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case # 4993

File # 153

4404

1   IN THE DISTRICT COURT FOR THE FIFTH JUDICIAL DISTRICT

2   WASHAKIE COUNTY, STATE OF WYOMING

3

4   IN RE:)
)
5   THE GENERAL ADJUDICATION   )
       OF RIGHTS TO USE WATER   )
6   IN THE BIG HORN RIVER   )   Civil No. 4993
       SYSTEM AND ALL OTHER   )
7   SOURCES, STATE OF WYO-   ) FILED
       MING.   )
)
8   _____ 19.81

9   _Margaret N. Hampton_ CLERK

10   _____ DEPUTY

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15   VOLUME 46

16   Afternoon Session

17   Thursday, April 23, 1981

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25   **ORIGINAL**

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

2

3   THE SPECIAL MASTER: Please come to order.

4   Mr. White?

5   MR. WHITE: For the purposes of the record,

6   Your Honor, the State has just been handed seven

7   replacement pages for Dr. Mesghinna's report which

8   we received on Monday.

9   THE SPECIAL MASTER: Very good. Mr. Clear?

10   MR. CLEAR: Your Honor, during the lunch

11   break Dr. Mesghinna reminded me that we have some

12   illustrative exhibits which are helpful I think to

13   explain his testimony. They are real evidentiary

14   in nature, they are more just drawings, but I think

15   they will put things in focus. I don't know whether

16   they have been shown to Mr. White.

17   MR. WHITE: I think most of them have, and

18   as we go through them --

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

20   think.

21   MR. WHITE: If I have any problems, I'll

22   let the Court know, Your Honor.   But I have several

23   of those, pictures of four of them, so we will see

24   if they are the same four.

25   MR. CLEAR: Okay, fine.

1   (CONTINUED) DIRECT EXAMINATION

2   BY MR. CLEAR:

3   Q   Dr. Mesghinna, I have hung on the easel what's

4   been marked as United States Exhibit WRIR

5   C-246. Are you familiar with that exhibit?

6   A   Yeah, I'm familiar.

7   Q   Okay.

8   MR. WHITE: What was the answer? I

9   couldn't hear it from here.

10   THE WITNESS: Yes, I'm very familiar with

11   it.

12   Q   (By Mr. Clear) Is this exhibit relevant or

13   helpful in your explanation of your testimony

14   on evapotranspiration?

15   A   Yeah, it is important not only for evapo-

16   transpiration, but as we go along we can picture

17   what we are talking about, so I can explain

18   really what we mean by crop consumptive use

19   just from this.

20   Q   Ckay.

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

22   Q   Sure.

23   A   Of course, this is the ground that we are

24   irrigating, and let's assume that crops are

25   mesghinna-direct-clear

1   growing, and for time being let's assume there's

2   only one crop there and let's assume that this

3   is alfalfa, just to make things easier. The

4   crop as we can see above the surface, it lives

5   in soil, and below the surface we can see the

6   roots penetrate. Okay, what happens is when we

7   apply water by irrigation, by side roll, this

8   is side roll or other means of irrigation, the

9   water comes out as we can see with these drops.

10   Some of it will be retained on the leaves of the

11   plants, some of the water will enter deep in

12   the roots in here, and some of the water will

13   go out a surface runoff due to the soil. Some

14   of the water will evaporate from the soil

15   surface, and after the water enters down here

16   and taken by the roots of the crop, then the

17   water has demanded by the atmosphere -- or by

18   the climate in here will be transferred from

19   the root zone in the plants. After the plant

20   uses the water, the water will be transpired.

21   The amount of water which we are going to discuss

22   later on that passes the root zone then goes

23   through deep percolation, that is the amount

24   of water that's not going to be used by the plant

25   mesghinna-direct-clear

1   at all. It passes beyond the root zone, and

2   then it will be collected by the drains as we

3   can see the drains in here, and it will be taken

4   out from the fields. So really what we discuss

5   when we talk of crop water use, we are merely

6   talking about the transpiration from the plant

7   and evaporation from the soil. That is what

8   makes evapotranspiration equal to transpiration

9   plus evaporation. And as we can see, this will

10   have use in the future, there will be water

11   that's not going to be used by the plant.

12   Some of it goes to surface runoff, some of it

13   goes to deep percolation, and we see how we

14   are going to collect or how we are going to

15   come up with the necessity -- the necessary

16   amount of water for the plant. So I hope this

17   one shows a pictorial view of the situation.

18   THE SPECIAL MASTER: It is helpful.

19   THE WITNESS: Okay.

20   MR. CLEAR: Your Honor, I'll move the

21   admission of that exhibit just for illustrative

22   purposes.

23   THE SPECIAL MASTER: No objection or no

24   voir dire?

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1   MR. WHITE: No objection with respect --

2   THE SPECIAL MASTER: So WRIR C-246 is

3 admitted into evidence. It is a crop water

4 use illustration.

5   (Whereupon, U.S. Exhibit
                       (WRIR C-246 was hereby

6   (admitted into evidence.

7 Q (By Mr. Clear) Dr. Mesghinna, I think where

8   we stopped at lunchtime was I think we had

9   gone into the third step of evapotranspiration,

10   we had gone up to the point where you had

11   described how in general terms you formulate

12   the irrigation consumptive use or net irrigation

13   requirement of a crop. What do you do after

14   that?

15 A Okay. Just to refresh our minds, first we

16   determined the potential evaporation, then

17   we determined the crop consumptive use, and

18   then we determined by subtracting the effective

19   rainfall from the crop consumptive use, we

20   determined the net irrigation requirement, or

21   sometimes I call it irrigation consumptive

22   use. Okay, so we are at this point.

23   If we add all the net irrigation require-

24   ments for all the months in which the crop

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1   is planted --

2   Q   All the months?

3   A   During the months in which the crop is planted

4   or started to use water up to maturity of the

5   crop or harvest of the crop more or less, then

6   that is really the total of all of these months

7   is really the amount of water that the crop

8   requests.

9   Q   The crop itself requires?

10 A   Yes. Okay, but the problem is if we apply the

11   water or if we divert that water to the stream,

12   the net irrigation requirement at the stream.

13   All that water will not reach the point where

14   we want. Some of it will be lost through

15   seepage, some of it will be lost through

16   leakage in the pipeline, and some of it, as

17   we said, through deep percolation. Some of it

18   is surface runoff, so we remain with very few

19   water, which is not enough for the plant. So

20   we have to correct this thing in order to get

21   enough water at the site or at the fields.

22   In order to do this there are several

23   things that have to be determined. One thing

24   is we have to determine what is our efficiency

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1   at the -- what is our efficiency or water use

2   at the farm level. What is our efficiency

3   between the farms and the pumps.

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1   We call that distribution efficiency and another

2 thing we have to consider is what is our efficiency

3 between the pumps via the canal up the diversion

4 structure. That is called conveyance efficiency

5 and we have to determine that. And efficiency that

6 we need at the farm level is called application

7 efficiency or sometimes they call it on-farm efficiency.

8 So prior to the determining the gross water requirement

9 or water duty for that matter, we have to know this

10 different irrigation efficiencies step by step.

11 Q   You have to know how much water is lost before it

12   gets to the plants?

13 A   Yes. We have to do that. If we know the loss of

14   water, then we have to add that loss of water to

15   the necessary irrigation requirement, and then

16   we divert that water.

17   Okay. This determination of efficiency in the

18 field of irrigation is quite complex and it is not

19 an easy method and there might be fewer field formulas

20 here and there, but people have to use their judgment

21 on it as much as they can. While I am here, it is

22 important to note, I guess, that irrigation is not --

23 the field of irrigation is not really a complete

24 science. It is a combination of science and art,

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1   more or less, so there are a lot of judgments that

2   enter into the works of irrigation design, meaning

3   scientific judgments. They are not judgments just

4   from the -- (pause) Okay.

5   So our work is now to determine the application

6   efficiency. After we find that efficiency, we deter-

7   mine the distribution efficiency and then the convey-

8   ance efficiency. After we determine all of those,

9   there is what we call "overall efficiency". So that

10   is a combination of these three efficiencies in a

11   sense, in short mathematical, for overall efficiency

12   is nothing but application efficiency times dis-

13   tribution efficiency times conveyance efficiency.

14   THE SPECIAL MASTER: In that formula, do you

15   apply the credit for return of detour to outlet

16   or a credit for deep percolation of engine to outlet,

17   or for --

18   THE WITNESS: In that formula we don't consider

19   the water that can be used after it is outlet,

20   because we believe that eventually that water is

21   going to find its way in the streams back and can

22   be used again. So really what we are trying to do

23   is quantify the amount of water lost on the way

24   coming from the diversion to the point of water use.

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1   Now, before I go to determining the overall

2 efficiency, now, we have some kind of perspective

3 what we are looking for. I think it would be a

4 better idea if we enter into the on-farm systems

5 design, because while we are there we'll discuss

6 the application efficiency.

7   THE SPECIAL MASTER: Let's do it.

8   THE WITNESS: Okay. I think that is easier.

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

10 Q (By Mr. Clear) So let's go on to number four on

11 farm systems design and can you explain what that

12 is and what you did in relation to it?

13 A When I say "on-farms systems design" I am specifically

14 talking to the fields themselves.

15 Q The fields?

16 A The fields, at the field level. I wish I could show

17 in a map just what a field means, really.

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

19   (At this time Mr. Echohawk and Mr. Clear moved

20 a map to the board.)

21 Q (By Mr. Clear) On the top of the board I just put

22 on the easel is Exhibit WRIR C-249. I don't want

23 you to go into what that shows, but you wanted to

24 show us what you meant by a "field". Is that useful

25 mesghinna-direct-clear

1   to you?

2 A   Yeah. So people will have in their minds what I

3   am talking about, so it's not in the abstract, I

4   just want to show what a field is.

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

6   MR. WHITE: Your Honor, I would like to inter-

7   pose an objection if this is used for anything but

8   illustrative purposes. This exhibit also falls

9   outside of the ten day rule, or within the ten days.

10   THE SPECIAL MASTER: If this is used just for

11   illustrative purposes, I'll overrule the objection.

12   Go ahead.

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25   mesghinna-direct-clear

1 A. Just to show what I mean by fields. As you see, we

2 have different fields. For example, this is one

3 field, this is the boundary by this area. This is

4 another field. This is another field. This is

5 another field. All those areas with the boundaries

6 are fields. So each and every of this field has

7 been studied by itself.

8 So when I say a field, I'm talking of one plot

9 of land. For example, this is one field, you know.

10 THE SPECIAL MASTER: Yeah, one plot of land.

11 THE WITNESS: One plot of land.

12 THE SPECIAL MASTER: Yeah, very good.

13 THE WITNESS: That's what I mean.

14 Q (By Mr. Clear) Okay.

15 A. Okay. When we talk on the on-farm systems design,

16 what we're trying to do is we are trying to put

17 together what we have learned so far. We have

18 learned -- I mean, we have learned what climate

19 is, what cropping pattern is, what evapotranspira-

20 tion is. Okay, so all these things relate to the

21 atmosphere and the plant water needs.

22 Okay, so we have to add into this other things,

23 such as the soil. Okay, HKM has discussed the soil

24 and we have to relate the plant and the soil. We

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1   have to get it together -- we have to put it

2   together. In a sense, what we will do is we will

3   put together the relationship of the plant, the

4   water and the soil.

5 Q   Okay.

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

7   yield.

8 Q   Uh-huh.

9 A.   So, the important thing is to put all these things

10   for each of the fields, the crop water requirements

11   and the soil characteristics. Now, what are the

12   most important things in terms of system design,

13   crop characteristics? Well, the most important or

14   a paramount important crop characteristic is the

15   water-holding capacity of the soil.

16 Q   Of the soil? Should we go back to your -- to that

17   other drawing we had or --

18 A.   Okay.

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

20 A.   Yeah, we can do that.

21   Okay, we have studied the atmosphere in here

22   as evapotranspiration and crop consumptive use, and

23   now the plant is there and we want to relate the

24   water that is to be absorbed in here later to be

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1   used by the plants. Unless we know the capacity of

2   the water to hold in here (indicating), we won't be

3   able to define the plant. We won't be able to design

4   our system. So we have to know. We have to quantify

5   how much water is available, can be available, can be

6   stored to be used by the plant in the subsurface of

7   the soil.

8   The other thing of importance in this on-farm

9   system design is the intake rate of the soil. The

10   intake rate of the soil is nothing but the amount

11   of water that enters into the soil that can perco-

12   late into the soil per hour. In most cases it is --

13   it's units or inches per hour.

14   THE SPECIAL MASTER: Is the term -- Yesterday

15   we lived all day long with horizontal --

16   MR. WHITE: Do you mean hydraulic conductivity?

17   THE SPECIAL MASTER: Yeah, we talked about

18   horizontal conductivity. Could this be vertical

19   gravity hydraulic conductivity?

20   THE WITNESS: Yes, sir, you can call it more

21   -- it is the vertical --

22   THE SPECIAL MASTER: Saturation or absorption?

23   THE WITNESS: Yeah, vertical entrance of water.

24   The ability of the water to enter through the soil.

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1   Let me give you an example. Let's take clay

2   soil. Clay is a very tight soil, meaning that it

3   is a very cohesive soil. The texture of the soil

4   is held together and the soils are so fine in order

5   for water to penetrate through it, it takes more

6   time. However, if we have granular soil, which is

7   soil like sand, and if we apply water into it, the

8   water will be absorbed, enter quite easily as com-

9   pared to clay.

10   So when we say intake rate of the soil, it is

11   the ability of the soil to let water enter down in

12   here.

13   THE SPECIAL MASTER: Does your science include

14   the science and study of texture of soils to deter-

15   mine that, too, or do you accept the other profes-

16   sionals' judgment on that?

17   THE WITNESS: Well, we have to know the texture

18   of the soil, and that is very important. And I will

19   come to it --

20   THE SPECIAL MASTER: Okay.

21   THE WITNESS: -- later on.

22   THE SPECIAL MASTER: All right.

23   A.   (Resumed) The other thing of importance in the

24   on-farm system design besides water-holding capacity

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1 and intake rate is the root depths of the crop.

2 What I mean by this is every crop has an ability

3 to penetrate into the ground and take water from

4 the ground. Some of them are very efficient. They

5 can go down, way down, in the ground and take water,

6 and some of them are not that efficient and they

7 can't take water, only from the upper part of the

8 soil.

9 To give you an example, for example, alfalfa

10 can go deep as compared to, say, for example, small

11 grain or pasture which have shallower root depths.

12 So the soil depths should be related to the root

13 depths of the plants.

14 Okay. So, now, I discussed about what water-

15 holding capacity of the soil, I discussed about the

16 intake rate of the soil, I discussed about the root

17 depths of the soil, and I discussed earlier before

18 the crop consumptive use of the plant. So we have

19 defined really the immediate environment of the

20 plant.

21 The next thing is we have to put these things

22 together so as that they can be interrelated because

23 one without the other cannot work.

24 Okay, just to give more explanation so as that

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1   we'll have clear -- so that it will be clear in the

2   minds of everyone: the higher the water capacity,

3   the higher the water-holding capacity of the soil,

4   the better the soil is. The reason for this is be-

5   cause if -- what we're trying to say is if I can

6   store more water in the root zone, if I can store

7   more water in the root zone, then it will take me

8   more days to irrigate (sic). I don't have to come

9   every now and then and irrigate because there is

10 water stored in the root zone in here. And on the

11 other side, let's see what intake rate means. If

12 the soil is very tight soil and water cannot pene-

13 trate easily, what will happen is if I put more

14 water into it, either there will be ponding or sur-

15 face runoff or I have to change my management, and

16 that is I have to put the crop -- I mean, I have to

17 apply the water in very slow manner so as that most

18 of the water can enter down into the soil.

19   So what we are trying to say is now we have to

20 relate the intake rate of the soil with the sprinkler

21 itself. Because if I bring a sprinkler that has a

22 nozzle size, high size, it will apply water, the

23 amount of water that I want per day. But most of

24 the water might be lost.

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1   So what I have to do is I have to be careful

2   that I have to apply the water, if the soil is

3   tight, I have to apply the water in a small amount

4   so that -- to be sure that the water enters into

5   the ground. So these are the things that we want

6   to relate together.

7   Okay, how do you determine water-holding capa-

8   city? First of all, water-holding capacity is mainly

9   a function of texture of the soil. So each soil, say,

10   sandy soil or clay soil or silt soil or gravelly soil

11   has a certain -- can hold a certain amount of water.

12   It can hold a certain amount of water in it.

13   And how do we determine that each of these soils

14   can hold a certain amount of water? Well, this one

15   is -- a lot of work has been done on this and some

16   irrigation handbooks relate textures versus water-

17   holding capacity. And we used some handbooks, such

18   as Irrigation Handbook by Amos; secondly, we used

19   the Israelson and Hanson to a certain extent, which

20   is Irrigation Principles book from Utah State. We

21   also have used the water-holding capacity that has

22   been done in connection at the Midvale Irrigation

23   District, which is Soil Survey of Riverton.

24   So, we put all these things together and we

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1   came up with water-holding capacity versus texture

2   and the same thing with intake rate. Okay, but what

3   we know is only a certain texture can have a certain

4   water-holding capacity. But the ground, the actual

5   ground is not homogenous, it is not all clayey, it is

6   not all sand or it is not all loam. It changes. It

7   is heterogenous. So we have to determine the

8   weighted average of the water-holding capacity in

9   the ground.

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1   THE SPECIAL MASTER: For each plot of

2 ground?

3   THE WITNESS: Yes, for each volume that

4 we have, for each plot.

5   THE SPECIAL MASTER: For each plot?

6   THE WITNESS: Well, wherever there is a

7 boring hole that has been --

8   THE SPECIAL MASTER: A bored hole?

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

10 holes?

11 A Yes, and HKM provides us with soil logs. We

12   took their soil logs and we plotted them in

13   our working plans, our working plans. After

14   we did that we took each and every log that we

15   can and we see on the soil profile what kind

16   of soil textures are there, complete soil

17   textures are there, then we determined the

18   weighted water holding capacity. I think it

19   would be a good idea if I can jot down what

20   these water holding capacities --

21   THE SPECIAL MASTER: Why don't you use

22 the other half of the blackboard, if it's

23 agreeable to Counsel. You can bring that

24 exhibit down, too, if you wish. Okay.

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1   (Brief pause.

2   THE SPECIAL MASTER: You can put it down.

3 I wish you would, in fact. That's better.

4 Just set it down anywhere.

5   THE WITNESS: Let's assume this is the

6 ground, ground surface.

7   (Whereupon, the witness
                (is drawing on the black-

8   (board.

9   Here are the plants you're growing, and

10 here are roots, roots growing over here. Now,

11 let's assume there is a log here, blank log

12 that goes like this. Let's assume that the

13 soil has -- log has different soil textures.

14 And let's call, for simplicities sake, the first

15 part D_1, depths 1. It can be feet or feets,

16 whatever. The second one is D_2; third one is

17 D_3; fourth, D_4. Okay. And I have stated earlier

18 that for each of the textures, since we know

19 the texture in here, we know the water holding

20 capacity for each of the textures. Let's call

21 this one water holding capacity $_1$, water holding

22 capacity $_2$, water holding capacity $_3$, water

23 holding capacity $_4$. We know the water holding

24 capacities for each of the stratum in here, but

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1   we don't know the hole depths, so we have

2   to devise a way on how to estimate this overall

3   water holding capacity or average weighted water

4   holding capacity.

5   We know these depths from here because it

6   is in the log. For the time being I want to

7   call this one (witness indicating) D weighted,

8   D depths weighted total, weighted total.

9   THE SPECIAL MASTER: Weighted total depths?

10   Weighted total.

11   THE WITNESS: Now, the overall water

12   holding capacity that I have to discuss about,

13   the whole thing in here is water holding capacity

14   weighted of overall is equal to Depths $_1$ divided

15   by water holding capacity $_1$ times total Depths,

16   DW_T plus the second Depths over the second water

17   holding capacity times DW_T, plus the third Depths

18   over water holding capacity $_3$ times DW_T, plus

19   Depths $_4$ over water holding capacity $_4$ times

20   DW_2 -- oh my God.

21   This is DW_T times water holding capacity $_1$,

22   (witness indicating), DW_T times water holding

23   capacity $_2$, DW_T times water holding capacity $_3$,

24   DW_T times water holding capacity $_4$. In a sense

25   mesghinna-direct-clear

1   what we are doing is the ratio of the water

2   holding capacity of this one over all the

3   depths is this (indicating), Depths $_1$ over total

4   depths. Means that the proportion of water

5   holding capacity of this depths is this times

6   the water holding capacity $_1$.

7   THE SPECIAL MASTER: Why can't you take

8   finding the simplistic root of my moronic

9   mind, which should go to add 1, 2, 3 and 4,

10 getting tne total of what, ten, and divide by

11 four and come up with a two and a half of the

12 weighted average for that area?

13   THE WITNESS: Okay, that would be good if

14 all these are equal, all the depths are equal,

15 but the depths are not equal. I mean, the

16 strata of the soil are not, you know, made

17 equally. Some of them are --

18   THE SPECIAL MASTER: Deeper?

19   THE WITNESS: The clay might be deeper,

20 and sometimes the soil might be only a few

21 inches or something of that sort. So in order

22 to have a proportionate weighting water

23 holding capacity we have to take into consideration

24 what each soil strata represents in terms of

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1   water holding capacity. So that's the reason

2   we have to go through this long way.

3   THE SPECIAL MASTER: I see your numbers

4   1, 2, 3 and 4 are just designations, they are

5   not your results?

6   THE WITNESS: They are not. This might

7   be only two depths, might be three depths,

8   might only be one, or, I mean, only one soil

9   all the way; it might be seven different kinds

10   of soils. This is just to show the approach

11   of the water. That's why I didn't put different

12   depths -- I mean, two feet, one foot or something

13   of this sort.

14   Okay, this is how we determined the water --

15   weighted water holding capacity of a different --

16   of a different soil log. That soil log, as you

17   will see in the future, will present certain

18   areas on the fields. Now, I said something about

19   DW_T. Now, let me stay here.

20   DW_T is nothing but the weighted total of

21   the crops. So DW_T is always about 4.5 feet.

22   MR. CLEAR: I think you -- explain in

23   lay terms what the 4.5 feet is.

24   * * * * * *

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1   A   Okay what I am trying to say about the formula,

2   it is -- now we have 67 percent of alfalfa

3   growing there in actuality as is proposed by

4   the economist, and there is 12 percent of corn

5   growing there and the rest is small grain. Now,

6   if we come up with a weighted average of all

7   the crops, there effective root depths, it will

8   be 4.5. Say, for example, if alfalfa is five

9   feet, let's assume -- let's say that, which

10   is usually the case, alfalfa takes water up to

11   depths of five feet down, and if we say corn

12   takes water from 3 to 4 feet, and let's assume

13   it is 3.5 feet and if we assume that small

14   grain takes all the way from about 2.5 feet

15   to about 3.5 or 3.75 feet, if we say on the

16   average it consumes water from as deep as 3.25

17   feet, and if we apply the porportion of this

18   crop in pattern, if we multiply 67 percent by

19   five feet, 12 percent by 3.5 feet, then whatever

20   is left on the small grain, which is -- 16 plus 5

21   in the lower areas -- 21 percent by 3.25, we'll

22   come up with a weighted root depth of 4.5. So

23   it is the weighted root depths of all the crops,

24   you see. We have to combine them together.

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1   Q   That's your weighted average root depths?

2   A   That's the weighted average root depth.

3   Now, the question might arise that,

4   "Hey, some of the logs are quite shallow as

5   have been provided by HKM and some of them

6   are deep, greater than 4.5 feet. What do you

7   do on this problem?"

8   Okay. Let me go through the simpliest

9   one first. If it is greater than 4.5 feet,

10   well and good. You assume if the plant can

11   take water from the 4.5 feet, beyond that it

12   can't take it. So if we have six feet of

13   water, we don't say the plant takes from six

14   feet down. It takes only up to 4.5 feet.

15   However, there is a problem that arises

16   there. How do you know the rest of the stuff

17   if the borings are shallower than 4.5 --

18   Q   Let me see if I understand. If the boring was

19   four and -- four and a half feet, you disregarded

20   any information below four and a half feet?

21   A   Yes, because the assumption that we have to

22   make is the plant can take water only up to

23   depths of 4.5 feet.

24   Q   And everything below that is irrelevant?

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1   A   As far as the plant is concerned.   It's going

2   to deep percolation or some sort.   Okay.

3   You see, plants have -- they have some

4   kind of mechanism.   If the head is -- the head

5   that they have to draw is too much for them,

6   they can't take it, you know.   So it can't take --

7   we're saying that the plants on the average are

8   not taking below 4.5 feet.

9   Q   Now we go to the example with the HKM bore

10   hole which did not go to 4.5 feet, and you're

11   going to tell us what you did there to determine

12   the water holding capacity?

13 A   Okay, yes.   Now, let's assume that for that matter

14   we have only a log that says 12 inch --

15   THE SPECIAL MASTER: Says what?

16   THE WITNESS: Twelve inch.

17   THE SPECIAL MASTER: One foot.

18 A   Just to make things easier, what do we do if

19   this 12 inch -- you tell me that you need 4.5

20   feet of root depths and how are we going to

21   grow crop there?   Okay.

22   So in order to answer this question, first

23   what we do is we take the 12 inch, which is

24   equal to one feet, so the water holding capacity

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1   total would equal that one feet which is 12

2   inch of this one, over 12.5 feet, times the

3   water from the capacity of that soil texture.

4   What we do is if HKM gives or says that the

5   soil below this is gravelly soil --

6   THE SPECIAL MASTER: What if they say the

7   soil beyond that one foot is a barrier?

8   THE WITNESS: By definition the barrier

9   is at six feet.

10 THE SPECIAL MASTER: You don't deal with

11 barriers closer to the surface than six feet?

12 THE WITNESS: We will when it comes to

13 drainage.

14 THE   SPECIAL MASTER: Go back to your own

15 definition, then.   It's gravelly.

16 A   Let's say gravelly or for some matter the

17 driller quit his drilling from there, so what

18 we are assuming, we assume the water holding

19 capacity of the rest, 3.5 feet of gravelly soil.

20 Gravelly soil has a very low water holding

21 capacity, so what we are doing is we are

22 punishing ourselves on the water holding capacity

23 on the rest of the profile.   What it means is

24 that we are taking a conservative estimate,

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1   meaning we are saying that the soil can hold

2   only very few water and as I have stated it

3   earlier, if the water can hold a small amount

4   of water, then you have to irrigate every now

5   and then, which means more equipment, which

6   means more cost on your investment. As we see

7   it, later on this will be reflected in some

8   of the units which have more of the sandy or

9   gravelly soil, they have the higher costs.

10   THE SPECIAL MASTER: You would identify

11   those as less efficient or more expensive?

12   THE WITNESS: More expensive, and even

13   less efficient, yeah.

14   THE SPECIAL MASTER: Yeah.

15   A So what we do for the rest of this one, if they

16   say gravelly, then we take all the way gravelly.

17   The 3.5 feet would be gravelly soil, and when

18   we say "Gravel" it's not pure gravel; it has

19   some fine soils into it. It can hold a little

20   amount of water. It can hold it but not as good

21   as loam or clay or silt or even sand soil. So

22   the rest, 3.5 feet, will be 3.5 feet over 4.5

23   feet times the water holding capacity of that

24   specific soil. So this is how we come up with

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1 the different kinds of soil depths that we

2 have for all the areas where we have loss.

3 THE SPECIAL MASTER: Is the science so

4 advanced that computer companies put out hand-

5 held computers on which these formulas can

6 be cranked out and get your answer, or do you

7 just use a computer to do that?

8 THE WITNESS: This part of the area, one

9 has to see each part of the soil, what they call

10 the "Stratum" is a very painstaking job and

11 it has to be done manually.

12 THE SPECIAL MASTER: By hand?

13 THE WITNESS: And people have to spend a

14 lot of time going through this and putting

15 together. But after we put all these things

16 to analyze it, if one has to go through hand

17 calculations, it will take him years and years

18 probably to come up with what we are trying to

19 show is efficiency and gross water application.

20 So we have a completed program called on

21 farm systems design program.

22

23 * * * * *

24

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1   Q   (By Mr. Clear)   Can I ask you a question?   Now, you

2   were testifying about the weighted average holding

3   capacity of the HKM logs.   How many logs did you

4   figure out the weighted average, weighted holding

5   capacity for?

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

7   Q   Uh-huh.

8   A   But we made sure that each field gets, you know,

9   something.   This does not mean that there are

10   fields, some fields, which don't have, you know,

11   logs of that kind.

12   Q   Uh-huh.

13   A   What we do is we go to the nearest point, to the

14   nearest boring log and we apply that value.

15   Q   What I asked, did you figure out the weighted hold-

16   ing capacity for each and every log?

17   A   For each and ever log.

18   Q   Okay.

19   A   In the North Crowheart there can be hundreds, you

20   know, and we have to do that for each and every

21   log.   We have determined the water-holding capacity

22   and the intake rate for all of these acres.

23   THE SPECIAL MASTER: You've been testifying

24   about an hour.   Do you want to take a little break?

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1   THE WITNESS: That would be very nice.

2   THE SPECIAL MASTER: All right, let's take a

3   ten-minute recess.

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

5   THE SPECIAL MASTER: Shall we come to order,

6   please.

7   Proceed, Mr. Clear.

8   Q   (By Mr. Clear) All right. Are we still on water-

9   holding capacity?

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

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

12   Q   (By Mr. Clear) Okay.

13   A.   And if needed so, we'll come back later on and it

14   will enter into other things and we'll relate it

15   with the other things.

16   Q   Uh-huh. Okay. Now, you have determined the weighted

17   water-holding capacity for each hole and the intake

18   rate for each hole. What did you do with that infor-

19   mation?

20   A.   Okay. Now, we determined this soil characteristic

21   data and we have to relate it with the plant and the

22   crop consumptive use.

23   Q   Uh-huh.

24   A.   And how do we do that? Okay, first, what we have to

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1   do is we have to transfer this data to our working

2   maps.

3   Q   Uh-huh.

4   A   When we transfer it there, there will be the water-

5   logging capacity and the intake rate and the other

6   necessary things.

7   Q   Uh-huh.

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

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

10   the --

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

12   Q   Right.

13   A   Okay.

14   THE SPECIAL MASTER: Which we have called plots,

15   we have called them fields and we have called them

16   tracts. And should we make one word for --

17   MR. CLEAR: We were calling them on-farm systems

18   design. Should we call them fields?

19   THE SPECIAL MASTER: Yeah. Well, that's not

20   literally or figuratively true.

21   MR. WHITE: We would stipulate to "field",

22   Your Honor.

23   THE SPECIAL MASTER: All right, let's use

24   "field" from now on, "field" from now on for the

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1   one word.

2   THE WITNESS: Okay.

3 A. So we transferred the data in each of the fields,

4   and what we have to do is now we have the boundaries

5   of the irrigable lands.

6   THE REPORTER: I'm sorry.

7   THE WITNESS: The irrigable lands --

8   THE SPECIAL MASTER: Irrigable.

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

10   working map.

11   MR. WHITE: Your Honor, I would move to strike

12   the answer because the HKM data which is in evidence

13   all relates to arable.

14   THE SPECIAL MASTER: I was about to --

15   Do you mean arable?

16   THE WITNESS: I mean arable.

17   THE SPECIAL MASTER: Not irrigable, but arable.

18   That is my fault, Lamont, not yours. I tried to

19   prompt the reporter and I loused it up.

20   Okay. Okay. Arable.

21 A. On the arable lands one thing that we have to be

22   careful in putting the fields there is we don't

23   just put the field because it looks nice this way

24   and it looks better that way and so on. We have

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1   to consider some things as to topography of the

2   field as to the slope of the field and so on. And

3   we try to put as much as we can -- this is not al-

4   ways true -- as much as we can we plot the fields

5   so that the sprinkler lateral, the lateral lines

6   will be on slope parallel with the slope of the

7   land.

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

9   A.   Okay. Then after that, after we plotted each field,

10   we try to see the dimensions of the field, meaning

11   the length of the field and the width of the field.

12   This field, when we put the field, it took us a long

13   time and there has been several changes. You know,

14   we improve it every now and then until we think we

15   are near perfection. Of course, we started with

16   84,000 acres of arable land and we have cut it down

17   to less than 54,000. This is due to sometimes leav-

18   ing areas when we square off --

19   Q   Uh-huh.

20   A.   Sometimes mainly too high to irrigate it and, you

21   know, that kind of makes sense.

22   THE SPECIAL MASTER: Just a moment, please.

23   Will the reporter please go back and read that to

24   me, the figures on arable lands reduced to certain

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1   arable lands?

2   (The above portion of the

3   (answer was read back by the
                                 (reporter as follows; "-- we

4   (started with 84,000 acres of
                                 (arable land and we have cut
                                 (it down to less than 54,000.

5   (This is due to sometimes leav-
                                 (ing areas when we square off --"

6

7   THE SPECIAL MASTER: Go ahead, Mr. Clear.

8 Q   (By Mr. Clear) Dr. Mesghinna, you mentioned just

9   a little while ago in laying out your fields, you

10   tried to lay them out parallel to the contours be-

11   cause of slope, is that --

12 A   Yeah, because we want to have the laterals to be

13   as level as we can as much as possible, although

14   in sprinkler irrigation that's not necessary. But

15   it will be better if it is as level as can be. So

16   if we put it parallel with the contour, then there's

17   not much change in the, you know, the differences

18   of slope between the beginning of the lateral and

19   the end of the lateral. The beginning of the lateral

20   is here (indicating) and the end of the lateral is

21   here. So we don't want to have --

22 Q   Excuse me, I thought you were pointing to an exhibit

23   I have just put up. It is United States WRIR C-247,

24   which is another one of the illustrations --

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1 THE SPECIAL MASTER: Entitled, "Side Roll".

2 MR. CLEAR: Entitled, "Side Roll".

3 A. So we'll try -- what we are trying to do is we are

4 trying to, if the contour is going like this (indi-

5 cating), we'll try to put it with the contour as

6 much as we can, but this is not necessarily true in

7 all cases. If we cannot do that, then we have to

8 go the other way, you know.

9 Q (By Mr. Clear) Uh-huh. What's the -- Do you have

10 a limit on the amount of slope in a field or did

11 you --

12 A. Well, as you probably know, according to the soil

13 classification, the maximum you can go is 20 percent

14 slope, 20 percent slope. But as to my recollection,

15 I don't think we have greater than between 10 and

16 15 percent. We have eliminated as much as possible

17 those areas that have high slopes.

18 THE SPECIAL MASTER: Of your total acreage

19 that you're going to recommend, how much of that

20 would be between 10 and 15, relatively little?

21 A. A very, very small, extremely small, probably, oh,

22 this is just approximately, I mean just -- probably

23 10 percent or 5 percent, something of that sort.

24 Well, in order to have a better understanding of

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1   what we're discussing, this is the canal as we can

2   see it and this is a pumping station. It is taking

3   water from the canal. And this is called a distri-

4   bution line, the line that goes from here, which I'm

5   going to discuss later on in detail, and this line

6   is called on-farm main line.

7   THE SPECIAL MASTER: On-farm main line?

8   THE WITNESS: Yeah, or field main line.

9   THE SPECIAL MASTER: Uh-huh.

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

11 THE SPECIAL MASTER: What distinctions are

12 made as to whether those are lined or unlined or

13 what action has been taken to conserve loss of

14 water in a distribution -- Did you deal with those

15 factors?

16 THE WITNESS: Yeah. I'm going to discuss

17 about them later on.

18 THE SPECIAL MASTER: All right, then I'll

19 wait.

20 A. Okay. So we have the canal, we have the distribu-

21 tion line, we have the farm main line and then the

22 -- and the lateral is connected with the farm main

23 line. So when I say "lateral", I'm talking the

24 sprinkler, including the pipes that have the sprinklers

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1   and the wheel of the lateral, this (indicating) and

2   plus the drive unit. That's what I mean by lateral.

3   So the drive unit is the unit, the motor that drives

4   it.

5   THE SPECIAL MASTER: Yeah. Yeah.

6   A. Okay.

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

8   THE SPECIAL MASTER: Are we on No. 5? Did we

9   just sort of naturally gravitate to it?

10   MR. CLEAR: Not quite. We are still on the

11   farm systems.

12   THE SPECIAL MASTER: We are still on farm

13   systems?

14   Q. (By Mr. Clear) I think maybe, Dr. Mesghinna, you

15   ought to just explain the difference. Can you

16   explain it in that 247, the difference between the

17   pipe system and the on-farm system?

18   A. Oh, when we talk of on-farm system, really, we're

19   only dealing with this.

20   THE SPECIAL MASTER: I see.

21   A. And what you call the joints. Other than that --

22   the valves, I mean the valves and also the sprinkler

23   lateral.

24   THE SPECIAL MASTER: Lateral.

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1   THE WITNESS: That is the on-farm system.

2 A.   I haven't touched anything that relates to the dis-

3   tribution line or field main line or canal or any-

4   thing so far.

5   THE SPECIAL MASTER: I see. I see.

6 A.   So I'm only talking now in here because from here

7   we'll move to here, from here we'll move to here

8   (witness indicating several times) and so on to

9   here and then to here and so on.

10   THE SPECIAL MASTER: Yeah, as we go on down

11   the line.

12 Q.   (By Mr. Clear) Well, now, you have laid out the

13   farm or you have laid out the farms --

14 A.   Uh-huh.

15 Q.   -- or fields. And I suppose now we are trying to

16   figure out the sprinkling system we need or the

17   irrigation system, is that right?

18 A.   Uh-huh.

19 Q.   All right.

20 A.   Okay.

21   Now, that we have put the necessary data in

22   order to design our system, on-farm systems design,

23   then we can go ahead and find out what are the

24   necessary things that enter into it. Okay. Now,

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1   we know --

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

3   louder.

4 A.   Okay, we know our water-holding capacity and we

5   know our root depths and sizes of our fields, and

6   now we are ready to crank on and relate the crop,

7   meaning the plant, the soil characteristics and

8   the crop water requirements.

9

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1   THE WITNESS: Okay. But I have to define

2   certain things before I do that, and that is

3   net depths of irrigation.

4   THE SPECIAL MASTER: Net depth of

5   irrigation?

6   THE WITNESS: Yes, net depths of irrigation

7   is the amount of water, the net amount of water

8   that we apply at a given irrigation time. I

9   will define it this way: Net depths of

10   irrigation is equal to the water holding capacity

11   times the root depths times depletions.

12   THE SPECIAL MASTER: What was the last

13   item?

14   THE WITNESS: Depletion.

15   Q   (By Mr. Clear) Well, we have the water

16   holding capacity and we have the root depth.

17   Explain what depletion is, then we'll have all

18   three elements.

19   A   Okay. Depletion is nothing but -- it is the

20   amount of water that is to be used by the

21   plants between irrigations. If we irrigate

22   today in one spot and we come back and we

23   irrigate -- we come back after 12 days, it is

24   the amount of water that has been depleted

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1   between this]2 days.

2   Let me explain it really more because

3   it's a very important thing. When I say

4   water holding capacity, I mean water holding

5   capacity inch per foot. So the water holding

6   capacity inch per foot multiplied by the

7   total depths, which is 4.5, will give us

8   the total amount of water that can be

9   stored in the soil surface, the total

10   amount of water that can be stored in the

11   soil surface.

12   The soil surface has two limits: One

13   is called field capacity.

14   THE SPECIAL MASTER: Field to capacity?

15   THE WITNESS: Yes, field capacity.

16   THE SPECIAL MASTER: Field capacity?

17   THE WITNESS: Field capacity.

18   Q   (By Mr. Clear) Filter or field?

19   A   Field.

20   Q   Field?

21   A   Yes, field, field capacity, and the other

22   limitation is called wilting point.

23   Q   Wilting point?

24   A   Wilting point. Now, let me define it more.

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1   Field capacity is the capacity -- it is the

2   amount of water that is stored when the soil

3   has enough water, is filled with water. That

4   doesn't mean saturation, it is not saturated

5   with water. There is some air to it. It is

6   usually, you know, when we talk about an

7   irrigation, it is usually -- the amount of

8   water stored in a given field after irrigating

9   it, 24 hours after irrigating it, then if you

10   go in and measure that amount of water in

11   that field, that is field capacity.

12   THE SPECIAL MASTER: Twenty-four hours

13   after completing irrigation?

14   THE WITNESS: Yes, after we apply water,

15   because what happens is at -- in saturation

16   there is gravity flow going down, but at field

17   capacity gravity flow ceases, there is no

18   gravity flow, the water is there, it's available

19   for the plant.

20   Okay, the other limit that I brought up

21   is the wilting point. The wilting point is

22   the amount of water left in the soil at which

23   the plant can no longer -- can no longer take

24   water, but dies. It dies, the plant starts to

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1   die.

2   THE SPECIAL MASTER: Because there is

3   simply no longer any water to take?

4   THE WITNESS: There's no water there, it

5   can't take -- it can't suck water from the root

6   zone. So that is called the wilting point.

7   Okay, so if we see in a sense really the

8   difference between field capacity and wilting

9   point, that is the total amount of water

10   available in the root zone. But, should we

11   wait until the plant uses all this water --

12   THE SPECIAL MASTER: You are not going to

13   be a very good farmer.

14   THE WITNESS: You are not going to be a

15   very good farmer. So we have to give some

16   allowance, and in this case we gave it a

17   generous allowance. We have said -- we have

18   assumed that our depletion will be only 50

19   percent. What it means is when 50 percent

20   of the water is finished by the plant,

21   irrigation, add water, don't wait below that.

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

23   A   Well, for plants like alfalfa, you can go way

24   down than 50 percent, you can go 60 or even more

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1 than that, and still the plant will be in good

2 shape. But there are crops that are very

3 sensitive crops like potatoes, and you need

4 to apply water every now and then because they're

5 sensitive crops. We call them sensitive crops.

6 They are not stress resistant, they don't have

7 the resistance of stress of water.

8 　　　　But crops like alfalfa, I think alfalfa

9 is one of the easiest crops to manage than any

10 other crop because it's --

11 　　　　THE SPECIAL MASTER: Do you know offhand

12 if the sugar beet is also stress resistant or

13 can it take a dry spell, the sugar beet?

14 　　　　THE WITNESS: Sugar beet, I will say it's

15 medium as much as anything, so alfalfa is easy

16 to manage really because if a farmer cannot do

17 good in alfalfa, he cannot do good in other crops.

18 Q (By Mr. Clear) So we have the depletion set

19 at 50 percent?

20 A Yes. We could have set it more than 50 percent,

21 but it would be more conservative. It would

22 cost more, you know, if you set it 50 percent

23 rather than 60 percent. But it's better to be

24 on the safe side. But at any rate, in our design

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1   it is at least 50 percent.   In many cases

2   it's not even 50 percent because when you

3   adjust all those intake rates and so on and

4   so on, it makes it harder to hit on 50 percent,

5   you have to be less than 50 percent because

6   if the intake rate is low, meaning that the

7   water cannot take the water anymore, cannot

8   enter anymore, so you have to look for a lower

9   depletion, you know, to satisfy the plant so --

10   which means you have to irrigate it frequently.

11 Q   Okay.

12 A   Okay.

13 Q   So by using the weighted water holding capacity

14   and the root depths times the depletion

15   allowance, we have come up with the net depth

16   of irrigation?

17 A   Yeah.   We determined the net depths of irrigation

18   for each field.   We are talking -- when we talk

19   of fields, just to give you some magnitude,

20   we are talking about like 300 fields just in

21   the Diversion Dam area, in the Diversion Dam

22   climatic zone of North Crowheart.

23 Q   All right.

24   *   *

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1 A We have to go through each of these in the net

2 depths of irrigation. After we determine the net

3 depths of irrigation, what we are saying is we need,

4 the plant needs this amount of water between irri-

5 gations. But that does not mean you have to apply

6 that amount of water to the plant. You need more

7 water to apply to it, because there are some avoid-

8 able and unavoidable water losses and that is where

9 the application efficiency comes.

10 I have stated earlier that I would discuss

11 the application efficiency when it is -- when it

12 is related to the things I am discussing, so I think

13 I can go ahead and discuss it, because now we are

14 in the net depths of irrigation, we want to deter-

15 mine the gross depths of irrigation, so we need to

16 know the application efficiency.

17 Efficiencies are hard to compute. They are

18 probably one of the hardest things, and people

19 use certain amount of application efficiency and

20 they go -- they say 50%, 40%, 30%, even 70, 80%,

21 and so on. But there are some guidelines to come

22 up with application efficiency. Application

23 efficiency is mainly a function of net depths

24 irrigation.

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1   Q   Which we just figured that out.

2   A   We just figured that out, and the wind speed.

3   The reason why wind enters is because when you

4   apply water in a sprinkler, the wind can deflect

5   the water application and give you a different

6   uniformity of the irrigation application and the

7   uniformity of irrigation also affects application

8   efficiency. So that has to enter into play in

9   sprinkler irrigation.

10   The determination of application efficiency --

11   the other parameter that is important in determination

12   of application efficiency is peak consumptive use --

13   Q   Peak?

14   A   Peak consumptive use, p-e-a-k, consumptive use of

15   the crop. Peak consumptive use is nothing but the

16   consumptive use, the peak consumptive use, during

17   the warmest months or during the time when it is

18   at its peak, and that is determined by soil conser-

19   vation method which is a standard formula in the

20   Technical Release No. 21.

21   Q   Okay.

22   A   So we have the peak crop consumptive use, we have

23   the net depths irrigation, and we ought to say

24   something about the wind speed.

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1   Wind speed is hard to get as data. People

2 assume certain wind speeds and so on, but we found

3 some wind data in the Riverton area that has been

4 done from 1967 until 1971 and for each month, and

5 we determined those. What you call "wind speed" --

6 wind speed is not really very critical in this deter-

7 mination of application efficiency because --

8   THE SPECIAL MASTER: A statement like that

9 will make you very popular in Wyoming. Wind speed

10 is not very critical.

11 A Yeah, what I mean is you don't have to know the

12 exact wind speed is 4.5 miles per hour or 6.2.

13 What you have to know is the range of wind speed

14 from 0 to 4.

15   THE SPECIAL MASTER: Oh, the gusts?

16   THE WITNESS: No, miles per hour. The wind

17 speed in miles per hour.

18   THE SPECIAL MASTER: Oh, the rate. Wind

19 speed in miles per hour.

20   THE WITNESS: Yes. That's what you need to

21 know, and that should not necessarily be -- we

22 shouldn't necessarily be exact in knowing that.

23   What is needed is from 0 to 4 miles per hour,

24 it will get a certain amount of application efficiency.

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1   From 4 to 10 miles per hour it will give us certain

2   amount of application efficiency.

3   THE SPECIAL MASTER: How do you measure a wind

4   that gusts from 1 to 2 to 15 in the course of an

5   hour, and can gust 25 times in an hour? That is

6   variable winds are gusting.

7   THE WITNESS: Yes.

8   THE SPECIAL MASTER: What does that do to

9   sprinkler efficiency?

10   THE WITNESS: What we have to do is for that

11   kind of different speeds we have to find the fre-

12   quency at which these wind speeds are coming. Say,

13   for example, 10 to 15 miles per hour, it might come

14   10 times per day, so we have to know this.

15   THE SPECIAL MASTER: Then what do you do with

16   that?

17   THE WITNESS: Average it out for the month.

18   THE SPECIAL MASTER: I see.

19   THE WITNESS: And then we determine at what

20   stage -- at what range we are from 0 to 4, 4 to 10,

21   or greater than 10. That's the only thing necessary

22   in this application efficiency.

23   So after we enter the, what you call wind

24   speeds, net depths of irrigation, and peak consumptive

25   mesghinna-direct-clear

1   use, then we can find the application efficiency

2   from handbook --

3   THE REPORTER: Pardon me?

4 A   -- from handbook, which is Irrigation Handbook by

5   Amos. However, in doing this, as I have stated it

6   earlier, in connection with the overall on-farm

7   system design we have a computer program that

8   scans through all this and finds the application

9   efficiency. Okay.

10   Okay, now, we know the application efficiency.

11   Where do we use it? So if we divide the net depths

12   of irrigation by the application efficiency, then

13   we determine the gross depths of irrigation. Gross

14   depths of irrigation is nothing but the amount of

15   water that the farmer should apply on his field during

16   a given day.

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

18   THE SPECIAL MASTER: A farmer should apply

19   on his field in any given day?

20   THE WITNESS: Yes, in any, you know, and the

21   management schedule that we have is the sprinklers

22   will move twice a day. We'll put the sprinkler

23   at one position for about half a day and then we

24   come in the evening and we move it to another

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1　　　position and then we come back the next day and

2　　　move it to another position and so on.

3　　　　　So during the time -- during that time, about

4　　　half a day, the gross depths of application should

5　　　be applied in that land which is only 60 feet in

6　　　size.

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

8　　　go ahead.

9　Q　(By Mr. Clear) For example, suppose we said we

10　　had an application efficiency of 50%. What does

11　　that mean in amount of water you have to apply?

12　A　Okay.

13　Q　Maybe 50% is not very good. Let's say 55% so we

14　　know what it means.

15　A　Well, I will choose the 50% in order to make things

16　　easier for everyone.

17　　　　　Let's say that we determined the net depths

18　　of irrigation, which the water holding capacity

19　　times depths times depletion, it's two inch for

20　　that month to make things easier, so the gross

21　　depths of irrigation will net depths of irrigation

22　　divided by the application efficiency, which means

23　　that two inch divided by 50%. So the farmer should

24　　apply four inch of water -- four inch of water is

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1   this high (indicating) -- which means he had to

2   apply during those about 12 hours he should apply

3   about four inch of water in order for the ground

4   to be at fill capacity. In order for the ground

5   to be filled with the water necessary for the

6   plant.

7 Q   So basically he would have to apply four inches of

8   water to get two inches into the ground?

9 A   Exactly. The other water either goes to surface

10   run off or deep percolation or might even evaporate

11   while the sprinkler is running, you know.

12   THE SPECIAL MASTER: Yes.

13 A   So that is what I am calling gross depths of irri-

14   gation, and that is the place where the application

15   efficiency enters.

16 Q   All right.

17 A   Okay.

18   THE SPECIAL MASTER: Now, we're ready for a

19   pipe network system?

20   MR. CLEAR: Just about there. There is one

21   more area to cover, right?

22   THE WITNESS: I think we will have more.

23   THE SPECIAL MASTER: Well, I am not trying

24   to gloss over anything substantive; I am trying to

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1   respect our goals of moving along.

2   MR. CLEAR: I think we are actually. We've

3   been on less than a day, Your Honor. This trial

4   has been on several months, and this is very im-

5   portant testimony, Your Honor.

6   THE SPECIAL MASTER: Fine, no problem.

7   THE WITNESS: One thing is after we finish

8   this thing, things will be easier. We have laid

9   the foundation of everything and things will move

10   fast.

11   THE SPECIAL MASTER: Certainly.

12   MR. CLEAR: After we get past this one.

13   THE WITNESS: If we finish number four, things

14   will be easier. We take the rules from number four

15   and apply it to the others, and it will be easier.

16   THE SPECIAL MASTER: I think this is probably

17   the most crucial of all ten. It's so complex you

18   can't get any more facts into it.

19   THE WITNESS: Okay.

20   A Now, the next thing is what we call the "irrigation

21   frequency" -- every how many days do we have to

22   irrigate. That is what irrigation frequency means.

23   Okay.

24   The irrigation frequency is nothing but the

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1   net depths of irrigation divided by the peak con-

2   sumptive use.   Peak consumptive use is namely in

3   terms of inch per day -- inch per day.

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1	Q	(By Mr. Clear) Right.
2	A.	Okay. So, if we say we need 2 inches of water as
3		a net depth of water, of the net depth of water,
4		2 inches of water, and let's assume for simplicity
5		sake that the peak consumptive use is .2 inches
6		per day --
7	Q	This is the consumptive use is the amount of water
8		the plant takes, right?
9	A.	The plant takes at its peak time during its peak
10		time.
11	Q	Uh-huh.
12	A.	Then the irrigation frequency will be 2 inches
13		divided by .2, you know, net depths of irrigation
14		divided by the peak use, because it will take it
15		10 days in order for the plant to finish that half
16		part which is 50 percent of the soil reserve. So
17		what it means is the farmer should come back again
18		and irrigate that land after 10 days.
19	Q	Uh-huh.
20	A.	And in reality, however, this does not happen.
21		Probably it happens only once because the peak
22		consumptive use, there's no peak consumptive use
23		except at one time. You know, the rest of the
24		time in May, April and September it's cool and
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1 you don't irrigate every now and then. Most -- a

2 substantial amount of your sprinklers will be idle,

3 standing there. You need all of them only during

4 one time, during the peak season.

5 Q Uh-huh.

6 A. Okay. So after we determined the irrigation fre-

7 quency then, now we are ready to determine the num-

8 ber of sprinklers needed to -- the number of laterals

9 needed for a given field.

10 Q Before we go on to that, I did ask you about the

11 slope before with relation to the farm design system.

12 I haven't asked you about -- I think what's taken in

13 much time of the trial heretofore is the classes of

14 lands established by HKM. They have those Class 1,

15 2, 3 and 4. Are you familiar with those?

16 A. Yes.

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

18 A. You know, different classes of soil are due to dif-

19 ferent reasons. The soil is of lower class, probably

20 because it has a high slope, or it might have topo-

21 graphy that is not too good, or it might have drain-

22 age problems. You know, things of this sort. But

23 when we do the on-farm system design, we are looking

24 at each and every boring hole.

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1   Q   Uh-huh.

2   A.   And when it is a slope, we don't have much limita-

3   tion in sprinkler irrigation. So that thing comes

4   out. When it is drainage, we take care of the

5   drainage problem in our drainage analysis and that

6   comes out. The other things, say, for example, it

7   has lower water-holding capacity or its intake rate

8   might be low or something of this sort.

9   Q   Uh-huh.

10   A.   So what we do is we are taking care -- taking that

11   one into consideration, as I have explained it

12   earlier.

13   Q   Uh-huh.

14   A.   So it means we are examining it in a more detailed

15   manner. Where does all this reflect? All these

16   things will reflect in the cost. If you have an

17   area that has less water-holding capacity, you have

18   to irrigate it every now and then, which means you

19   need more laterals.

20   Q   Uh-huh.

21   A.   So you have more costs. Let's say, for example,

22   just to cite one example, if we say Riverton East

23   Unit. The classes of soils in that unit are mainly

24   Class 3 and Class 2 soils. There's no Class 1, as

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1   I remember it in that unit. So what happens is the

2   cost of your on-farm system gets higher. You need

3   more laterals per unit acre. So all these classes

4   will be reflected in our cost estimate and in your

5   management and in the amount of facilities you need

6   in the irrigation system design.

7 Q   All right. So we are back now, I guess, determining

8   the number of laterals and actually designing this

9   system, is that where we are or --

10 A.   Yeah.

11   Okay. The next thing we need to know is we

12   need to know about money. Okay, we have the crop.

13   We studied the climate. We know the crop water use.

14   We found out the soil characteristics and the mechan-

15   isms and so on, how the water is going to be taken.

16   All these things have been studied. What does it

17   take to apply the water to the farm? How much does

18   it cost? So we have to determine the number of

19   laterals needed in each of the units.

20 Q   Each of the fields?

21 A.   Yeah. Then we added up to each pump station.

22   Then we added up in the unit as a whole.

23 Q   Yeah.

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

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1		something?
2	A.	The number of laterals is estimated in the following
3		way: We have a field this long (indicating). One
4		lateral covers 60 feet per irrigation.
5	Q	Uh-huh.
6	A.	So that lateral covers, since we move it twice, it
7		covers 120 feet per day. If there's 1,440-feet
8		long field, how many days will it take to cover it?
9		It is 120 -- I mean, 1,440 feet long divided by
10		1,440 feet (sic). This is the number of days.
11		So, if, instead of doing that, I know the irriga-
12		tion frequency, let's say it is 10 --
13	Q	Uh-huh.
14	A.	And I multiply and I have the one lateral moves 120
15		feet per day. So in 10 days it will cover 1,200 feet.
16		But my field is 1,440 feet. So I need one lateral in
17		it and a little more than a lateral.
18	Q	Uh-huh.
19	A.	So the number of laterals is nothing but the field
20		length divided by the amount -- I mean, the length
21		of feet covered per day by each lateral multiplied
22		by the irrigation frequency.
23		Okay, so we go on like this and the computer
24		determines the number of laterals. But what do we do
25		mesghinna - direct - clear

1   because the computer cannot distinguish between

2   land that is perfectly square or perfectly rectan-

3   gular. It can't see a rectangular or square field

4   and so on. It can't see it because, you know, there

5   are fields that are something like trapezoidal shape

6   or, what shall I say, somehow triangular shape.

7   THE SPECIAL MASTER: Semicircles, triangles,

8   obtuse triangles --

9   THE WITNESS: Uh-huh.

10   A. So what we have to do is after we take out that from

11   the computer program, then we have to take all those

12   fields, all those outputs, and go by hand each and

13   every field and determine what is the maximum size

14   of laterals needed, lateral lengths needed.

15   Q. (By Mr. Clear) Now, when you're talking about the

16   number of laterals, the maximum number of laterals,

17   you're talking about during the time of peak con-

18   sumptive use?

19   A. Yes, this is only during the peak consumptive use.

20   If we need, for example, in a certain field three

21   laterals, that is only during very few days.

22   Q. Uh-huh.

23   A. After that some of the laterals will be idle, you

24   know, or they have not much to do because they are --

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1   the temperature is low or -- I mean, the demand for

2   water is low, so we don't need those laterals. So

3   we use less laterals after that.

4 Q   But even though they are only used a few times, you

5   still have to go out and buy them?

6 A   You have to buy them. That is very necessary if

7   you have to get optimum yield.

8   So, after taking out from the computer, and

9   then we go each field by field and see how many

10   laterals are, indeed, necessary if we have this

11   triangular shaped field. The computer will give

12   us an average size of lateral.

13   I think -- Let me put this -- this might help,

14   on the blackboard.

15   MR. CLEAR: Let me take this down.

16   THE SPECIAL MASTER: Do you want to erase that

17   portion? Why don't you?

18   THE WITNESS: Okay.

19   THE SPECIAL MASTER: But leave the listing,

20   won't you?

21   THE WITNESS: Yeah, I'll leave those.

22 A   If it so happens that-- Let's take the worst kind

23   of field that looks something like this (witness

24   drawing). We have the farm main line here and we

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1   have the laterals going like this (indicating).

2   Now, the problem is what do you -- what the com-

3   puter does. It takes an average field size, pro-

4   bably somewhere in this area. You have a lateral

5   and it gives you that lateral size. But if I use

6   this lateral, it might help me to, you know, irri-

7   gate this area on this lateral by cutting some of

8   the sprinklers as I go along this way (indicating).

9   But it won't be useful this way because it is short.

10   If I use it this way, it will irrigate only this

11   area, it won't be able to irrigate this area in

12   here. So what we do is we go take the computer

13   output and we take the maximum size lateral, and

14   if this lateral requires two laterals, then we

15   have to buy those laterals that are maximum in

16   length, although we don't need them, because some

17   of the sprinklers in the laterals will be taken

18   out as we go along the way. But that is only

19   tough luck.

20   So we have to buy those laterals, although

21   it costs more, to satisfy the irrigation. So

22   that's what I meant when I say we have to adjust

23   the lateral size by hand.

24   So after we determine the number of laterals,

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1   after we determine the number of laterals required

2   in each of the fields, then we go to each pump

3   station. I'm not going to discuss about pump-

4   station, I'll discuss only in relation to the num-

5   ber of laterals in a given pump station.

6   Say, there are almost -- let's say there are

7   59 pump stations in the North Crowheart.

8   THE SPECIAL MASTER: North Crowheart?

9   THE WITNESS: Yeah.

10   A.   And our assumption there is that within a given

11   pump station, within a given pump station we can

12   exchange laterals, but we cannot exchange laterals

13   from one field to another field outside of a given

14   pump station. Okay, what I mean is if in one place,

15   in one field we need five laterals --

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

17   A.   -- and we are short of a lateral in another field,

18   then we can move one lateral from one field to

19   another field to cover that field. Okay, but that

20   is only applicable in a given pump station. It

21   can't get out of that because we believe it will

22   be too long to transport it. You know, the laterals

23   and so we can only do this within a given pump

24   station.

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1   So in that way we determine the number of

2 laterals required for each pump station; and after

3 determining the number of laterals in each pump

4 station, we determine the total laterals in the

5 whole unit and we determine also the cost of the

6 laterals because laterals are different in cost,

7 and we determine the cost of each lateral.

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1   THE WITNESS: And here we have some hand

2 moves and -- what do you call them --

3   THE SPECIAL MASTER: Side rolls?

4   THE WITNESS: Side rolls, and side rolls

5 are almost as twice as expensive as the hand

6 move, so for the hand move we apply different

7 costs, which is almost about $2. per feet of

8 lateral. ' For the side rolls we apply a different

9 cost that we received from Riverton supply of --

10 sprinkler · supply from a dealer by the name of

11 Tom Shepard.

12 Q He's the one who gave you the prices of the

13 various sprinklers?

14 A The prices of the various sprinklers, so we

15 used those costs in order to determine the

16 cost of laterals.

17   THE SPECIAL MASTER: Doctor, we have been

18 another hour without a break. Do you want to

19 take five or ten minutes?

20   THE WITNESS: That would be very nice.

21   THE SPECIAL MASTER: All right. Let's

22 take a break for five or ten minutes.

23   (Whereupon, a short
                     (recess was taken.

24

25 mesghinna-direct-clear

1   THE SPECIAL MASTER: Okay, we will please

2   come to order.

3   MR. CLEAR: Yes, Your Honor. I would

4   like to offer for introduction into evidence

5   Government Exhibit U.S. WRIR 247, which is

6   the side roll diagram.

7   MR. WHITE: Could I voir dire for just

8   one moment, please?

9   MR. CLEAR: Sure.

10   THE SPECIAL MASTER: Sure.

11   MR. WHITE: Would you put it up on the

12   podium, and maybe I can voir dire from here.

13   VOIR DIRE EXAMINATION

14   BY MR. WHITE:

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

16   if you know --

17   A   That's okay.

18   Q   What is the elevation or height of the pipe

19   which runs down the center of those wheels on

20   the side roll to which you received the cost

21   quotations from the man in Riverton, I believe

22   Mr. Shepard, Tom Shepard?

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

24   Q   Seventy-six inches in diameter?

25   mesghinna-direct-clear

1   A   Uh-huh.

2   THE SPECIAL MASTER: The wheels are 76 --

3   THE WITNESS: So you have --

4   Q   So you are talking about --

5   A   So the height of the pipeline would be half

6   of that, which would be 38 inches above the

7   ground.

8   Q   With respect to the corn which you are growing

9   in this area, what is the height of the corn?

10   A   Corn grows from -- it can grow as high as

11   probably six feet.

12   THE SPECIAL MASTER: That's an interesting

13   question. With respect to the corn we are

14   growing in this area, that's a real interesting

15   question.

16   MR. WHITE: No further questions on voir

17   dire, Your Honor.

18   THE SPECIAL MASTER: I think in regard

19   to the corn grown in the North Crowheart

20   area I thought he said just the opposite, you

21   eliminated the five percent corn --

22   MR. WHITE: The question had to do with

23   the corn that's being grown in the area which

24   he done his work, which would extend beyond the

25   mesghinna-voir dire-white

1   North Crowheart, and all I was trying to

2   point out is corn grows to six feet and that

3   pipe is 38 inches. He might have difficulty

4   in irrigation.

5   THE SPECIAL MASTER: Especially in the

6   second half of irrigation, that's for sure.

7   MR. WHITE: I have no objection to the

8   exhibit for illustrative purposes.

9   THE SPECIAL MASTER: Thank you, Mr. White.

10   United States Exhibit WRIR C-247 is admitted

11   into evidence. This is a diagram of the side

12   roll.

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

15

16   THE WITNESS: However, I would like to

17   make a comment on what has been said.

18   THE SPECIAL MASTER: All right, very well.

19   Please proceed.

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

21   THE WITNESS: Okay, we perfectly under-

22   stand and we perfectly know that the side

23   rolls that we have in here cannot take corn,

24   especially before harvest, but there are side rolls

25   mesghinna-voir dire-white

1   which are up to ten feet that I know of, at

2   least in diameter.

3   Let's forget that, and for convenience

4   sake we have assumed that the corn would be

5   irrigated by hand roll.

6   THE SPECIAL MASTER: Okay.

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1   DIRECT EXAMINATION (CONTINUED)

2   BY MR. CLEAR:

3   Q   Well, before the break we were discussing

4   the cost of the field layout and what information

5   you gathered from that. Assuming you have

6   gathered all that information on the costs,

7   what did you do with that?

8   A   Well, you know, there are -- although I don't

9   want to go into details as I have been told

10   there are other things besides the lateral costs.

11   There are the stick-up costs and the valves, and

12   so on, have been included in these costs. Then

13   actually determining the overall costs of all

14   these things, we added it in, we determined the

15   cost per acre of the on-farm system. So what

16   it means is there are several costs that enter

17   into the overall investment costs of capital

18   costs in the irrigation system. One is the

19   on-farms system cost. The second is pipeline

20   network costs. The third is pump and pumping

21   plant costs. The fourth is what you call

22   "Canal and related structure costs". The fifth

23   is drainage costs.

24   And there is another cost, if we may, which

25   mesghinna-direct-clear

1   does not much have to do with the system as

2   such, but what we term as engineering and

3   contingencies, and that has been included in

4   the --

5   THE SPECIAL MASTER: What was that first

6   word? That was contingencies and -- ?

7   THE WITNESS: Engineering.

8   THE SPECIAL MASTER: Engineering

9   contingencies.

10   THE WITNESS: Yes.

11   A   So for what we have determined to make things

12   simpler and faster is determined on-farm

13   system costs on per acre base.

14   Q   (By Mr. Clear) You determined the on-farm

15   system costs on a per acre basis?

16   A   Yes. So now we find the cost of pipeline

17   network and ground our way as we go.

18   Q   Okay. Do you want to go onto the pipe network

19   system? Do you want this other drawing of

20   the -- I'll show it to you --

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

22   Q   That one will do?

23   A   Yeah.

24   Q   Okay.

25   mesghinna-direct-clear

1   A   I better go up and --

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

3   A   Thank you.

4   (Standing at the board.

5   As I have pointed out before, we have been

6   discussing about this thing so far and also

7   the valves needed there. Okay. But we have

8   to -- we have the sprinkler system, we have

9   the on-farm system, but we have to supply

10   water to it and we have to know two things:

11   One is, how much water do we supply to it;

12   and the other thing is, what do we need to

13   supply it?

14   So the network that starts from the pump

15   stations up to the farm level, including the

16   distribution line and field main line are --

17   we are calling them the pipe network system.

18   So what we are trying to do now is we're trying

19   to determine the sizes necessary and lengths

20   necessary for this pipeline network and find

21   out and determine the costs of these lines of

22   the pipeline network..

23   So the pipeline network -- pipeline network

24   is the network between the pump -- pumps and

25   mesghinna-direct-clear

1   on-farm systems.

2   THE SPECIAL MASTER: Is this the pipe

3   network or the pipeline network?

4   THE WITNESS: Pipeline network.

5   Q   (By Mr. Clear)   On your -- on 247, that

6   diagram, you have a pumping station and

7   distribution line serving one field?

8   A   Yes.

9   Q   Is that in fact how it will operate?

10   A   Well, this is a very simplistic way, just to

11   show how the thing is.   But a pumping plant

12   can serve several fields, only two fields,

13   or probably even one field.   It depends on the

14   configuration of the area and where we are

15   in relation in elevations and so on.   So in

16   reality, really there are more than on farms.

17   that are supplied by a given pump station.

18   Okay.

19   So the next thing to do is to design

20   our pipeline network.   In order to design our

21   pipeline network, we have to input the results

22   that we have got in the on-farm systems design.

23   So what did we get from the on-farm system

24   design?   From the on-farm system design we got

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1   results in terms of gross irrigation requirements

2   per irrigation, and we also determined the

3   irrigation frequency. We also said that we'll

4   irrigate twice a day and about 120 feet per

5   day and based on this, we'll determine the Q

6   or discharge required for a given pumping plant

7   station.

8   There are, however, many fields, and we

9   have to determine the number of -- the flow

10 necessary for that.

11 Q   The what necessary?

12 A   Flow, F-l-o-w.

13   THE SPECIAL MASTER: Flow.

14 A   Yes, flow necessary for each pumping station;

15 okay? The formula for determining the flow

16 or discharge is -- I can't state it right away,

17 just sitting here, if you don't mind.

18   A Q is equal to Discharge GPM --

19 gallons per minute -- equals 453 times A --

20 A stands for acres -- times D -- D stands for

21 gross depths of irrigation, which we have

22 already found -- divided by F times H -- F is

23 the irrigation frequency in days, and H is the

24 number of operation hours per day.

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1   THE SPECIAL MASTER: The number of -- ?

2   THE WITNESS: Operation hours per day.

3   THE SPECIAL MASTER: All right.   Operating

4 hours per day.

5   THE WITNESS: Yes.

6 A   Okay.   Now, we determined the GPM necessary

7 for a given --

8   THE SPECIAL MASTER: The what necessary?

9   THE WITNESS: Gallons per minute.

10   THE SPECIAL MASTER: Right.

11 A   -- for a given pumping station.   If we know

12 the acreages, then we can determine the flow

13 necessary; okay.   But this is a total flow

14 that should go out for, say, 20 fills in a

15 given pump station.   This is at the head of --

16 at the head of the pumping plant.   But the

17 pumping plant distributes to every field and

18 the amount of water that goes to every field

19 is different from the other, depending on the

20 acreage from each field.   If there is a line

21 that goes this way and there are 100 acres,

22 the amount of water that flows through that

23 land should be the flow necessary for that

24 100 acres.   If there is a line that passes long

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1 distance to supply 500 acres, then it has to

2 carry the amount of water necessary for 500

3 acres.

4 In essence, what I'm trying to say is

5 there are different flows in different pipeline

6 networks. So we have to size the pipeline

7 network based on the flows that pass or go to

8 each of these -- to each of these lines to

9 serve the acreage there.

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1   THE WITNESS: Now, in order to size our pipeline

2 network, we have to make some criterions. The criterion,

3 for example, one of the criterions that we have used

4 is to -- not to go above seven feet per second in

5 velocity. Let's limit ourselves to seven feet per

6 second.

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

8 A. Well, that is a standard procedure in design of pipelines.

9 It goes seven to ten and so on. So it's better to

10 be on the seven-feet per second, which is more conserva-

11 tive. Okay, so we limit ourselves in that seven feet

12 per second. The other thing that we have taken into

13 consideration is when water flows through a pipe,

14 there will be head losses, there will be losses due

15 to friction. There will be losses due to friction.

16   THE SPECIAL MASTER: There will be losses due to

17 friction?

18   THE WITNESS: Yes.

19   THE SPECIAL MASTER: Even in a closed pipe?

20   THE WITNESS: Yes, even in a closed pipe. There

21 is always friction -- when the water flows through the

22 pipe, there will be friction on the inside part of the

23 pipe where the water passes. So in order to over-

24 come that friction, we need more energy.

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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

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1 feet of head loss is equal to 1 PSI or one pound per

2 square inch of head loss. So the head loss that I said

3 is really pressure loss, but we can relate it to --

4 in terms of feet by this formulation.

5 Okay. Now, we have all the necessary instruments

6 and methods of determining the size, the friction losses

7 and so on so we size our pipes. Okay, after sizing a

8 pipe in a given pumping plant, there will be several

9 kinds of size, and the smallest pipe size that we have

10 used is six-inch pipe.

11 Q. Six inch in diameter?

12 A. Six inch in diameter. And our pipes are from six

13 to twelve inch PVC, which are plastic pipes.

14 Q. Six to twelve inch what?

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

16 inch asbestos cement pipes.

17 THE SPECIAL MASTER: How do you spell the second

18 word, asbestos --

19 THE WITNESS: Cement.

20 THE SPECIAL MASTER: Oh, cement. Very good.

21 THE WITNESS: The pipeline network I think we only

22 went forty-eight inch, and forty-two inch and forty-eight

23 inch of steel pipes.

24 Okay, now, using these pipe diameters and based

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1 on the equations that I gave, we determined the size

2 of the pipes for each -- for a given amount of flow

3 in each direction. Okay, then we determined costs.

4 We have to add the costs of the whole pipeline network

5 that goes back and forth. In order to do that what

6 we assumed, which is optional, may not be necessary,

7 we assumed that the pipes will be covered below ground.

8 That's not necessary, but that increases the cost of

9 the pipeline network. That is optional.

10 So we have added to the cost of pipes the cost of

11 restoring the pipes. The cost of pipes have been

12 determined from several sources. The PVC pipes, we

13 have got it from Riverton, from the same dealer I

14 discussed before, and also from other areas. The

15 ACP pipes for the Wyoming area we got it from the

16 Johns-Manville.

17 THE SPECIAL MASTER: Would you spell the first

18 name?

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

20 THE REPORTER: And also the last name.

21 THE SPECIAL MASTER: Manville, headquartered in

22 Denver, Colorado, world headquarters now.

23 THE WITNESS: Yes, and we received the costs from

24 them. And the steel pipes I believe we used the costs

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1   from Dodge. Guy for heavy construction.

2   Q.   (By Mr. Clear)   Dodge?

3   A.   Dodge Guy; Dodge like a car.

4   THE SPECIAL MASTER: You didn't propose any use

5   of pipe over thirty-six inches over the asbestos

6   cement side in the pipeline network systems, though,

7   did you?

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

9   THE SPECIAL MASTER: Yeah, but what size is your

10   biggest pipes?

11   THE WITNESS: Forty-eight inch.

12   THE SPECIAL MASTER: Forty-eight?

13   THE WITNESS: In the pipeline network, and that is

14   steel pipe.

15   Okay, after we determined the costs of the --

16   what do you call it -- of this material cost we call

17   it, we have to add it in establishing costs below the

18   ground. But I would like to make clear this is not

19   really necessary, but we have this in considering

20   the cost of the site. The cost of installation was

21   added to it, and using the added cost of the pipe

22   costs plus the installation costs, and we must apply

23   each length. What it means is a six-inch pipe of

24   a cost per feet. If we have one thousand length of

25   mesghinna-direct-clear

1   six-inch pipe, then we must multiply it by that cost.

2   If we have twenty-inch pipe, then we must multiply that

3   length of twenty-inch pipe necessary by the cost per

4   feet. So we did this for all the units, for all the

5   pumping plants, and we determined the cost of each

6   pumping plant of pipeline network.

7   After we determined that, I believe just to be on

8   the safe side, we multiplied it by an extra five percent.

9   There might be some things necessary as to pressure

10   reduced and so on and so forth. In this matter we

11   increased it by five percent, the cost of -- after

12   determining the per acre cost, the per acre cost. The

13   per acre cost of the pipeline network is the total

14   cost of pipeline divided by the total acres of each

15   pumping station. Then after determining each pumping

16   station, we determined the cost of a given unit like

17   North Crowheart or South Crowheart or whatever it is

18   and that way we determined the pipeline network cost

19   on a per-acre basis.

20   As far as pipeline network is concerned, I tried

21   to make it as concise as possible to this point.

22   Q.   (By Mr. Clear) When we were talking about the on-farm

23   system, you mentioned in there, you mentioned one

24   of the efficiencies and one was a distribution efficiency.

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1   Is that an efficiency in a pipeline?

2   A.   Okay, let me go into it.   I think that's a very

3   important point. I think we are clear on the on-farm

4   efficiency or application efficiency. But in my

5   earlier discussion I said that there are two other

6   efficiencies necessary. One of them is the distribution

7   efficiency, which is between the pump and on-farm

8   system. And there's another efficiency called conveyance

9   efficiency between the diversion point of the river

10   and the pump station. So in this area we need to know,

11   in my discussion area here, we need to know the

12   efficiency of the pipeline network.

13   Again, in pipeline network there is no hard evidence,

14   no one can find out what efficiency of a certain pipe

15   is. But it is generally believed that conduits,

16   closed pipes, have an efficiency between ninety --

17   above ninety percent. They go probably up to ninety-

18   eight percent or ninety-seven percent. Based on the

19   kind of configurations that we have and based on our

20   professional judgment, we came up with a ninety-five

21   percent distribution efficiency, and we have allowed

22   for that in our design of the flow that I have stated

23   earlier, so we increased the flow. This does not mean

24   that -- when I say the flow, we are designing the pipes

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1   so that when I talk about the flows, this has nothing

2   to do with the water claim. This is for the pipe.

3   We are sizing the pipe to take care of the loss,

4   so we did allow a loss in the pipes of five percent

5   loss, which is not much, due to leakage and --

6   Q.   Pardon?

7   A.   Due to the leakage in the pipes and, you know, as a

8   mismanagement and so on in the pipes. So as far as

9   I am concerned, I think this is the most way I can

10 make it as concise as possible on the pipeline network.

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

12 A.   Yeah. Okay, the pump and pumping plant is -- first

13 of all, let me make it clear. Pump and pumping plant,

14 what we mean by this is the pumping plant includes

15 the structure --

16 THE SPECIAL MASTER: Includes what?

17 THE WITNESS: The structure.

18 THE SPECIAL MASTER: Structure of what, the

19 pumping plant or several pumping stations?

20 THE WITNESS: Yes.

21 THE SPECIAL MASTER: Of several pumping stations?

22 THE WITNESS: Yes, yes.

23 THE SPECIAL MASTER: All right.

24 THE WITNESS: This pump station here requires this

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1   structure in order for the water to enter to the

2   pump. So we include the pump.

3   THE SPECIAL MASTER: Pump and cylinder and some

4   screens?

5   THE WITNESS: The screens, yes, screens and

6   structures.

7   THE SPECIAL MASTER: Yeah, yeah.

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1   Q.   (By Mr. Clear)   I have put on the board the United

2   States Exhibit WRIR C248.   Can you describe that?

3   A.   Okay.   I think this one shows almost a complete picture

4   of the whole thing.   Here we have a diversion structure

5   (witness indicating).   First of all this is the river.

6   Let's assume this is the Wind River (witness indicating)

7   and here we have the river and this is called the

8   diversion structure (indicating).   We have the head

9   canal structure in here (indicating).   We have the

10   spillway in here and water comes --

11   THE SPECIAL MASTER: Did you find the diversion

12   structure already in place to serve the -- this is

13   kind of a cruel question -- the North Crowheart?

14   THE WITNESS: Yes.

15   THE SPECIAL MASTER: In the future?   Is it already

16   in place?

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

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

19   THE WITNESS: Its location and elevation and so on.

20   THE SPECIAL MASTER: All right.

21   A.   So --

22   MR. WHITE: Well, Your Honor, I don't think he

23   answered the question.

24   THE SPECIAL MASTER: Well he said he knows where

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1　　they are going to put it so I guess there is not one

2　　in place.

3　　　　MR. WHITE:　Thank you.

4　Q.　(By Mr. Clear)　When you got to canals and related

5　　structures, will you describe　the diversion structures

6　　that you have --

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

8　　　　Okay.　So this is a diversion structure (indicating).

9　　There are gates and so on.　Here there is a spillway

10　　here.　You know, and so on.　And the water is diverted

11　　to the canal, let's call this one North Crowheart

12　　Canal, that will make things simpler.　And the pump

13　　station is in here (indicating), you know water

14　　will enter into the pump station through this and

15　　then the pump will pump water and distribute it

16　　through the pipeline network as we see it in here

17　　and then the pipeline network will distribute it

18　　through the laterals.

19　　　　THE SPECIAL MASTER:　And did your work include

20　　the cost of pump stations and design pump stations?

21　　　　THE WITNESS:　Yeah, it will include the cost of

22　　pump stations and I am almost near to it now.

23　　　　THE SPECIAL MASTER:　All right.

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

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1   THE SPECIAL MASTER: All right. Very good.

2   THE WITNESS: Okay. In order to determine the

3   cost of the pump station which I said it includes

4   the pump itself and the prime movers of the pump

5   station it also includes the structures, it also

6   includes the valves, manifolds and so on necessary.

7   Again, I would like to state in here that it's not

8   really necessary to have an over structure in a pump

9   station but we have included the cost for over structure

10   just to be on the safe side. And that can always be

11   subtracted if it is not necessary but at any rate

12   we have included those costs and other costs, such as

13   parking lots and so on and so on.

14   In order to design a pump what do we need? What

15   do we have to know? What is the most important

16   thing? The most important thing in order to know a

17   pump capacity -- pumps are -- there are, if someone

18   wants to go and wants to buy a pump from a pump dealer

19   he has to know certain things and those things are

20   horse power, what size of horse power do you want?

21   These are the questions that the dealer is going to

22   ask first. The second thing is he would like to know

23   what kind of head are you talking about how high are

24   you planning --

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1   THE SPECIAL MASTER: To lift your water?

2   THE WITNESS: To lift your water. And

3   the other thing he's going to ask is how much flow

4   are you talking about, how much flow do you expect

5   your pump to pump out water from the canal? So these

6   questions should be answered so that someone would

7   know about the costs of pumps.

8   Okay. What are these things? Again, we have to

9   go back to pipeline network. You see what we are doing

10   is we first determined the climate, then we entered

11   the necessary data to determine the evapotranspiration

12   from the climate, then we entered the results that we

13   got from evapotranspiration to on-farm system, and

14   then the result of on-farm system entered into pipeline

15   network. Now we need the results. We get from pipeline

16   network in order to design our pump station. So what

17   did we get from the pipeline network? From the pipeline

18   network I indicated that we determined the head losses

19   of pipe so that is a very important thing in order

20   to determine the capacity of the pump. The other thing

21   that is necessary in order to determine the capacity

22   of the pump meaning that the head that -- that the lift

23   it should serve. We need to know the static head.

24   The static head is nothing but the elevation between the

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1   pump station and the high point in field. We have to

2   know this. The other thing that we have to know is

3   we have sprinklers there so they need pressure. When

4   the water comes out from the sprinkler, it requires a

5   certain amount of pressure in order to irrigate

6   uniformly. And we assumed fifty-five PSI which is about

7   127 feet of head. Really nowadays you can go with much

8   less than that in sideroll or on hand-move, less than

9   fifty-five PSI. We can go like forty or even forty-five

10   PSI. But we have used that in order to be on the

11   safe side because the higher head, the higher the head

12   you pump out, the higher the cost of your pump will be.

13   Not only that, your energy will be higher every year.

14   Okay. So then these three things, the head loss

15   or friction loss in the pipes plus the static head

16   which is the elevation difference plus the pressure

17   required for the sprinklers added all together are

18   called total dynamic head. In reality this is the

19   head that the pump should pump out in order to bring

20   water to the point of interest.

21   Okay. One thing that we have entered into this

22   is when we determine the head loss, the friction loss

23   in the pipes, we increase it also by five percent

24   in order to account for connections here and there,

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1   joints here and there which is hard to estimate in

2   terms of head losses. So we increased this. So

3   then we determined the total dynamic head. This is

4   the head that the pump is supposed to pump out water.

5   This is the lift that it's going to pump out water.

6   Okay. Now from my former discussions I gave you Q

7   or the discharge required in a given pumping station.

8   That is, a pump station might have twenty fields, I

9   said before, and we determine that flow necessary for

10   all these fields in GPM, gallons per minute. Okay,

11   so now we have these two things. We have the total

12   dynamic head, we have the discharge required from the

13   pump. Also, in my former discussion, I said that three

14   things are important to know in order to design a

15   pump station. And I said the total dynamic head which

16   we just found out what it is, the discharge or flow

17   in GPM which we found, so one thing is left and that

18   is the brake horsepower.

19   Q. What is the first word, what horsepower?

20   A. Brake, horsepower.

21   THE SPECIAL MASTER: Brake.

22   THE WITNESS: Brake horsepower. That is the

23   horse power in the pump required.

24   Okay. Now how we determine brake horsepower?

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1   Brake horsepower is a function of total dynamic

2   head and discharge. And BHP, brake horsepower,

3   if I remember correctly, is the Q in GPM times the

4   total dynamic head divided by 3,960 again divided by

5   the efficiency of the pump. So if we go and do this

6   for each pump station like this will determine the

7   brake horsepower.

8   THE SPECIAL MASTER: This is fascinating to me.

9   Is that formula devised to the person to whose name

10 has been given to it, the formula? Is that from the

11 British classification of horse power, brake horsepower?

12 THE WITNESS: Yeah, it is a British classification.

13 THE SPECIAL MASTER: Okay.

14 THE WITNESS: Okay. So this is the way on how

15 to determine the brake horse power.

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

17 A. Okay. The next thing is -- now we know the brake

18 horse power meaning we know the pump size. Someone

19 can go to the dealer for pumps, Berkley pumps for

20 that matter. He knows all the necessary constituents

21 there and can ask for the pump cost.

22 Okay. But we did not go to the pump dealer and

23 as the costs, you know, of each. We asks several costs

24 but that does not really help us very much because there

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1   are, as I said, other structures necessary there.

2   So we depended on the works that have done by the

3   USBR in this aspect.

4 Q.   Bureau of Reclamation?

5 A.   Bureau of Reclamation.

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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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1 A   Just to have what you call "Q flows", the

2   cubic feet per second. Then you have the

3   total dynamic head, then you get what you call

4   the cost of pumping and then from -- based on

5   that, and determine the cost of structures

6   and so on. It is just a mechanical thing.

7   But that is 1968 prices.

8 Q   Um-hum.

9 A   But --

10   THE SPECIAL MASTER: Then the prices in

11   your report are 1968 prices?

12   THE WITNESS: No. I will come to it.

13 A   Those guidelines given by the Bureau of

14   Reclamation are 1968 costs, but we indexed them

15   to 1979 costs, because all our costs are 1979

16   costs. Everything is based on 1979.

17   So after we came up with the overall

18   pumping plant costs, really what we did is

19   we have all these different graphs and we

20   lumped them up into one graph, you know, much

21   easier. You can -- I mean the office studied

22   several of them and we lumped them up to one

23   graph.

24   What you do is first find the cost of a

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1   pump based on the pump, then you can determine

2   overall costs. One graph would do -- in fact

3   two graphs, really. The first graph determines

4   based on pump costs, then determine the pumping

5   plant costs.

6   THE SPECIAL MASTER: Give me that

7   distinction again.   What additions are there

8   for pumping plant costs not included in pump

9   costs?

10   THE WITNESS: Okay. Let me clarify it

11 more, then.

12   The graphs given by USBR are several

13 graphs. One is for the pump itself; another

14 one is for manifolds; another one for the

15 structures, and so on. Okay.

16   So what we did is first we went on and

17 determined different size of pumps in using

18 that one -- using those guidelines, using

19 those graphs.

20   THE SPECIAL MASTER: Um-hum.

21   THE WITNESS: And then we said there must

22 be some kind of relationship in here. So we

23 related it to just the pump costs.

24   If I determined the pump costs, how can

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1 I determine the overall pumping plant costs?

2 Just by knowing if, say, for example, the

3 pump cost is, let's say $50,000, what will

4 be the cost of the overall pumping plant?

5 Okay, then we made a graph out of their graph,

6 one graph instead of four, five. We made one

7 graph and by just knowing the cost of the

8 pump --

9 THE SPECIAL MASTER: You extrapolated --

10 THE WITNESS: -- we extrapolate and

11 find out the cost of all the whole pumping

12 plant. That cuts the work and the tediousness

13 of it.

14 So we did this for all the pumping plants

15 in all the five units, and after determining

16 the cost of each pumping plant, we added the

17 cost of each pumping plant. After adding the

18 cost of each pumping plant, then we determined

19 the cost per acre on the pumping plant.

20 MR. CLEAR: Your Honor, I think he's

21 been on the stand another hour, and --

22 THE SPECIAL MASTER: You divided the number

23 of acres in the unit to the cost and got the

24 cost of the pumping plant; is that it?

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1   THE WITNESS: That's about it, yes.

2   THE SPECIAL MASTER: Okay. It's four

o'clock. Are we going to set the record today,

or should we adjourn to tomorrow?

5   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 --

9   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 --

17   MR. SACHSE: Could we go --

18   MR. WHITE: I'd already agreed to let Mr.

Sachse go home at noon.

20   THE SPECIAL MASTER: Did you?

21   MR. WHITE: And I'd like to ask if we

bring sandwiches that we go to one o'clock.

23   MR. SACHSE: I could catch the plane if

we went until one o'clock.

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

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1   get back east --

2   THE SPECIAL MASTER: There's no way.

3   I moved west and -- just a minute; the record

4   is closed. We'll be in session again at

5   eight o'clock in the morning.

6   (Proceedings recessed
                                (at approximately

7   (4:10 p.m.

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REPORTERS' CERTIFICATE

State of Wyoming)
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       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.

_____
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Registered Professional
Reporter

_____
MARY NELSON
Registered Professional
Reporter

_____
MONIKA FLEISCHLI
Certified Shorthand Reporter

Lamont Miller - Notary Public
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My Commission Expires March 29, 1983