS: Can we ask everyone to take their seats, please.

I think that we covered all the formal presentations this morning, this afternoon is more a matter of digesting what we have heard this morning. I indicated that there might be participation, in fact we expect participation from everybody and with no further ado, I'll turn this back over to Mr. Wilson.

CHAIRMAN WILSON: I think I'd like to discuss, while all the Group is here, the primary thing is the evaluation of the Harvey Gap Reservoir. The recommendations that were made by Doctor Seed, as I understood them, were Number one to evacuate the people immediately downstream from the dam. There was some question on how many should be evacuated. Number two, it behooves us to draw down the reservoir to the order of 10 feet free board from the crest of the existing dam which might be plus or minus a foot or two. It behooves us to have something available to seal any cracks that might develop in the dam-- it was suggested either cheap piles or stockpiles of sand and gravel. I think my preference would be for sand and gravel and not cheap piles. Fourth, a careful observation of the behavior of the dam itself.

As far as I'm concerned, I completely agree one hundred percent with the comment. I think we might have some discussion of the evacuation of people, how many and under what conditions. The possibility of a catastrophic failure is truly remote maybe so remote as to be unlikely, but in my own mind, I can't completely dismiss it. The combination of the input frequencies corresponding with the natural frequencies of the dam, the possibility of resonance condition developing, and finally the unknowns with respect to the foundation material underneath the dam itself and down inside and from personal observation, I am convinced that these are materials that could be critical and therefore I think we have to say that we cannot dismiss the possibility of some kind of catastrophic failure. And my original thinking was that this might involve the complete loss of the dam but upon reconsideration of this, discussion of the very small amplitude of motion and the possibility that we're already too high on the seismic effect, I think I would modify that to only a possibility that there would be enough slumping to permit overtopping of the dam which could lead to erosion and slow destruction of the dam. I say this because this has an influence on the area that has to be evacuated and I think I would be willing to go that far to agree that it would not be a complete sliding down slope of the entire dam but only enough topping and enough movement which could possibly cause overlapping or overtopping which could lead to erosion and breaching and this would be an escape phenomena which would occur over a matter of hours and not minutes.

MR. AAMODT: Could this be repairable?

CHAIRMAN WILSON: No. What I'm talking about, I don't think

it could be caught in time--to have overtopping of this dam the initial erosion will begin to develop pretty fast. Cracking is repairable.

MR. AAMODT: What about the season--later in the year with a lower level of water, could you see a situation where evacuation would not be necessary?

CHAIRMAN WILSON: Most definitely but not with respect to the season of the year because this doesn't influence the foundation but with respect to the quantity of water behind the dam, oh yes. If the water were down, there would be no need for evacuating people and there is no possibility of a catastrophe in this case.

DR. THOMPSON: I would think, seasonally although it might not have an effect on this particular thing, however some of the other aspects of the safety problem might be better if this could be put off in the fall.

CHAIRMAN WILSON: Yes, landslides would not be a problem and failure of the canal banks would all be greatly improved in the fall there is no doubt about that. I'm talking now only about Harvey Gap Dam.

DR. MAXEY: There are other advantages to that too which allow us to get other information on Battlement Mountain Reservoirs for example and other high level phenomena that we are not going to get.

CHAIRMAN WILSON: Yes. I don't have very strong feelings about the Battlement Mountain Reservoirs. It seems to me that the extent of the damages are confined pretty well to the small channels. There is only one house to be evacuated and the dams are not of very great importance.

110B4  
POCR  
-1-69

DR. MAXEY: I was thinking more from the standpoint that it just hasn't been looked at. We just plain don't have some of this information.

DR. THOMPSON: I would like to look at our functions again. Do you have a copy of what we're supposed to look into?

DR. MAXEY: Our definition of safety?

MR. KINNAMAN: We'll pull that out so you can look at it. Are you concerned about identifying whether you should be looking at the problems of properties?

DR. THOMPSON: Yes, that's right.

DR. MAXEY: Not from the standpoint of assessing. Just that it's a hazard for damage.

MR. KINNAMAN: From what Mr. Miller said this morning, I understood that he wanted that sort of consideration made.

DR. DOUTHETT: I think he meant in terms of unacceptable damage.

CHAIRMAN WILSON: Well, with regard to the Bureau's project, we didn't have enough information as to whether or not this is acceptable as to the extent of damage--probable damage.

DR. ROUSE: Just canals.

CHAIRMAN WILSON: Just canals, yes. Supposing you get a lot of slides which cause a lot of rubble to go into your canal.

DR. ROUSE: Well then the Bureau would move in immediately and open up the canals and you would probably, the AEC, in addition would be responsible for the crops if there was any. There are quite a few crops downstream--sugar beets and this sort of thing.

CHAIRMAN WILSON: How much outage can you take say for the end of May--for two weeks?

DR. ROUSE: The end of May is fine compared to sometime in the later part of August--we would rather have the outage in May than we would in August.

CHAIRMAN WILSON: If you had a complete loss of power and water for irrigation and so forth for a two week period, what would be the consequences of this?

DR. ROUSE: I'm certainly not qualified to report on this, but from my own experience, I don't believe it would be too serious so far as water so long as the loss of water if they lose their crops then I suppose AEC would be responsible.

CHAIRMAN WILSON: You wouldn't lose crops in May, would you?

DR. ROUSE: No.

DR. MAXEY: But you might in August.

DR. ROUSE: Yes.

CHAIRMAN WILSON: At a crucial time in August.

DR. MAXEY: By the first of September your water seems to be essentially over.

DR. ROUSE: No. The water season is essentially over October 15th.

DR. MAXEY: You keep your canals full?

DR. ROUSE: Yes.

DR. VON LOSSBERG: How strict is this scheduling, Ross?  
Maybe it would be better to schedule this in the autumn.

MR. KINNAMAN: You really can't ask me that kind of question-- you can ask me that kind of question but I don't know the answer. I

think this is tied up with the industrial participants as well as the management of AEC. I am sure that everyone is anxious to accomplish these experiments as well as anyone else but without an expense of causing some sort of catastrophic results.

DR. JACOBSEN: However, the industrial participants are only liable for the 10,000 dollar damages.

MR. KINNAMAN: This is my understanding but I haven't seen that contract.

DR. DOUTHETT: Delay would mean something in the terms of cost and we have the CER Group here. Can anybody talk to that problem?

MR. FRANK: We made a rough estimate this morning, I'm Will Frank of Austral Oil, and a delay would probably cost in the order of an additional \$200,000 in cost to us. To clarify this \$10,000 bit, that is only a minor portion. You jeopardize the development of the whole area by having excess damages also. If we have excess damages or if there are little accidents, we'll fire a second or third shot.

DR. ROUSE: I would like to point out one thing that is important. In May, there probably won't be very many people in the area but in the fall and in the late summer, there would be numerous people up there because this is a recreation area and it might be difficult to keep them out.

MR. AAMODT: There must come a time in the fall when there wouldn't be as many people there as the children would be going back to school and there must be a hunting season.

DR. ROUSE: As soon as the snow falls, you've got the snowmobiles

in there.

MR. KUIPER: If you wait until after October 15th, you're right back into your snow falls again.

CHAIRMAN WILSON: Well, at the risk of the dam slumping enough to go over the top--we don't have to talk about the possibility of postponing the shot because of the property damage--but you can't take any possibility of the loss of human life regardless of how small that possibility is. So, as far as I'm concerned, we'll ask that some people be evacuated.

MR. AAMODT: Could you specify a level at which that may be necessary? Evacuating may be a very difficult thing to do. It is conceivably hard to see people evacuating without wanting to take along their property if they feel there is a risk.

CHAIRMAN WILSON: Well, I think that risk is so small--we could take that risk.

MR. AAMODT: Well, that's a pretty difficult thing to do is to get across to a person that he has to get out of his home because you want it evacuated.

CHAIRMAN WILSON: Because it involves human life and no one is going to take that chance, at least I'm not.

MR. AAMODT: If there is a chance with respect to lowering the level--

DR. MAXEY: You mean lowering the level of the reservoir?

DR. VON LOSSBERG: Well, I can see for the next 25 years, if anything happens to the reservoir in that area, you are going to have a suit on your hands. It will be considerable damage or something

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that you did to lock up energy that weakened the dam or something.

DR. JACOBSEN: May I ask this question, Doctor Rouse?

If there is no real objection to lowering the level and if they start lowering it now as soon as you get back, do you have to do that?

DR. ROUSE: This is not my responsibility. The gentleman back here--

DR. JACOBSEN: How long before the shooting date if, by doing that, that can be done, where we don't have to evacuate. That might be a point here.

DR. THOMPSON: The cost of the water to begin with.

CHAIRMAN WILSON: If you don't have enough water, then you may lose the crop.

DR. JACOBSEN: We do have the thing versus the nuisance of the evacuation and the psychological effect of evacuation. It would be much better if we did not have to evacuate.

MR. CONWELL: I would like to make a statement here to follow along what Mr. Frank said. The wildlife in the forestry groups have had more contact with the local people than anybody else. Now, we have been singularly impressed with the attitude that has been very good. We have encountered very little in the way of public hostility in the people who are sympathetically against this sort of thing who also saw the possibilities of progress and development in the area. To put an off-sited event--that I have been on and it's been the best probable attitude that I have ever run into. I think that the individuals who live there who continue to live there would count in

the long run more so in the advantages than the transients, hunters and fishermen who are traditionally evacuated or kept out of the area--now, this is for whatever it is worth.

DR. MAXEY: Has the subject of evacuation of these people been brought up to them?

MR. CONWELL: Not by us nor have we discussed it.

DR. MAXEY: This is very different--

MR. CONWELL: That's right. I'm thinking more in terms of-- they're very sensitive about their water. This is one thing that you are going to get everywhere. What are you going to do to our system? What are you going to do to the flow? Because they are farmers for the most part and this really seems to be the overriding concern which has been expressed to us.

DR. SHERARD: Well, what if the fact arises that someone refuses to be moved. What do you do about that?

MR. KINNAMAN: I've asked the Test Manager to come down. I noticed that he is not here but he should address those problems because those problems certainly fall in his program. I can say, in general, that that has rarely posed a serious problem although we understand that on occasion, it has happened. I don't know the consequences of it. I understand that in Mississippi the State Patrol gave the Test Manager assurance that whoever had to be evacuated would be evacuated and this was taken care of.

MR. AAMODT: You can't do that in Colorado.

MR. KINNAMAN: We're dealing with a different State organization.

CHAIRMAN WILSON: Well, this seems to me that if we had people

who are reasonable and who are approached in a reasonable manner and you say, just look, we'd like you to just stay up in higher ground just for an hour for a matter of safety, I am sure they would do this.

DR. THOMPSON: This point that Ross mentioned is something they had to do in Mississippi but of course there wasn't any danger of anybody getting washed away but the question raised really would it be possible to get the State Police to literally take somebody out if they had to. You could run into somebody that just didn't want to move.

CHAIRMAN WILSON: Well, if we make a lowering of the dam, it will only involve six or seven farm houses. It's not 75.

DR. SHERARD: It will be a minimum of 12.

CHAIRMAN WILSON: All right. A minimum of 12 is still a small number.

MR. KINNAMAN: I see that Mr. Shaw and Mr. Mudra came in. I don't know whether you would want to raise any questions in this regard of evacuation, problem or not.

DR. MAXEY: One question. What if one person just refuses to evacuate?

MR. SHAW: We expect that some of that is going to take place. What we would do, is to have some individual from the Public Health Office or some operation office go there and talk with the individuals and point out what the problems are and stay with them and have communications with him until the shot is over, even though he desires to stay in his own habitation.

DR. THOMPSON: Well, what if this is downstream from the dam

and there was a slight possibility that this thing might go up.

How is your organization going to talk to this person?

MR. SHAW: Well, let me back up a little bit. We have enlisted the assistance of the County and the State Authorities, the Colorado Highway Patrol with the Highway Police Department and one of the County Commissioners who lives downstream from Harvey Gap Dam and he thinks that a little local influence will handle this problem.

MR. MUDRA: The cooperation seems to be pretty good. We don't like to use any police tactics on these people. If somebody would actually have to be evacuated, we have a way of getting it done through the local authorities and we will attempt to do so.

MR. AAMODT: Is there a legal basis to do that?

MR. SHAW: I don't think so.

MR. MUDRA: We have run into opposition before but even though we've had opposition from individuals, I think that as the shot time approaches, he realizes that this is more or less for his safety and even though, begrudgingly, he leaves and he has left. I don't believe we have any previous times when we had to hold up an event because of someone being in the area or in the close area.

MR. AAMODT: I think that this is completely a different kind of evacuation and as Rollie said, you don't ask one to stay there because what the man is giving up, conceivably, you are telling him it's serious enough. It is a loss of all of his personal possessions but that is not true in any other cases that we've had in the past.

T10B12  
JPOCR  
-1-69

MR. SHAW: We would propose to back ourselves up with local authorities if we had to in the matter of saving a man's life. Maybe he wants to watch what is going on.

MR. AAMODT: He could go to court and get an injunction and bring the entire thing to a stop.

CHAIRMAN WILSON: Well, there is only one or two people involved. You can have a car with his engine running out at his front door and you're going to have some warning on it because you will have somebody at the dam site.

MR. AAMODT: This doesn't quite meet this worry because if a man is informed that he has to leave, then he is going to be worried about his property. It doesn't do any good just to stand there and he gets in the car and drives away in the case of a flood.

MR. MUDRA: I think that one of the things that comes to light here is the Test Manager. I don't think that he will proceed unless he is assured that those people in hazardous areas are accounted for. In other words, when it comes down to making a decision before proceeding with the execution, he has no choice when it comes to people in hazardous areas. In other words, he will stop and go and talk to the people personally if he has to do it and try to convince them that this is for his own benefit.

MR. FRANK: Well, naturally we wouldn't want to forcibly remove anyone from their property. This could be a very bad tactical area especially if we plan to fire another one. It seems that we might be overlooking all the time an effort that we spent to have this study made of the dam and then as someone said this morning, putting it in complete

disproportion to the data that we found to be true. Of course, I obviously have a little different approach to the problem than you fellows do because in the data that we received from both Doctor Seed and Doctor Sherard indicated that this was so much more safe than we expected it to be even using the safety factors which someone conceded to would be possibly twice too high or twice too low, I should say--of the dam having any problems. So, I have just kind of lost the scope of the thing. I don't see why it is necessary to cause a psychological problem of evacuation, not just for this shot but for all future shots.

DR. VON LOSSBERG: Well, you're correct but the idea is that they're going to have to face up to evacuation and the idea is, isn't this a reasonable thing to ask and will the people do it?

DR. THOMPSON: When you're talking about future shots, which ones are you talking about now?

MR. FRANK: Of course, we're firing this one with the expectations that we will be able to fire several other ones for some commercialization to help us get part of this six million dollars we have invested back.

DR. THOMPSON: Are your future shots going to be comparable to this or are you going to escalate?

MR. FRANK: We hope to get sufficient information from this shot to see whether it could be safely done and hopefully it could be escalated. With this single shot, it is not economical.

MR. MUDRA: I might mention that the evacuation of the downstream area at Silt or in that vicinity would not be given much more consideration than that of the evacuation of Grand Valley which is proposed. The

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POCR  
-1-69

damages are from a different source but we are making arrangements now for evacuating people out of their homes at least a distance of two buildings high out in Grand Valley. In other words, they are also leaving the property. Damage, of course, is not the same but the idea here is to employ civil authorities in the area such that they could also patrol to make sure that there is no vandalism or that type of thing. We are not leaving their property vulnerable.

MR. MILLER: Would you have a guard in every home that is evacuated in the downstream area of the dam?

MR. SHAW: Areas under the local area.

CHAIRMAN WILSON: I would visualize under some extreme evacuation for people to stay inside of their house. They don't have to evacuate, they just have to go to higher ground--they're not going to a neighboring community (reporter unable to hear speaker.)

DR. MAXEY: The maximum we're asking is 60 feet above where they are.

DR. THOMPSON: This is out on the flatter area.

CHAIRMAN WILSON: If you see from the earthquakes you quoted there from the 64 dam of which three suffered cracks,  $3/64^{\text{ths}}$ , it is still five percent.

DR. SEED: From a slightly higher motion than what we might be getting. I agree with your intention--there is a very remote possibility that it might slump enough to cause overtopping. It is a very unlikely event but it is slightly credible.

DR. SHERARD: A compromise might be the assumption that we might have a couple of hours and be prepared to use that time.

MR. SHAW: But we find operationally, we sometimes have difficulty staying within the timeframe of doing it because how many times have we had to take care of irrigation water and take care of livestock so a preplan thing would be very necessary to back up with reasonable assurance that we could communicate and tell the Test Manager it is done.

DR. SHERARD: For the kind of thing I was thinking of--it was to perhaps have one of your men alongside of each individual with a vehicle and assuming we have a half an hour and have communications between everyone.

CHAIRMAN WILSON: Yes, but you probably have women and children--

DR. MAXEY: Do you have any ideas of this general problem, Bill, you have some experience with it?

MR. ALLAIRE: I have had some experience in this thing of evacuation. It is an awful sticky thing. Some of them might not want to evacuate.

CHAIRMAN WILSON: But you are up around the black areas?

MR. ALLAIRE: Yes.

CHAIRMAN WILSON: Why do you evacuate up there and make them get off their property? They should certainly not be shook up. There is no possibility if he stays up there, is there?

MR. ALLAIRE: Not if they are outside but it is just a question of something falling off on them. We had one specific item of something falling off the roof and hitting a woman on the head so we are going to ask some people outside of the immediate area just to be outside but well away from the walls. But, to answer George's question, we would

BT10B16  
SPOCR  
5-1-69

have some problems in evacuating these 75 families. And I agree with Rollie that if there is a chance that they might evacuate, it would be better to pre-evacuate than to wait.

DR. MAXEY: Have it over with.

CHAIRMAN WILSON: I think we've changed the speed of the reservoir to something that may be nine or twelve family houses, not the 75.

MR. ALLAIRE: This reduces the problem.

MR. MILLER: I was not here at that time. Did you say it is now nine or twelve families?

CHAIRMAN WILSON: My first thinking on this was, Mr. Miller, that there would be a possibility of a complete loss of the dam instantaneously in which the reservoir would have been evacuated within minutes--twenty minutes or whatever time it would take but after the--after the facts had been presented this morning of the reduced shock and the small amplitude of motion and this sort of thing, I have modified my thinking to think that the worst that could reasonably happen would be that the dam would slump enough and crack enough so that there would be overtopping locally which could erode and eat through and reach the dam and you would get the complete loss of the water but it might take place over hours--three or four hours rather than over the twenty minutes. And this then changes the size of this water frequently from the width and the depth of the water.

MR. MILLER: Well, this changes this problem considerably.

CHAIRMAN WILSON: So, based on the problem, it looks like there might also be nine or twelve houses that would be involved and I believe the Board would be willing to reduce the probability to that.

MR. ALLAIRE: Well, if we're talking about having several hours reaction time, this changes my mind about evacuation that we would have some hours.

CHAIRMAN WILSON: Well, it's hours to empty the reservoir, but not hours to--before the water gets there--I don't know if you have a feeling?

DR. MAXEY: Of course, one alternative is to evacuate the water instead of the people.

DR. THOMPSON: Well, this could get rather expensive, I suppose from the standpoint of the cost of the water from producing a crop later on.

MR. MUDRA: I think that the problem of that is that there is a probability that we won't lose any water out of the dam. In other words, if you took the water out, it's gone. If the dam doesn't fail, than you have still lost water instead of an evacuation of seven or nine. I might even reflect a little bit on our evacuation for the ground motion. The Public Health Service, in the rural areas and this would be comparable, are talking about assigning two man teams both with mobile units and they are assigned to get five or six families to congregate in one area and they have a capability that if one family doesn't show up by a preassigned time than he will go back in and see where the family is. So, this would not be too uncommon to what we're thinking now in the rural areas for ground motion.

MR. MILLER: Let me intercede here just a minute. I don't think we should ask the Panel's recommendation as to the judgment as to the evacuation. The numbers that they are now talking about is a reduced

BT10B18  
SPOCR  
5-1-69

number and an increase in time and this is what we're really after.

And the mechanics in dealing with that problem is a different judgment and I'd like to keep them right in one set of circumstances which has to do with the safety of the dam and whether or not they recommend evacuation. The fact that they have now determined that it is a reduced number of people makes it much simpler obviously for us to deal with this. I want to stay right with that kind of thought. The mechanics of that is kind of a dollar versus people problem.

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-69

CHAIRMAN WILSON: We could get involved here and spend a couple of days and still not get anything accomplished.

MR. AAMODT: It might be advisable, Bob, to get this other alternative on such a level that you wouldn't have to fool with evacuation, particularly if you are thinking about the recreation program later on.

MR. THALGOTT: Yeah, but that goes to evacuation or non-evacuation, and I think that is another one of their judgments.

CHAIRMAN WILSON: If you have to pull the water down.

MR. AAMODT: If we address the problem now it might be helpful.

DR. VON LOSSBERG: You have to move people or water and we have decided to move people. We'll leave the mechanics up to the experts who have done it before.

MR. MILLER: I think the question that I would ask you is, whether by reducing the head, do we reduce any failure on the part of the dam?

CHAIRMAN WILSON: You reduce the consequences.

DR. SEEDS: I would like to see eight or ten feet below the crest—(The reporter was unable to hear the speaker.)

DR. THOMPSON: Would it still overflow?

DR. SEEDS: It might slump to five feet and then it would have to slump eight feet then to go over the top, and I think that is very unlikely, also. The chances of cracking are far greater than ever slumping. And the chances of sealing a crack are far easier to stop it than the slumping.

MR. AAMODT: There might be another point here, I gather that after the experience of the shot it will not prevent it from rising if

11B2  
SPOCR  
-69

the force were a little higher than, say, twice as high or something like that.

DR. THOMPSON: I think you will find out that at least you have the guidance from the first one.

MR. AAMODT: We don't because you're talking about a six-foot topping.

DR. MAXEY: No.

CHAIRMAN WILSON: No.

MR. AAMODT: It's not a case of failure of that sort because of the change due to the shock?

CHAIRMAN WILSON: Oh, no. Let's be honest. I mean, I don't think any of us thinks that anything is going to happen to the dam. I don't even anticipate any cracking. If I were downstream from the dam I would evacuate myself voluntarily.

DR. MAXEY: I think that we're back to our original suggestion that some evacuation should take place.

DR. JACOBSEN: It's a question of how much.

DR. MAXEY: That is really in the judgment of the AEC. It is not within the judgment of the Safety Panel, we've made the recommendation.

CHAIRMAN WILSON: Well we have to give some--

DR. THOMPSON: Well, we have pretty much decided that it is not going to be--I think everyone is convinced that it is not something that is going to drain the reservoir in 20 minutes, so this is one move. We could possibly set the other limit on this thing to give you some basis for deciding how much evacuation is in line.

CHAIRMAN WILSON: Well, I don't think we're going to gain

1B3  
POCR  
39

anything more, unless someone else has some comments.

DR. BANISTER: I was just going to ask if we assume that it took six hours--do they make any calculations of what the area involved would be?

MR. LEE: I think what you do in that case is you consider a widening rift, it's more or less of a constant flow, but it is spread out over a six-hour period. You're not talking about high velocity or high rate--you're talking about quite a bit of area.

CHAIRMAN WILSON: Are there any comments that you gentlemen would care to make?

MR. KUIPER: I think it's a decision that the Atomic Energy Commission has to make--it's a gamble, and I think you certainly take the safe way out and I think if you drain water out of the reservoir you know that you would have that expense if it increased the factor of safety enough to make it worthwhile I think that's a point you have to consider.

MR. ROUSE: They would have to pay for crops, too.

MR. KUIPER: Oh, yes, you would have to pay the damages on the crops that would suffer as a result of being denied that water. On the other hand, if you want to gamble, Las Vegas is the place to do it. Just don't take any water out and take the whole gamble. I think that is a decision that the Atomic Energy Commission has to make and I don't think the State can make that decision.

MR. MILLER: In respect to the involvement of crops, in making some assumption and in your knowledge of the general area, I'm certainly not going to hold you to any number, but assuming that they did decide to

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drop the reservoir, say, some five feet, I think that's about 1,200 acre feet of water?

CHAIRMAN WILSON: This is a requirement--this is a requirement now that we're going to ask for.

DR. MAXEY: Well, we have got a couple alternatives.

CHAIRMAN WILSON: An additional five or ten feet.

MR. MILLER: That is a lot of water, I'm afraid.

MR. KUIPER: --you would be talking about 400 acre crops-- and that is cattle country, and that is \$75 a acre, and equate that to the acre feet.

DR. THOMPSON: This is the amount we're going to do anyway in accordance with our thinking to bring it down below normal cracking.

CHAIRMAN WILSON: Yes.

DR. THOMPSON: I believe that using this approach that you could come up with approximately what it is going to cost you for anything below this and if there is no danger by dropping it down by various increments below this ten-foot level--presumably we don't get any insurance--any added insurance.

CHAIRMAN WILSON: Yes we do.

DR. THOMPSON: Well, what is the added insurance?

DR. MAXEY: Well, you have reduced the estimated 4,800 acre feet, so you're starting out with 4,800 acre feet and dropping out another 20 there after. If you reduce it another 1,200, you're down to 36 and pretty soon you're getting down to an increment that will not cause a flood at all.

DR. SEEDS: Another point is that we're speculating that the

1B5  
POCR  
-69

crest will go down and it's certainly not going to go down the whole height of the dam, so surely if it was about 15 feet below the crest there is an extremely unlikelihood that it would reach the dam.

DR. MAXEY: Even if the dam slumps the manner in which the water would be released and the quantity of the water is reduced to a point where I would be willing to say there is no risk.

DR. SHERARD: If the water goes down 15 feet I think the risk is so small that it would be comparable to the risk that you are taking shooting up out of the ground.

(Due to the multiplicity of voices the reporter was unable to hear or understand the speakers.)

DR. SEEDS: You can get to ten feet of freeboard without any complications.

DR. MAXEY: This is pretty much a linear relationship, isn't it, as far as the head on the dam--five feet equals about 1,200 acrea feet at this level--it's linear pretty much?

MR. PADDOCK: It's 900 acre feet on the next 2,100 acre feet.

MR. CONWELL: Now, this water that would normally be diverted in from East Rifle Creek is part of the proprietary rights which would be forgiven.

DR. JACOBSEN: The question is that we feel or it has been established by Professor Seeds that even if the limit is reduced to the ten feet below the crest there still is a possibility, although a very remote one that something will happen, therefore, evacuation must be resorted to. Now, if by going down another ten feet or by 15 feet, would you still have the same attitude that you should evacuate? I'm trying to do some horse trading with you now.

B6  
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DR. SEEDS: You see, I'm prejudiced in advance because I think that it's much easier to evacuate the people than to get the last five feet of water level lowered. After you go to ten feet freeboard at that stage they've got a slack drawing in the river-- there's no one objecting to evacuating right now. I just think that it would be far easier to evacuate ten families than to try to lower it below the water level below ten feet. I don't feel it's going to go anyway. I mean, all we're doing is talking safety precautions. What I would say there is--I have faced this question many times and Stanley has faced the question a number of times, and I ask this; what if we were the people who were there, would we be willing to stay there and, if I were there my own judgment would say that I would be better off to go somewhere else. If I can't convince myself to stay there, why should I convince somebody else to stay there.

CHAIRMAN WILSON: I have no hesitation at all of staying within five kilometers of ground zero.

DR. MAXEY: What if the Board, Stanley, would word its recommendation in the terms of alternatives?

CHAIRMAN WILSON: Yes, I think we can do this.

DR. MAXEY: Then it is really not our decision, all we are doing is defining safety. So we say evacuate 12 people or evacuate another five feet of water or whatever the numbers are. Here are two situations which demonstrate safety.

MR. CONWELL: This is 12 family units, not 12 people.

DR. MAXEY: Well whatever it is, 12 domiciles.

CHAIRMAN WILSON: Yes, I think we can do that.

DR. MAXEY: That will preclude our being here until 8:00 o'clock tonight.

1E7  
CR  
69

DR. JACOBSEN: If it's lowered at 15 feet you and your family would stay?

DR. THOMPSON: I wouldn't.

DR. SEEDS: I wouldn't stay anyway.

MR. MILLER: That makes a fairly easy decision for us--in the alternative. That decision comes out very easily.

MR. AAMODT: There is a time in the year though when that dam is essentially empty.

CHAIRMAN WILSON: That is one of the alternatives.

DR. MAXEY: That just follows.

CHAIRMAN WILSON: The only reason for lowering it down to ten feet is that I think we can get, without a foundation failure, cracks that may stand within ten feet. If water goes through those cracks it will start within the downstream slope, but we have enough time with the water down ten feet to take care of those cracks, to repair them and then we don't have a catastrophe. But, if we have a foundation failure then I would raise that limit to 15 feet. And this I cannot accept the possibility of a foundation failure.

DR. JACOBSEN: You base that on pure experience--you have time to prepare?

CHAIRMAN WILSON: Yes, oh yes, I know this.

DR. MAXEY: I think you could shovel it in, don't you? The cracks I have seen in dams have not been impressive I assure you, and with much greater energy. The Proesser Dam I think is an excellent example, and I don't give a damn who built it, and they were not excessive. A layman walking across that dam would probably have to have it pointed out to him where the cracks were.

T11B8

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CHAIRMAN WILSON: If we have a foundation problem the cracks would be deeper.

DR. SEEDS: The cracks at Proesser did not look excessive because there is no water--there is no water to go through them, and if there had been water it might have been different.

MR. MILLER: May I ask one question? With respect to one of your alternatives, if the dam were essentially empty in August or September, that kind of time frame, what is the possibility of damage to the foundation up under those--

CHAIRMAN WILSON: --none or about the same--exactly the same. Whether or not it is the dry season of the year has nothing to do with the foundation failure.

(Due to the multiplicity of voices the reporter was unable to hear or understand the speakers.)

DR. SEEDS: If you're talking about a downstream slope failure I don't think it would make any change in the possibility-- it would effect the possibility of an upstream slope.

DR. SHERARD: It's just as likely that the whole section of the center portion of the dam could move.

CHAIRMAN WILSON: But not that much. Yes, the whole section.

DR. SHERARD: The only thing we have at all is the Sheffield Dam and the whole thing went down.

DR. SEEDS: In order to put this whole thing in perspective, it might help to say within ten miles of the San Andreas Fault in California there were perhaps 40 or 50 dams that are higher than this one, that are no safer than this one, and there are people living right downstream, and these dams have either gone through or they're surely

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going to go, and nobody is jumping up and down about it. I am just looking at one photo of San Andreas right now, it's about 120 feet high and a two to one downstream slope. The homogenous dam of clay, surely no safer than this one, much higher, and six miles from San Jose Falls.

CHAIRMAN WILSON: --here we have a man-made shot, a known structure with known problems and this is different.

DR. SEEDS: With an earthquake, no one causes it.

DR. MAXEY: I think it's quite important to put your thinking in the context of the \_\_\_\_\_. This is an extremely difficult thing for us to get over to Mr. Austral Oil or even experts. It is a very different context and the danger the people live in all the time. It's your fault if you step off a curb and get hit by a car, but we're put in the position of saying this will not happen, and that is a very different thing.

DR. SHERARD: Couldn't it be said then that we do not know what this risk is?

CHAIRMAN WILSON: No, we know the risks.

DR. SHERARD: We don't know the likelihood.

DR. VON LOSSBERG: Since we don't know we have to take precautions.

DR. SHERARD: That is to say that we don't know whether it's one in a hundred or one in ten thousand.

DR. VON LOSSBERG: We don't have the right to jeopardize the lives.

DR. MAXEY: If you start with the outside limitations and empty the reservoir, for example, we know what the risk is. All r now, how far away from that limitation can we get? We have said

T11B10  
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-69

evacuating 12 domiciles and keeping a ten-foot freeboard, we have essentially the same risk as far as human life is concerned, we're not talking about property damage, which would worry me much more if I were an engineer. I think if you go through this kind of a process you come to these two alternatives and I think one is as good as the other and it is really up to the Commission or to the Oil Company or them combined, to make their decisions on how they want to go. And I don't think that we're taking any risk on our shoulders at all. I think we have set the conditions and we all firmly believe it. I don't know why we're sitting here talking about it.

CHAIRMAN WILSON: Well, there are people and there is money involved, but I don't think that anything further will be gained by further discussion. I think we have reached the point where we will have to say what we believe.

DR. JACOBSEN: Well, let's get down to the business of writing our report.

DR. VON LOSSBERG: I think we ought to ask Sam a couple of questions.

DR. MAXEY: Sam West?

MR. KINNAMAN: He is not here, would you like him brought forth?

DR. VON LOSSBERG: Yes, I would like to ask him a couple of questions about the water condition.

MR. FRANK: Can I ask a question? What I understood earlier that if this water was lowered down to an additional five feet that this could be replaced and this is not the time of year that we're talking about cost involved and the loss of water or the removal of water because

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the replacement would come down from Crawford Creek, is this true?

CHAIRMAN WILSON: Up to five feet is my understanding.

MR. FRANK: It was earlier mentioned that this would be considerable cost for removing this 1,200 acre feet, how do we clarify that point?

DR. MAXEY: I think Fred has the answers for you on a piece of paper here.

MR. KUIPER: I think this charge of water could be explored very easily, it wouldn't be too difficult to have the Division Engineer give that to us, very quickly.

CHAIRMAN WILSON: But this is not a question that we can answer here.

MR. KUIPER: If you have a plan, let us take it back with us and we can tell you very quickly, I realize that it is not your question, but it may have some bearing on the AEC, on which alternative you choose.

MR. MILLER: I think that is a pretty good question. In sitting here doing arithmetic I'm getting pretty close to the same kind of number for the alternatives.

MR. KUIPER: Well, when you're talking about 12 acre feet in some areas you're talking somewhere in the neighborhood of \$30,000 and if this removes a lot of risk, that is for the Atomic Energy Commission to decide.

CHAIRMAN WILSON: Well the first five feet has to be removed.

MR. KUIPER: If you could get the water by exchange.

CHAIRMAN WILSON: Apparently you can for the first five feet, the second five feet is the problem--the second five feet is the one you have to think of the dollars and cents on.

MR. KUIPER: Can the Bureau actually release 1,200 acre feet of water, the water we'll say normally stored in Rifle Gap?

MR. CONWELL: In the normal drawdown that they anticipate in Rifle Gap, starting now, between now and May 22nd, would amount to 1,200 acre feet, and at the same time they would not revert any water from East Rifle Creek into Harvey Gap, but continue to dump that into the Rifle Gap Dam, and the proprietary rights there were something like 4,500 acre feet--these are estimated numbers. And if they did that they could still recover their full capacity from East Rifle Creek after the shot and come out all right at the end of the season. For these kinds of numbers--now over and above that, I have no guidelines to go on, except that this would be a matter of looking into another area and looking into the problem.

MR. KUIPER: If these are the only two water rights involved it would be very simple--

MR. CONWELL: Well, according to the way I've read, on the original Silt operation plan, there may be a way of rehabilitating damaged canals, Harvey Gap and Rifle Gap, whereby water seepage could be made. There are several abandoned canals in there, some of which they talked about rehabilitating and they are such an intricate network, but this is a possibility--

DR. MAXEY: What kind of effect might this have on downstream? Is there a complication there? They're depending on return flow in a set pattern that is going to be interrupted here. I just wonder, it gets pretty complicated.

Is there any disagreement or is there anything that anybody wants to add on these four points that the Panel has made? I think it

71B13  
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69

is important that we reach consensus--we like to have consensus with the working people that are involved if we can get it.

DR. SHERARD: Do I understand that one of the alternatives would be to pull it down to 15 feet of freeboard at the time of shot and not evacuate?

DR. THOMPSON: Is that a fair statement--would you say that?

DR. SHERARD: That's correct insofar as the conversation that has been had in the last 30 minutes or so.

CHAIRMAN WILSON: Just a few very careful observations. The means of evacuation are available, but I don't think you will evacuate-- this is the difference.

DR. SEEDS: If you have 15 feet of freeboard you have time to do things and time to evacuate.

CHAIRMAN WILSON: You have time available to get people out.

DR. MAXEY: And you might have to pay for 900 acre feet of water.

CHAIRMAN WILSON: Well the Board is charged with the responsibility of getting a report out before 5:00 o'clock.

(At this time the meeting was adjourned so that the Executive Committee could prepare their report.)

SAFETY PANEL OF CONSULTANTS MEETING ON "RULISON"

HARVEY GAP DAM

NEVADA OPERATIONS OFFICE

MAY 1, 1969

A T T E N D E E S

R. L. Aamodt	LASL
W. W. Allaire	AEC/NVOO
P. W. Allen	ESSA
R. H. Armstrong	ESSA
J. R. Banister, Dr.	SANDIA
W. Bell	ISOTOPES
B. G. Bray	CER
R. S. Brundage	CER
E. Campbell	AEC/NVOO
N. Cefaratti	AEC/NVOO
J. R. Compton	WES, Vicksburg, Colo.
F. R. Conwell	BLUME & ASSOC.
R. Cooper	AEC/NVOO
Frank Cluff	AEC/NVOO
E. M. Douthett, Dr.	AEC/NVOO
D. Edwards	AEC/NVOO
James Fisher	MT. FUEL & SUPPLY
Tom Fleming	AEC/NVOO
Will Frank	AUSTRAL OIL CO.
E. H. Freeman	AEC/NVOO
L. S. Germain, Dr.	LRL

Page 2

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Lyle A. Hale	MT. FUEL & SUPPLY
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W. W. Hays	ERC
Lyman Heller	WES, Vicksburg, Colo.
D. W. Hendricks	AEC/NVOO
F. Holzer, Dr.	LRL
Tom Humphrey	AEC/NVOO
O. A. Israelsen	ERC
L. S. Jacobsen, Dr.	PSC
R. A. Johnson	AEC/NVOO
W. D. Johnson	WOODWARD, CLYDE & ASSOC.
Ross Kinnaman	AEC/NVOO
Clarence Kuiper	STATE ENG., COLORADO
L. A. Lee	BLUME & ASSOC.
P. C. Loux	ERC
J. Maher	AEC/NVOO
G. B. Maxey, Dr.	PSC
Roy Maxwell, Dr.	AEC/HQ
M. L. Merritt, Dr.	SANDIA
D. F. Miller	AEC/NVOO
R. E. Miller	AEC/NVOO
P. Mudra	AEC/NVOO
V. E. Nork	ISOTOPES
Fred Paddock	SUPVR. OF DAMS, COLO.
Miles Reynolds	AUSTRAL OIL CO.
R. M. Richardson	DPNE

George Rouse, Dr.	BUREAU OF RECLAMATION, DENVER
H. B. Seed, Dr.	BLUME & ASSOC.
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James Sherard, Dr.	BERKLEY
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Ron Stearns	AEC/NVOO
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L. G. Von Lossberg, Dr.	PSC
H. G. Vermillion	AEC/NVOO
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C. Williams, Dr.	LRL
S. D. Wilson, Chairman	AEC/NVOO
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