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Trial Transcript, Vol. 46, Afternoon Session

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case # 4993

File # 153

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IN THE DISTRICT COURT FOR THE FIFTH JUDICIAL DISTRICT

WASHAKIE COUNTY, STATE OF WYOMING

IN RE: THE GENERAL ADJUDICATION OF RIGHTS TO USE WATER IN THE BIG HORN RIVER SYSTEM AND ALL OTHER SOURCES, STATE OF WYOMING.	))))))))	Civil No. 4993

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Margaret V. Haughton CLERK

DEPUTY

VOLUME 46

Afternoon Session

Thursday, April 23, 1981

ORIGINAL

(The following proceedings
(were continued at 1:04 p.m.

THE SPECIAL MASTER: Please come to order. Mr. White?

MR. WHITE: For the purposes of the record, Your Honor, the State has just been handed seven replacement pages for Dr. Mesghinna's report which we received on Monday.

THE SPECIAL MASTER: Very good. Mr. Clear?

MR. CLEAR: Your Honor, during the lunch break Dr. Mesghinna reminded me that we have some illustrative exhibits which are helpful I think to explain his testimony. They are real evidentiary in nature, they are more just drawings, but I think they will put things in focus. I don't know whether they have been shown to Mr. White.

MR. WHITE: I think most of them have, and as we go through them --

MR. CLEAR: There are only four or so, I think.

MR. WHITE: If I have any problems, I'll let the Court know, Your Honor. But I have several of those, pictures of four of them, so we will see if they are the same four.

MR. CLEAR: Okay, fine.

(CONTINUED) DIRECT EXAMINATION

BY MR. CLEAR:

Q Dr. Mesghinna, I have hung on the easel what's been marked as United States Exhibit WRIR C-246. Are you familiar with that exhibit?

A Yeah, I'm familiar.

Q Okay.

MR. WHITE: What was the answer? I couldn't hear it from here.

THE WITNESS: Yes, I'm very familiar with it.

Q (By Mr. Clear) Is this exhibit relevant or helpful in your explanation of your testimony on evapotranspiration?

A Yeah, it is important not only for evapotranspiration, but as we go along we can picture what we are talking about, so I can explain really what we mean by crop consumptive use just from this.

Q Ckay.

A So if I may, shall I go into this?

Q Sure.

A Of course, this is the ground that we are irrigating, and let's assume that crops are growing, and for time being let's assume there's only one crop there and let's assume that this is alfalfa, just to make things easier. The crop as we can see above the surface, it lives in soil, and below the surface we can see the roots penetrate. Okay, what happens is when we apply water by irrigation, by side roll, this is side roll or other means of irrigation, the water comes out as we can see with these drops. Some of it will be retained on the leaves of the plants, some of the water will enter deep in the roots in here, and some of the water will go out a surface runoff due to the soil. Some of the water will evaporate from the soil surface, and after the water enters down here and taken by the roots of the crop, then the water has demanded by the atmosphere -- or by the climate in here will be transferred from the root zone in the plants. After the plant uses the water, the water will be transpired. The amount of water which we are going to discuss later on that passes the root zone then goes through deep percolation, that is the amount of water that's not going to be used by the plant

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at all. It passes beyond the root zone, and then it will be collected by the drains as we can see the drains in here, and it will be taken out from the fields. So really what we discuss when we talk of crop water use, we are merely talking about the transpiration from the plant and evaporation from the soil. That is what makes evapotranspiration equal to transpiration plus evaporation. And as we can see, this will have use in the future, there will be water that's not going to be used by the plant. Some of it goes to surface runoff, some of it goes to deep percolation, and we see how we are going to collect or how we are going to come up with the necessity -- the necessary amount of water for the plant. So I hope this one shows a pictorial view of the situation.

THE SPECIAL MASTER: It is helpful.

THE WITNESS: Okay.

MR. CLEAR: Your Honor, I'll move the admission of that exhibit just for illustrative purposes.

THE SPECIAL MASTER: No objection or no voir dire?

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MR. WHITE: No objection with respect --

THE SPECIAL MASTER: So WRIR C-246 is admitted into evidence. It is a crop water use illustration.

(Whereupon, U.S. Exhibit
(WRIR C-246 was hereby
(admitted into evidence.

Q (By Mr. Clear) Dr. Mesghinna, I think where we stopped at lunchtime was I think we had gone into the third step of evapotranspiration, we had gone up to the point where you had described how in general terms you formulate the irrigation consumptive use or net irrigation requirement of a crop. What do you do after that?

A Okay. Just to refresh our minds, first we determined the potential evaporation, then we determined the crop consumptive use, and then we determined by subtracting the effective rainfall from the crop consumptive use, we determined the net irrigation requirement, or sometimes I call it irrigation consumptive use. Okay, so we are at this point.

If we add all the net irrigation requirements for all the months in which the crop

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is planted --

Q All the months?

A During the months in which the crop is planted or started to use water up to maturity of the crop or harvest of the crop more or less, then that is really the total of all of these months is really the amount of water that the crop requests.

Q The crop itself requires?

A Yes. Okay, but the problem is if we apply the water or if we divert that water to the stream, the net irrigation requirement at the stream. All that water will not reach the point where we want. Some of it will be lost through seepage, some of it will be lost through leakage in the pipeline, and some of it, as we said, through deep percolation. Some of it is surface runoff, so we remain with very few water, which is not enough for the plant. So we have to correct this thing in order to get enough water at the site or at the fields.

In order to do this there are several things that have to be determined. One thing is we have to determine what is our efficiency

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at the -- what is our efficiency or water use at the farm level. What is our efficiency between the farms and the pumps.

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We call that distribution efficiency and another thing we have to consider is what is our efficiency between the pumps via the canal up the diversion structure. That is called conveyance efficiency and we have to determine that. And efficiency that we need at the farm level is called application efficiency or sometimes they call it on-farm efficiency. So prior to the determining the gross water requirement or water duty for that matter, we have to know this different irrigation efficiencies step by step.

Q You have to know how much water is lost before it gets to the plants?

A Yes. We have to do that. If we know the loss of water, then we have to add that loss of water to the necessary irrigation requirement, and then we divert that water.

Okay. This determination of efficiency in the field of irrigation is quite complex and it is not an easy method and there might be fewer field formulas here and there, but people have to use their judgment on it as much as they can. While I am here, it is important to note, I guess, that irrigation is not -- the field of irrigation is not really a complete science. It is a combination of science and art,

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more or less, so there are a lot of judgments that enter into the works of irrigation design, meaning scientific judgments. They are not judgments just from the -- (pause) Okay.

So our work is now to determine the application efficiency. After we find that efficiency, we determine the distribution efficiency and then the conveyance efficiency. After we determine all of those, there is what we call "overall efficiency". So that is a combination of these three efficiencies in a sense, in short mathematical, for overall efficiency is nothing but application efficiency times distribution efficiency times conveyance efficiency.

THE SPECIAL MASTER: In that formula, do you apply the credit for return of detour to outlet or a credit for deep percolation of engine to outlet, or for --

THE WITNESS: In that formula we don't consider the water that can be used after it is outlet, because we believe that eventually that water is going to find its way in the streams back and can be used again. So really what we are trying to do is quantify the amount of water lost on the way coming from the diversion to the point of water use.

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Now, before I go to determining the overall efficiency, now, we have some kind of perspective what we are looking for. I think it would be a better idea if we enter into the on-farm systems design, because while we are there we'll discuss the application efficiency.

THE SPECIAL MASTER: Let's do it.

THE WITNESS: Okay. I think that is easier.

MR. CLEAR: Yeah, you're the boss.

Q (By Mr. Clear) So let's go on to number four on farm systems design and can you explain what that is and what you did in relation to it?

A When I say "on-farms systems design" I am specifically talking to the fields themselves.

Q The fields?

A The fields, at the field level. I wish I could show in a map just what a field means, really.

Q Well, we have -- or we had --

(At this time Mr. Echohawk and Mr. Clear moved a map to the board.)

Q (By Mr. Clear) On the top of the board I just put on the easel is Exhibit WRIR C-249. I don't want you to go into what that shows, but you wanted to show us what you meant by a "field". Is that useful

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to you?

A Yeah. So people will have in their minds what I am talking about, so it's not in the abstract, I just want to show what a field is.

Q Use that and show us what you mean by a field.

MR. WHITE: Your Honor, I would like to interpose an objection if this is used for anything but illustrative purposes. This exhibit also falls outside of the ten day rule, or within the ten days.

THE SPECIAL MASTER: If this is used just for illustrative purposes, I'll overrule the objection. Go ahead.

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A. Just to show what I mean by fields. As you see, we have different fields. For example, this is one field, this is the boundary by this area. This is another field. This is another field. This is another field. All those areas with the boundaries are fields. So each and every of this field has been studied by itself.

So when I say a field, I'm talking of one plot of land. For example, this is one field, you know.

THE SPECIAL MASTER: Yeah, one plot of land.

THE WITNESS: One plot of land.

THE SPECIAL MASTER: Yeah, very good.

THE WITNESS: That's what I mean.

Q. (By Mr. Clear) Okay.

A. Okay. When we talk on the on-farm systems design, what we're trying to do is we are trying to put together what we have learned so far. We have learned -- I mean, we have learned what climate is, what cropping pattern is, what evapotranspiration is. Okay, so all these things relate to the atmosphere and the plant water needs.

Okay, so we have to add into this other things, such as the soil. Okay, HKM has discussed the soil and we have to relate the plant and the soil. We

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have to get it together -- we have to put it together. In a sense, what we will do is we will put together the relationship of the plant, the water and the soil.

Q. Okay.

A. Because these are the things that make up the yield.

Q. Uh-huh.

A. So, the important thing is to put all these things for each of the fields, the crop water requirements and the soil characteristics. Now, what are the most important things in terms of system design, crop characteristics? Well, the most important or a paramount important crop characteristic is the water-holding capacity of the soil.

Q. Of the soil? Should we go back to your -- to that other drawing we had or --

A. Okay.

Q. -- to show what we're talking about?

A. Yeah, we can do that.

Okay, we have studied the atmosphere in here as evapotranspiration and crop consumptive use, and now the plant is there and we want to relate the water that is to be absorbed in here later to be

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used by the plants. Unless we know the capacity of the water to hold in here (indicating), we won't be able to define the plant. We won't be able to design our system. So we have to know. We have to quantify how much water is available, can be available, can be stored to be used by the plant in the subsurface of the soil.

The other thing of importance in this on-farm system design is the intake rate of the soil. The intake rate of the soil is nothing but the amount of water that enters into the soil that can percolate into the soil per hour. In most cases it is -- it's units or inches per hour.

THE SPECIAL MASTER: Is the term -- Yesterday we lived all day long with horizontal --

MR. WHITE: Do you mean hydraulic conductivity?

THE SPECIAL MASTER: Yeah, we talked about horizontal conductivity. Could this be vertical gravity hydraulic conductivity?

THE WITNESS: Yes, sir, you can call it more -- it is the vertical --

THE SPECIAL MASTER: Saturation or absorption?

THE WITNESS: Yeah, vertical entrance of water. The ability of the water to enter through the soil.

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Let me give you an example. Let's take clay soil. Clay is a very tight soil, meaning that it is a very cohesive soil. The texture of the soil is held together and the soils are so fine in order for water to penetrate through it, it takes more time. However, if we have granular soil, which is soil like sand, and if we apply water into it, the water will be absorbed, enter quite easily as compared to clay.

So when we say intake rate of the soil, it is the ability of the soil to let water enter down in here.

THE SPECIAL MASTER: Does your science include the science and study of texture of soils to determine that, too, or do you accept the other professionals' judgment on that?

THE WITNESS: Well, we have to know the texture of the soil, and that is very important. And I will come to it --

THE SPECIAL MASTER: Okay.

THE WITNESS: -- later on.

THE SPECIAL MASTER: All right.

A. (Resumed) The other thing of importance in the on-farm system design besides water-holding capacity

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and intake rate is the root depths of the crop. What I mean by this is every crop has an ability to penetrate into the ground and take water from the ground. Some of them are very efficient. They can go down, way down, in the ground and take water, and some of them are not that efficient and they can't take water, only from the upper part of the soil.

To give you an example, for example, alfalfa can go deep as compared to, say, for example, small grain or pasture which have shallower root depths. So the soil depths should be related to the root depths of the plants.

Okay. So, now, I discussed about what water-holding capacity of the soil, I discussed about the intake rate of the soil, I discussed about the root depths of the soil, and I discussed earlier before the crop consumptive use of the plant. So we have defined really the immediate environment of the plant.

The next thing is we have to put these things together so as that they can be interrelated because one without the other cannot work.

Okay, just to give more explanation so as that

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we'll have clear -- so that it will be clear in the minds of everyone: the higher the water capacity, the higher the water-holding capacity of the soil, the better the soil is. The reason for this is because if -- what we're trying to say is if I can store more water in the root zone, if I can store more water in the root zone, then it will take me more days to irrigate (sic). I don't have to come every now and then and irrigate because there is water stored in the root zone in here. And on the other side, let's see what intake rate means. If the soil is very tight soil and water cannot penetrate easily, what will happen is if I put more water into it, either there will be ponding or surface runoff or I have to change my management, and that is I have to put the crop -- I mean, I have to apply the water in very slow manner so as that most of the water can enter down into the soil.

So what we are trying to say is now we have to relate the intake rate of the soil with the sprinkler itself. Because if I bring a sprinkler that has a nozzle size, high size, it will apply water, the amount of water that I want per day. But most of the water might be lost.

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So what I have to do is I have to be careful that I have to apply the water, if the soil is tight, I have to apply the water in a small amount so that -- to be sure that the water enters into the ground. So these are the things that we want to relate together.

Okay, how do you determine water-holding capacity? First of all, water-holding capacity is mainly a function of texture of the soil. So each soil, say, sandy soil or clay soil or silt soil or gravelly soil has a certain -- can hold a certain amount of water. It can hold a certain amount of water in it.

And how do we determine that each of these soils can hold a certain amount of water? Well, this one is -- a lot of work has been done on this and some irrigation handbooks relate textures versus water-holding capacity. And we used some handbooks, such as Irrigation Handbook by Amos; secondly, we used the Israelson and Hanson to a certain extent, which is Irrigation Principles book from Utah State. We also have used the water-holding capacity that has been done in connection at the Midvale Irrigation District, which is Soil Survey of Riverton.

So, we put all these things together and we

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came up with water-holding capacity versus texture and the same thing with intake rate. Okay, but what we know is only a certain texture can have a certain water-holding capacity. But the ground, the actual ground is not homogenous, it is not all clayey, it is not all sand or it is not all loam. It changes. It is heterogenous. So we have to determine the weighted average of the water-holding capacity in the ground.

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THE SPECIAL MASTER: For each plot of ground?

THE WITNESS: Yes, for each volume that we have, for each plot.

THE SPECIAL MASTER: For each plot?

THE WITNESS: Well, wherever there is a boring hole that has been --

THE SPECIAL MASTER: A bored hole?

Q (By Mr. Clear) Where did you get the bored holes?

A Yes, and HKM provides us with soil logs. We took their soil logs and we plotted them in our working plans, our working plans. After we did that we took each and every log that we can and we see on the soil profile what kind of soil textures are there, complete soil textures are there, then we determined the weighted water holding capacity. I think it would be a good idea if I can jot down what these water holding capacities --

THE SPECIAL MASTER: Why don't you use the other half of the blackboard, if it's agreeable to Counsel. You can bring that exhibit down, too, if you wish. Okay.

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(Brief pause.

THE SPECIAL MASTER: You can put it down. I wish you would, in fact. That's better. Just set it down anywhere.

THE WITNESS: Let's assume this is the ground, ground surface.

(Whereupon, the witness
(is drawing on the black-
(board.

Here are the plants you're growing, and here are roots, roots growing over here. Now, let's assume there is a log here, blank log that goes like this. Let's assume that the soil has -- log has different soil textures. And let's call, for simplicities sake, the first part D_1, depths 1. It can be feet or feets, whatever. The second one is D_2; third one is D_3; fourth, D_4. Okay. And I have stated earlier that for each of the textures, since we know the texture in here, we know the water holding capacity for each of the textures. Let's call this one water holding capacity $_1$, water holding capacity $_2$, water holding capacity $_3$, water holding capacity $_4$. We know the water holding capacities for each of the stratum in here, but

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we don't know the hole depths, so we have to devise a way on how to estimate this overall water holding capacity or average weighted water holding capacity.

We know these depths from here because it is in the log. For the time being I want to call this one (witness indicating) D weighted, D depths weighted total, weighted total.

THE SPECIAL MASTER: Weighted total depths? Weighted total.

THE WITNESS: Now, the overall water holding capacity that I have to discuss about, the whole thing in here is water holding capacity weighted of overall is equal to Depths $_1$ divided by water holding capacity $_1$ times total Depths, DW_T plus the second Depths over the second water holding capacity times DW_T, plus the third Depths over water holding capacity $_3$ times DW_T, plus Depths $_4$ over water holding capacity $_4$ times DW_2 -- oh my God.

This is DW_T times water holding capacity $_1$, (witness indicating), DW_T times water holding capacity $_2$, DW_T times water holding capacity $_3$, DW_T times water holding capacity $_4$. In a sense

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what we are doing is the ratio of the water holding capacity of this one over all the depths is this (indicating), Depths $_1$ over total depths. Means that the proportion of water holding capacity of this depths is this times the water holding capacity $_1$.

THE SPECIAL MASTER: Why can't you take finding the simplistic root of my moronic mind, which should go to add 1, 2, 3 and 4, getting tne total of what, ten, and divide by four and come up with a two and a half of the weighted average for that area?

THE WITNESS: Okay, that would be good if all these are equal, all the depths are equal, but the depths are not equal. I mean, the strata of the soil are not, you know, made equally. Some of them are --

THE SPECIAL MASTER: Deeper?

THE WITNESS: The clay might be deeper, and sometimes the soil might be only a few inches or something of that sort. So in order to have a proportionate weighting water holding capacity we have to take into consideration what each soil strata represents in terms of

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water holding capacity. So that's the reason we have to go through this long way.

THE SPECIAL MASTER: I see your numbers 1, 2, 3 and 4 are just designations, they are not your results?

THE WITNESS: They are not. This might be only two depths, might be three depths, might only be one, or, I mean, only one soil all the way; it might be seven different kinds of soils. This is just to show the approach of the water. That's why I didn't put different depths -- I mean, two feet, one foot or something of this sort.

Okay, this is how we determined the water -- weighted water holding capacity of a different -- of a different soil log. That soil log, as you will see in the future, will present certain areas on the fields. Now, I said something about DW_T. Now, let me stay here.

DW_T is nothing but the weighted total of the crops. So DW_T is always about 4.5 feet.

MR. CLEAR: I think you -- explain in lay terms what the 4.5 feet is.

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A Okay what I am trying to say about the formula, it is -- now we have 67 percent of alfalfa growing there in actuality as is proposed by the economist, and there is 12 percent of corn growing there and the rest is small grain. Now, if we come up with a weighted average of all the crops, there effective root depths, it will be 4.5. Say, for example, if alfalfa is five feet, let's assume -- let's say that, which is usually the case, alfalfa takes water up to depths of five feet down, and if we say corn takes water from 3 to 4 feet, and let's assume it is 3.5 feet and if we assume that small grain takes all the way from about 2.5 feet to about 3.5 or 3.75 feet, if we say on the average it consumes water from as deep as 3.25 feet, and if we apply the porportion of this crop in pattern, if we multiply 67 percent by five feet, 12 percent by 3.5 feet, then whatever is left on the small grain, which is -- 16 plus 5 in the lower areas -- 21 percent by 3.25, we'll come up with a weighted root depth of 4.5. So it is the weighted root depths of all the crops, you see. We have to combine them together.

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Q That's your weighted average root depths?
A That's the weighted average root depth.
Now, the question might arise that, "Hey, some of the logs are quite shallow as have been provided by HKM and some of them are deep, greater than 4.5 feet. What do you do on this problem?"
Okay. Let me go through the simpliest one first. If it is greater than 4.5 feet, well and good. You assume if the plant can take water from the 4.5 feet, beyond that it can't take it. So if we have six feet of water, we don't say the plant takes from six feet down. It takes only up to 4.5 feet.
However, there is a problem that arises there. How do you know the rest of the stuff if the borings are shallower than 4.5 --
Q Let me see if I understand. If the boring was four and -- four and a half feet, you disregarded any information below four and a half feet?
A Yes, because the assumption that we have to make is the plant can take water only up to depths of 4.5 feet.
Q And everything below that is irrelevant?
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A As far as the plant is concerned. It's going to deep percolation or some sort. Okay.

You see, plants have -- they have some kind of mechanism. If the head is -- the head that they have to draw is too much for them, they can't take it, you know. So it can't take -- we're saying that the plants on the average are not taking below 4.5 feet.

Q Now we go to the example with the HKM bore hole which did not go to 4.5 feet, and you're going to tell us what you did there to determine the water holding capacity?

A Okay, yes. Now, let's assume that for that matter we have only a log that says 12 inch --

THE SPECIAL MASTER: Says what?

THE WITNESS: Twelve inch.

THE SPECIAL MASTER: One foot.

A Just to make things easier, what do we do if this 12 inch -- you tell me that you need 4.5 feet of root depths and how are we going to grow crop there? Okay.

So in order to answer this question, first what we do is we take the 12 inch, which is equal to one feet, so the water holding capacity

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total would equal that one feet which is 12 inch of this one, over 12.5 feet, times the water from the capacity of that soil texture. What we do is if HKM gives or says that the soil below this is gravelly soil --

THE SPECIAL MASTER: What if they say the soil beyond that one foot is a barrier?

THE WITNESS: By definition the barrier is at six feet.

THE SPECIAL MASTER: You don't deal with barriers closer to the surface than six feet?

THE WITNESS: We will when it comes to drainage.

THE SPECIAL MASTER: Go back to your own definition, then. It's gravelly.

A Let's say gravelly or for some matter the driller quit his drilling from there, so what we are assuming, we assume the water holding capacity of the rest, 3.5 feet of gravelly soil. Gravelly soil has a very low water holding capacity, so what we are doing is we are punishing ourselves on the water holding capacity on the rest of the profile. What it means is that we are taking a conservative estimate,

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meaning we are saying that the soil can hold only very few water and as I have stated it earlier, if the water can hold a small amount of water, then you have to irrigate every now and then, which means more equipment, which means more cost on your investment. As we see it, later on this will be reflected in some of the units which have more of the sandy or gravelly soil, they have the higher costs.

THE SPECIAL MASTER: You would identify those as less efficient or more expensive?

THE WITNESS: More expensive, and even less efficient, yeah.

THE SPECIAL MASTER: Yeah.

A So what we do for the rest of this one, if they say gravelly, then we take all the way gravelly. The 3.5 feet would be gravelly soil, and when we say "Gravel" it's not pure gravel; it has some fine soils into it. It can hold a little amount of water. It can hold it but not as good as loam or clay or silt or even sand soil. So the rest, 3.5 feet, will be 3.5 feet over 4.5 feet times the water holding capacity of that specific soil. So this is how we come up with

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the different kinds of soil depths that we have for all the areas where we have loss.

THE SPECIAL MASTER: Is the science so advanced that computer companies put out hand-held computers on which these formulas can be cranked out and get your answer, or do you just use a computer to do that?

THE WITNESS: This part of the area, one has to see each part of the soil, what they call the "Stratum" is a very painstaking job and it has to be done manually.

THE SPECIAL MASTER: By hand?

THE WITNESS: And people have to spend a lot of time going through this and putting together. But after we put all these things to analyze it, if one has to go through hand calculations, it will take him years and years probably to come up with what we are trying to show is efficiency and gross water application. So we have a completed program called on farm systems design program.

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Q (By Mr. Clear) Can I ask you a question? Now, you were testifying about the weighted average holding capacity of the HKM logs. How many logs did you figure out the weighted average, weighted holding capacity for?

A. Well, I can't exactly remember the number of logs.

Q Uh-huh.

A. But we made sure that each field gets, you know, something. This does not mean that there are fields, some fields, which don't have, you know, logs of that kind.

Q Uh-huh.

A. What we do is we go to the nearest point, to the nearest boring log and we apply that value.

Q What I asked, did you figure out the weighted holding capacity for each and every log?

A. For each and ever log.

Q Okay.

A. In the North Crowheart there can be hundreds, you know, and we have to do that for each and every log. We have determined the water-holding capacity and the intake rate for all of these acres.

THE SPECIAL MASTER: You've been testifying about an hour. Do you want to take a little break?

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THE WITNESS: That would be very nice.

THE SPECIAL MASTER: All right, let's take a ten-minute recess.

(Recess, 1:56 p.m. to 2:10 p.m.

THE SPECIAL MASTER: Shall we come to order, please.

Proceed, Mr. Clear.

Q (By Mr. Clear) All right. Are we still on water-holding capacity?

MR. WHITE: I think we are on the computer.

A. I think we beat it to death now. So --

Q (By Mr. Clear) Okay.

A. And if needed so, we'll come back later on and it will enter into other things and we'll relate it with the other things.

Q Uh-huh. Okay. Now, you have determined the weighted water-holding capacity for each hole and the intake rate for each hole. What did you do with that information?

A. Okay. Now, we determined this soil characteristic data and we have to relate it with the plant and the crop consumptive use.

Q Uh-huh.

A. And how do we do that? Okay, first, what we have to do is we have to transfer this data to our working maps.

Q. Uh-huh.

A. When we transfer it there, there will be the water-logging capacity and the intake rate and the other necessary things.

Q. Uh-huh.

A. From that then we make a layout of the fields.

Q. Uh-huh. Like those total units you pointed out on the --

A. Yes, the fields that I pointed out before.

Q. Right.

A. Okay.

THE SPECIAL MASTER: Which we have called plots, we have called them fields and we have called them tracts. And should we make one word for --

MR. CLEAR: We were calling them on-farm systems design. Should we call them fields?

THE SPECIAL MASTER: Yeah. Well, that's not literally or figuratively true.

MR. WHITE: We would stipulate to "field", Your Honor.

THE SPECIAL MASTER: All right, let's use "field" from now on, "field" from now on for the one word.

THE WITNESS: Okay.

A. So we transferred the data in each of the fields, and what we have to do is now we have the boundaries of the irrigable lands.

THE REPORTER: I'm sorry.

THE WITNESS: The irrigable lands --

THE SPECIAL MASTER: Irrigable.

A. -- from HKM and that is also transferred into our working map.

MR. WHITE: Your Honor, I would move to strike the answer because the HKM data which is in evidence all relates to arable.

THE SPECIAL MASTER: I was about to --

Do you mean arable?

THE WITNESS: I mean arable.

THE SPECIAL MASTER: Not irrigable, but arable. That is my fault, Lamont, not yours. I tried to prompt the reporter and I loused it up.

Okay. Okay. Arable.

A. On the arable lands one thing that we have to be careful in putting the fields there is we don't just put the field because it looks nice this way and it looks better that way and so on. We have

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to consider some things as to topography of the field as to the slope of the field and so on. And we try to put as much as we can -- this is not always true -- as much as we can we plot the fields so that the sprinkler lateral, the lateral lines will be on slope parallel with the slope of the land.

Q (By Mr. Clear) Uh-huh.

A. Okay. Then after that, after we plotted each field, we try to see the dimensions of the field, meaning the length of the field and the width of the field. This field, when we put the field, it took us a long time and there has been several changes. You know, we improve it every now and then until we think we are near perfection. Of course, we started with 84,000 acres of arable land and we have cut it down to less than 54,000. This is due to sometimes leaving areas when we square off --

Q Uh-huh.

A. Sometimes mainly too high to irrigate it and, you know, that kind of makes sense.

THE SPECIAL MASTER: Just a moment, please. Will the reporter please go back and read that to me, the figures on arable lands reduced to certain arable lands?

(The above portion of the
(answer was read back by the
(reporter as follows; "-- we
(started with 84,000 acres of
(arable land and we have cut
(it down to less than 54,000.
(This is due to sometimes leav-
(ing areas when we square off --"

THE SPECIAL MASTER: Go ahead, Mr. Clear.

Q. (By Mr. Clear) Dr. Mesghinna, you mentioned just a little while ago in laying out your fields, you tried to lay them out parallel to the contours because of slope, is that --

A. Yeah, because we want to have the laterals to be as level as we can as much as possible, although in sprinkler irrigation that's not necessary. But it will be better if it is as level as can be. So if we put it parallel with the contour, then there's not much change in the, you know, the differences of slope between the beginning of the lateral and the end of the lateral. The beginning of the lateral is here (indicating) and the end of the lateral is here. So we don't want to have --

Q. Excuse me, I thought you were pointing to an exhibit I have just put up. It is United States WRIR C-247, which is another one of the illustrations --

THE SPECIAL MASTER: Entitled, "Side Roll".

MR. CLEAR: Entitled, "Side Roll".

A. So we'll try -- what we are trying to do is we are trying to, if the contour is going like this (indicating), we'll try to put it with the contour as much as we can, but this is not necessarily true in all cases. If we cannot do that, then we have to go the other way, you know.

Q. (By Mr. Clear) Uh-huh. What's the -- Do you have a limit on the amount of slope in a field or did you --

A. Well, as you probably know, according to the soil classification, the maximum you can go is 20 percent slope, 20 percent slope. But as to my recollection, I don't think we have greater than between 10 and 15 percent. We have eliminated as much as possible those areas that have high slopes.

THE SPECIAL MASTER: Of your total acreage that you're going to recommend, how much of that would be between 10 and 15, relatively little?

A. A very, very small, extremely small, probably, oh, this is just approximately, I mean just -- probably 10 percent or 5 percent, something of that sort.

Well, in order to have a better understanding of what we're discussing, this is the canal as we can see it and this is a pumping station. It is taking water from the canal. And this is called a distribution line, the line that goes from here, which I'm going to discuss later on in detail, and this line is called on-farm main line.

THE SPECIAL MASTER: On-farm main line?

THE WITNESS: Yeah, or field main line.

THE SPECIAL MASTER: Uh-huh.

THE WITNESS: Let's call it field main line.

THE SPECIAL MASTER: What distinctions are made as to whether those are lined or unlined or what action has been taken to conserve loss of water in a distribution -- Did you deal with those factors?

THE WITNESS: Yeah. I'm going to discuss about them later on.

THE SPECIAL MASTER: All right, then I'll wait.

A. Okay. So we have the canal, we have the distribution line, we have the farm main line and then the -- and the lateral is connected with the farm main line. So when I say "lateral", I'm talking the sprinkler, including the pipes that have the sprinklers and the wheel of the lateral, this (indicating) and plus the drive unit. That's what I mean by lateral. So the drive unit is the unit, the motor that drives it.

THE SPECIAL MASTER: Yeah. Yeah.

A. Okay.

Q. (By Mr. Clear) Actually you're --

THE SPECIAL MASTER: Are we on No. 5? Did we just sort of naturally gravitate to it?

MR. CLEAR: Not quite. We are still on the farm systems.

THE SPECIAL MASTER: We are still on farm systems?

Q. (By Mr. Clear) I think maybe, Dr. Mesghinna, you ought to just explain the difference. Can you explain it in that 247, the difference between the pipe system and the on-farm system?

A. Oh, when we talk of on-farm system, really, we're only dealing with this.

THE SPECIAL MASTER: I see.

A. And what you call the joints. Other than that -- the valves, I mean the valves and also the sprinkler lateral.

THE SPECIAL MASTER: Lateral.

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THE WITNESS: That is the on-farm system.

A. I haven't touched anything that relates to the distribution line or field main line or canal or anything so far.

THE SPECIAL MASTER: I see. I see.

A. So I'm only talking now in here because from here we'll move to here, from here we'll move to here (witness indicating several times) and so on to here and then to here and so on.

THE SPECIAL MASTER: Yeah, as we go on down the line.

Q. (By Mr. Clear) Well, now, you have laid out the farm or you have laid out the farms --

A. Uh-huh.

Q. -- or fields. And I suppose now we are trying to figure out the sprinkling system we need or the irrigation system, is that right?

A. Uh-huh.

Q. All right.

A. Okay.

Now, that we have put the necessary data in order to design our system, on-farm systems design, then we can go ahead and find out what are the necessary things that enter into it. Okay. Now, we know --

Q I think you're going to have to speak a little louder.

A. Okay, we know our water-holding capacity and we know our root depths and sizes of our fields, and now we are ready to crank on and relate the crop, meaning the plant, the soil characteristics and the crop water requirements.

* * * * *

THE WITNESS: Okay. But I have to define certain things before I do that, and that is net depths of irrigation.

THE SPECIAL MASTER: Net depth of irrigation?

THE WITNESS: Yes, net depths of irrigation is the amount of water, the net amount of water that we apply at a given irrigation time. I will define it this way: Net depths of irrigation is equal to the water holding capacity times the root depths times depletions.

THE SPECIAL MASTER: What was the last item?

THE WITNESS: Depletion.

Q (By Mr. Clear) Well, we have the water holding capacity and we have the root depth. Explain what depletion is, then we'll have all three elements.

A Okay. Depletion is nothing but -- it is the amount of water that is to be used by the plants between irrigations. If we irrigate today in one spot and we come back and we irrigate -- we come back after 12 days, it is the amount of water that has been depleted

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between this]2 days.

Let me explain it really more because it's a very important thing. When I say water holding capacity, I mean water holding capacity inch per foot. So the water holding capacity inch per foot multiplied by the total depths, which is 4.5, will give us the total amount of water that can be stored in the soil surface, the total amount of water that can be stored in the soil surface.

The soil surface has two limits: One is called field capacity.

THE SPECIAL MASTER: Field to capacity?

THE WITNESS: Yes, field capacity.

THE SPECIAL MASTER: Field capacity?

THE WITNESS: Field capacity.

Q (By Mr. Clear) Filter or field?
A Field.
Q Field?
A Yes, field, field capacity, and the other limitation is called wilting point.
Q Wilting point?
A Wilting point. Now, let me define it more.

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Field capacity is the capacity -- it is the amount of water that is stored when the soil has enough water, is filled with water. That doesn't mean saturation, it is not saturated with water. There is some air to it. It is usually, you know, when we talk about an irrigation, it is usually -- the amount of water stored in a given field after irrigating it, 24 hours after irrigating it, then if you go in and measure that amount of water in that field, that is field capacity.

THE SPECIAL MASTER: Twenty-four hours after completing irrigation?

THE WITNESS: Yes, after we apply water, because what happens is at -- in saturation there is gravity flow going down, but at field capacity gravity flow ceases, there is no gravity flow, the water is there, it's available for the plant.

Okay, the other limit that I brought up is the wilting point. The wilting point is the amount of water left in the soil at which the plant can no longer -- can no longer take water, but dies. It dies, the plant starts to

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die.

THE SPECIAL MASTER: Because there is simply no longer any water to take?

THE WITNESS: There's no water there, it can't take -- it can't suck water from the root zone. So that is called the wilting point.

Okay, so if we see in a sense really the difference between field capacity and wilting point, that is the total amount of water available in the root zone. But, should we wait until the plant uses all this water --

THE SPECIAL MASTER: You are not going to be a very good farmer.

THE WITNESS: You are not going to be a very good farmer. So we have to give some allowance, and in this case we gave it a generous allowance. We have said -- we have assumed that our depletion will be only 50 percent. What it means is when 50 percent of the water is finished by the plant, irrigation, add water, don't wait below that.

Q (By Mr. Clear) If you wait below that you --

A Well, for plants like alfalfa, you can go way down than 50 percent, you can go 60 or even more

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than that, and still the plant will be in good shape. But there are crops that are very sensitive crops like potatoes, and you need to apply water every now and then because they're sensitive crops. We call them sensitive crops. They are not stress resistant, they don't have the resistance of stress of water.

But crops like alfalfa, I think alfalfa is one of the easiest crops to manage than any other crop because it's --

THE SPECIAL MASTER: Do you know offhand if the sugar beet is also stress resistant or can it take a dry spell, the sugar beet?

THE WITNESS: Sugar beet, I will say it's medium as much as anything, so alfalfa is easy to manage really because if a farmer cannot do good in alfalfa, he cannot do good in other crops.

Q (By Mr. Clear) So we have the depletion set at 50 percent?

A Yes. We could have set it more than 50 percent, but it would be more conservative. It would cost more, you know, if you set it 50 percent rather than 60 percent. But it's better to be on the safe side. But at any rate, in our design

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it is at least 50 percent. In many cases it's not even 50 percent because when you adjust all those intake rates and so on and so on, it makes it harder to hit on 50 percent, you have to be less than 50 percent because if the intake rate is low, meaning that the water cannot take the water anymore, cannot enter anymore, so you have to look for a lower depletion, you know, to satisfy the plant so -- which means you have to irrigate it frequently.

Q Okay.

A Okay.

Q So by using the weighted water holding capacity and the root depths times the depletion allowance, we have come up with the net depth of irrigation?

A Yeah. We determined the net depths of irrigation for each field. We are talking -- when we talk of fields, just to give you some magnitude, we are talking about like 300 fields just in the Diversion Dam area, in the Diversion Dam climatic zone of North Crowheart.

Q All right.

* *

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A We have to go through each of these in the net depths of irrigation. After we determine the net depths of irrigation, what we are saying is we need, the plant needs this amount of water between irrigations. But that does not mean you have to apply that amount of water to the plant. You need more water to apply to it, because there are some avoidable and unavoidable water losses and that is where the application efficiency comes.

I have stated earlier that I would discuss the application efficiency when it is -- when it is related to the things I am discussing, so I think I can go ahead and discuss it, because now we are in the net depths of irrigation, we want to determine the gross depths of irrigation, so we need to know the application efficiency.

Efficiencies are hard to compute. They are probably one of the hardest things, and people use certain amount of application efficiency and they go -- they say 50%, 40%, 30%, even 70, 80%, and so on. But there are some guidelines to come up with application efficiency. Application efficiency is mainly a function of net depths irrigation.

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Q Which we just figured that out.

A We just figured that out, and the wind speed. The reason why wind enters is because when you apply water in a sprinkler, the wind can deflect the water application and give you a different uniformity of the irrigation application and the uniformity of irrigation also affects application efficiency. So that has to enter into play in sprinkler irrigation.

The determination of application efficiency -- the other parameter that is important in determination of application efficiency is peak consumptive use --

Q Peak?

A Peak consumptive use, p-e-a-k, consumptive use of the crop. Peak consumptive use is nothing but the consumptive use, the peak consumptive use, during the warmest months or during the time when it is at its peak, and that is determined by soil conservation method which is a standard formula in the Technical Release No. 21.

Q Okay.

A So we have the peak crop consumptive use, we have the net depths irrigation, and we ought to say something about the wind speed.

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Wind speed is hard to get as data. People assume certain wind speeds and so on, but we found some wind data in the Riverton area that has been done from 1967 until 1971 and for each month, and we determined those. What you call "wind speed" -- wind speed is not really very critical in this determination of application efficiency because --

THE SPECIAL MASTER: A statement like that will make you very popular in Wyoming. Wind speed is not very critical.

A Yeah, what I mean is you don't have to know the exact wind speed is 4.5 miles per hour or 6.2. What you have to know is the range of wind speed from 0 to 4.

THE SPECIAL MASTER: Oh, the gusts?

THE WITNESS: No, miles per hour. The wind speed in miles per hour.

THE SPECIAL MASTER: Oh, the rate. Wind speed in miles per hour.

THE WITNESS: Yes. That's what you need to know, and that should not necessarily be -- we shouldn't necessarily be exact in knowing that.

What is needed is from 0 to 4 miles per hour, it will get a certain amount of application efficiency.

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From 4 to 10 miles per hour it will give us certain amount of application efficiency.

THE SPECIAL MASTER: How do you measure a wind that gusts from 1 to 2 to 15 in the course of an hour, and can gust 25 times in an hour? That is variable winds are gusting.

THE WITNESS: Yes.

THE SPECIAL MASTER: What does that do to sprinkler efficiency?

THE WITNESS: What we have to do is for that kind of different speeds we have to find the frequency at which these wind speeds are coming. Say, for example, 10 to 15 miles per hour, it might come 10 times per day, so we have to know this.

THE SPECIAL MASTER: Then what do you do with that?

THE WITNESS: Average it out for the month.

THE SPECIAL MASTER: I see.

THE WITNESS: And then we determine at what stage -- at what range we are from 0 to 4, 4 to 10, or greater than 10. That's the only thing necessary in this application efficiency.

So after we enter the, what you call wind speeds, net depths of irrigation, and peak consumptive

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use, then we can find the application efficiency from handbook --

THE REPORTER: Pardon me?

A -- from handbook, which is Irrigation Handbook by Amos. However, in doing this, as I have stated it earlier, in connection with the overall on-farm system design we have a computer program that scans through all this and finds the application efficiency. Okay.

Okay, now, we know the application efficiency. Where do we use it? So if we divide the net depths of irrigation by the application efficiency, then we determine the gross depths of irrigation. Gross depths of irrigation is nothing but the amount of water that the farmer should apply on his field during a given day.

Q (By Mr. Clear) That's --

THE SPECIAL MASTER: A farmer should apply on his field in any given day?

THE WITNESS: Yes, in any, you know, and the management schedule that we have is the sprinklers will move twice a day. We'll put the sprinkler at one position for about half a day and then we come in the evening and we move it to another

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position and then we come back the next day and move it to another position and so on.

So during the time -- during that time, about half a day, the gross depths of application should be applied in that land which is only 60 feet in size.

THE SPECIAL MASTER: Uh-huh. Yes, Mr. Clear, go ahead.

Q (By Mr. Clear) For example, suppose we said we had an application efficiency of 50%. What does that mean in amount of water you have to apply?

A Okay.

Q Maybe 50% is not very good. Let's say 55% so we know what it means.

A Well, I will choose the 50% in order to make things easier for everyone.

Let's say that we determined the net depths of irrigation, which the water holding capacity times depths times depletion, it's two inch for that month to make things easier, so the gross depths of irrigation will net depths of irrigation divided by the application efficiency, which means that two inch divided by 50%. So the farmer should apply four inch of water -- four inch of water is

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this high (indicating) -- which means he had to apply during those about 12 hours he should apply about four inch of water in order for the ground to be at fill capacity. In order for the ground to be filled with the water necessary for the plant.

Q So basically he would have to apply four inches of water to get two inches into the ground?

A Exactly. The other water either goes to surface run off or deep percolation or might even evaporate while the sprinkler is running, you know.

THE SPECIAL MASTER: Yes.

A So that is what I am calling gross depths of irrigation, and that is the place where the application efficiency enters.

Q All right.

A Okay.

THE SPECIAL MASTER: Now, we're ready for a pipe network system?

MR. CLEAR: Just about there. There is one more area to cover, right?

THE WITNESS: I think we will have more.

THE SPECIAL MASTER: Well, I am not trying to gloss over anything substantive; I am trying to

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respect our goals of moving along.

MR. CLEAR: I think we are actually. We've been on less than a day, Your Honor. This trial has been on several months, and this is very important testimony, Your Honor.

THE SPECIAL MASTER: Fine, no problem.

THE WITNESS: One thing is after we finish this thing, things will be easier. We have laid the foundation of everything and things will move fast.

THE SPECIAL MASTER: Certainly.

MR. CLEAR: After we get past this one.

THE WITNESS: If we finish number four, things will be easier. We take the rules from number four and apply it to the others, and it will be easier.

THE SPECIAL MASTER: I think this is probably the most crucial of all ten. It's so complex you can't get any more facts into it.

THE WITNESS: Okay.

A Now, the next thing is what we call the "irrigation frequency" -- every how many days do we have to irrigate. That is what irrigation frequency means. Okay.

The irrigation frequency is nothing but the net depths of irrigation divided by the peak consumptive use. Peak consumptive use is namely in terms of inch per day -- inch per day.

* * * * *

Q (By Mr. Clear) Right.
A. Okay. So, if we say we need 2 inches of water as a net depth of water, of the net depth of water, 2 inches of water, and let's assume for simplicity sake that the peak consumptive use is .2 inches per day --
Q This is the consumptive use is the amount of water the plant takes, right?
A. The plant takes at its peak time during its peak time.
Q Uh-huh.
A. Then the irrigation frequency will be 2 inches divided by .2, you know, net depths of irrigation divided by the peak use, because it will take it 10 days in order for the plant to finish that half part which is 50 percent of the soil reserve. So what it means is the farmer should come back again and irrigate that land after 10 days.
Q Uh-huh.
A. And in reality, however, this does not happen. Probably it happens only once because the peak consumptive use, there's no peak consumptive use except at one time. You know, the rest of the time in May, April and September it's cool and

you don't irrigate every now and then. Most -- a substantial amount of your sprinklers will be idle, standing there. You need all of them only during one time, during the peak season.

Q Uh-huh.

A. Okay. So after we determined the irrigation frequency then, now we are ready to determine the number of sprinklers needed to -- the number of laterals needed for a given field.

Q Before we go on to that, I did ask you about the slope before with relation to the farm design system. I haven't asked you about -- I think what's taken in much time of the trial heretofore is the classes of lands established by HKM. They have those Class 1, 2, 3 and 4. Are you familiar with those?

A. Yes.

Q How do they fit into your on-farm or field system?

A. You know, different classes of soil are due to different reasons. The soil is of lower class, probably because it has a high slope, or it might have topography that is not too good, or it might have drainage problems. You know, things of this sort. But when we do the on-farm system design, we are looking at each and every boring hole.

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Q Uh-huh.
A. And when it is a slope, we don't have much limitation in sprinkler irrigation. So that thing comes out. When it is drainage, we take care of the drainage problem in our drainage analysis and that comes out. The other things, say, for example, it has lower water-holding capacity or its intake rate might be low or something of this sort.
Q Uh-huh.
A. So what we do is we are taking care -- taking that one into consideration, as I have explained it earlier.
Q Uh-huh.
A. So it means we are examining it in a more detailed manner. Where does all this reflect? All these things will reflect in the cost. If you have an area that has less water-holding capacity, you have to irrigate it every now and then, which means you need more laterals.
Q Uh-huh.
A. So you have more costs. Let's say, for example, just to cite one example, if we say Riverton East Unit. The classes of soils in that unit are mainly Class 3 and Class 2 soils. There's no Class 1, as

I remember it in that unit. So what happens is the cost of your on-farm system gets higher. You need more laterals per unit acre. So all these classes will be reflected in our cost estimate and in your management and in the amount of facilities you need in the irrigation system design.

Q. All right. So we are back now, I guess, determining the number of laterals and actually designing this system, is that where we are or --

A. Yeah.

Okay. The next thing we need to know is we need to know about money. Okay, we have the crop. We studied the climate. We know the crop water use. We found out the soil characteristics and the mechanisms and so on, how the water is going to be taken. All these things have been studied. What does it take to apply the water to the farm? How much does it cost? So we have to determine the number of laterals needed in each of the units.

Q. Each of the fields?

A. Yeah. Then we added up to each pump station. Then we added up in the unit as a whole.

Q. Yeah.

MR. CLEAR: Do you want a glass of water or something?

A. The number of laterals is estimated in the following way: We have a field this long (indicating). One lateral covers 60 feet per irrigation.

Q. Uh-huh.

A. So that lateral covers, since we move it twice, it covers 120 feet per day. If there's 1,440-feet long field, how many days will it take to cover it? It is 120 -- I mean, 1,440 feet long divided by 1,440 feet (sic). This is the number of days. So, if, instead of doing that, I know the irrigation frequency, let's say it is 10 --

Q. Uh-huh.

A. And I multiply and I have the one lateral moves 120 feet per day. So in 10 days it will cover 1,200 feet. But my field is 1,440 feet. So I need one lateral in it and a little more than a lateral.

Q. Uh-huh.

A. So the number of laterals is nothing but the field length divided by the amount -- I mean, the length of feet covered per day by each lateral multiplied by the irrigation frequency.

Okay, so we go on like this and the computer determines the number of laterals. But what do we do

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because the computer cannot distinguish between land that is perfectly square or perfectly rectangular. It can't see a rectangular or square field and so on. It can't see it because, you know, there are fields that are something like trapezoidal shape or, what shall I say, somehow triangular shape.

THE SPECIAL MASTER: Semicircles, triangles, obtuse triangles --

THE WITNESS: Uh-huh.

A. So what we have to do is after we take out that from the computer program, then we have to take all those fields, all those outputs, and go by hand each and every field and determine what is the maximum size of laterals needed, lateral lengths needed.

Q. (By Mr. Clear) Now, when you're talking about the number of laterals, the maximum number of laterals, you're talking about during the time of peak consumptive use?

A. Yes, this is only during the peak consumptive use. If we need, for example, in a certain field three laterals, that is only during very few days.

Q. Uh-huh.

A. After that some of the laterals will be idle, you know, or they have not much to do because they are --

the temperature is low or -- I mean, the demand for water is low, so we don't need those laterals. So we use less laterals after that.

Q. But even though they are only used a few times,you still have to go out and buy them?

A. You have to buy them. That is very necessary if you have to get optimum yield.

So, after taking out from the computer, and then we go each field by field and see how many laterals are, indeed, necessary if we have this triangular shaped field. The computer will give us an average size of lateral.

I think -- Let me put this -- this might help, on the blackboard.

MR. CLEAR: Let me take this down.

THE SPECIAL MASTER: Do you want to erase that portion? Why don't you?

THE WITNESS: Okay.

THE SPECIAL MASTER: But leave the listing, won't you?

THE WITNESS: Yeah, I'll leave those.

A. If it so happens that-- Let's take the worst kind of field that looks something like this (witness drawing). We have the farm main line here and we have the laterals going like this (indicating). Now, the problem is what do you -- what the computer does. It takes an average field size, probably somewhere in this area. You have a lateral and it gives you that lateral size. But if I use this lateral, it might help me to, you know, irrigate this area on this lateral by cutting some of the sprinklers as I go along this way (indicating). But it won't be useful this way because it is short. If I use it this way, it will irrigate only this area, it won't be able to irrigate this area in here. So what we do is we go take the computer output and we take the maximum size lateral, and if this lateral requires two laterals, then we have to buy those laterals that are maximum in length, although we don't need them, because some of the sprinklers in the laterals will be taken out as we go along the way. But that is only tough luck.

So we have to buy those laterals, although it costs more, to satisfy the irrigation. So that's what I meant when I say we have to adjust the lateral size by hand.

So after we determine the number of laterals,

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after we determine the number of laterals required in each of the fields, then we go to each pump station. I'm not going to discuss about pump- station, I'll discuss only in relation to the number of laterals in a given pump station.

Say, there are almost -- let's say there are 59 pump stations in the North Crowheart.

THE SPECIAL MASTER: North Crowheart?

THE WITNESS: Yeah.

A. And our assumption there is that within a given pump station, within a given pump station we can exchange laterals, but we cannot exchange laterals from one field to another field outside of a given pump station. Okay, what I mean is if in one place, in one field we need five laterals --

Q. (By Mr. Clear) Uh-huh.

A. -- and we are short of a lateral in another field, then we can move one lateral from one field to another field to cover that field. Okay, but that is only applicable in a given pump station. It can't get out of that because we believe it will be too long to transport it. You know, the laterals and so we can only do this within a given pump station.

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So in that way we determine the number of laterals required for each pump station; and after determining the number of laterals in each pump station, we determine the total laterals in the whole unit and we determine also the cost of the laterals because laterals are different in cost, and we determine the cost of each lateral.

* * * * *

THE WITNESS: And here we have some hand moves and -- what do you call them --

THE SPECIAL MASTER: Side rolls?

THE WITNESS: Side rolls, and side rolls are almost as twice as expensive as the hand move, so for the hand move we apply different costs, which is almost about $2. per feet of lateral. For the side rolls we apply a different cost that we received from Riverton supply of -- sprinkler supply from a dealer by the name of Tom Shepard.

Q He's the one who gave you the prices of the various sprinklers?

A The prices of the various sprinklers, so we used those costs in order to determine the cost of laterals.

THE SPECIAL MASTER: Doctor, we have been another hour without a break. Do you want to take five or ten minutes?

THE WITNESS: That would be very nice.

THE SPECIAL MASTER: All right. Let's take a break for five or ten minutes.

(Whereupon, a short
(recess was taken.

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THE SPECIAL MASTER: Okay, we will please come to order.

MR. CLEAR: Yes, Your Honor. I would like to offer for introduction into evidence Government Exhibit U.S. WRIR 247, which is the side roll diagram.

MR. WHITE: Could I voir dire for just one moment, please?

MR. CLEAR: Sure.

THE SPECIAL MASTER: Sure.

MR. WHITE: Would you put it up on the podium, and maybe I can voir dire from here.

<u>VOIR DIRE EXAMINATION</u>

BY MR. WHITE:

Q Wold, if you know -- excuse me -- Dr. Mesghinna, if you know --

A That's okay.

Q What is the elevation or height of the pipe which runs down the center of those wheels on the side roll to which you received the cost quotations from the man in Riverton, I believe Mr. Shepard, Tom Shepard?

A Yes, yes. The wheels are 76 inches in diameter.

Q Seventy-six inches in diameter?

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A Uh-huh.

THE SPECIAL MASTER: The wheels are 76 --

THE WITNESS: So you have --

Q So you are talking about --

A So the height of the pipeline would be half of that, which would be 38 inches above the ground.

Q With respect to the corn which you are growing in this area, what is the height of the corn?

A Corn grows from -- it can grow as high as probably six feet.

THE SPECIAL MASTER: That's an interesting question. With respect to the corn we are growing in this area, that's a real interesting question.

MR. WHITE: No further questions on voir dire, Your Honor.

THE SPECIAL MASTER: I think in regard to the corn grown in the North Crowheart area I thought he said just the opposite, you eliminated the five percent corn --

MR. WHITE: The question had to do with the corn that's being grown in the area which he done his work, which would extend beyond the

North Crowheart, and all I was trying to point out is corn grows to six feet and that pipe is 38 inches. He might have difficulty in irrigation.

THE SPECIAL MASTER: Especially in the second half of irrigation, that's for sure.

MR. WHITE: I have no objection to the exhibit for illustrative purposes.

THE SPECIAL MASTER: Thank you, Mr. White. United States Exhibit WRIR C-247 is admitted into evidence. This is a diagram of the side roll.

(Whereupon, United States
(Exhibit WRIR C-247 is
(hereby admitted into
(evidence.

THE WITNESS: However, I would like to make a comment on what has been said.

THE SPECIAL MASTER: All right, very well. Please proceed.

MR. WHITE: Do I have rebuttal, Your Honor?

THE WITNESS: Okay, we perfectly understand and we perfectly know that the side rolls that we have in here cannot take corn, especially before harvest, but there are side rolls

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which are up to ten feet that I know of, at least in diameter.

Let's forget that, and for convenience sake we have assumed that the corn would be irrigated by hand roll.

THE SPECIAL MASTER: Okay.

* * * * *

DIRECT EXAMINATION (CONTINUED)

BY MR. CLEAR:

Q Well, before the break we were discussing the cost of the field layout and what information you gathered from that. Assuming you have gathered all that information on the costs, what did you do with that?

A Well, you know, there are -- although I don't want to go into details as I have been told there are other things besides the lateral costs. There are the stick-up costs and the valves, and so on, have been included in these costs. Then actually determining the overall costs of all these things, we added it in, we determined the cost per acre of the on-farm system. So what it means is there are several costs that enter into the overall investment costs of capital costs in the irrigation system. One is the on-farms system cost. The second is pipeline network costs. The third is pump and pumping plant costs. The fourth is what you call "Canal and related structure costs". The fifth is drainage costs.

And there is another cost, if we may, which

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does not much have to do with the system as such, but what we term as engineering and contingencies, and that has been included in the --

THE SPECIAL MASTER: What was that first word? That was contingencies and -- ?

THE WITNESS: Engineering.

THE SPECIAL MASTER: Engineering contingencies.

THE WITNESS: Yes.

A So for what we have determined to make things simpler and faster is determined on-farm system costs on per acre base.

Q (By Mr. Clear) You determined the on-farm system costs on a per acre basis?

A Yes. So now we find the cost of pipeline network and ground our way as we go.

Q Okay. Do you want to go onto the pipe network system? Do you want this other drawing of the -- I'll show it to you --

A This one will do, I guess, (indicating).

Q That one will do?

A Yeah.

Q Okay.

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A I better go up and --

Q If you want, yeah. Use your pointer, I think.

A Thank you.

(Standing at the board.

As I have pointed out before, we have been discussing about this thing so far and also the valves needed there. Okay. But we have to -- we have the sprinkler system, we have the on-farm system, but we have to supply water to it and we have to know two things:

One is, how much water do we supply to it; and the other thing is, what do we need to supply it?

So the network that starts from the pump stations up to the farm level, including the distribution line and field main line are -- we are calling them the pipe network system. So what we are trying to do now is we're trying to determine the sizes necessary and lengths necessary for this pipeline network and find out and determine the costs of these lines of the pipeline network..

So the pipeline network -- pipeline network is the network between the pump -- pumps and

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on-farm systems.

THE SPECIAL MASTER: Is this the pipe network or the pipeline network?

THE WITNESS: Pipeline network.

Q (By Mr. Clear) On your -- on 247, that diagram, you have a pumping station and distribution line serving one field?

A Yes.

Q Is that in fact how it will operate?

A Well, this is a very simplistic way, just to show how the thing is. But a pumping plant can serve several fields, only two fields, or probably even one field. It depends on the configuration of the area and where we are in relation in elevations and so on. So in reality, really there are more than on farms. that are supplied by a given pump station. Okay.

So the next thing to do is to design our pipeline network. In order to design our pipeline network, we have to input the results that we have got in the on-farm systems design. So what did we get from the on-farm system design? From the on-farm system design we got

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results in terms of gross irrigation requirements per irrigation, and we also determined the irrigation frequency. We also said that we'll irrigate twice a day and about 120 feet per day and based on this, we'll determine the Q or discharge required for a given pumping plant station.

There are, however, many fields, and we have to determine the number of -- the flow necessary for that.

Q The what necessary?

A Flow, F-l-o-w.

THE SPECIAL MASTER: Flow.

A Yes, flow necessary for each pumping station; okay? The formula for determining the flow or discharge is -- I can't state it right away, just sitting here, if you don't mind.

A Q is equal to Discharge GPM -- gallons per minute -- equals 453 times A -- A stands for acres -- times D -- D stands for gross depths of irrigation, which we have already found -- divided by F times H -- F is the irrigation frequency in days, and H is the number of operation hours per day.

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THE SPECIAL MASTER: The number of -- ?

THE WITNESS: Operation hours per day.

THE SPECIAL MASTER: All right. Operating hours per day.

THE WITNESS: Yes.

A Okay. Now, we determined the GPM necessary for a given --

THE SPECIAL MASTER: The what necessary?

THE WITNESS: Gallons per minute.

THE SPECIAL MASTER: Right.

A -- for a given pumping station. If we know the acreages, then we can determine the flow necessary; okay. But this is a total flow that should go out for, say, 20 fills in a given pump station. This is at the head of -- at the head of the pumping plant. But the pumping plant distributes to every field and the amount of water that goes to every field is different from the other, depending on the acreage from each field. If there is a line that goes this way and there are 100 acres, the amount of water that flows through that land should be the flow necessary for that 100 acres. If there is a line that passes long distance to supply 500 acres, then it has to carry the amount of water necessary for 500 acres.

In essence, what I'm trying to say is there are different flows in different pipeline networks. So we have to size the pipeline network based on the flows that pass or go to each of these -- to each of these lines to serve the acreage there.

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THE WITNESS: Now, in order to size our pipeline network, we have to make some criterions. The criterion, for example, one of the criterions that we have used is to -- not to go above seven feet per second in velocity. Let's limit ourselves to seven feet per second.

Q . (By Mr. Clear) Why do we do that?

A. Well, that is a standard procedure in design of pipelines. It goes seven to ten and so on. So it's better to be on the seven-feet per second, which is more conservative. Okay, so we limit ourselves in that seven feet per second. The other thing that we have taken into consideration is when water flows through a pipe, there will be head losses, there will be losses due to friction. There will be losses due to friction.

THE SPECIAL MASTER: There will be losses due to friction?

THE WITNESS: Yes.

THE SPECIAL MASTER: Even in a closed pipe?

THE WITNESS: Yes, even in a closed pipe. There is always friction -- when the water flows through the pipe, there will be friction on the inside part of the pipe where the water passes. So in order to overcome that friction, we need more energy.

Q. (By Mr. Clear) When you say there will be loss due to friction, you mean losses of water or losses of what?

A . No, no.

THE SPECIAL MASTER: Of energy.

THE WITNESS: Of energy.

THE SPECIAL MASTER: The loss of pressure.

THE WITNESS: Yeah, loss of pressure.

THE SPECIAL MASTER: All right.

THE WITNESS: So that should be counted for. So in order to determine that, we will call it sub F head loss due to friction, we used an equation by Hazen Williams. This is a standard equation in civil engineering in pipeline network design.

If I remember it correctly, the equation states that H_F which is in feet of head loss, equals to Q, which is in GPM, to the power of 1.852 times the length times 10.44 over C, which is Hazen Williams' coefficient to the power of 1.852 times D, the diameter of the pipe in inches, to the power of 1.852. This will give head loss in feet.

Okay, as it has been stated earlier, when we said head loss, it is really pressure. But we can relate it also to feet because in water, two points of one feet of head loss is equal to 1 PSI or one pound per square inch of head loss. So the head loss that I said is really pressure loss, but we can relate it to -- in terms of feet by this formulation.

Okay. Now, we have all the necessary instruments and methods of determining the size, the friction losses and so on so we size our pipes. Okay, after sizing a pipe in a given pumping plant, there will be several kinds of size, and the smallest pipe size that we have used is six-inch pipe.

Q. Six inch in diameter?

A. Six inch in diameter. And our pipes are from six to twelve inch PVC, which are plastic pipes.

Q. Six to twelve inch what?

A. Plastic pipes, PVC; from fourteen inch to thirty-six inch asbestos cement pipes.

THE SPECIAL MASTER: How do you spell the second word, asbestos --

THE WITNESS: Cement.

THE SPECIAL MASTER: Oh, cement. Very good.

THE WITNESS: The pipeline network I think we only went forty-eight inch, and forty-two inch and forty-eight inch of steel pipes.

Okay, now, using these pipe diameters and based

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on the equations that I gave, we determined the size of the pipes for each -- for a given amount of flow in each direction. Okay, then we determined costs. We have to add the costs of the whole pipeline network that goes back and forth. In order to do that what we assumed, which is optional, may not be necessary, we assumed that the pipes will be covered below ground. That's not necessary, but that increases the cost of the pipeline network. That is optional.

So we have added to the cost of pipes the cost of restoring the pipes. The cost of pipes have been determined from several sources. The PVC pipes, we have got it from Riverton, from the same dealer I discussed before, and also from other areas. The ACP pipes for the Wyoming area we got it from the Johns-Manville.

THE SPECIAL MASTER: Would you spell the first name?

THE WITNESS: J-o-h-n-s.

THE REPORTER: And also the last name.

THE SPECIAL MASTER: Manville, headquartered in Denver, Colorado, world headquarters now.

THE WITNESS: Yes, and we received the costs from them. And the steel pipes I believe we used the costs

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from Dodge Guy for heavy construction.

Q. (By Mr. Clear) Dodge?

A. Dodge Guy; Dodge like a car.

THE SPECIAL MASTER: You didn't propose any use of pipe over thirty-six inches over the asbestos cement side in the pipeline network systems, though, did you?

THE WITNESS: I didn't, I used the steel pipes.

THE SPECIAL MASTER: Yeah, but what size is your biggest pipes?

THE WITNESS: Forty-eight inch.

THE SPECIAL MASTER: Forty-eight?

THE WITNESS: In the pipeline network, and that is steel pipe.

Okay, after we determined the costs of the -- what do you call it -- of this material cost we call it, we have to add it in establishing costs below the ground. But I would like to make clear this is not really necessary, but we have this in considering the cost of the site. The cost of installation was added to it, and using the added cost of the pipe costs plus the installation costs, and we must apply each length. What it means is a six-inch pipe of a cost per feet. If we have one thousand length of

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six-inch pipe, then we must multiply it by that cost. If we have twenty-inch pipe, then we must multiply that length of twenty-inch pipe necessary by the cost per feet. So we did this for all the units, for all the pumping plants, and we determined the cost of each pumping plant of pipeline network.

After we determined that, I believe just to be on the safe side, we multiplied it by an extra five percent. There might be some things necessary as to pressure reduced and so on and so forth. In this matter we increased it by five percent, the cost of -- after determining the per acre cost, the per acre cost. The per acre cost of the pipeline network is the total cost of pipeline divided by the total acres of each pumping station. Then after determining each pumping station, we determined the cost of a given unit like North Crowheart or South Crowheart or whatever it is and that way we determined the pipeline network cost on a per-acre basis.

As far as pipeline network is concerned, I tried to make it as concise as possible to this point.

Q. (By Mr. Clear) When we were talking about the on-farm system, you mentioned in there, you mentioned one of the efficiencies and one was a distribution efficiency.

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Is that an efficiency in a pipeline?

A. Okay, let me go into it. I think that's a very important point. I think we are clear on the on-farm efficiency or application efficiency. But in my earlier discussion I said that there are two other efficiencies necessary. One of them is the distribution efficiency, which is between the pump and on-farm system. And there's another efficiency called conveyance efficiency between the diversion point of the river and the pump station. So in this area we need to know, in my discussion area here, we need to know the efficiency of the pipeline network.

Again, in pipeline network there is no hard evidence, no one can find out what efficiency of a certain pipe is. But it is generally believed that conduits, closed pipes, have an efficiency between ninety -- above ninety percent. They go probably up to ninety-eight percent or ninety-seven percent. Based on the kind of configurations that we have and based on our professional judgment, we came up with a ninety-five percent distribution efficiency, and we have allowed for that in our design of the flow that I have stated earlier, so we increased the flow. This does not mean that -- when I say the flow, we are designing the pipes

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so that when I talk about the flows, this has nothing to do with the water claim. This is for the pipe. We are sizing the pipe to take care of the loss, so we did allow a loss in the pipes of five percent loss, which is not much, due to leakage and --

Q. Pardon?

A. Due to the leakage in the pipes and, you know, as a mismanagement and so on in the pipes. So as far as I am concerned, I think this is the most way I can make it as concise as possible on the pipeline network.

Q. Okay. That brings us to the pump and the pumping plant.

A. Yeah. Okay, the pump and pumping plant is -- first of all, let me make it clear. Pump and pumping plant, what we mean by this is the pumping plant includes the structure --

THE SPECIAL MASTER: Includes what?

THE WITNESS: The structure.

THE SPECIAL MASTER: Structure of what, the pumping plant or several pumping stations?

THE WITNESS: Yes.

THE SPECIAL MASTER: Of several pumping stations?

THE WITNESS: Yes, yes.

THE SPECIAL MASTER: All right.

THE WITNESS: This pump station here requires this

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structure in order for the water to enter to the pump. So we include the pump.

THE SPECIAL MASTER: Pump and cylinder and some screens?

THE WITNESS: The screens, yes, screens and structures.

THE SPECIAL MASTER: Yeah, yeah.

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Q. (By Mr. Clear) I have put on the board the United States Exhibit WRIR C248. Can you describe that?

A. Okay. I think this one shows almost a complete picture of the whole thing. Here we have a diversion structure (witness indicating). First of all this is the river. Let's assume this is the Wind River (witness indicating) and here we have the river and this is called the diversion structure (indicating). We have the head canal structure in here (indicating). We have the spillway in here and water comes --

THE SPECIAL MASTER: Did you find the diversion structure already in place to serve the -- this is kind of a cruel question -- the North Crowheart?

THE WITNESS: Yes.

THE SPECIAL MASTER: In the future? Is it already in place?

THE WITNESS: Yeah, we know where it is going to be.

THE SPECIAL MASTER: Where it is going to be put?

THE WITNESS: Its location and elevation and so on.

THE SPECIAL MASTER: All right.

A. So --

MR. WHITE: Well, Your Honor, I don't think he answered the question.

THE SPECIAL MASTER: Well he said he knows where they are going to put it so I guess there is not one in place.

MR. WHITE: Thank you.

Q. (By Mr. Clear) When you got to canals and related structures, will you describe the diversion structures that you have --

A. Yeah, we'll discuss it quite a bit, if necessary.

Okay. So this is a diversion structure (indicating). There are gates and so on. Here there is a spillway here. You know, and so on. And the water is diverted to the canal, let's call this one North Crowheart Canal, that will make things simpler. And the pump station is in here (indicating), you know water will enter into the pump station through this and then the pump will pump water and distribute it through the pipeline network as we see it in here and then the pipeline network will distribute it through the laterals.

THE SPECIAL MASTER: And did your work include the cost of pump stations and design pump stations?

THE WITNESS: Yeah, it will include the cost of pump stations and I am almost near to it now.

THE SPECIAL MASTER: All right.

THE WITNESS: Okay. In fact, let me go through it.

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THE SPECIAL MASTER: All right. Very good.

THE WITNESS: Okay. In order to determine the cost of the pump station which I said it includes the pump itself and the prime movers of the pump station it also includes the structures, it also includes the valves, manifolds and so on necessary. Again, I would like to state in here that it's not really necessary to have an over structure in a pump station but we have included the cost for over structure just to be on the safe side. And that can always be subtracted if it is not necessary but at any rate we have included those costs and other costs, such as parking lots and so on and so on.

In order to design a pump what do we need? What do we have to know? What is the most important thing? The most important thing in order to know a pump capacity -- pumps are -- there are, if someone wants to go and wants to buy a pump from a pump dealer he has to know certain things and those things are horse power, what size of horse power do you want? These are the questions that the dealer is going to ask first. The second thing is he would like to know what kind of head are you talking about how high are you planning --

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THE SPECIAL MASTER: To lift your water?

THE WITNESS: To lift your water. And the other thing he's going to ask is how much flow are you talking about, how much flow do you expect your pump to pump out water from the canal? So these questions should be answered so that someone would know about the costs of pumps.

Okay. What are these things? Again, we have to go back to pipeline network. You see what we are doing is we first determined the climate, then we entered the necessary data to determine the evapotranspiration from the climate, then we entered the results that we got from evapotranspiration to on-farm system, and then the result of on-farm system entered into pipeline network. Now we need the results. We get from pipeline network in order to design our pump station. So what did we get from the pipeline network? From the pipeline network I indicated that we determined the head losses of pipe so that is a very important thing in order to determine the capacity of the pump. The other thing that is necessary in order to determine the capacity of the pump meaning that the head that -- that the lift it should serve. We need to know the static head. The static head is nothing but the elevation between the

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pump station and the high point in field. We have to know this. The other thing that we have to know is we have sprinklers there so they need pressure. When the water comes out from the sprinkler, it requires a certain amount of pressure in order to irrigate uniformly. And we assumed fifty-five PSI which is about 127 feet of head. Really nowadays you can go with much less than that in sideroll or on hand-move, less than fifty-five PSI. We can go like forty or even forty-five PSI. But we have used that in order to be on the safe side because the higher head, the higher the head you pump out, the higher the cost of your pump will be. Not only that, your energy will be higher every year.

Okay. So then these three things, the head loss or friction loss in the pipes plus the static head which is the elevation difference plus the pressure required for the sprinklers added all together are called total dynamic head. In reality this is the head that the pump should pump out in order to bring water to the point of interest.

Okay. One thing that we have entered into this is when we determine the head loss, the friction loss in the pipes, we increase it also by five percent in order to account for connections here and there,

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joints here and there which is hard to estimate in terms of head losses. So we increased this. So then we determined the total dynamic head. This is the head that the pump is supposed to pump out water. This is the lift that it's going to pump out water. Okay. Now from my former discussions I gave you Q or the discharge required in a given pumping station. That is, a pump station might have twenty fields, I said before, and we determine that flow necessary for all these fields in GPM, gallons per minute. Okay, so now we have these two things. We have the total dynamic head, we have the discharge required from the pump. Also, in my former discussion, I said that three things are important to know in order to design a pump station. And I said the total dynamic head which we just found out what it is, the discharge or flow in GPM which we found, so one thing is left and that is the brake horsepower.

Q. What is the first word, what horsepower?

A. Brake horsepower.

THE SPECIAL MASTER: Brake.

THE WITNESS: Brake horsepower. That is the horse power in the pump required.

Okay. Now how we determine brake horsepower?

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Brake horsepower is a function of total dynamic head and discharge. And BHP, brake horsepower, if I remember correctly, is the Q in GPM times the total dynamic head divided by 3,960 again divided by the efficiency of the pump. So if we go and do this for each pump station like this will determine the brake horsepower.

THE SPECIAL MASTER: This is fascinating to me. Is that formula devised to the person to whose name has been given to it, the formula? Is that from the British classification of horse power, brake horsepower?

THE WITNESS: Yeah, it is a British classification.

THE SPECIAL MASTER: Okay.

THE WITNESS: Okay. So this is the way on how to determine the brake horsepower.

Q. (By Mr. Clear) Uh-huh.

A. Okay. The next thing is -- now we know the brake horse power meaning we know the pump size. Someone can go to the dealer for pumps, Berkley pumps for that matter. He knows all the necessary constituents there and can ask for the pump cost.

Okay. But we did not go to the pump dealer and as the costs, you know, of each. We asks several costs but that does not really help us very much because there

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are, as I said, other structures necessary there. So we depended on the works that have done by the USBR in this aspect.

Q. Bureau of Reclamation?

A. Bureau of Reclamation.

A But we did not take their word as a Bible, and we have also seen other projects and --

THE SPECIAL MASTER: Did you inquire of pump manufacturers in the Rocky Mountain West to buy them directly from them rather than from dealers?

THE WITNESS: Well, when I am saying "Dealers" I meant the overall industries, including dealers and --

THE SPECIAL MASTER: Distributers, jobbers?

THE WITNESS: Yes.

A Okay. So as I have indicated if, and you'll see it in my summary report, I have cited the reference, and those I have given in my deposition, the reference on the different graphs used in determining the cost of pumping station by USBR and we mostly follow that one. But also, we have also compared it with other costs that have been done before this time, and we were satisfied with our results and in general what those graphs are. I don't know if it is necessary to go one by one,

Q (By Mr. Clear) No, I don't think so.

THE SPECIAL MASTER: You can summarize it.

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A Just to have what you call "Q flows", the cubic feet per second. Then you have the total dynamic head, then you get what you call the cost of pumping and then from -- based on that, and determine the cost of structures and so on. It is just a mechanical thing. But that is 1968 prices.

Q Um-hum.

A But --

THE SPECIAL MASTER: Then the prices in your report are 1968 prices?

THE WITNESS: No. I will come to it.

A Those guidelines given by the Bureau of Reclamation are 1968 costs, but we indexed them to 1979 costs, because all our costs are 1979 costs. Everything is based on 1979.

So after we came up with the overall pumping plant costs, really what we did is we have all these different graphs and we lumped them up into one graph, you know, much easier. You can -- I mean the office studied several of them and we lumped them up to one graph.

What you do is first find the cost of a

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pump based on the pump, then you can determine overall costs. One graph would do -- in fact two graphs, really. The first graph determines based on pump costs, then determine the pumping plant costs.

THE SPECIAL MASTER: Give me that distinction again. What additions are there for pumping plant costs not included in pump costs?

THE WITNESS: Okay. Let me clarify it more, then.

The graphs given by USBR are several graphs. One is for the pump itself; another one is for manifolds; another one for the structures, and so on. Okay.

So what we did is first we went on and determined different size of pumps in using that one -- using those guidelines, using those graphs.

THE SPECIAL MASTER: Um-hum.

THE WITNESS: And then we said there must be some kind of relationship in here. So we related it to just the pump costs.

If I determined the pump costs, how can

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I determine the overall pumping plant costs? Just by knowing if, say, for example, the pump cost is, let's say $50,000, what will be the cost of the overall pumping plant? Okay, then we made a graph out of their graph, one graph instead of four, five. We made one graph and by just knowing the cost of the pump --

THE SPECIAL MASTER: You extrapolated --

THE WITNESS: -- we extrapolate and find out the cost of all the whole pumping plant. That cuts the work and the tediousness of it.

So we did this for all the pumping plants in all the five units, and after determining the cost of each pumping plant, we added the cost of each pumping plant. After adding the cost of each pumping plant, then we determined the cost per acre on the pumping plant.

MR. CLEAR: Your Honor, I think he's been on the stand another hour, and --

THE SPECIAL MASTER: You divided the number of acres in the unit to the cost and got the cost of the pumping plant; is that it?

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THE WITNESS: That's about it, yes.

THE SPECIAL MASTER: Okay. It's four o'clock. Are we going to set the record today, or should we adjourn to tomorrow?

MR. CLEAR: He's been on the stand since eight o'clock this morning and I think in fairness to the witness he's been an accurate witness, but --

THE SPECIAL MASTER: He's already put in an eight-hour day; he doesn't have to put in a nine-hour day.

We will be in session again at eight o'clock in the morning. We will go from eight until two if you want to bring sandwiches and work straight through, or we could break at twelve --

MR. SACHSE: Could we go --

MR. WHITE: I'd already agreed to let Mr. Sachse go home at noon.

THE SPECIAL MASTER: Did you?

MR. WHITE: And I'd like to ask if we bring sandwiches that we go to one o'clock.

MR. SACHSE: I could catch the plane if we went until one o'clock.

MR. MEMBRINO; Your Honor, it's rough to

get back east --

THE SPECIAL MASTER: There's no way. I moved west and -- just a minute; the record is closed. We'll be in session again at eight o'clock in the morning.

(Proceedings recessed
(at approximately
(4:10 p.m.

* * * * *

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INDEX TO EXHIBITS

REPORTERS' CERTIFICATE

State of Wyoming)
: SS
County of Laramie)

We, Lamont Miller, Mary Nelson and Monika Fleischli, Registered Professional and Certified Reporters and Notaries Public, hereby certify that we did at the time, date and place, as set forth, report the proceedings had before the Honorable Teno Roncalio, Special Master Presiding, in stenotype; that the foregoing pages, numbered 3978-4196, inclusive, constitute a true, correct and complete transcript of our stenographic notes as reduced to typewritten form under our direction.

We further certify that we are not agents, attorneys or counsel to any of the parties hereto, nor are we interested in the outcome thereof.

Dated this 23rd day of April, 1981.

LAMONT MILLER
Registered Professional
Reporter

MARY NELSON
Registered Professional
Reporter

MONIKA FLEISCHLI
Certified Shorthand Reporter

Lamont Miller - Notary Public
COUNTY OF LARAMIE STATE OF WYOMING
My Commission Expires March 29, 1983