IN THE UNITED STATES DISTRICT COURT

DISTRICT OF NEW MEXICO

STATE OF NEW MEXICO, ex rel., S. E. REYNOLDS, STATE ENGINEER Plaintiff, vs. MOLYBDENUM CORPORATION OF AMERICA, INC., et al., Defendants. vs. UNITED STATES OF AMERICA, Plaintiff-in-Intervention.	)	CIVIL # 9780-JB

DEPOSITION OF ROBERT W. PENNAK, Ph.D

BE IT REMEMBERED that on to-wit, the thirteenth day of November, 1979, this matter came on for the taking of the deposition of ROBERT W. PENNAK, Ph.D., before Howard W. Henry, a Certified Shorthand Reporter and Notary Public of the firm of HOWARD W. HENRY & COMPANY, 601 Tijeras, Northwest, Albuquerque, New Mexico, at the Bureau of Land Management Conference Room, Santa Fe, New Mexico, at the hour of eleven o'clock in the forenoon.

A P P E A R A N C E S

FOR THE PLAINTIFF:

MR. CHANNING KURY
Special Assistant Attorney General
State Engineer Office
Bataan Memorial Building
Santa Fe, New Mexico 87501

FOR THE DEFENDANTS:

STROOCK & STROOCK & LAVAN
Attorneys at Law
61 Broadway
New York, New York 10006
By: Mr. Gary J. Greenberg

FOR THE UNITED STATES OF AMERICA:

MR. R. E. THOMPSON
United States Attorney
United States Federal Courthouse
500 Gold Avenue, Southwest
Albuquerque, New Mexico 87102
By: Mr. Charles N. Estes

ALSO PRESENT:

MR. STEVEN RAE
MR. HERBERT S. GARN
MR. CHARLES "MIKE" PREWITT

* * * *

STIPULATION

IT IS HEREBY STIPULATED AND AGREED by and between the parties hereto, acting through their counsel of record, that this deposition is taken at this time and place according to the Rules of Civil Procedure and notice; that the parties waive the notice of filing of this deposition and do not waive the signature of the witness.

* * * *

ROBERT W. PENNAK, Ph.D.

was called as a witness by the plaintiff in intervention, and having been first duly sworn, testifed upon his oath as follows, to-wit:

DIRECT EXAMINATION

BY MR. ESTES:

Q Could you give us your name, sir?

A My name is Robert W. Pennak.

Q And your residence address?

A 2898 South Lakeridge Trail, Boulder, Colorado. 80302.

Q And you are a professor emeritus of the University of Colorado?

A Yes, I am.

Q And could you -- thank you for providing a resume, and I think it has the details.

Could you just sketch your professional career? What field have you concentrated in?

A I should be glad to, and particularly I will mention some things that are not in the curriculum vitae, with your permission.

Q All right.

A I had all of my university education at the University of Wisconsin, beginning in 1934, and most of my emphasis was in the area of aquatic biology and fish training.

Now, for most of you people, that would be a little difficult to transport, back to the situation that we had in 1934. For example, that year there were only two courses in ichthyology taught in the whole United States. One was at Stanford, which was mainly taxonomy of marine fishes. The other was at the University of Michigan.

I was, however, enormously fortunate in addition to any regular aquatic work, to be exposed to a great deal of fisheries research at Wisconsin, because

we had a large group of people working on their doctorate under the leadership of the two prominent limnologists there at that time.

I, while I was at the University of Wisconsin, then, chiefly by virtue of four whole summers and parts of some years, I became familiar with a good many fish techniques, as well as with a great many kinds of aquatic techniques. For example, I participated in a lot of pioneer programs having to do with the business of reading scales of fish. I had a lot to do with calculating the populations of fishes in lakes and some of the streams there, and I am familiar with the use of git nets, whoop nets, trap nets, gill nets, and so on.

Now, since 1934, then, I literally have grown up with the business of aquatic biology, because it has burgeoned enormously during all these years.

I came to the University of Colorado in 1938, right after I obtained a doctorate, and my chief interests ever since that time have been in the areas of limnology and stream biology. In fact, I think so far as I am able to determine, I have been teaching, and I instituted the first stream biology course ever to be given anywhere in the world.

Now, there are other kinds of courses that were called "stream biology," but these were mostly for engineers, and having to do with wastewater control, and so on.

In addition to these two areas, I taught such things as oceanography, marine biology; of course, especially during my early years, invertebrate biology, parasitology, and several types of graduate courses, including writing papers and so on.

I published something over a hundred papers in technical journals, and in addition, the things that are not mentioned in there would include such items as about twenty-five environmental impact statements in which I have been involved, most of these having to do with streams.

I have given something over a hundred oral presentations at meetings of technical societies during my career. I have given well over a hundred, perhaps two hundred seminars, invitational seminars at universities all over the country.

Among my students who took their work with me, I have had fifty at the M.A. level, and I have had eighteen at the Ph.D. level.

Some years ago I published a book called

The Collegiate Dictionary of Zoology, which was chosen as a reference book of the year by the American Library Association.

Also, as some of you may know, I have written a book called Freshwater Invertebrates of the United States. This, while it has to do in the main with identification of freshwater invertebrates, also has in it an enormous amount of ecology, lake and stream ecology, pond ecology, and so on. Freshwater Invertebrates came out as a second edition complete revision about thirteen months ago. It is now in its third printing, and it is selling very widely, and is very handsomely accepted. And it's been called by many people a "classic" in biology.

I'm sorry to have to talk this way, it's a little embarrassing to have to brag about myself. I hope you appreciate my situation, but I will do the best I can.

I "retired," in quotes, in 1974, at the age of sixty-two. This was an early retirement. But the Regents of the university are very kind, and as long as you are still productive at the University of Colorado, you may keep your laboratory, and you may keep all of your research facilities. As a result, my facilities -- they

are in the magnitude of six times the space that we are occupying here this morning, so I have very handsome facilities.

I am still full-time. In other words, I go to my office every day, full-time research on my laboratory and field programs, concentration work, editing, national and international committee work, and so on. But most of all -- and perhaps one of the things of which I am most proud -- is the fact that I am past president of five different professional biological scholarly societies. Probably there is no other man in the world who can make this kind of statement.

Is that sufficient?

Q Well, that's sure good for openers. I am impressed.

What is the distinction -- you mentiond both limnology and stream biology. What's the distinction?

A Originally, the word "limnology" included running waters as well as standing waters. But the few limnology courses that were taught when I was early in my career had a negligible amount of running water being included with them. And very early -- very soon after I came to Boulder, I decided that the field of running

water biology was so different from the field of limnology, or standing waters, that I decided that this needs a separate kind of course, it needs separate kind of training.

So as a result, I established the course for the first time, and I think the year was 1942, and have taught it continuously ever since.

Now, of course, with the burgeoning of stream biology over the past thirty or forty years, we even have textbooks. When I began, there were no textbooks, I had to go to the original journal sources.

But I should mention also that my area in Colorado is a fabulous place to study both running water biology and standing water biology. But the two are quite distinct areas, as I think of them.

Q Who have been the people who wound up writing testbooks on stream biology? Are there a couple of prominent books?

A The best stream biology book is done by a man by the name of Hines, who is in Canada. His book on stream biology came out about -- I should say seven years ago. Before that, we had really very little.

Then, also, as additional limnology texts have come out, especially during the last fifteen years,

you will find, instead of there being just a portion of one chapter devoted to stream biology, you will find two or three full chapters devoted to it. So it's a burgeoning area, and we are getting lots and lots of interest at the graduate level in the whole business of stream biology.

Q Can the study of the field of stream biology be subdivided into particular focus areas?

A Oh, you can, but it's a very rough division, because there's so many interdigitations. You can talk about the physical qualities of a stream; you can talk about the chemical qualities of a stream; you can talk about the biological qualities of a stream. But they are so closely associated that it is difficult to teach a course and give it three different sections, you see?

Q I just -- in glancing through the list of your publications, they don't, for the most part -- and I think there are a couple of exceptions -- but they don't, for the most part, focus explicitly on vertebrates, trout and larger fish --

A This is correct.

Q -- in the stream.

A This is correct. After all, you have got to decide to go one way or the other; you can't be all

things to all people, you see?

I should tell you that a couple of my master's degree folks who are working on strictly fish problems, distribution of fishes, the ecology of fishes in our local area, and as I say, I grew up with the whole development of ichthyology in the freshwater sense, so that I feel that I am familiar with it. And, after all, my limnology course through the years was about a quarter ichthyology, and my stream biology course was about a third ichthyology. So they are solid portions, you see?

Q Is it fair to say that your own research, though, has not particularly concentrated on the fish, themselves, but rather on the invertebrates and perhaps other --

A This, I think, is fair, but it's almost impossible to separate the two.

Q Okay. I am sure that's true.

Is there, on the faculty at the University of Colorado, is there an associate of yours who is a specialist particularly in the fish, themselves?

A Yes, John Wendell is there. He is interested, however, almost exclusively in fish nutrition, from the standpoint of keeping his fishes in a large laboratory,

feeding them pellets, and seeing how efficient their usage is of the kinds of food materials that he feeds to them; sort of an efficiency thing. He's taken over my stream biology course after I retired, but this is the slant of his approach. He's not primarily a field man, he's primarily a laboratory man.

Q Have you, yourself, done field work that looked specifically at fish populations or habitat?

A Oh, yes. A good deal, particularly in connection with my classes. We do electrofishing regularly, and estimates of population, and stomach studies, food studies, on trout and so on, taxonomy, vertical distribution -- altitudinally, that is.

Q Have you published in that area?

A No. I, myself, have published relatively little, strictly speaking, a fish paper. But the -- it is very difficult to draw the line between what I am doing in the way of stream productivity and the fish population, which is dependent upon that, you see?

Q I see. One of your publications -- I'm sorry.

A No, go ahead.

Q I was going to say, one of your publications

makes that connection in that it seems to be explicit in vertebrates of high mountain lakes in relation to trout populations?

A This is right.

Q Have you published a similar paper with respect to stream studies?

A We have -- I have in press, and it's not on there, I have in press a paper that is going to appear in the European Journal. It has to do with the productivity of the Arkansas River with respect to the bottom fauna and the associated fish fauna.

Q I see.

A If you are trying to get me to tell you that I don't know anything about fish, why, you are wasting your time.

Q I will concede that right off the bat. You obviously know all about things in streams.

Okay. What's the handwritten -- on my list of your publications, there is a Fish and Wildlife Service publication, Classification, Inventory and Analysis of Fish and Wildlife Habitat. Could you describe that?

A What's the title of that?

MR. GREENBERG: Here.

MR. ESTES: I guess there's a portion of that publication --

A You must go to the first part of that, see? Dilemma of Stream Classification.

Q I see.

A This was the title of the specific paper, and the Classification, Inventory and Analysis of Fish and Wildlife Population is a typical long-winded governmental book title.

Q Not just the government that has long-winded book titles.

A I know what you mean.

Q What's the thrust of that article? What is the dilemma of stream classification?

A The dilemma is, we don't know how really to classify streams. And more specifically, stream classification is enormously difficult, and the point I make in it is that there are -- I don't know how much detail you want here -- the chief points I make in it are, "A", there are several kinds of streams that are similar, in general, the world over. For example, irrigation ditches. It doesn't make much difference whether you have an irrigation ditch in Georgia or Montana or California, they are

pretty much the same; they are sterile, there isn't very much in them. So this is one kind of running water that you can recognize as a type, it doesn't make any difference whether it's a dirt-lined ditch or a concrete-lined ditch.

In general, a heavily polluted stream is a definite kind of stream habitat. By "heavily polluted," I mean here so heavily polluted that it's almost a biological desert. And we can put those into one category very nicely, because of the fact that so much stuff has been dumped in them they are no longer of any use as a recreation or biological device.

And there are several similar such categoris where you can pigeonhole certain kinds of streams. But most of our streams do not fit into pigeonholes.

Now, the question is, how can we compare streams? The comparison scheme I use is a relatively simple one. If, for example, you work on a stream -- let's say in Wyoming, to take it out of my home state -- say you are working on a small stream in Wyoming, and I locate a similar stream that is in the Andes of Bolivia. If we find that the temperature regime of both those streams are the same, if they are the same in average width, in average pool development, in average chemistry, and most

of the things that we are able to mention -- let's say fish population, too -- we will then discover that the invertebrates, fish food on the bottoms of those two streams will be parallel. I am not saying they are the same species, or even the same genus, but that they will be parallel and occupy similar niches in those kinds of habitats.

This, then, is the whole thrust of my article.

Now, another pigeonhole, if you want it, would be the broad braided sandy bottom streams such as we have in our Great Plains. The water, for the most part -- let's take the Platte River, and Missouri, and Arkansas, and so on. Once you get out on the Great Plans, they are shallow, broad, sandy bottoms, and they have relatively similar fauna, so that they fit into a particular category. And you really ordinarily don't have to worry about measuring the physical, chemical, and biological parameters in order to compare one with the other.

Q Have your stream biology studies concentrated on particular types of streams?

A I should say -- you have to make a choice; as I said before, you can't be all things to all people. But we have concentrated, for the most part, on small mountain streams, the size of the Red River, up to -- well, some

streams are half the size of the Red River, a third the size of the Red River, some are two or three times the size of the Red River. But we haven't worked on anything, for example, as large as the Colorado River in its lower reaches. We haven't worked on anything such as the South Platte when you get way out to the northeast of Colorado, where there is an enormous area involved.

Q I take it the Red River is rather similar to many of the streams that you have studied?

A Very similar, with a couple of exceptions I may bring out later on.

Q Okay. How about -- you mentioned the problem of pollution, and that being a category of streams. Have you done much work with the effect of pollutants on fish life?

A We have done a lot of work, particularly in class. Every year we have pollution projects. When I talk about pollution here, we are referring, for the most part, about pollution that you get from large cities or large chemical operations where the water is grossly polluted.

In other words, what we are looking for is a place where you get such gross pollution that it kills

everything, and then you watch the self-purification of stream as it goes down the basin.

Q How about the effect of specific chemical constituents on fish life? Have you done any research of that sort?

A Very little. I have done a little bit on the effects of sulfates, for a coal company, on the western slope, as a part of an impact study, but it's relatively negligible, I should say.

And we have done some work, I should say, also over in the Piceance Basin, trying to correlate the occurrence of fish downstream with the relative salinity of the water. And for that matter, we have done some work on wide spots in our streams, where you have the accumulation of considerable quantities of sulfates and carbonates. And we have traced, for example, the disappearance of fish faunas over a long period of time as a result of the increasing salinity.

But, to answer your question perhaps more specifically, I have not taken specific ions and determined the toxicity, no.

Q I assume you have not, then, been involved in helping to set recommended standards --

A No, thank God, I have not.

Q -- for such matters?

Okay. Have you been a witness in court proceedings before?

A No, and I was explaining to Gary last night, I have been on the verge of four other court proceedings, four suits that were being brought against coal companies and mining companies, but in all four cases, just when we were about ready to have depositions, the things were all settled out of court, so that I hadn't actually come into court to have to give depositions or testify.

Q I would think they would have to hear your deposition first, before they would be scared off enough to settle.

A I don't know. I don't know. But they apparently knew some of the data that we are gathering, and realized ahead of time it wasn't worth the expenditure of a hundred thousand, so they were called off.

Q You might just tell us briefly what has been the nature of the four cases that you -- I take it you were retained as a potential expert witness?

A One was in Montana for the American Smelting and Refining, and had to do with their copper activities

up there. And that was canceled when they saw that the thing wasn't going to work out.

Q Who was the plaintiff, or --

A Asarco, American Smelting and Refining, and they were against the state. And a lot of people there didn't want the -- didn't want the new copper mining effort to come into existence there.

Q I see. And I take it you were retained by the copper companies?

A That's right.

And another one was with the so-called "Marble Ski Company," which is on the western slope in Colorado. And as a result of our research on one of the streams over there, we discovered that it was already a very poor habitat for trout because of the fact there was so much inwash of bits of shale. Now, shale is not a good kind of substrate in a trout stream, so the thing was called off there on the basis of what we were finding.

Another one was over -- with a coal company on the western slope. And, frankly, I don't know what the details of that were, but the whole thing was dropped all of a sudden. I was working on a small stream associated with the coal company, and we were showing that there was

considerable quantity of sulfate coming into the stream from their waste piles of the coal company.

Q Who were you working for in that case?

A This was Union -- Union Coal, I think it was called, but it has -- it has had several different names over the years.

A fourth case was on the Purgatory River in southern Colorado, and we were working again on bottom fauna of the Purgatory River. And that case was settled out of court. And, frankly, I don't know what details were involved, and I take no credit for that.

Q Who were you working for in that case?

A I was working for --

Q I don't really care about the name.

A I would have to look it up.

Q What was the nature of the entity that you were working for?

A It was an outfit that was going to mine coal, south of the Purgatory River. They suddenly decided it wasn't going to be worth it, that the pollution of the stream in that small valley where the coal mine was set up, was going to be too much, so they stopped the proceedings.

Q Were any of these, or all of these four that

you mentioned, were you involved with Thorne Ecological Institute?

A Yes, I was involved with Thorne. I frankly don't remember whether it was two or three. I have done consultation work for some twenty or twenty-five different agencies, and it gets a little hard to remember which was which.

Q I have been provided an outline by Mr. Greenberg of your testimony, expected testimony, and I guess at least to some extent my questions will follow that. A lot of the information is in here, and I don't mean to ask you to just repeat what's here, but to some extent, I would like to hear it in your own words. Maybe we could start, if you could summarize what your first involvement with the Red River was all about.

A All right. When I first worked on the Red River, beginning in 1971, it was with the Thorne Ecological Institute. And my job was to work particularly on the biology of the Red River between a point above Molycorp and a point below the outfall of Pope Creek. They were interested in seeing what damage, if any, was being done by the occasional breaks, or ruptures, in their pipes, accidents, and they simply wanted to run, first of all, a baseline study so

we knew what was there, before anything happened.

And then over the years I have been retained by Molycorp independently of Thorne. In other words, Thorne was in on it for only one year, you see? I have been retained independently to come down and run baseline studies, and particularly to take bottom samples and run some of the more obvious chemical parameters, in various years since 1971.

Q Just in looking at this first paragraph under Roman numeral one, were all -- well, up at least until March, '78, it seemed like each of your field efforts was directly related to a break in one of the pipelines, is that a fair statement?

A I don't think that's quite fair, because sometimes, there would be a break, and I would come down immediately; sometimes, I would be down early in the year, for example, in March, that had nothing to do with any break. And sometimes, I would come down in September or October or November; that had nothing to do with a break.

So that as I think of it, my own subterfuge, my own involvement in it, was centered around the fact that I wanted to get as much data as possible from the Red River, because the more data you have, the more reliable your

average results are going to be.

Q Had you done, or have you done, since, any other work, studied any other streams in New Mexico?

A No. The Red River of New Mexico is the only New Mexican river that I have studied.

Q Have you -- are you familiar with some of the other mountain streams in New Mexico?

A No, I am not, but as I think -- if I may continue, mountain streams are fairly well within a category, if you are talking about similar elevations, and similar physical conditions, and similar size, and so on. So that often there are mountain streams, let's say at an elevation of ten thousand in New Mexico, that will be quite similar to mountain streams at an elevation of ten thousand, or ninety-five hundred, in Colorado or elsewhere.

Q Just the last sentence of that paragraph indicates that you did an update and summary in September, 1979. Does that mean that you did further field work of the same sort?

A I did further field work in August and September of 1979, chiefly because of our renewed interest in the lower portion of the Red River.

Now, my original work, you see, extended

down only as far as the fish hatchery. And then, of course, when this litigation came up, they asked me to work on the lower portion of the Red River, and particularly to have a sharp look at it and see what I thought of it.

Q I have, I think, copies of your reports, starting with 1971, '72, and then up through 1978. And, of course, they are summarized in this outline.

Did you do further work of pretty much the same areas? That is, did you do bottom sampling and so forth?

A Exactly.

Q Is that written up in a form that we could have a copy of? That's one thing I think may have -- just by accident, we didn't wind up with.

A The 1975 -- the 1979 detail material has not yet been written up. You mean bottom fauna, and things like that?

Q Yes, similar to the earlier reports.

A It's very similar to the earlier reports, and I think I have some of it summarized in here, in some of these -- yeah. Yeah, we have August and September.

MR. GREENBERG: We have a summary of -- the summary sort of traces the 1971 through '78 material, and

then gives some update on 1979.

THE WITNESS: But the complete report for 1979, I mean the detailed one that will go into Molycorp, has not been finished. This is simply a summary of the stuff that is yet to be written up in detail form, because Molycorp requires a detailed report from me every time I work for them.

Q Would it be possible for us to have a copy of what is available of the 1979?

MR. GREENBERG: Yes.

MR. ESTES: Thank you, sir.

Q Did your research and field work in 1979, include any parameters which you hadn't looked at earlier? Did you extend the scope of your work?

A I had a few analyses done by a commercial laboratory in Denver, so that I could -- and it was in a laboratory equipped with analytical methods that I could not hope to duplicate in my lab. They did, for example, some cadmium analyses on the water, which I could not do; otherwise, most of it was my own standard observations and measurements.

Q Can you think what else besides the standard work -- what else besides cadmium analyses was done?

A We did some work on fish analyses, likewise --

Q Is that --

A -- cadmium.

Q Was that looking at fish tissues?

A Yes.

Q In general, has the -- in your standard areas of interest, are the results for 1979 pretty comparable to the earlier?

A Very much similar; very much. In the temperature regime, for example, there's very little change from one year to another, at least in the open months of the year.

Q Just for my own curiosity, going on in your report, you discuss a little bit the way you took some of your samples. Is it a Surber sampler?

A Shall I use the board for this?

Q If you are interested; you can write it on a piece of paper.

A I will speak of it.

It encloses a square foot of bottom. There is a brass frame that encloses a square foot of bottom. On the downstream side is the opening of long, coarse, mesh net. And what you do is put this down at a random place

on rubble, and then you work over with your hands, or with a brush, all of the pieces of bottom that are within that square foot.

Now, the current is coming down in sufficient force so that when you dislodge organisms from the rubble and gravel, they are washed into this net, and that constitutes one sample.

Ordinarily, at one spot I will take five such random samples. And the whole idea, of course, is to take as many samples during any period of time as you possibly can, because of variation.

But the trap, the Surber sampler works only where you have a good current of water. And this was the case on all of the Rocky Mountain streams with which -- on which I have done specific studies.

This happens to be -- this is the result of that study. Do you have a copy of this?

Q I have seen that. I won't say that I have thoroughly understood it, but I have seen it.

A Okay.

Q We might indicate -- why don't you indicate for the record what it is that you were showing me? Just tell us the title.

A It's called "Trophic Variables in Rocky Mountain Trout Streams."

Q And "trophic", referring to nutrition?

A Yes, nutrition, specifically.

Q And --

A And it has -- this paper has -- I have already received over seven hundred reprint requests, by the way, from all over the world, for it. It has the advantage of using the same methodology by the same person, for all of the streams that were studied. You see, this is what makes it difficult in much of our stream work, is if some one person works on a particular stream, he has idiosyncrasies about the way he gathers his samples. And we have felt, then, by taking -- by using the same method in all the streams, at least we would have something that is comparable within our region, within the, oh, twenty or thirty streams that are discussed in this paper.

MR. KURY: Excuse me. Do you have an extra reprint with you?

THE WITNESS: No, I don't. I'm sorry. This is the only copy I have to my name. As I say, we have had such --

MR. KURY: Nick, could we have someone

in B.L.M. office xerox that?

MR. ESTES: Yes, over the lunch hour.

MR. KURY: Thank you.

THE WITNESS: But I have to have it back, since it's the only one that I have.

Q The Red River winds up in your study?

A It does, indeed.

Q The next technique that you mention involves scraping the periphyton --

A Where are you? What page?

Q I'm sorry, on page two, paragraph four, at the top.

A Paragraph four.

Q Is that all self-evident, or is there any trick to the technology?

A I guess this is self-evident. What we do is pick up a piece of rubble at random and scrape off the exposed surface with a sharp scalpel. The substrate in any stream is covered with an enormously heterogeneous microcosm, I suppose you might call it. Now, I am not talking about the aquatic insects, but I am talking about algae, bacteria, bacterial slime, and debris, both organic and inorganic debris.

And it is upon that periphyton layer, which sometimes is extremely tenuous, that trout fundamentally must depend; and bottom organisms, more particularly, must depend immediately.

And we were interested, again, in doing the same thing in a wide variety of streams.

Q What is the food -- nature of the food chain in these streams?

A We will start off -- let's start off at the bottom of the so-called "food chain" -- and let's not call it a "food chain," let's call it a "food web."

At the bottom of the web are the algae. These are, for the most part, diatoms and blue-green algae, and they carry on photosynthesis and manufacture more and more protoplasm.

In addition to the algae are bacteria, which does integrate or feed on the dead algae, which generate and which feed on the slime generated by the dead algae, and which also feed upon all sorts of inorganic detritus.

Now, in addition to living organisms, in this thin film of periphyton, there is also a considerable quantity of dead material, and that serves as a food for insects as well as the algae serving for food for insects.

Now, some time ago, it was thought that the aquatic insects on the bottom of a stream were absolutely dependent only upon grean algae cells on the substrate, but we have come to the realization -- I first promulgated this idea thirty years ago, but they finally came around complete circle -- so now most stream biologists are agreed that the great majority of food material for aquatic insects is, indeed, particulate, dead stuff, rather than the living algae, themselves -- although it is invariably a mixture.

In other words, a lot of stream insects are simply opportunistic feeders; they will go over the surface, the stone, with their scraping mouth parts and scrape off whatever is there, and that includes live stuff, dead stuff, bacteria, protozoans, and so on.

Q When you say just in the abstract of your paper, there was no quantitative relationship between lithophyton organic matter and bottom microfauna biomass?

A Correct, and this, I think, is the major contribution of this paper. It's a thing we didn't expect, but which, nevertheless, came out, and which now is being incorporated into the literature of stream biology.

It appears that in any ordinary stream, you may have a small quantity of lithophyton, and anywhere

between a small number of fish and a large number of fish. By the same token, you may have a rich periphyton layer associated with a small fish population, to a large fish population.

Now, just what the dynamics are here, I am sure we don't know. But one of the difficulties, I am sure, is the fact that so many of our streams are planted regularly, and, of course, they destroy the natural picture. One of the great needs in any kind of stream work, and I am talking here particularly about pollution of certain ions and so on, and fish populations in general, is to let a stream alone for twenty years, and then go in and electrofish the thing, and see what its natural density of fish is.

When we go into electrofishing of a stream, now, as some of you people know, what we are doing, ordinarily, is collecting fish that were put in there by the planting program, rather than there being natural fish. And, unfortunately, the closer you are to a large city, the more electrofishing we do. And by the same token, the closer you are to a large city, the more fish have been planted in there artificially.

Q In the sentence I read the phrase, "bottom macrofauna biomass." What does that include?

A Aquatic insects, for the most part. In other words, anything that you can see and recognize with the naked eye, we call "macrofauna."

Q This paper that we have been discussing, the "Trophic Variabilities," as I read it, did not specifically look at --

A These are they --

Q -- did not specifically look at fish vertebrates?

A This is correct.

Q In general, again with reference to this paper, would you say that you had found substantial similarities among the streams that you studied, or would you say that they were dissimilar?

A I would say that I was surprised to see what similarity there is in the long haul. I intentionally took samples from many streams, so I could average all the results together and look at them as a whole, because so many times, if you go into a stream once and take one square-foot sample, this means nothing.

If I might use an analogy: suppose you were a meteorologist, and you wanted to find out what the climate of Santa Fe is, you came out one morning and discovered

that it was warm and sunny and clear; six months later on New Year's Eve you came back for another sample, and you discovered that it's ten below zero, and dark, and perhaps snowing. Now, an average between those situations is absolutely meaningless, you see? But by taking a bunch of samples, you come up with something in the general nature of what the climate is like here.

Q Would you, although it's not reported in this study, would you go so far as to say that -- or would you be in a position to say, from your working in these streams, that the habitats or the variables that are important to the fish were somewhat similar among these streams, too?

A If you use the term "somewhat similar," yes, I will agree with you.

Q There's kind of a range, I would assume?

A Yes, there is a range, to be sure, but for the most part, I selected areas of streams which had rubble bottom -- and "rubble", in my sense, means particles on the bottom anywhere between two and seven inches in diameter. You must select similar types of bottom; otherwise, your results are absolutely meaningless. A sand bottom is quite different. A great big boulder surface in the stream is quite different. It's a kettle of fish.

Q Is a gravel bottom quite different, as well, or are you getting closer --

A We will get to that later on, and I will discuss the substrate types at some length, if you wish. I have that, if you are going to question me about that.

Q Why don't we go through in the order you have it in your outline, and maybe we can talk about what you found in your various studies of the Red River? If it's all right with you -- well -- did you have something you wanted to --

A No, nothing in particular. I was going to comment especially on the classification of the bottom materials that are presented in some of the instream flow data.

Q Why don't you go ahead? Fine, why --

A Do you want me to talk about instream flow now --

Q Well --

A -- or do you want to go through this first?

Q Is there something about the substrate --

A It would take quite a long time, is all I am talking about. Because I read over those interesting mimeographed materials, and I found them extremely interesting,

although there are some things I don't agree with. So if you wish, if you want to dispose of this outline first, that's quite all right, because it's going to take me a while to justify my remarks with reference to the instream flow material.

Q Okay. I would prefer to go through the outline first, and possibly talk about the instream flows later.

A All right.

Q And the first physical parameter that you look at, or report about, I have one question, first: you set forth in your outline the seven sampling stations, and I think, again, that the locations are described. There is a comment about the very last one there, the one that's four-tenths of a kilometer above the mouth of the Red River. That says, "The substrate here is essentially all boulders, all large boulders, making it impossible to take bottom fauna samples."

Would you elaborate on that point?

A All right. I find that the lowermost -- especially the lowermost three miles of the Red River is an extremely interesting stretch. It is remarkably V-shaped, looking at it as a whole. And the substrate consists, for the most part, of large boulders, very large rubble, arranged

in a completely heterogeneous manner, so that you have very little gravel exposed.

So that it was difficult for me to go down at the last station and find a place where I could use a Surber sampler. In other words, they were all big boulders and no place to set the sampler down, you see, and get the organisms to go into the sampler.

Q When did you first begin to attempt sampling in the lower reach?

A The first time I went down was in August of this year, in the lower reach.

MR. GREENBERG: Now, let's clarify "lower." You don't mean by that, the Wild and Scenic River, because from --

MR. ESTES: Let's make any distinctions that are necessary.

MR. GREENBERG: -- from the very beginning, you recognize that one of his sampling points, number five, is within the Wild and Scenic River reach?

MR. ESTES: And that number five is two hundred meters above the east edge of the fish hatchery.

THE WITNESS: That's correct, and that was visited frequently, and that has a good rubble bottom.

MR. GREENBERG: Six and seven were added in 1979?

THE WITNESS: Right.

MR. ESTES: Just this summer, in August of '79?

THE WITNESS: Correct.

Q Have you --

MR. GREENBERG: So my only point is, I think we have to differentiate between the lower portion, which we have generally referred to as the four-mile Wild and Scenic River, and some other name which we want to give to the lower portion of that portion.

MR. ESTES: Okay. Fine.

Q Did you have an occasion to walk the whole lower three or four miles? Have you walked down from the fish hatchery?

A No, I didn't. I walked down about a mile, perhaps, below the fish hatchery, or at least I didn't go as far as that great cliff that juts out into the stream. And then I went out on the point where the Red River has its confluence with the Rio Grande, and walked back upstream about two-thirds of a mile. So that I think -- and you can look up, of course, and see what much of it looks like

off to the east, and it shows up remarkably on the topo map, as well, so that I feel that I have a fairly good idea of what the stream looks like, physically.

But to get back to your original question, down at sampling station number seven, it is almost impossible to find small rubble and gravel in order to take bottom fauna samples, because the stream so cascades between this jumble of large boulders and large rubble.

Now, I don't say there is no gravel there. Please don't misunderstand me. But I say there is a minimum of suitable gravel substrate for fish productivity.

Q How often -- what approximate dates, and how often did you go down to that area in the mouth?

A I was down there twice; once in August, and once in September. But, of course, as you know, there was a tremendous runoff this year, as well, and it was extremely difficult to sample. In fact, I was going to come to Molycorp and sample in May, June, and July of this year and carry on my regular studies on the first five stations, but we had such a terrific runoff that it's impossible to take any samples, unless you have a mind to drown.

Q We have all discovered that this summer.

Did you have some difficulty on your visits

in August and September -- well, I might back up. Did you put on waders, or whatever, and actually get in the stream?

A I always have waders on, yes.

Q Did you have any trouble getting into the stream in August and September because of the high flows?

A On station six, no, because this was down, you see, eight-tenths of a kilometer below the west edge of the fish hatchery, and the valley is still a little bit over there, and there are places you can sample. So I sampled there at number six, but I couldn't at number seven; waders wouldn't do you any good. I don't know what you could do.

Q Am I right, your conclusion about the bottom is based on what you could see standing very near the edge?

A That's right, and by the velocity of the current.

Q At the station number six, what's the -- obviously, there's some gravel there, enough for you to put in your sampler?

A This is correct.

Q And what would you say beyond that?

A Once you go very much below that, then, the thing becomes -- with the exception of a few spots -- becomes a series of cascades between large boulders and bedrock.

Q At and above station number six, you mention specifically both five and six, do you find there to be an average amount of gravel, or -- and again, with reference to some of the other Rocky Mountain streams.

A Number five is above the fish hatchery, and I would say that this is typical of most foothill mountain streams. And then you walk past the fish hatchery and you go down about, oh, I should say a quarter-mile, and then the bottom and the stream becomes more atypical. Then the farther down you go, the more boulders there are, and the more cascading the water becomes. So it is extremely difficult to take a sample.

Q What about some of your stations that are located further up? For instance -- well, the one -- number three above the mouth of Pope Creek. What's the substrate like there?

A These are all standard rubble. See, I sample only in rubble. This is the most productive kind of bottom that we have with reference to fish food materials, and what you want to do is sample the same kind of bottom, because it does you no good to sample rubble in one area and sands in another area, and bedrock in another area. They are absolutely incomparable.

Q Okay. And how about gravels in these upper stations, say at number three? Is there more or less normal distribution?

A There is, yes, there is more gravel and more sand intermingled among the rubble areas.

Q Is there -- from -- essentially from the fish hatchery on up in the area that you have dealt with, is there sufficient gravel to -- if all other things being correct -- to support a resident fish population? Could spawning go on in those upper areas?

MR. GREENBERG: When you say "upper," you mean --

MR. ESTES: Well, I mean essentially from the fish hatchery, or perhaps just below the fish hatchery, for the next mile above that point.

MR. GREENBERG: In other words, from the fish hatchery to the bridge?

MR. ESTES: All right, the highway bridge.

A This would be conjecture. I don't know much inflow of water there is in the gravel at the sides. I should say that theoretically, there may be some spawning in there; but how much spawning, natural spawning there actually is, I have no way of knowing. And you would have no specific way of knowing until you had stopped all artificial

planting of fish in the Red River, and let the thing go on by itself, and see whether or not the population would be self-sustaining.

Q I really meant to only address your attention to the existence or absence of gravel. Leaving other things aside, is there sufficient gravel to have a spawning fish population in that area?

A I should say "Yes," only from the standpoint of gravel.

Q Okay. I understand.

Did you have any -- now, going back down near the mouth again, what was the turbidity of water like at the time you were there? Did you have any trouble seeing the bottom?

A No. I came there late enough in August and September that the water was fairly clear, and except where the cascading was so violent as to cause froth and white water, you could see the bottom.

Q We might be wise to get the exact dates, if you have a record, in August and September --

A Yeah, I would have to --

Q -- when you were there. I don't mean to take time now, but perhaps at lunchtime we will get the

exact dates.

A I would have to fish out the original report.

MR. GREENBERG: Since you have -- dealing with gravels, and the question of spawning, I asked Doctor Pennak that, and he provided me a very brief sort of an opinion on that subject -- I don't have any problem -- summarized in the outline. But you can even see that, if you want.

Q In concluding, Doctor Pennak, that the Red River below the hatchery, and especially the lowermost two miles, has almost no suitable gravel areas for redds, is that based on essentially an extrapolation from the part of the river that you did walk along?

A Exactly; yes.

Q You haven't tried to go to the --

A When you see a V-shaped, cascading river loaded with boulders, you know that the reproduction rate is low. The finest trout reproduction areas in the world are in large, broad rivers with a rubble bottom, and particularly with seepage coming in the sides. I will come back to this problem later on, when we discuss instream flow at some length.

Q I might ask an obvious question: there's nothing inhibiting the trout from spawning somewhat upstream

in the areas that do have gravel, but then at least a portion of them living in the lower --

A Ordinarily, they won't go up that far, particularly if they have come out of the Rio Grande. If a fish -- shall I say -- "wants to spawn," and is already in the Red River, it will go upstream looking for a seepage area and the right kind of gravel. It may or may not find it. If a fish is in the Rio Grande and wants to spawn, it will come up -- some of them -- will, of course, come up the Red River, I don't know how far, looking for a place to spawn. And it's not a good spawning area, because it isn't the right kind of substrate, you see?

Q Why is it -- you say they wouldn't go up further, say, to the fish hatchery?

A This is our experience, ordinarily, that fish, except for the salmons, won't move more than a couple of miles up a stream looking for an area, at the very most. Usually, it's a matter of a couple hundred yards.

Q You are not ruling out -- I will be specific: say, a brown trout migrating up from the Rio Grande past the fish hatchery?

A I am not ruling them out, no. But I would say it doesn't happen very often.

Q What if the trout are just living, are not from the Rio Grande, they are just living in the lower part of the Rio Grande; come spawning time, there's nothing to prevent them from going one more mile up past the fish hatchery, is there?

A No, this is correct.

Q I mean, is that sort of a life cycle that makes sense in that river?

A Yes, this is true.

Q We just have some information that they have even caught brown trout --

A This is correct.

Q -- passing the fish hatchery.

A We are dealing here in generalities. There are always the exceptions, please remember that. I am talking only about the majority of cases, not all of them. There are exceptions to everything I have said here today, and nobody knows that better than I do.

Q Okay. I would be happy to get into some of the specific physical features that you found over the years ofthe Red River.

A Okay.

Q Why don't we start with temperature?

A Nothing to comment. I should say --

Q Right, I was --

A -- it's typical of foothill streams everywhere.

Q Do you find anything about your temperature measurements that suggest in some way temperatures are a limiting part of the habitat?

A Never. Never.

Q This is --

A Stream's cool enough -- excuse me -- the stream is cool enough so there should be no difficulty, and the river, of course, is shaded by those enormous cliffs, so you are fortunate. If it were out on the flat plains, it might occasionally, during a long, hot spell, be a limiting factor. But as it is now, it's my opinion that it does not act as a limiting factor.

Q And we might be specific about in connection with trout population, this is the kind of temperature range that trout like?

A We will talk about that later, if you wish. We have it already diagramed for us very nicely.

Q All right. But as far as your own data measurements go --

A Yeah.

Q -- the temperature is fine for trout?

A No problem. No problem at all.

Q The next thing you deal with is turbidity, and I can tell by looking at your studies and looking at this outline that this varied somewhat --

A Yes.

Q -- depending on what had happened on the river. Is there --

A It's well --

Q Is there any comment you wish to make about that?

A It's well within the tolerance.

No, in the measurements I have made, there has never been any sign of any turbidity damage to the trout population.

Q What would you look for to determine turbidity damage? What is it you looked at to rule that out?

A Oh, mostly the literature. The literature says that you don't get trout being killed by turbidity until you get way up in the thousands of parts per million.

For example, there was a review done by Sorensen in 1977, out of Corvallis, and if you had eighty thousand parts per million, trout would survive one day.

And we are talking -- you see here, even in exceptional circumstances, in terms of one to two hundred, and those are all exceptional and very temporary kinds of circumstances.

Even natural sediments at the level of one to three thousand will take thirty days to kill trout, and we never have anything like that.

If there is a turbid time in the Red River, it has passed very quickly. And as I mention in the text, there were a couple of odd-ball turbidities that we have no way of explaining. For example, in the first -- I don't believe you have that -- I don't believe you have that.

MR. GREENBERG: Yes, they do.

THE WITNESS: Does he have that data?

MR. GREENBERG: Yes.

THE WITNESS: "Suspended solids in the Red River, Parts Per Million."

No, he is talking from the general outline.

MR. GREENBERG: Look at page five of the summary of eco conditions.

THE WITNESS: Page five?

MR. ESTES: This is your 1979 --

MR. GREENBERG: That summarizes everything.

THE WITNESS: That's a summary, page five.

Now, you see in the first column, three twenty-four, it should have three asterisks after it.

MR. ESTES: Yes.

THE WITNESS: This was severe pollution upstream from Molycorp. I don't know what it was, but the water was intensely yellow, but it only amounted -- to look at it, you would think it would kill the trout population, but it was actually only three hundred and twenty-four parts per million. I don't know the source of it. It lasted four hours, and then was gone, and the stream cleared up, and the population was all right.

You see, what you must realize, what all of us should realize, and many times we forget, is the fact that silting and sedimentation has been with trout since the dawn of history. They have always had to contend with sedimentation as a result of gully washes, they have always had to contend with times of drought, and they have come through it all right. So they have a built-in mechanism, really, to withstand these temporary peculiarities of the habitat.

Q Back on page nine of your outline, you say that the Red River trout are well adapted to temporary unfavorable conditions. This is the sort of thing you are

describing?

A This is exactly the sort of thing. You could have said of this, "any trout."

Q What's the definition of turbidity? And I am thinking what's essentially the distinction between turbidity and your next two classes, suspended organic and inorganic material?

A What pages are you on?

Q I am back on page three of the outline.

A "Turbidity trends." Okay.

By "turbidity," I mean here just a general impression that you get by looking at the streams. It is taken care of in detail by part C and D, which are suspended organic material and suspended inorganic. In other words, part B is qualitative; parts C and D are quantitative.

Q Okay. Is turbidity essentially visible suspended matter?

A Yes. This is the way I think of it here. Now, when I determined part C and part D, I do it gravimetrically, unlike a good many other federal and state agencies, because I feel that if you weigh your results in a semimacro balance, your results are far more accurate, because many times you don't know what fraction of the

suspended material is organic, because that's harmless, and what fraction is inorganic, because that is the more harmful part of it.

So I always split the two and did it quantitatively in the lab. So C and D are an outgrowth of B.

Q Okay. When you say that the organic material is harmless, I assume you mean at the levels we are talking about here?

A That's right. Within reasonable levels.

Q Below a municipal sewage treatment plant, that's a different problem?

A That's a different problem. I am not talking about that. I am talking about typical mountain streams of the foothill zone.

Q With respect to suspended organic material, what has been your conclusion over the years?

A Let's see, we got it on the last page?

I can give you my conclusion very easily. I should say suspended organic materials are negligible in the times I was there. Usually, it was in the nature of less than five parts per million, which is so small that you can scarcely see it in the water sample.

Here we are. If you look on page eight --

page eight, part B, it says this -- part B, page eight. You see that?

Q Oh, yes.

A "Except for temporary tailings problems and cloudbursts, the Red River has a favorable suspended load situation for the bottom fauna and trout populations."

Q And that's true for both organic and inorganic?

A Yes, indeed.

I was trying to see whether or not we had much organic material there. There wasn't, really. It was typical of other mountain streams.

Q Is that true of inorganic material, as well?

A Yes; very low. You are lucky to have it that low, believe me. The stream is lucky.

Q What about for purposes of trout population? Is that beneficial to have it as low as it is?

A It makes no difference. It makes no difference to the trout population at the levels we are talking about.

Now, if we got up to three or five thousand that lasted for weeks at a time, we would have something to worry about. When you go occasionally to one or two hundred, it's no problem at all.

Q These levels of inorganic materials, I take it, were also pretty typical of Rocky Mountain streams?

A Exactly.

Q Okay. We come to -- in the outline, come to stream substrate, on page four. Of course, we have discussed that already.

Where you indicate that in the 1971 report, all substrate studied were eighty percent rubble, ten percent boulders, and the rest silt sand, did the rubble -- does that include some portion of gravel?

A Rubble, to me, is two to seven inches in diameter, and you would have, of course, sand and debris, gravel, you have got everything mingled in with it, really; but predominantly rubble, that was the important thing that I was talking about.

Q All the stations in 1971 were above the fish hatchery, were they not?

A Yes.

Q And --

A All the stations through 1978 were above the fish hatchery.

Q And you indicated before, I think, that there was sort of a normal complement of gravels in those upstream

stations?

A Exactly.

Q Why don't you, if you would, discuss your conclusions in paragraphs five and six there? In general, I gather that there was a deposit at one of the stations that at first you felt was from Molycorp's activities, and then you changed your mind?

A Exactly.

Q What went into your thinking on both those occasions?

A When I came in March, in 1978, I discovered that at station two, but not upstream from it, nor downstream from it, some of the rubble seemed to have a very thin, microscopically thin yellowish-tan deposit. It didn't seem to have anything to do with the bottom fauna population that we found at the same time. In other words, it had no harmful effect upon the bottom fauna, but at the time I wondered whether this was some chemical waste that had been somehow or other emptied into the water by Molycorp, and it just settled out in those few miles on the substrate, and then you go farther down and don't see it.

But when I came the next time, in October of 1978, in talking with the Molycorp, and in particular

in examining the canyon wall on the north side of the Red River Canyon, I was convinced that, indeed, this yellow material, whatever it was, had originated from a gully washer that had come down from a side canyon and carried some sort of a mineral material into the water, and that mineral material had settled out on the stones.

Q At the lower stations, say at station five, just above the fish hatchery --

A Yes.

Q -- did you find silting of the -- on the materials or between the materials?

A Very little. Very little.

Q You would call that clean rubble?

A I would, indeed, yes.

Q How about at the station this year, looking below the fish hatchery; same conclusion?

A Station six, you mean, below the fish hatchery?

Q Yes.

A Yes, that is a clean bottom. In fact, this year, 1979, all stations had a clean bottom. You couldn't have anything else but, after the runoff you had, you see, in the spring and summer.

And this, by the way, is a problem, a thing

that stream biologists have not brought out. I maintain -- and many of my colleagues will disagree with me -- I maintain that a periodic washing of a stream is a good thing for the stream, because you get rid of a lot of the fine sand that is between the rubble particles, you get rid of a lot of organic material that serves as packing, and thereby takes away lebensraum for bottom organisms.

And I have no proof of it, but it's been my observation that once you have a nice, clean gully washer, the following year, the following two or three years, are very good years for the production of bottom fauna, because they have more interstices, you see; and the more space you have, the more interstices there are, the more animals are capable of living there.

Q Does it have something to do with the flow of water, oxygen, and so forth?

A Nothing at all to do with oxygen, no.

Q Silt doesn't have anything to do with that?

A Nothing; absolutely nothing.

Q Does silting, at least in the levels we are talking about, have anything to do with the usefulness of gravel for spawning for fish?

A Yes, it does. It simply means that you will

have fewer areas available for spawning. It all depends on the individual configuration of the bottom, and where you happen to be getting subsurface hyporheic waterflow, and so on.

Q Let's say at station five, just above the fish hatchery, is silting there -- well, you have described it as a "clean bottom," do you mean that you are not aware of a siltation problem that could interfere with spawning for trout?

A I am not aware; it's not that serious, no.

Q You don't look upon that as a limiting factor?

A I don't.

Q Okay. The chemical conditions on the river, starting on page five.

A All right.

Q I would be happy to have you just go through those one by one and essentially describe what your findings have been.

A Certainly. Dissolved oxygen is close to one hundred percent in any rapidly flowing water that does not have gross commercial, domestic, or industrial pollution. In other words, as soon as you have mixing of the water and any white water at all, there is an equilibrium set up

between the oxygen in the water and the oxygen in the air, and it averages out a hundred percent saturation. This is something that a good many people simply do not keep foremost in their minds. There is never a lack of oxygen in any hill or mountain stream, anywhere where the water is polluted.

MR. GREENBERG: When the water is unpolluted?

A When the water is unpolluted, I'm sorry.

And when I say "near saturation or slightly above," I mean that -- and I have taken hundreds and hundreds of samples on all sorts of mountain streams -- the saturation will ordinarily range between ninety-five and a hundred and five percent saturation, depending on how many accidental bubbles you happen to get in your sample; you see, that will run it about a hundred percent.

Number two, free CO_2, again, it is precisely the same matter. CO_2 will roughly have an equilibrium with air. It enters, air explicitly does, from the air in water very easily, and you have a mixing of water.

You could get precisely the same results if you took a thermos bottle full of any kind of water, closed the top and shook it up, and ran an analysis on that water. You would get these results.

Q What's the significance in terms of productivity of the stream, of both of those, of both oxygen and free CO_2? Why are those two things that you look at?

A Oxygen is ordinarily -- analyses for oxygen ordinarily are run in questionable areas, and I ran them particularly in the first years of this study at the insistence of Molycorp.

If, however, you are working on a stream that is below a village, or below a town, where you have organic matter come into the water, then, you have perhaps something to worry about, and you wonder whether the oxygen will go down a little bit immediately below that sewage outfall.

So it's ordinarily just one of these standard measurements that you make, particularly since people over all these years have assumed that you should make a dissolved oxygen determination.

Now, if you were back on the Illinois River, or the Wabash River, or the Cuyahoga, the termination of oxygen would be absolutely critical, because there, you see, it may fall to very low levels because of excessive pollution; but not here.

Q How about free CO_2?

A The same is true for free CO_2. A lot of people simply insist that you take CO_2 readings, so we do, even though it invariably shows that you have got an equilibrium of partial pressure arrangement with air.

Bound CO_2 is of greater importance. This is the carbon dioxide which is bound up in the carbonate molecule in water. It ordinarily, and for some unknown reasons, is an indicator of productivity of a body of water.

Our finest trout waters in the world, on a per-acre basis, are the chalk streams of England. We call them chalk streams of England, because there is so much calcium bicarbonate dissolved in the water.

The same is true, to a certain extent, of the -- some of the chalk streams we have in New England. The same is true, to a certain extent, of some of the large calcium carbonate springs that we have in parts of Idaho and Montana.

Now how carbonate affects the fish population, we are not prepared to say. We don't know whether that's a physiological manifestation, or whether it operates somehow or other through the food web.

Q In any event, you found the Red River to be somewhat harder than the average of the other trout --

other mountain streams you have looked at?

A This is correct. It is harder than the average mountain streams that I have studied. And it is harder than I had anticipated when I came down here.

Ordinarily, I would expect pH readings of around seven point three, or seven point four, as the usual thing. Here, your pH -- there is no such thing as an average pH, but the median probably was pH seventy-seven, I should say, or something of that sort.

Q Does that have a significance in this range, anyway, for the fish in the stream?

A I think it does, but I don't know what the mechanism is.

Q What -- in what way? What's better, higher pH or lower?

A Higher pH means more fish, unless, of course, you get up to something extremely alkaline, let's say pH eighty-six or eighty-seven. Then this curve begins to go down. But you are in a very favorable portion of the pH curve with reference to bottom fauna and fish productivity. But how the mechanism operates, we do not know.

Q I take it that the pH is a little higher here than you found in other streams?

A Yes, it is.

Q In your second paragraph under that letter C, indicates that the water became slightly harder as it went downstream. Did this turn out to be true as you got down to stations six and seven, as well?

A This is true of any flowing water. The closer you are to the headstreams, the softer the water is, because, after all, that's rainwater and snow water, snowmelt. As you bring it down through the -- through the thalweg, it is in contact with more and more substrate, and the longer it is in contact -- in contact with the substrate, the more salt it picks up.

So if you go to the headwaters of the Red River -- I haven't been there, but I would absolutely guarantee that the water is extremely soft. The farther down you come, the harder it is, with reference to its total dissolved load and carbonates, and so on. But this is a worldwide phenomena.

Q Okay. The next category is dissolved materials.

A Again, I think we can summarize this very quickly, if you wish.

The dissolved materials vary enormously from time to time, in spite of the general comment that I have

just made. One of the reasons for this revolves around the fact that the quantity of dissolved materials is dependent upon the amount of water being carried by the stream. If, for example, Red River were a miserable little trickle coming down its streambed throughout the entire length, you would discover that it would have a very high salt content, because each molecule of water in that little trickle has greater opportunity to come in contact with the substrate.

Now, if you have a gully washer, with a tremendous torrent of water coming downstream, each molecule of water has less opportunity to come in contact with the substrate, and thereby pick up more dissolved materials.

So this is why any stream, and particularly mountain streams, will vary enormously in their dissolved load from one time to another. All you can do is take what you hope are a lot of readings, and take an average of the thing. And that shows up in that table I believe you are looking at.

Q Total dissolved solids.

A Total dissolved solids, yes. And these are simply arranged chronologically from top to bottom, there is no rhyme nor reason, and every one of those determinations simply means that we evaporated down a water sample and got

the total dissolved solids out of it.

But if you wanted to average the results out, you would discover pretty well that there would be small quantities at station one, large quantities at station five, station seven is not so typical because you must remember this was a time of high flow, even in August and September, and, of course, a lot of additional water comes through in the lower part of the stream through hyporheic sources.

Q What's the significance on the biota for -- of different levels of TDS?

A Would you restate your question to mean what is the significance with reference to varying T.D.S.? Would that be all right?

Q Well, you can start with it, and if that doesn't do it, I will try again.

A To answer your first question, we will go back to a problem we were discussing a minute ago: the greater the dissolved salt content within reason, the better it is for the bottom fauna. Again, there is a correlation --

Q What's "within reason"? What levels are we talking about?

A Oh, I should say up to six hundred, perhaps five hundred parts per million, maybe seven hundred if they

were mostly carbonates.

Chlorides will spoil the thing, but chlorides are apparently not a problem in the Red River, the rocks here are very low in chlorides.

Q What about trout, specifically? Any difference with respect to them?

A No, except that they like a lot of dissolved salts. By a "lot", I mean two or three or four hundred parts per million. You always -- if you had two areas that are essentially comparable in their physical habitat, except that one has harder water than the other, you will get better trout growth here in the hard water, than you will in the soft water. This is one of several reasons why trout at very high elevations have such a low growth.

Q Okay. And this, I think, explains your statement that there is some evidence that Pope Creek water has increased the TDS of the Red River, and this phenomena has a beneficial fertilizing effect on the biotic community. That's on page six of the outline, paragraph six.

A Yes. Now, you will notice, I said, "Suggesting that the entry of Pope Creek into the Red River may have a fertilizing effect." I did not say categorically that it does affect the productivity. It looks like it. It

may be true. And for the time being, I will go along with the belief that the Pope Creek does, indeed, have a beneficial effect on the Red River, until somebody disproves me.

Q This might.

Did your -- with respect to Pope Creek, did your measurements indicate that the watering in Pope Creek, itself, had a higher TDS level than the stream water?

A Yes, it did in most instances.

Q And, likewise, the measurement station below on the river, below Pope Creek, wound up a higher TDS?

A This is correct, station five.

Q When you say that you believe it had a beneficial fertilizing effect, is that also reflected in finding higher number of organisms and higher biomass?

A This is my primary reason for saying so. Station five, below the Pope Creek inlet, had the best production of bottom organisms, of any of the seven stations -- eight stations.

Q If I might just try to summarize with respect to the parameters that we have talked about so far, I guess, except for this question of gravel and spawning, just about everything else you have discussed here seems to be very good conditions for a trout population; is that a fair

statement? The chemical characteristics seem to be okay.

A No, I wouldn't -- well, let's see. I should say that conditions are as good, or somewhat better, in the Red River, than they are in other similar Rocky Mountain streams. I do not say that the Red River is a good trout stream.

Q You might want -- that's putting it on the same scale with the ones in England, the chalk streams and so forth?

A That's right, or the Yellowstone River, or for that matter, the Gunnison on our western slope.

Q But you are not aware of anything unusual about the Red River that would make it a bad trout stream by Rocky Mountain standards?

A Absolutely not.

Q Okay. Why don't we go to the next category, then, your work on bottom fauna.

Would you care to summarize that?

A Okay. What page are you on?

Q Starts on page six.

A Okay. You must remember, first of all, that the bottom fauna in any rapid stream is a highly variable thing. It's variable because each species has its own kind

of reproductive cycle. So the idea is to take a good many samples and hope to come out with a reasonable estimate of the -- what we call the "standing crop" of bottom organisms.

I should say in general that Pope Creek has a bottom fauna which is relatively similar to what we find in other Rocky Mountain streams; the same genera of bottom organisms are there. The only, I think, serious interruption in the bottom fauna occurred when we had some of these silting incidents, but after a couple of months the bottom fauna came back and there was no permanent harm done at all.

And we know now that in mountain streams this is a common mechanism that aquatic insects have. We know that below the surface of the gravel, below the surface of the substrate, there are always residual eggs, and there are residual early larvae, which come out and grow very quickly after the temporary destruction of a portion of their population.

To me, the -- one of the most interesting things about a bottom fauna as a whole, is the fact that they are able to weather over such savage natural conditions over relatively surprisingly long periods of time.

Q What do you have in mind when you speak of "relatively long periods of time"?

A I am talking about a drought that may last a month or six weeks. I am talking about a heavy runoff that may last two or three months.

Q What can you tell us about the comparison again between the Red River and other Rocky Mountain streams, with respect to the bottom fauna? How does it seem to stack up?

A I can give you specific answers, if you wish. Just a moment.

I have to refer to this other publication, since you asked about other Rocky Mountain streams.

Q That will be fine.

A I am talking now in terms of biomass. Red River average ranged from two point four, to nine point three. All of the other fifteen or twenty ranged from zero point seven, to eighteen point six. So it falls very nicely in the middle, I should say. It's quite typical of what we have in these many other streams.

Q In larvae, summarizing your 1971 report -- and that's on page six of the outline -- you make the statement that by a criterion of number of organisms at that time, the Red River was a poor producer. Has your view of that changed since 1971? Some of the other years you

seem to have gotten a higher result from your biomass collections.

A Not particularly, in the average long run. All of these small Rocky Mountain streams are poor producers, let's face it. We haven't got any rich streams here at all.

Q When you say that it might be due to the small size of the stream, how would that work? Why would that affect --

A We don't know. It's the only way I can answer it. But there is a size correlation. In general, the smaller the stream, other things being equal, the lower will be the production of bottom organisms.

Q In general, I take it it's your conclusion that at station five just above the fish hatchery, the number of organisms and biomass is generally higher than at the stations further upstream?

A Exactly. I have no other way of explaining it, other than the entry of water from Pope Creek.

Q Could it have something to do with the general phenomena of the water becoming harder and harder as it goes downstream?

A This may be, but on the other hand, if you will look at the stream -- let me phrase it another way.

MR. GREENBERG: Let me interrupt a minute, Mr. Estes. If you look at page three of the summary, eco system conditions --

MR. ESTES: Right, 1979.

MR. GREENBERG: Right.

MR. ESTES: Right.

THE WITNESS: If the results at station five were due solely to gradual increasing in the hardness of water, I would have expected higher results for station three, and higher results for station two. In other words, it comes up on you all of a sudden, at station five.

Q Okay. So it may very well be a combination of both those phenomena?

A It undoubtedly is, but I would give more credence to the business of the Pope Creek waters having some sort of fertilizing effect. Bear in mind, now, I do not say categorically that this is so, this is nothing more than a guess.

Q I see that in 1979 at all the stations you got real low readings. I think you report that's because of the high runoff?

A Yes, I am sure. And I am sure that by next spring, or even this fall, that things will come back very

quickly to normal.

At the same time, I don't think this point has been brought out yet, the trout will get along with a very restricted fauna. In other words, it means they hunt around a little more, but they will get enough food.

If you and I had to exist on berries, there would be some years when we would have lots of berries to eat, there would be other years when there would be only a few berries, and we would have to walk around a little more and scrounge a little more to get them.

It's the same way with trout, and people forget that trout have a lot of anthropomorphic human characteristics. The trout has to have a place to feed, and hide, and to breed and to rest, and everything else. We can't view a trout as something that's completely inanimate.

I'm sorry, go ahead.

Q I have tried to catch them, and I know they are plenty animate. They manage to get away from me without any trouble.

Then, the last of your categories of things that you sampled for was the lithophyton or periphyton. Again, could you summarize what results you found?

A I should say that the periphyton has a

remarkable power of recovery after a scouring, even more rapid than do the bottom insects. And that the periphyton, in general, is highly variable, and that a surprisingly large quantity of it consists of organic detritus, rather than algae or blue- -- rather than diatoms or blue-green algae. It is a clean water periphyton, it is not the sort of thing that you get down in a river below a sewage effluent, you see?

Q One other question concerning the ability of the trout to survive these temporary difficulties: is the fact that in the Red River, especially in the lower portion, by definition there is another large river nearby, there's also the possibility, isn't there, of the trout migrating out temporarily into the Rio Grande and living there until river conditions improve?

A Yes. I don't know -- we don't know, frankly, how often this happens. I don't think really critical studies have been carried on in that area.

I will say this: I manage a trout lake, and it has a good flow coming into it and a good flow going out of it, there are about as many fish going upstream as there are coming downstream at any one time. I mean excluding breeding. It's hard to know -- fish in general don't like

a powerful current coming toward them. If you have ever seen them plant trout in a lake, you know what this is like. They come -- with a truckload of trout, and they lower the spout down to the water, and they are going to dump all the trout in here. And they turn on the water up there, and the trout come whooshing down in that water. These trout are trying like crazy to stay upstream, they don't like to come down with the current, you see?

Q In general, were you suggesting, though, that the trout are perfectly capable of moving from one location to another?

A Absolutely. This is a point I will bring out later on today. Trout move around much more than we suspect. They don't stay in the same home twenty-four hours a day. They are like people, they move around.

Q Do they seek out --

A You don't stay in your apartment twenty-four hours a day; you get out and you move around. Trout are the same way, believe me.

Q They seek out conditions that they consider most favorable?

A Or they just move around for no particular reason, like people.

MR. ESTES: Okay. All right, let's break for the noon recess.

(THEREUPON, the noon recess was held.)

Q (Mr. Estes continuing.) Let me ask you a couple more questions now from the top of page nine of the outline, of your number F. "There is a correlation between stream size and size of the resident trout population."

Is that based on any special studies of yours?

A This is based on the literature, and it -- it really is taken out of context from the more general report that was in here, but what I am saying is that there -- the larger the stream, in general, the larger will be the resident trout population. So there's a positive correlation.

Q Are you -- and you are speaking of making comparisons between different streams?

A Streams in general, right.

Q How about flows, water flows in the same stream? Are you aware of any studies that have tried to determine whether there's a correlation between water flow in the stream and the size of the trout population?

A Do you mean variations from one time to another within the same stream?

Q Well, we could start with that, but I am

also interested in any kind of permanent changes in the amount of water. I realize it varies seasonally. In fact, why don't we start with that?

Are you aware of any studies that have tried to correlate if you change the average stream flow, whether you wind up with --

A No, I am not aware of any specific studies --

Q Do you have --

A -- and you must be -- I must be skeptical about such studies, because as I say, most such studies are done on streams that are heavily planted, you see, so you have no way of telling, usually.

Q Dealing with the natural trout population, would you have an opinion as to whether or not a significant change in the average stream flow would be correlated with the change in the number of trout?

MR. GREENBERG: I have to object to that. I don't know what you mean by "significant." I think you should quantify it in some specific way.

Q Okay. Why don't we say a reduction in the average of a third of what has previously been the average?

A I could only speculate here. I would guess that after a long period of time, if the stream were made

OFFICE MEMO

TO: 76' Trout move — little people.

Date

FROM: 78' not familiar w/ streets re: flow & trout biomass

SUBJECT: - would be skeptical due to stocking

REMARKS: - most · why · etc.
colo -

→ larger stream more trout

132-33 - critiques - useable habitat · disagree - fish move around great deal

— Mike - all data — plan — what do
— critique

permanently smaller, that the trout population would, indeed, be permanently smaller. But this is a principle that fisheries people have been aware of for many, many years.

Q Would you expect, over the long run -- and I understand you want that to be a qualification -- over the long run, would you expect a smaller change in the average stream flow to be similarly correlated?

I gave you a change of a third; what about a change of ten percent?

A I don't know. I don't know. I don't know of anyone who's tried such measurements. It would be very difficult to find such a stream.

Q From what you know about -- you spent virtually your whole life looking at these streams; from what you know about them, would you expect there to be such a correlation?

A I can only come back to my original intention, which simply says that in general, other things being equal, the larger the stream, the greater will be the trout population. So you may interpret that any way you wish.

Q In your sentence G, where you say, "Red River trout are well adapted to temporary unfavorable conditions," what are some of the unfavorable conditions? We have --

A Trout --

Q We have talked about turbidity.

A Turbidity, drought, very low temperatures, especially during the winter, heavy fishing pressure -- I have been continually amazed by how few trout are taken out of the thing, if you can call that an "unfavorable condition."

I think those perhaps are the chief ones.

Q What time period did you have in mind when you use the word "temporary"?

A Depends on the particular parameter that you are talking about. If you are talking about silting -- and again, you would have to specify what the silting is, and it's -- it would be difficult for me to say, unless I knew what parts per million we are talking about and so on, you see?

In other words, these parameters are so vague that you can't hook them together and attach a number to them.

Q In general, did you have in mind a period of time, say, less than a year? Can you go that far?

A Oh, yes, certainly. A year, yes.

Q When you say, "Red River trout are well

adapted," do you mean there's something special about Red River trout?

A No, that could have read "trout in general." It's taken out of any discussion in general. We could say trout are generally unfavorably adapted.

Q I guess you said that with respect to both F and G, that it was taken out of something else. I am not sure I understand what that is.

A That was taken out of the general report on the ecosystems, "Summary of Systems Conditions in the Red River."

On page -- lower portion of page two, and the central paragraph on page two, applies to bottom fauna and fishes, and also on page four there is the -- under "stream flow" -- correlation between size of stream, best trout stremas, and I give examples of streams that have very low flow, page four, particularly.

Q Well, the point you are trying to make, I take it, is that there is -- that the trout can stand conditions for a reasonably short period of time, that -- without perhaps suffering any population loss to speak of?

A This is correct.

Q But perhaps the same conditions, if they

lasted -- became permanent, you would recognize that there would be some impact on the population?

A That is a generalization that is true of any animal in any habitat.

Q What don't we talk about cadmium? Your reference in paragraph A-one, "Recent analyses." Are these the analyses that you mentioned earlier, that you had done for you?

A Yes, these were done at a Denver laboratory.

Q And you found values of less than one microgram in the river?

A Yes. Just as they are indicated here, and those are the only cadmium analyses with which I had anything to do, on the Red River.

Q Do you know what dates those were taken? In fact, we were going to talk about the dates. Were they the same dates that you were down on the Red River?

A Yes, that's correct.

Q Maybe we ought to get the dates, if we could.

A All right. I can give you those dates, I think. The August and September dates are what you want, aren't they?

Q Yes, sir.

A The first would be August 5th to 7th. The second would be September 9th to 11th.

Q In the next paragraph, it indicates that "Almost all studies indicate that identifiable cadmium is to be expected in the majority of aquatic habitats."

Are the levels as high as these that you mention?

A They are considerably higher. In Colorado, 1974, Moran and Wentz found an average of two point ninety-eight micrograms per liter. These are active trout population, so that's -- but micrograms per liter.

Goettl and Davies, also 1976, working on a group of trout streams in Colorado, found from less than one, to one point six micrograms per liter.

Abdullah and Royle, a study in Wales, which considered, I think, a couple of dozen small streams in Wales -- I mean in Great Britain -- now, where there's no pollution, no industry involved, the average quantity of cadmium in those streams was point four one micrograms per liter, with a standard deviation of plus or minus sixty percent. Which means that a good many of them undoubtedly are up as high as one microgram, unquestionably.

Q Why don't we go right on down to your conclusion

that an average daily concentration of two micrograms per liter allows an ample safety margin?

A All right.

Q What is that based on? The studies you just read from?

A Let me tell you how I arrived at that.

In reading the literature on cadmium concentrations in natural habitats, I have restricted myself only to recent papers, particularly those since 1973 or 1974, because it is only recently that refined analytical techniques have come into existence for analyzing very low concentrations of cadmium.

So as I say, in arriving at my conclusions, I had that point in mind.

Secondly, you must remember that when you are trying to find out what the toxicities of cadmium to trout might be, you are keeping those trout in a laboratory, in an aquarium, where the fish are under considerable hormonal stress. And this is a point that everybody seems to forget about when you are dealing with these experimental animals; the trout are in an unfavorable environment, a completely strange environment.

When anybody walks past the aquarium, or

frequently when you walk past the aquarium, the fish are excited, they bump around, they -- they actually have a hormone stress and a lactic acid stress within the body, because of this unusual habitat.

Now, we have known for many years that this kind of sequence of physiological events occurs in mammal populations, wild mammal populations that you have out in the wild, and when you have them in the laboratory. We also know that it occurs within bird populations. We are just now beginning to feel that when you have wild fish in a laboratory, that they are excited and physiologically are weakened.

So it is my contention that those fish that we have in the lab are actually much more susceptible to cadmium poisoning than are wild fish out on their own, and not subjected to these physiological and hormonal stresses.

So that is the second fact that I took into consideration. And then going over the recent literatures, combined with that fact, I came out with this two micrograms and eight micrograms. It is my own contention, only.

Q You might indicate what literature it is that you are relying on. Are there several studies?

A Yes. I mentioned three of them. There are

others. And they will be -- they are in the end of this cadmium report that you have.

MR. GREENBERG: No, that's a report to me, but you can read into the record your -- the reports.

THE WITNESS: All right.

Literature on cadmium -- significant literature, that is, in my estimation: Abdullah and Royle, 1972.

Benoit -- no date.

Brown and Chow, 1977.

Brungs, 1978.

Durum, 1971.

Eaton, 1978.

Enk and Mathis, 1976.

Goettl and Davies, 1976.

Goettl and Davies, 1978.

Hale, 1977.

Kopp and Kroner, 1967.

Kumada, 1973.

Spehar, 1979.

Sauter, 1976.

Q Would it be possible to xerox those two pages, the two bibliography pages, so we will have the titles and references?

MR. GREENBERG: Yes.

Q Did any of the authors in those publications, themselves, form a conclusion about what were safe levels of cadmium for trout in hard water?

A Most of them are actually done in soft water. A few of them predict the effect on fishes in hard water.

I have indicated just four in here. I don't have the original papers with me so I can give you the rest. And that's about as much as I can say for the moment.

Q The four are ones that deal with hard water, you mean?

A These are soft waters. I don't have any -- well, there may be one or two in here that deal with hard waters, but I would have to go back and get the original papers out and look at them.

Q I noticed, I think in the summary, in the E.P.A. Red Book -- have you read that?

A Yes, I have.

Q "Quality Criteria for Water"?

A Yes.

Q I take it -- am I not correct that they conclude that recommended criteria for trout in hard water is one point two micrograms per liter?

A Yes, sir.

Q I take it you feel that's too conservative?

A Absolutely. Absolutely.

Q You would prefer a level of two?

A I would prefer a higher level. This is my opinion, yes.

Q What is it specifically about their chain of reasoning that --

A I don't know, you can't tell from reading this. The whole book is a faceless thing, you don't know who the authors are, it's -- it is their collective opinion based on earlier literature than my individual opinion based on more recent literature.

MR. GREENBERG: May I suggest something, Mr. Estes, which I think we have encountered before, which wasn't clarified in the E.P.A. criteria originally, and may be unclear to you. I think you may want to establish whether Doctor Pennak is referring to total or dissolved cadmium.

MR. ESTES: Sure, I would be happy to.

Q What are you referring to?

A I am talking about just dissolved. Total cadmium involves particulate cadmium that cannot be absorbed

through the membranes of fish gill.

Q Do you have any opinion as to what the difference between those two may be in the Red River?

A No, I haven't the faintest notion.

Q The figures that you have given us here --

A Yeah.

Q -- with the analyses that you had done, were those dissolved?

A Those are total cadmiums.

Q You did not ask to have dissolved broken out?

A No. Too hard, apparently, nowadays; have trouble enough at this level.

Q You said that -- did you say that none of the studies that you looked at were studies of the toxicity levels of cadmium on trout in hard water, that they all were soft water?

A No, I think there are one or two on hard water, but as I say, I would have to get out the individual papes and I simply haven't brought them along with me. The majority are on soft water, and that's the best way to put it.

Q Did you use some --

A The Wales study, for example, is clearly

soft water. Goettl and Davies is clearly soft water. Moran and Wentz is soft water.

Q In the Red River, especially in the lower four miles, we are dealing with hard water, are we not?

A That's right.

Q How did you make the translation between the two? Isn't there a difference in the effects of cadmium, depending on whether it's in soft or hard water?

A Yes. In general, cadmium is more toxic in soft water than it is in hard water.

Q Did you feel the level of two micrograms would be a safe level in soft water?

A This conclusion here, I think, refers to soft, yes. I would be willing to go along with that, in view of what's been said in the literature. So that actually, for the Red River, if you want to make it specific, I should say that you could even have higher levels than that. But to be on the conservative side, I indicated two micrograms.

Q Well, E.P.A. concludes that for salmonid fishes in soft water, the level ought to be four-tenths of a microgram.

A That's quite all right. They are entitled to their opinion. But you asked me for my opinion, and

I gave it to you.

Q Sure. Your opinion is that a leval of five times that high would still be safe?

A That's correct.

Q Again, you make a reference to temporary concentrations as high as eight micrograms per liter. What did you have in mind as "temporary"?

A I am thinking here in terms of two or three, five, seven days, perhaps as much as ten days. I would say ten days is "temporary."

Q Again, what specifically has -- what sort of background have you had in this type of analysis, in determining -- dealing with the effects on different species of toxic elements?

A You mean what personal experience have I had dealing with fish and testing them with toxic materials in the lab?

None.

Q Have you done -- backing off one level from that, have you done the sort of thing that you have done for us in this case? -- that is, studying the literature and coming up with your own interpretation of it? What sort of background do you have in that kind of activity?

A I have a background which is just as good as those who made up the recommendations for E.P.A.

Q Now, how do you know that?

A Or better. I know -- I know who most of the people were on the original committee, who have not signed this.

Q Are they academics?

A Most of them are academics, yes. What they did was go through the literature and come up with a very conservative best guess.

What I have done is go through the most recent literature and come up with what I consider to be the best guess.

Q Do you specifically know who it is that prepared or --

A No.

Q -- concurred in the cadmium levels that were set?

A No, sir. You can have no way of knowing this. You can only go through the list of people who are listed in the green edition of this thing, and know that somehow or other they were involved. But who specifically said what, no one knows.

Q You have suggested that you believe that a couple of these studies were done in hard water. To your memory, did the studies done in hard water wind up recommending safe levels for cadmium?

A This I cannot recall, without seeing the original papers.

Q Can you remember, if you look at the list, which one of the studies you have talked about may deal with hard water?

A No, I would rather not guess, because it would be only a guess, and I would mislead you.

Q I take it, though, that you primarily -- that you did not specifically try to come up with a different criteria for soft and hard water?

A I did not try, no.

Q So you were looking at all the studies and determining from looking at those, most of which were in soft water, what you felt they indicated?

A That's correct. Most of those are in soft, so my recommendations of two and eight micrograms are typically for soft waters, of which Red River is not one.

Q Okay. Let's talk about the cyanide, which you have also looked at. In your paragraph two-B -- B-two,

you list several factors which you believe lessened the potential adverse effects of cyanide. One of them is the alkaline nature of the water. Would you elaborate?

A This is high pH, or high carbonate, whichever you wish, either way.

Q At what pH level does the --

A Alkaline is anything above pH seven, and moderately alkaline would be pH seven five. Strong alkaline would be pH eight, if you want some parameters.

Q Well, through that range of seven -- from seven point zero, to eight point zero, do you believe that it makes a difference where you are in that range as to how toxic the cyanide is likely to be?

A Well, you are dealing with, here, with a chemical problem, and I wouldn't be able to give it to you in terms of -- in chemical terms, no. Simply siffice it to say that the more alkaline you get, the more of the cyanide will be bound up in unusable form as far as fish absorption is concerned.

Q So if the pH is eight point zero, instead of seven point five, there will be less cyanide in a harmful form --

A Right.

Q -- potential harmful form?

A This is my understanding.

Q In the next paragraph, on top of the next page, ten, you refer to one recent study. Could you tell us what that is?

A I would have to go back to the original Doudoroff monograph, which is a very thick report, and as a matter of fact, he has several reports in there indicating that more than twenty-five micrograms of free cyanide apparently had been reported as not being toxic to trout. But again, you would have to go through the whole monograph. This is based very largely on the Doudoroff monograph; he brought together all the literature.

Q Do you have a reference to that monograph?

A Doudoroff, 1976. You have that there.

Q No, what is --

A "Toxicity: Fish to Cyanide and Related Compounds, a Review."

It's an E.P.A. study, hundred and fifty-five pages, mimeographed. That is -- that is actually the Bible for materials on cyanide poisoning. And I base my remarks here very heavily on that.

Q Does Doudoroff include the one study that

apparently showed cyanide concentrations --

A Yes, he does.

Q -- down at the ten micrograms?

A Yes, he did.

Q Excuse me, we are going to overlap too much. There's apparently a study showing cyanide concentrations as low as ten micrograms having an effect on the swimming ability of brook trout. Does Doudoroff include that?

A He includes a great many studies. In review, you include everything under the sun, whether it looks good or whether it's very good; you include old studies, as well as new studies.

Q Well, you have recommended --

MR. GREENBERG: I can -- I am familiar with the Doudoroff, and the answer is that the study about ten having an effect on swimming ability is in Doudoroff, 1976.

Q In setting your -- shall we say "recommended value," recommended maximum at ten, long-term maximum at ten, did you take into account the fact that that's a level at which effects on one species of trout were found? In other words, at the level you say --

A Yeah.

Q -- is an acceptable maximum?

A Yes.

Q At least, one study has found that at least there were adverse effects at that level?

A You cannot find one study in any lone series in a monograph that will show you anything. The purpose of a monograph is to review all the work that has been done, and come up with what you think is the most logical conclusion. And if you happened to find one paper that is an exception, there is no reason to believe or disbelieve that particular paper.

Q Does Doudoroff, in this 1976 paper, recommend a level for salmonids?

A I will read you what he said.

Doudoroff, 1976, sums up his long review paper as follows:

"Free cyanide, or molecular H.C.N. concentrations as low as ten micrograms per liter can rapidly and lastingly impair the swimming ability of salmonid fishes in well oxygenated water. Threshold concentrations may be as low as twenty to twenty-five micrograms per liter at very low temperatures, although they are generally above fifty micrograms per liter under favorable conditions. Clearly, free cyanide

concentrations above five micrograms per liter cannot always be entirely harmless to the salmonids. And only much lower levels may be truly safe concentrations in most waters in which such susceptible forms must be fully protected from any possible injury by toxicants.

"On the other hand, there is as yet no evidence that even persistent free cyanide or H.C.N. concentrations not far exceeding twenty-five micrograms per liter in waters not otherwise seriously polluted, are incompatible with the persistence of valuable fisheries."

So he puts it at twenty-five.

Q Doesn't he -- it sounded to me like he concluded the evidence was not conclusive?

A Correct, but his last sentence, I think, is the most significant one. You have to operate that way when you are doing a review paper.

Q Do you think that E.P.A., in apparently choosin a level one-half the value of the lowest level of demonstrated effect in a study, do you think -- I take it you believe they are unnecessarily conservative?

MR. GREENBERG: Wait, that's an unfair question.

Doudoroff's ten micrograms were ten micrograms of free cyanide. The E.P.A. level is a total cyanide level of five, and there's no way you can relate the two as being one-half, or -- I don't think there's any way you can relate them percentagewise.

THE WITNESS: Thank you.

Q Well, is that a criticism you would make of the E.P.A. study? What -- I think it's -- you have read it, and what they say is that -- I will read it: "Cyanide concentrations as low as ten micrograms per liter" --

MR. GREENBERG: What page are you on?

MR. ESTES: Page sixty-eight of the E.P.A. book.

MR. GREENBERG: That final paragraph?

MR. ESTES: Yes, last sentence.

A Yes, I disagree with that. You asked for a personal opinion; this is my opinion, bearing in mind what I said when I first started out, all of these tests have been done on caged fisheries, which are highly susceptible.

Q With what point do you disagree? If, in fact, you were convinced that a level of "X" micrograms per liter of cyanide, in fact, had adverse effects, would you feel it unreasonable to set the recommended maximum

concentrations at one-half "X"? Do you think that's an unreasonable step to take?

MR. GREENBERG: For what purpose?

MR. ESTES: For dealing in connection with the cyanide.

MR. GREENBERG: No, no, for what purpose is the level set?

THE WITNESS: I don't understand --

MR. GREENBERG: I mean, their criteria which are referred to, or which is what quality criteria for water is all about, their standards, their guidelines, all have different aims and different purposes. So I think it's very important that you so specify what you are aiming at. Do we want a scientific goal which would be a criteria, or do we want, you know, a reasonable standard which will protect the stream and at the same time allow for, you know, economic use of water by other users?

MR. ESTES: Well, as I understand it, and I will let this be the basis of my question, a criteria is E.P.A.'s view of what a demonstrated long-term safe level, maximum safe level of an element in water for various purposes -- in this case to protect salmonid fishes -- may be, without any consideration of economic effects of achieving

that, or whatever.

THE WITNESS: All right.

Q That's my idea of what the criteria is intended to be, and I am asking you whether you feel it's unreasonable for them to essentially set that level at a value one-half of what they believe to have been a demonstrate adverse level of that element?

MR. GREENBERG: With the qualification I made before, that the adverse level is in free cyanide, and they are talking about total cyanide. So I don't think your one-half is a fair characterization. But if you can answer that question, Doctor Pannak, go ahead.

A No, I would rather not answer that question. There are so many variables involved here, that it's difficult to come out with a flat-on statement.

Q When you say that you are in as good a position as the individuals apparently on the E.P.A. committee, what is it about -- why do you say that? Could you be more specific, what it is about their background?

A Because the men who are on the committee are not, themselves, conducting the individual research on cadmium. I could just as soon have been on the committee as anybody else who was there. What they have done is go

through the literature and come up with what they think is a judgment.

Q Do we not have -- I am just going to speculate, because I don't know who was on the committee. But I will ask you, since apparently you do -- don't we have people on the committee whose expertise is to do just this type of work?

A Yes, and this is also my expertise.

I disagree with their collective judgment, and I am sure some of the people on their committee certainly disagreed with the final draft as it was drawn up. This is true of any large committee, and as I recall, there were twenty or thirty.

Q Well, you say that this is your expertise, yet I don't believe that you claim to have done work in --

A That's right.

Q -- in setting levels of toxic elements --

A This is it --

Q -- for aquatic life?

A -- all I am saying is that I am just as well-qualified as the twenty or thirty people who did this. And none of those people wrote any of the articles on cyanide poisoning which are in the bibliography.

I am here as an expert, and I am giving you my opinion.

Q Fair enough. Fair enough.

In your paragraph four, near the top of page ten, you did some work, I take it, for both cyanide and cadmium. You had tissues from fish analyzed, and apparently it showed that there was some cyanide in the trout?

A This is correct.

Q Now, you state that larger quantities were found in the trout taken above Molycorp. Do you mean above the Pope Lake discharge point?

A No, above the Molycorp plant.

Q You had indicated on your previous page that as far as you could tell from the data, there was no detectable background cyanide concentration in the Red River, so I assume that means there would not be any cyanide in the river above the Molycorp plant?

A "Detectable". "Detectable" is the word I will use; I assume so.

Q I take it the fish -- how did they -- how do the fish taken above the Molycorp plant, how do they --

A I don't know. There must have been some releases of cyanide above the Molycorp plant, which they

incorporated in their body.

Q Isn't it possible that these are the trout that are migrating back and forth, and up and down the river?

A Six miles? No, not a remote chance.

Q You are not aware of anything that would cause cyanide to get in the river?

A I am not aware of anything, no, sir. There must be some source of cyanide above the Molycorp plant, if you look at the fish tissues that were analyzed and were taken above the Molycorp plant.

Q Did this phenomena show up both in August and September?

A Yes, it did.

Q Can you tell us -- again, I will confess, it won't mean anything to me, but in some terms it would be meaningful to another scientist -- can you tell us what levels of cyanide were found in the tissues?

A On August 5th to 7th, there were a hundred and fifteen micrograms per gram of dry tissue.

On September 9th to 11th, there were less than four micrograms per gram of dry tissue -- both above Molycorp, one kilometer above the mouth of Red River.

August 5th to 7th, there were seventy-six

micrograms per gram of dry tissue. And on September 9th to 11th, there were less than two point three micrograms per gram of dry tissue.

Those are the only data I have.

Q Do you have anything to account for the tremendous disparity between August and September?

A No, sir, I do not.

Q What does that, if anything, suggest to you?

Let me throw out a possibility that there's some sort of mistake in the laboratory.

A Any analysis might be a mistake in analysis, but I have reason -- I have great confidence in the Rinehart Laboratories.

Q Do you -- well, is cyanide something that steadily accumulates -- it's available in the water?

A It does, it accumulates.

Q In the tissues?

A In the tissues.

Q So whatever caused the very high level of cyanide found in fish in August, that same level, and if anything, a little more, should have been found in September, shouldn't it?

A Who knows?

Q Is the explanation just --

A I wouldn't --

Q -- you happened to catch different fish?

A I wouldn't -- I would not speculate. All I can do is give you these data, and that's it. I can't --

Q Do you feel like from data with such a tremendously wide variation, that really we can deduce anything at all?

A I don't know. I am giving you these analyses, for whatever they are worth. The point is, we did get fish above Molycorp in August that had a high concentration of cyanide in the tissues.

Q What were the -- as long as we have got you -- what were the accumulations, or what were the concentrations that were found for cadmium in the tissues? Can you pull that out for us?

A August 5th to 7th, Red River above Molycorp -- no, that's water, excuse me.

August 5th to 7th, trout taken from the Red River above Molycorp, muscle, point one micrograms per gram of dry tissue. Liver, point nineteen. Above the fish hatchery, a collective sample of muscle plus liver gave point eighteen micrograms per gram of dry tissue, cadmium.

One kilometer above the mouth of the Red River, August 5th to 7th, point fifteen in the muscle; in the liver, point thirty-six. On September 9th to 11th, above Molycorp, muscle contained point oh for eight micrograms per gram of dry tissue. The liver contained one point twenty-nine micrograms per gram of dry tissue.

One kilometer above the mouth of Red River, same date, point oh three two micrograms per gram of dry tissue. The liver contained point one nine micrograms per gram of dry tissue.

Those are the only data I have.

Q How many fish do you actually pull out and send to the lab?

A These are -- these are all summation of the tissues from two fish.

Q One fish at the -- one fish at each station?

A You have to get -- no, two fish at each station.

Q I'm sorry.

A But you have to get as much tissue as you possibly can. Cyanide in a biological material is very difficult to analyze for, and the laboratory told me, however, that they have a brand new method, and this is why they

are able to go to the third decimal points.

MR. GREENBERG: You said "cyanide," you mean --

A Cadmium, I'm sorry. Cadmium.

Q Likewise, with respect to cyanide, was it --

A This is correct.

Q -- was it the same two fish?

A Did I -- yes, they were the same fish; two fish from each station.

And then the results -- well, you just took tissue from both fish and put it in one big sample, you see?

Q Okay. And do you have -- have you formed -- let me stay with cadmium for a moment. We have backtracked.

Have you formed an opinion as to what the LC_{50} level is?

A No, I have not.

Q How about with respect to cyanide?

A I don't care to do it with either of them, for the reason that you have to keep the fish in the laboratory and it's not a natural condition at all. And I don't think most of those data that are in the literature are comparable, for the reason that every laboratory is different, when it comes to holding and keeping your animals.

Q I ought to make one thing clear here, too:

back on the cyanide again, the recent sudy that was mentioned on the top of page ten, that you say is a study that is recounted, the results of which are recounted in the Doudorhoff book?

A That's right, it's in Doudorhoff, and I don't recall what it is.

Q When you -- the very top line there -- talk about "free cyanide" --

A Just a minute. Let me go back, and I will see if I have it in the cyanide report.

Well, here, for example, here's one example cited by Doudoroff, "Fifty micrograms per liter were nonlethal for ten to thirteen centimetered brook trout for forty days."

Q It raises a definitional problem. If I might ask you a clarifying question: you used the word at the top of page ten, the word "toxic," and in using that, do you mean that to be synonymous with "lethal"?

A Not necessarily, no.

Q What do you mean by that?

A "Toxic" means that it harms the animal, which may be a little, or which may actually be lethal. It's a generic term.

Q So you meant "toxic" to mean having some

adverse effect?

A Right. Correct.

Okay, where are we now? Cyanide or cadmium?

Q Let me, to conclude what you are saying on cyanide, what you are saying at the top of page ten, is that this one study found that only levels of free cyanide far in excess of twenty-five micrograms caused any adverse effect at all, is that --

A This is the way I read it in Doudorhoff, yes.

Q What opinion do you have, if any, about the possibility of the effects of cadmium and cyanide in the Red River being additive, or in some way working together so that it's worse than if either one were just taken alone?

A I don't have an opinion. I don't know whether they are mutually antagonistic, or whether they are mutually additive, particularly since so much depends on what chemical form they happen to be in. And you have to seek the expert opinion of some chemist to tell you that.

Q Are you acquainted with the National Academy of Sciences' 1972 publication, "Water Quality Criteria"?

A This is '72? No, I hadn't seen this. Is this a summary, or --

Q I think it's similar to the E.P.A. book.

A Oh, it's taken out of the green E.P.A. book, yeah.

Well, yeah, it's blue, a big, thick one which I didn't bring along.

Q I think it's fair to say that they indicate in that publication that the effects of several elements together are often additive, although not always, as you indicate, and that in absence of specific study to determine whether or not they are additive, that they should -- it should be, for safety purposes, should be presumed to be additive.

Would you disagree with that approach?

A I have no opinion. I am not enough of a chemist in cadmium or cyanide to be able to tell you that.

Q Okay. Why don't we leave the cadmium and cyanide?

Have you done any studies on this stream of the fish populations?

A On the Red River?

Q Yes.

A No, I have not.

Q Have you done any specific study on the fish,

the trout habitat in the Red River? That is, have you looked specifically to see -- to make some analysis of the nature of the habitat that would be available?

A Only inasmuch as I can compare it with many, many other trout streams that I have seen. And I think a similar opinion could easily be formed by any good fisherman.

Q I think in your 1971 study, you had the observation that you would not expect it to have a large resident trout population because it had few pools?

A Correct.

Q Do you still --

A In the part of the river I was studying, that's correct; I stick with that.

Q And that was the part at that time, from -- essentially from the fish hatchery to somewhat above the Moly plant?

A Yes.

Q Do you have any conclusion about the availability of pools in the lower part of the river below the fish hatchery?

A From what I have seen of the lower part of the fish hatchery, I should say that there you had -- not pools, but whole series of small, deep holes, and a lack of rubble. So you have the opposite situation from what

you have in the upper part of the Red River.

Q In general, do you have a conclusion about the -- if I may use the word -- "value" of the Red River as a trout stream, the relative worth of it as a trout stream? If that's too general for you, let me know, but do you have an opinion on that subject?

A It is so similar to other foothill streams, but it's very difficult to say what its own potential is, because the stocking was so heavy.

Now, I have seen brook trout at various times that have come out of the Red River, and I see a fisherman rarely, by the way, that has fish that he has caught in the Red River. I ask to see them in every case. All the fishes I have ever seen were washed out and silvery. They don't have the bright red, iridescent coloration that a good rainbow trout has.

Q Are these all rainbow trout?

A They are all rainbows that I saw. I have never seen a brown, and according to the reports that we have here from the electrofishing, there are very few brown trout in the river.

Q What reports are you referring to?

A I am referring to the state Fish and Game

Department's, that were summarized for us by --

MR. GREENBERG: It's the material that Patterson referred to, and was made available to us by Herb Garn.

Q Do you have a summary of those reports by the Fish and Wildlife Service? Did it have a sort of cover attachment on it?

A I don't recall that it had a cover.

Q I was --

A They were state data, for the most part, on electrofishing.

MR. GREENBERG: This is the material.

THE WITNESS: That's it. That's the one.

MR. GREENBERG: It's both the United States Department of Interior, Fish and Wildlife material, and the state data. This was --

Q Just in the summary that the Fish and Wildlife Service made of the state data, they referred to numbers of brown trout of four hundred and eighty per mile in one survey, and five hundred and twenty per mile in another.

Are those the numbers that you had in mind when you said there were very few brown trout in the stream?

A All I said was I had never seen any brown trought caught by fishermen.

Q I thought you said you based that view on -- what I'm trying to drive at, do you consider that a low number of brown trout?

MR. GREENBERG: Let's clarify which electro-fishing.

A There are several reports in here on electro-fishing. Some show more brown trout than others. Some show many -- one shows ninety-severn percent rainbows and three percent browns. Others show thirty-seventy, whatever it is. And there are various reports in here, and I have no way of summarizing. They are taken by different people, different times, for different purposes.

Q Let me just make sure I understand; your view is the level of -- a level of brown trout, of approximately five hundred brown trout per stream mile; do you consider that a low level, medium level?

A Are you talking about catchable brown trout, or total population brown trout?

Q I'm sorry, I don't know.

A Then, I can't answer your question.

Q Okay. Fair enough.

Are you of the impression that brown trout are stocked?

A I don't know. Brown trout have been stocked several times, but rather long ago, if you read this report. But I also gather that brown trout have not been stocked for at least five years.

Q On the Red River, specifically, have you made an effort to determine what the relationship between various levels of stream flow and the trout population might be?

A No, I have done none of that.

Q Have you made an effort to determine what levels of stream flow are desirable to maintain it as a fishery?

A No, I have not.

Q Okay. I understand in the last few weeks you have had a chance to review the Instream Flow Service Group's publications --

MR. KUPY: Nick, it might be better if the preference is -- for me to ask a few questions on this report that we just finished. I can wait to the end.

MR. ESTES: I would be happy to do that.

Do you mind, Gary?

MR. GREENBERG: No.

CROSS EXAMINATION

BY MR. KURY:

Q Doctor Pennak, I just have a few questions to clarify my understanding of your report and what your testimony will be. Some of them are rather simple.

For example, how do you define "gravel"?

A Gravel is divided, in my feeling, into three series; large gravel, medium gravel, and small gravel. Large gravel is from half-an-inch to one inch in diameter. Medium gravel is from a quarter-inch to half-an-inch. Small gravel, from an eighth-of-an-inch to a quarter.

Q When you measure a stone for size, what constitutes the diameter? Is it the maximum --

A You take the largest dimension, seven inches.

Q And what is detritus?

A Detritus is a general term given to any dead organic debris.

Q That includes both plant and --

A Yes, it does.

Q Is there a maximum size for detritus?

A No, it can be a tree branch.

Q Could it be a dead deer?

A Pardon?

Q It could be a dead deer or dead cow in the stream?

A It could be a dead bacterium.

Q But I was getting more maximum size. It could, in fact, be --

A In fact, under the terms, I suppose you are right, yes. It is detritus, but ordinarily, when we are speaking of streams, then, we talk about detritus, we are talking about bits of leaves, bits of branches, bits of twigs, dead animals, small dead plants, anything down to a dead bacteria.

Q I was under the impression that it referred to something only very small.

A It has no size connotation, no.

Q Out of curiosity, how does turbidity at these great levels actually kill trout?

A It's dependent on what is causing the turbidity Sometimes, the turbid substance will be a material which will form an irreversible film with a mucus of the fish gills. Other times, the turbidity may be caused by very, very sharp particles that will actually rupture some of the capillaries in the gills. Sometimes, it's relatively harmless. Usually, it's relatively harmless and has neither

of those effects.

Q On page seven, the summary of your proposed testimony, at the very top, the first sentence says, "Genera appear in greater abundance, indicating biologically 'cleaner' water in 1976, than in 1971," period.

What do you mean by the term "clean" water?

A This is a term that's used by environmentalists and refers to the fact that there is less suspended material in the water, less sedimentary load.

Q And any other --

A This is the connotation I have here. And I put it in quotes, because I am not real enthusiastic about using it.

Q I see.

Are you -- are you aware of any fish kills in streams orginating or being caused by cadmium in the stream?

A I have personally no experience, no.

Q You are not even aware of reports?

A Oh, there are reports in the literature, I am sure, but I don't have those references with me. I would have to look through my bibliography.

Q Is the same true of cyanide?

A The same is true of cyanide, and the same is true of many, many metals. They are in the literature, but most of these are massive cases of pollution, where an electroplating plant, for example, will dump a lot of stuff in the water.

Q But in the regions that we are talking about, you are unaware of --

A Absolutely; I am unaware.

Q Is cadmium concentrated through the food web?

A I don't think it's known, but I would expect it is.

Q What about cyanide?

A This, again, I couldn't say -- I don't know whether cyanide will transfer from aquatic insects, for example, to a fish, or not.

Q You would expect to find where -- let me back off.

In Red River, you would expect to find both cadmium and cyanide in the small organisms, as well as the trout?

A I would expect so, but I know of no analyses, and no way of knowing. So this is really speculation.

Q On page ten of your outline, at C-one, you

refer to, "Empiric data suggests that even trophy fish can exist in streams with total discharge of only fifteen c.f.s. over a considerable period of time."

Would you elaborate upon that for a little bit?

A Would you want me to give you some examples?

Q Please.

A One is Rio Grande River, another is South Platte. Many times in the past they have discharges of only fifteen c.f.s., sometimes for months on end, and yet they have trophy fish.

Q What do you mean by a "trophy fish"?

A There is no -- there is no definition of a trophy fish. If you think you have a large fish, you may call it a "trophy," and it may be that long.

Q I don't want to play word games.

A There is no definition of "trophy."

Q But how did you use it? Were you --

A This is -- this is a general term used by sportsmen. And, for example, if you go to the South Platte, if you catch a trout that's five pounds, that's a trophy fish. When I was up in Alaska the summer before last, if I caught a five-pound trout, it's by no means a trophy fish;

that's a minnow.

You see, so it depends where you are. Now, if you are fishing on a small stream in the Adirondacks, and I get a brook trout that's eleven inches long, that's a trophy fish.

Q Doctor Pennak, I appreciate what you are telling me, but we are talking about Red River, and north central New Mexico. There are a variety of fishery resources in the region. All I would like to know is, you know, some -- are we talking about fish that are greater than twelve, fourteen, sixteen inches?

A If you ask me --

Q Okay.

A -- if I were a fisherman fishing the Red River, if I caught a trout that was fifteen inches long, I would consider it as a trophy fish, from the Red River.

If I caught a fifteen-inch fish from the South Platte, it would not be a trophy fish, and certainly not in Alaska.

You have got to relate it to the area where you are fishing, you see? And there are no parameters.

Q One last question: you were talking about the difference between stocked fish, and fish that originate

from within the stream. You indicate that there are certain obvious characteristics that you could tell one from the other. Would you explain what those differences are?

A Well, let me put it this way: in most areas where you catch wild fish, or if you catch fish that were planted six months or a year previously, those fish will be highly colored. I am talking now about rainbow trout.

Q You are talking about the skin coloration?

A Absolutely, the skin coloration. There will be bright red dots, bright orange dots, bright violet dots on the thing. If you catch a fish that has been recently planted and has come from a hatchery, ordinarily, it will be pale. There are a few streams where for some unknown biochemical reason all of the trout are pale, and have very little coloration to them. We don't know the reason for this. Apparently, it has something to do with the carotene in the diet.

Now, if you go through your sporting magazines, Field and Stream, Sports Afield, any of the classical pictures of rainbow trout, and taking all those pictures and put them side-by-side, you will find an enormous range of coloration. It all depends on how old they were, where they came from, and what kind of food they had.

Q Let me follow up with just one question: can an individual trout vary in color from day-to-day, or from hour-to-hour?

A Not in my estimation, and in my experience, not in such intervals. It may, however, vary -- and I have seen this happen -- in a matter of two months. It happens, for example, in some of the very high streams and high lakes in areas where I fish. You get a fish at the end of the winter, it may be faded. You get it at the end of the summer, and it's brightly colored. Or, of course, if the fish happens to be in its breeding garb, it will be very much more brightly colored, because when they are manufacturing eggs and sperm, apparently somehow or other a lot of coloration gets into the skin and in the fins.

MR. KURY: Thank you, Doctor.

MR. ESTES: How about a couple minutes' break?

(THEREUPON, a recess was held.)

MR. ESTES: Back on the record.

REDIRECT EXAMINATION

BY MR. ESTES:

Q Why don't we start by getting a firm

understanding of what materials you have looked at in connection with this instream flow methodology?

A All right.

MR. GREENBERG: I can very simply explain that I provided Doctor Pennak with Prewitt and Bovee depositions, with the exhibits marked in both depositions, with the computer printouts that Mr. Prewitt gave to us, and with instream papers three, four, and five, which was all the material that was given to me.

Q And did you, in fact, review all of those things?

A I did, in fact, yes.

May I go on, or --

Q Well, why don't you -- maybe I would suggest, if you would, that you tell us what your understanding is at this point of the methodology, before we get into your views as to whether it's right or wrong, or whatever? How do you see it working? -- so we make sure we are on the same wave length.

A Well, I don't see it working.

Q Why don't you summarize what you understand they are trying to do?

A They are trying to measure what they calculated

as usable area, of which I don't agree at all.

In order to explain this, I would have to go through some preliminary materials here, and tell you what I think about a trout habitat, as opposed to the instream flow measurements and the hydrological aspects of it.

Q Okay. Why don't you go ahead?

A I read these documents over, by the way, with considerable interest. But after I had read them over, I said to myself, "What do instream flow determinations really mean?"

And I mean this in both the hydrological and more particularly the biological sense. There is a lot of hydrology done up in all those reports, and I do not dispute for a moment any detail of the hydrological methods that are in there. My comments are based chiefly on the biological applications and the inferences that are contained in these reports.

For example, in the -- I am going to give you some quote here -- Stalnaker says in his printed item, that he is not generating minimum flow recommendations. He also says that the instream flow method will not predict the number or production of fish. He also says that the

distribution and abundance of any species is related by varying degrees to all stream flow hydraulic parameters.

I don't quarrel with that for a moment, but the fact is, there are many other factors that determine whether or not a fish is present in a particular area. And by measuring three or four or five physical parameters of the stream, you have by no means determined whether or not it is suitable, or whether it forms a weighted usable area.

For example, the streamside vegetation is enormously important. Water chemistry, as I have been emphasizing all along today, is enormously important to a trout population. The temperature regime -- and by that I mean the extremes of temperature and the number of days when you are above, let's say seventy degrees, and the number of days that you are below forty degrees. This will affect the fish community.

The severity of the winter, when you have a twenty below zero, and have freezing ice and anchor ice form in the stream for any time. And whether or not root aquatics happen to be present. This does not apply, of course, to the Red River, but in the sense that their report here apparently deals with the whole continent of North America, root aquatics is a tremendously important part

of the trout habitat.

And certainly the kinds of bottom fauna, whether you have a bottom fauna that is, let's say, rich in large stoneflies or whether it is rich in mayflies, and so on. All of these enter into the story, and to me, as a biologist, it is imperative that you include, in measuring probability of use criteria, many of these other parameters.

Now, Bovee, on page a hundred and four, says:

"It was never our intention to come up with a model that predicted fish populations."

Well, that's fine, as long as you stick with this whole thing as a hydrological exercise in methodology, but as soon as you begin to apply it as habitat criteria for the salmonidae, then, you are in a completely different area.

So it seems that thus far, there have been sort of cross purposes. On the one hand, I can find statements that say these are merely hydrological measurements and shouldn't be used, and shouldn't be transported into biological meanings. On the other hand, I find that there are occasional freezes and, indeed, even reports where the hydrological material is, indeed, taken over and is used in predicting use criteria for the salmonidae.

Let's see, I will try to get this into perspective.

As I said before, a fish is not a simple organism. It's governed by physical features of its habitat. It's got to have a place to hide, it's got to have a place to associate with other fish, to play, and to feed, and to rest, and to breed. It's an extremely complicated matter. There are many, many ecological variables involved here.

Now, if you were to take a very simple kind of physical environment, and measuring a very simple population, say a bacterial culture, this is very easy to measure, very easy to put on a computer. You know what all the parameters are, you have made up an artificial sterile media, and you can follow the abundance of the bacteria, and they are very simple in their ecological requirements.

But to take something as complicated as a fish, to me, and try and make biological predictions on it on the basis of a few -- relatively few physical characters, is not simply getting anywhere near the crux of the thing. And I want to point out some exceptions, now, as we go along.

First of all, every stream is slightly different from all other streams; please bear that in mind. We can only group them into general categories and say that they

are relatively similar.

By the way, in Prewitt's report, I agree with him in several instances. He says, for example, that the Red River is very boulder-strewn. Boy, I sure go along with that. Page a hundred and two, he said, "There is nothing unique about the biology of the Red River." And I go along with him in that; it's a straight biological problem similar to many others.

Number three, he said, "This is not a spawning stream." And I agree with him on that; in particularly, I believe he was talking about the lowermost four miles.

He also says on the next page, page a hundred and four, "Spawning could occur in this stream." And I certainly go along with that.

Page one sixty-seven, Prewitt says -- speaking now of the Red River -- "A low flow regime. The current flow regime in the river cannot be said to have any deleterious effect on the fish community. It's the natural flow regime, essentially."

When we come along that far, and after looking at the computer printout and everything else, we then pick up this paper here, which is presumably based on the -- on many, many -- a great deal of data that they have gathered

up at this laboratory.

Before we get to that, and before I get into this form, particularly, let me draw your attention to this very short count here.

You have copies of this, don't you?

Q Yes.

MR. GREENBERG: Just for the record, let's identify what it is.

THE WITNESS: It is -- what do you want to call that?

MR. GREENBERG: This is the computer printout on weighted usable habitat, based on three replications for sites A and B on the Red River.

Q Okay. I think particularly you are referring to the graphs that indicate the summaries of the weighted usable area for these two species?

A Yes. I am very much puzzled with the Instream Flow Group, because of the fact that they got results that were diametrically opposite in these two areas, areas A and B. I am not going to bicker about a reason for it and so on, but to take two areas, in four miles of the Red River, and say that these are representative of the Red River, and then come out with results that were diametrically opposite

for the brown and the rainbow trout, I simply cannot understand.

I hope the Instream Flow Group has an explanation for it.

Here is this curve down here, which I see goes down, and here is the same curve over here for browns, and the thing goes up. On the other hand, here is the curve here for rainbows, comes up like so, and straightens out, and here's the curve for rainbows, and the thing goes down with reference to usable habitat. And I don't think the two trout are certainly that different in these two parts of the river.

Now, I like to think of a river or a stream as being a continuum. It isn't chopped up into a series of habitats. It is a gradual gradation of an enormous variety of habitats, from its beginnings up in the high country, down to its mouth, with relatively unpredictable sequences, except for the familiar holes every here and there, and the ripples every here and there. And even then, there's so many exceptions to it that it's difficult to generalize.

Instead of talking about fishes as being restricted to usable habitat, I rather think of a fish as moving around a great deal during a twenty-four-hour period.

To be sure, you will find a fish down in the deep hole at some of the day, maybe very much of the day, but at other times during a twenty-four-hour period, this same individual fish is up scrounging around in the ripples looking for food. And there is no reason why you should knock out a certain percentage of this because you don't think the thing ought to be there, and merely by a series of hydrological measurements.

The same is true in a sort of a rough comparison here with reference to human beings. Human beings have a certain amount of mobility, we don't stay in the same spot all the time. We have got to have a place to do this, and do that, and to do that, and so on. And that's why we have more than one room in our homes, you see? And to me, I like to think of a fish as a being very much similar in a sociological way.

Now, let me go back to this review here, which is to me the most important. This is the crux of the thing, this is what I like to talk about. And again, I am not going to argue with you on any of the computer mechanisms and so on, and --

MR. GREENBERG: Let's identify this.

A This is information paper number four.

Q Okay.

A Let's talk, first of all, about page -- small Roman numeral five, this diagram here, this classification of substrates.

I don't know the reason for giving it a series of code numbers, as we have over on the right. In the first place, number two, mud or soft clay, is very rarely present in a trout stream. This could simply be deleted. I have never seen mud or soft clay in a trout stream, in any amount, at any rate.

Number one, plant detritus, and number three, silt, are, for the most part, pooled substrates. You don't ordinarily find them in holes and so on, but more specifically, I question the use of either in number four as characterizing an area, or in number five, or somewhere in between them. Because the substrate very often is a mixture of various kinds of materials making up that bottom. You can have a mixture of boulders, gravel, cobbles, silt, sand, plant debris in the crevices, and so on. So it will be very difficult to come up with a code number that has any meaning, in view of the enormous variety of types of substrate that make the thing up.

Maybe they would have been a little bit better

off if they had listed these substrates in some order of food productivity for the trout. For example, the greatest food producer here, from the standpoint of substrates, is cobble and rubble. This is where you find the aquatic insects. Second most productive is gravel. And there are lots of studies in the literature on this, beginning with one that I did way back in 1941. Third most abundant is number three, plant detritus and organic marerial. Fourth, close behind it, is silt. Fifth would be boulder, very barren. Sixth would be a sand bottom, which is likewise very barren. And seventh would be bedrock.

And then there is another kind of substrate, at least from the fish standpoint, that ought to be in here, and this is rooted aquatics. You don't think of rooted aquatics as being down on the flat. Actually, it's suspended in the water. It is, nevertheless, substrate for trout, and should have something to do with the determining of their usable area. In general, where you have rooted aquatics, it will multiply the available fish food by a factor of a thousand percent.

So that this has been a sort of puzzlement for me. It's an attempt, I think the authors have attempted to oversimplify the thing with reference to code number.

Now, let's look at page thirty-six. You have it, this first graph? Rainbow trout spawning.

Look at the upper left graph, velocity in feet per second, graph gains probability.

I question the accuracy of this thing. This presumably is measuring the velocity of the surface current, or at least at a depth halfway down from surface down to the bottom. Actually, in the gravel, you need only a very, very small current. You may get along in the magnitude of fifty centimeters per hour, in gravel -- I am not talking about a water over the gravel.

This explains why trout may spawn at the edges of lakes where there is hyporheic water coming through the gravel, very slowly seeping through that gravel, and the trout come there to spawn.

So I don't agree with this upper left diagram here at all. It may -- as I say, it may be correct with reference to the speed of the water over a gravel substrate, where there may be spawning activities -- and, in fact, the vast majority of fishermen could draw a similar curve for you, based on their personal experience.

And while we are about it, let me mention a very serious item with reference to the whole business

of current.

A trout does not, gentlemen, require current all of its life history. Rainbows, brooks, browns, and natives are taken in tremendous quantities from lakes, reservoirs, and ponds, where there is no measurable current whatever. And to infer in this series of reports that a trout must have current during its life, is simply not correct.

There is only one time that a fish needs -- a salmonidae needs a current during its life history, and this is when it seeks out a suitable gravel to deposit its eggs. In other words, ninety-nine percent of its life history, it gets along beautifully with no current at all. And I know, because I have caught thousands of all kinds of trout in lakes, ponds, and reservoirs, where there isn't a smidge of a current.

Now, you may say, "Well, a fish prefers current."

I think you would have a difficult time proving that. Let me show you an example, from my own experience.

Here is a small, wide area in a stream. Actually, there is through here a very, very sluggish current, current coming down this way. It's nothing more than a wide spot in this small trout stream. The bottom isn't

rubble, it isn't bedrock, or it isn't sand; it's an organic muck, which, according to this report, isn't very good for trout.

Yet, the last time I went to this lake I caught thirty-four trout in thirty-seven casts.

MR. KURY: Precisely where is this?

THE WITNESS: You would like to know, I am sure, wouldn't you?

There is rubble down here, there is a current down here, and there is rubble here, and there is a pretty good current up here, maybe two or three or four feet per second. But you don't find the fish leaving this shallow pond, this wide place in the stream, and going up here where there is a current. They are perfectly happy to stay down here.

And, in fact, if you fish in either of the streams above or below this small lake, you will have very poor success.

I manage a trout lake, I have managed a trout lake for the last six years; we have an inlet and we have an outlet. We don't lose any appreciable number of trout through the outlet going down to a gravel substrate, or anything of the kind. We perhaps get a few going up through

the inlet, but by the same token, we get some coming down, wild trout coming down that inlet into our lake, so that we end up relatively evenly.

So let's not kid ourselves about this business of current. To be sure, there are a lot of fish in streams where there is a good current, but to put it in a more practical sense, the largest brown trout in the world are caught over at Echo -- at -- over in Utah, Flaming Gorge, the biggest brown trout in the world, thirty-three pounds eight ounces.

The biggest cutthroats, of course, are gotten out of some of the inland lakes of Nevada. The finest trout fishing I have ever had has been in Alaskan streams and Alaskan lakes. And do we find them in two-, or three-, or four-foot pools? No, we find them at a depth of fifteen feet; very, very deep pools.

You can cast all day with a fly, or a lure, in the uppermost three feet of water, and you won't catch a trout. But you get down near the bottom, you will get them all the time.

Now, going back to this business of trout living in lakes; most lakes, of course, don't have very much in the way of seepage coming in at the shores, but

there are some lakes where the shorelines are gravel and you get a seepage through the shores. And it is in these areas where many of our trout are able to spawn, and the eggs live very nicely in those gravels near shore. They don't need a running water; they have running water in the gravel, you see, and it doesn't need to amount to very much. Maybe relatively fast. On the other hand, you may measure it in terms of centimeters per hour.

Let me go over now to the next page, page thirty-seven. This is presumably four types of variables with reference to adult rainbow trout. And I don't want to take the time to go into immature trout, because the principles here are essentially the same.

Let's talk about the temperature curve that is down in the lower right. Such a curve has been known for a long, long time. Any fisherman can give you this sort of curve. Anyone giving a course in stream briology or fish biology can make a curve of this sort.

In other words, the preferendum of the thing, especially during the summer, is somewhere around sixty degrees. The winter minimum, to be sure, is at thirty-two degrees. I wouldn't put this curve as far to the right as it is. It indicates that you even get rainbow trout at

about eighty-three degrees. I think that's too warm for a rainbow trout, and I think any rainbow trout will avoid it.

But take this and compare it, for example, with brown trout, which are adults, page fifty-nine. And those two curves are almost identical. And I seriously doubt whether that is true. The brown trout can get along in waters which are considerably warmer than does the rainbow; yet, these two curves can be almost superimposed on one another. Just very small differences in them.

I think for the rainbow, the temperature is too high.

Again, I don't know how these results were derived, but any fisherman can draw such a curve from his personal experience.

With reference to substrate makeup down on the lower left, on page thirty-seven, I seriously doubt the significance of that curve, simply because any one of us can catch trout where the substrate is almost pure organic silt.

Take a beaver pond, a small beaver pond where you have an appreciable current, the bottom is silt, the bottom is all organic matter, there is no gravel, no rubble, no nothing there. And, yet, a population of rainbows, a

population of brook trout, will get along perfectly well under such circumstances.

So I am very skeptical, as I say, about substrate as it's indicated here, lower left, on page thirty-seven.

I think I have said enough about current velocity already, and I have emphasized the fact that a trout actually does not need any current, except for a very short period when the thing is about ready to spawn.

To me, a trout is highly adaptable and highly mobile. We mustn't think of it staying in one simple hole down here -- and by the way, it's very difficult to measure the current when you have a deep hole, let's say a hole that is three or four feet deep, because most of the current passes over the top of the hole, and down there at the bottom the current is almost negliglble. Which takes us back to the fact that trout can get along just as well in the lake or a pond or a stream, you see?

But fish are mobile, they don't stay behind the same rock all day long. Fishermen like to think so, but they come out, they have got to forage in the rubble, particularly in the early morning and in the evening. And such things as a brown trout, especially, will forage even

in the middle of the night. And many people make a habit of going after big brown in both streams and lakes after it's dark.

It doesn't make any difference for a brown, particularly, what the substrate is like. It may be a mud substrate, it may be a stream that is overgrown with aquatic vegetation; so much the better. Some of the finest brown trout fishing in all of Europe occurs in streams where there is quite a growth of rooted aquatic plants, simply because there is so much food there. They are, in other words, opportunists. As an opportunist, it makes the best of all sorts of temporary adversities. It takes what comes with the least effort.

And don't think for a moment that a population of trout, any kind of trout, is going to be destroyed either by high water or low water. They are used to this sort of thing. They have it in the Rio Grande since time began. They have had it in most small streams, and even large rivers, since time began.

Look at the Colorado River: the Colorado River is a hopeless silted stream for, I suppose, six months out of every year. Yet, once that stream clears up, you can get good trout fishing there. They persisted through

that long time without having the siltation do them apparently very much harm.

So they are tough, they are opportunists, they move around, and, really, they are not very much different from all sorts of other vertebrates.

End of lecture.

But as I say, don't question me, because I won't argue with you for a moment on the techniques that have been used in measuring hydrology parameters in any river. I have no quarrel with that, whatever. But when you take a few physical factors and try to superimpose a trout population on that, in variable places, then, I object.

Q Well, all right, I will respond; I will ask you a question about that statement.

You, yourself, read several, or referred to several remarks by the people involved in creating this approach --

A Yes.

Q -- in which they disclaimed an effort to directly predict fish populations from the results.

A But here they have it, when you talk about -- we are dealing in a kind of gray borderline area here. One group disclaims, and then ever so slightly claims, and then

the biologist, particularly in this, he goes over ever so imperceptibly into the area of hydrological measurements. And by this, I mean the paper number four.

Q Let me try to put it this way: these curves of probability of use, now, as I understand it, the effort, when they disclaim the ability to predict population, to predict that there is going to be a fish in "X" spot, what they are trying to do is say something about how likely it is that there will be a fish in that spot?

A This is correct.

Q Is it -- when you say it is correct, do you agree with the general principle, I think, that's implicit behind this?

A I believe in the principle as written on the title, but I don't agree with many of the curves that are in there.

Q Fine. Let's start with beginnings.

Do you agree that it is reasonable to attempt to predict -- to predict whether or not -- the likelihood of a fish being in a particular area, by looking at the hydrologic parameters in that area?

A I don't need the hydrologic parameters; I can go and look at a stream, and any decent, competent fisherman

can look at a stream, and say there will be trout there, there will be big trout there, there will be few trout there, and so on.

In other words, I don't find a need of going through a computer to prove what we already know. What new information, in other words, has the computer told us? And I am asking myself that. I can't convince myself that there is new significant information there, that we do not already know. In fact, some of the information is skewed, and I pointed that out in some of these curves. I have said that fish are more widely adaptable than the implications of the few hydrological measurements would indicate.

Q Now, the other variables that you mentioned -- let me again try to ask a general question -- such as stream-side vegetation, termperature, chemical characteristics, let me ask this: if those variables are held constant, would you agree, or at least within a reasonable constant, within a reasonable range, would you agree that it makes -- it is not unreasonable, then, to make some predictions about what's happening to fish population based on some other things that are varied, such as velocities or depths of the stream?

MR. GREENBERG: I have to object to that. You

threw in "fish population," and I assume you are not doing -- we are not trying to predict numbers of fish, just probability that a fish will be in a particular area?

A See, this is the whole point: we have got a clash here between hydrology and biology, and we are trying to mesh the two. The thrust of my remarks is, you cannot mesh them adequately with the few hydrological measurements we have.

Q Let me try to be more specific. Let's take chemical characteristics.

A All right.

Q Now, your work on the Red River suggests that there is nothing wrong with the chemistry of the water insofar as sustaining a trout population is concerned; the trout can live perfectly well in the water --

A Yes.

Q -- of the quality found in the lower part of the Red River?

Can we, since that is the case, say something about the probability of finding trout in various stretches of that river, based on hydraulic variables; what the depth is in a particular area, what the velocity of the water is, knowing what the chemistry is, already? -- of course,

if the chemistry were bad, there would be no fish. But now that we know that's all right, can we say something about the relative probabilities of finding fish based --

A Sure.

Q -- on hydraulic variables?

A Anybody can do that. Any fisherman can do that.

Q Are you saying --

A See? I don't have to go to a computer to look at a stream and say, "Gee, this looks like a whacking good trout stream."

Q If we are trying to say something intelligent about what may happen to the probability of finding fish in a stream, because of changes in the flow regime of the stream, that is -- let's say a diminution of average flow of half -- do you feel that you are capable of going out and, knowing what you know now about the Red River --

A Yes.

Q -- of telling us what difference it will make, if average flows are cut in half on the Red River, just intuitively?

That's what I gather from your --

A Let me put it this way: suppose I go to the

Red River now and look at the way the thing is now. And suppose I were to know that the volume of water going through that stream was going to stay the same. Then, suppose for some untoward reason the amount of water going through the Red River was cut by fifty percent; I were to come back and look at it again.

It wouldn't take me -- it wouldn't take a fisherman to say, certainly, the trout population is going to increase in such a stream.

Q It is going to increase, if there's less water?

A Decrease, I mean.

Q Doesn't it make sense to try to determine what -- why it is -- well, let's start over.

To try to say something more specific than that, and --

A Sure, it makes sense, but I don't know that you come out with a more intelligent answer than the sharp observation of a good stream biologist. Every stream has to be measured in a whole -- of a great, tremendous series of areas, rather than picking out two spots which give results which are quite different from one another. That bothers the daylights out of me, to get those two curves that are

so different. I would have expected them to come out at least reasonably similar. And this, in itself, points out the fallacy of the system.

Let me talk about one other thing, about decreasing flow.

The Rio Grande sometimes goes down to fifteen cubic feet per second, and stays there for a couple of months at a time; the fish get along all right. There's a little bitty creek above my home, about three miles up in the mountains, dries up every fall in a series of puddles. I will go up there next spring and there will be big trout in those little bitty puddles. They get along all right, and they aren't exterminated, as long as they have reasonable conditions to get enough food to tide them over, as long as the water is well aerated, that is all they have to worry about.

Q Have you seen stream flow records on the Rio Grande that go down to fifteen?

A Yes, I have. I didn't bring the book along, there's a whole series of measurements on the Rio Grande. I am talking about the Rio Grande right above the border, on the border between New Mexico and Colorado; fifteen cubic feet per second. And I think it was last October, as I think I said in one of these reports, I walked across the

Rio Grande without getting my waders wet.

Yet, we don't worry about the fish population in the Rio Grande. We keep on taking out all of our irrigation water upstream.

So all I am saying is that fish are highly adaptable. You won't exterminate them by temporarily cutting off their water supply. They will get along. And you won't exterminate them by cutting off most of their food supply for a surprisingly long time.

Q But --

A That's my only point.

Q But you do agree that permanent change in average conditions is relevant?

A I would say that the best trout streams in the world are those that have the most constant environment, most constant flow, have the most constant chemistry, even the most constant temperature. The greater the variation, the more ecological impositions you put on the fish. But the population you have there will live in spite of those variations.

Q Why don't you look on page thirty-seven of this paper number four; there is a curve drawn for rainbow trout, adults, probability of use for depth, and it indicates

that --

A Anything up above is acceptable.

Q Anything above a foot-and-a-half of depth has a high probability of one finding fish in such areas?

A Yes, that's correct. I have no quarrel with that at all.

Q Do you have any sense for how these curves were derived?

A I don't know, but a fisherman will tell you the same thing that this curve says --

Q In other words, this --

A -- won't he?

Q That curve, at least, you don't disagree with?

A No, no. I don't disagree with all these curves. I pointed out a few cases where I disagree: velocity in cubic feet, kind of substrate in reservoirs, temperature for rainbows, and this is quite all right with reference to depth in feet, as I said before -- well, trolling, I have caught rainbow as deep as sixty feet. But the point I want to make is that current is not absolutely essential in the life history of the fish.

Q Let's take depth for a moment, and see if

we are on the same wave length about what this instream flow methodology is attempting to do.

What, as I understand, they attempt to do, is to determine from a series of measurements, and then a computer program, to extrapolate from those measurements how much depth -- how much area in selected reaches of the stream one will find in these different depths at different flow levels of the stream?

A That's correct.

Q Obviously, the less water you have got, the less --

A That's right.

Q -- fewer pools you are going to have?

A That's right.

Q And from that, say something about the likelihood of -- since the trout are known to like depths, and you agree that they do, to say something about the change in the relative likelihood of finding trout within that area of the stream; you have less depth, and trout are known to like depth?

MR. GREENBERG: I have to disagree -- wait a minute, I think you are misstating the witness, and I think you are not characterizing Mr. Prewitt's testimony.

All he is trying to predict, via putting into the habitat model the hydrologic characteristics and using these preference curves, is available habitat at particular flows. He is saying nothing at all about how many fish he will have, or what the probability of fish are.

THE WITNESS: That's correct.

MR. GREENBERG: Simply at a certain flow, it will be a certain amount of square feet of what he consideres weighted usable habitat, and that's all.

Q Well, do you find it -- essentially, you have said you don't see how this method gives anything -- any more information than any fisherman on the Red River, any good fisherman can tell you?

A I disagree with the business of designating two areas along a stream and extrapolating to the whole stream, and identifying those areas of the stream with what we have here in this curve. I am not kidding when I say the average fisherman knows what temperature a fish likes; the average fisherman knows what kind of a substrate the fish like.

Q But ask the average -- go ahead.

A And it varies. The point I am making is, it varies enormously more than is indicated here. This,

presumably, is not for the Red River, this is for the whole continent of North America, and I disagree strongly with it.

Q Just trying to stick with the one point, does the average -- knowing that fish like depth, and that's an important habitat for rainbow trout --

A That's right.

Q -- does the average fisherman on the Red River, or can you tell us, given different flow levels, how much area one has at different depths?

A No.

Q Do you understand that that is what this model attempts to say something about?

A The original -- other papers other than this paper four, say something about it, but I don't think this paper four, as such, sticks with that narrow parameter. I think it attempts to go further.

Q Do you understand that it takes the approach, takes the results of the hydraulic work, the predictions of what depths one will have and what velocities, and then imposes upon them what these preference curves for fish are, to come up with a weighted usable area? Do you understand that?

A I understand the principle, yes, as stated

in these papers.

Q And you find it of no use at all?

A I don't say "no use at all." I find it of little use, of limited use. I do not think that it is worth the enormous effort expended in field time and computer time to come up with such information.

And to extrapolate further, especially since the Red River is planted regularly with rainbows -- if this were a natural stream, I can see where you would -- that had no planting in it, I could see where your results would be very much more applicable than they are.

Q Well, if you were interested in determining what stream flow levels would provide the greatest habitat for rainbow trout in the Red River --

A Yeah.

Q -- would you not at least find the output of the hydraulic model to be useful to you, giving you some idea at various levels of the extent to which you have pools of various depths, the extent to which you have various velocities? Do you find that relevant information?

A Yes, I do.

To be sure -- I mean, the more water we get coming down, the more pools there are going to be; the deeper

the whole stream is, the larger we made the stream, the more productive it will become -- even though the people said they are not concerned with the productivity of the water at all.

Q Well, let me -- I will give you one example going the other way around -- something that Moly, I am sure, loves to hear -- that there are certain -- the preference curves indicate there are certain velocities which get too high for the fish, right? There are some velocities that their data base suggests rainbow trout -- on this curve, suggests that rainbow trout are statistically never found beyond a velocity of three feet per second.

A I doubt that.

Q Did you understand --

A I doubt that.

Q -- given the possibility that there may -- now, I understand that you may disagree with the way the curves are placed, based on your own personal experience, but knowing that there are some high velocities that are -- in which one does not find these fish, again, if one is interested in predicting what changes in habitat will occur at different levels of the stream as the stream there goes up, as the level of flow goes up, you get more and more

high velocities as a general rule; you would agree with that, wouldn't you?

A In general, yes, I think so.

Q Now, if you were engaged in the effort of trying to find out what is the effect on habitat of these different flow levels, again, would you not be interested in a systematic account to you, a base of information, as to how much velocity you get in what areas, at what flows? That's something you can't judge by eye, isn't it?

A This is correct. If I had a hundred thousand to work on the problem, yes.

Q Well --

A But we are dealing with practicalities, here. And every stream system is a different kind of arrangement, isn't it? Yeah. And this is postulated, apparently, for the whole country.

Q But I am trying to understand why we part company; you do agree that it's useful information to know what the velocities in that stream will be at different flow levels, at different points?

A I expect you are right, yes.

As I say, I have no quarrels with the hydrological measurements, at all. I am interested in the

biological expansions of the thing, only.

Q But I mean to be asking about that, because are not velocity and depth biologically relevant to rainbow trout, for instance?

A If you have a greater stream flow -- well, take last spring when we had the gully washer coming down and the terrific runoff in the Red River; who knows what happened to the fish population? We can't say it was killed off, we can't say it is decimated. We really don't know, do we?

We didn't collect any fish at the mouth of the Red River. Possibly, the fish simply went toward the edges of the stream where the velocity is very much lower; perhaps they went in deeper pools where the velocity is very much lower. You don't know what the biological effect was.

Q But we know that velocity is relevant --

A Oh, yeah, one way or another, yes.

Q -- to where fish can be found?

A It will change the habitat, unquestionably.

Q As I understand the approach of developing these curves, it was empirically based, it was to go look in streams and find out where, in fact, rainbow fish are,

to spot where that fish is, and to measure the velocity in the water where he is to be found. And then that data was all put together, and put -- essentially put on this curve.

Now, do you disagree with that, as an intellectual?

MR. GREENBERG: Let me just note that we still don't know the data base for those curves, and we are still waiting to be fully apprised of the fact, of the data -- how it was gathered, whether it was the guy with the hundred and sixty pounds of lead on his belt, or somebody electro-fishing, and wherever, or if it was more than that.

So there is -- I think it's almost unfair to ask a question based upon information that is supposed to be provided to us, which hasn't been, and which, of course, none of us, therefore, have seen and are able to consider when answering such a question.

MR. ESTES: Okay. But I think my question is more general, and that's whether he, as an expert in fish, finds there to be some intellectual flaw in gathering data about in the stream of where fish are found, putting that data together, and then putting on a graph the relation-ship between velocity at the point where a fish is found,

and the number of fish at that velocity.

A Let me put it another way.

If you were to give this pamphlet, paper number four, to any good fisherman, he would find it of no real use.

Q And that's because you do not believe that, in fact, fish are found, say, at the velocities that are indicated?

A Because a fisherman already knows what this says, and because some of the curves are faulty.

Q Well, I think we need to be specific about that. I get -- the ones that you mentioned you disagree with are velocity --

A That's right.

Q -- and --

MR. GREENBERG: He's mentioned three out of the four, he disagrees.

A The substrate, velocity, velocity, and temperature -- the details of temperature, only.

MR. GREENBERG: I think we can ignore temperature for the Red River study, because, in fact, the Instream Flow Group, for whatever reason, also ignored temperature.

THE WITNESS: Well, I have nothing further

to say, unless you have --

MR. ESTES: Let me think for a moment, and I may think of something else I would like to hear from you.

Q Have you, yourself, ever done stream velocity measurements?

A Sure; do them all the time in my classes.

Q Have you ever done any -- made an effort to correlate the places where fish are found in streams, with stream flow?

A No, no point in it, because the fish moves around in a rapid current one time, and zero current another time. If you have seen a steelhead jump as it is trying to get through an extremely rapid current, you would throw out this business of three feet per second. Currents are far swifter than that.

If you have seen a trout at the bottom of a hole where the current is zero, you would know what I am talking about.

There isn't any nice, clear-cut series of correlations. Thank God we can never learn that much about fish.

Q Do you believe that in streams there is simply

no relationship between velocities and where the fish are found, the likelihood of finding a fish?

A I cannot answer that question for you, because fishes move so much from one place to another. If you find it here one time, with such-and-such a velocity; and I might find it here another time, let's say up in riffles where the current is rapid, at some other time.

So I can't give you an answer.

Q Are you saying that if you took a series of -- let's say we had a way, with a stretch of stream, taking a series of graphs that would be detailed enough to show where the fish were, and we took --

A Which has been done.

Q -- a hundred or more such graphs, and could spot several hundred fish in the stream, and then we were able to correlate the points where those fish are on the graph with velocities in the stream; do you believe that they would essentially be a random distribution?

A No. At any one time there would not be a random distribution, but there would be an irregular distribution, if you took into consideration the whole twenty-four hours, or the whole activity sequence during twelve months' period.

Q I am trying to say over time, over time, and let's say for a given life stage of fish, adult rainbow trout, over a long period of time, do you believe that there is some correlation between the velocity of the stream and the place at which fish are more likely to be found? That is to say, the points at which more fish are gathered, if you are out electrofishing, or whatever?

A All you could come up with would be estimates of, say, a fish will be in a pool sixty percent of the time. It will be in the riffles near shore twenty percent of the time. It will be in riffles up in the middle of the stream another percent of the time. It will be behind a particular boulder another percent of the time. It will be going toward or from a spawning area at another percentage of time.

Q Okay. I recognize that, but if a large series of measurements of finding fish, and measuring associated velocities are taken, will that large series of that data base, do you believe that that will reveal any correlations over the long run between where --

A You are talking to me --

Q Yes.

A -- as an individual, with my opinion?

Q Yes, as someone who knows about Rocky Mountain

trout streams.

A No, I don't believe in it, because of the fact that trout fundamentally do not require a current.

Q But you have never tried to do any -- this is your belief, but you have never tried to do any studies to find out --

A Of course not.

Q -- whether your -- whether your hypothesis is correct?

A Nobody who's done that kind of thing, no.

Q Do you understand --

A I can tell you my experience two summers ago. We were up in a small plane -- every morning we go out, in Alaska, over some of the nearby streams, looking for rainbows, and looking for our old friends, oncorhynchus, the salmon. And some mornings we would come upon a stream and find that the fish are bunched in such-and-such a place. The next morning we would come over the same stream and find the fish aren't there, the same time of the day, but they are down here, or farther upstream, or somewhere else.

Q Do you think --

A So -- so I stick with this business of individuality.

Let me mention the Harvard law -- is that all right, if I tell them the Harvard law? Do you know what the Harvard law is, all of you?

Q No.

A Under the most carefully controlled decisions and conditions, and under the most favorable environmental conditions, the fish does just as it damned pleases.

And that's the way I like to think of a fish.

This is why we can't tell when we should go out on a stream or a lake and get our creel full in five minutes, because they are too unpredictable in what they do, when they feed and when they rest.

Q But it seems to me that human beings are at least as unpredictable, right?

A Absolutely.

Q Yet, somehow it is possible, if you take a large number of people, to make some statistical predictions about what will happen to the population at large. They determine how large to build various sewage treatment facilities, based on statistical probabilities.

As long as we are dealing in water here, you can't say what any individual will do, but you can say something about large population.

Isn't the same thing true of fish, that if you do a study, it's possible that certain statistical correlations will develop, where you never could have predicted where an individual fish would have been found?

A If you want to engage in such philosophizing, yes.

Q You just are saying you don't think it's worth the trouble?

A Absolutely not.

Q I am sorry, I frankly find that a very strange attitude for a scientist.

A That's all right.

MR. ESTES: All right, let's take a break.

(THEREUPON, a recess was held.)

MR. ESTES: Back on the record.

Q (Mr. Estes continuing.) Let me just ask a couple more. I don't think it will take very long.

Have you been asked -- you say that you have been involved in a number of environmental impact statements?

A Yes.

Q Have any of them involved proposals essentially to take water out of a stream on a permanent basis? -- for instance, building a dam?

A Yeah. Just let me think.

One of them, Asarco in Idaho would involve taking water from a stream and using it in their copper processing. The study was not followed up far enough, however to make any use of it.

A small project on the western slope had to do with taking a very minimal quantity of water out of a stream and using it in a washroom only, and then seeing to it that that was properly treated before it was run back into the stream again.

Let's see, there was nothing in Tunisia, nothing in Yugoslavia, not -- that problem didn't occur at any time in Wyoming, didn't occur at Vail -- I think those are the only such cases. But they never got along very far.

Q If you were asked -- an agency proposes to build a dam and divert some substantial portion of the stream flow, and is in the process of deciding how much stream flow to propose as a diversion -- could be a tenth of the flow, could be twenty-five percent, could be fifty percent -- and came to you as a stream biologist and said, "We would like you to help us predict what would happen to the available fish habitat in this stream if we took any one of these

possible levels of the flow out."

Now, do you believe that if given such a problem, that it is worthwhile doing more than simply giving an impressionistic response as "any fisherman might give"? Is this something that could be worthy of scientific study?

A It requries certainly investigation, but so much depends on the individual stream. Now, I did a study on Main Elk Creek over on the western slope. As it turned out, Main Elk Creek has essentially a zero trout population, nobody stocks it any more, and there is no natural reproduction there.

And one of the companies had in mind building a huge dam, and damming up the Main Elk Creek, simply disposing of the whole creek entirely, period. What would be the impact?

Well, the impact, as we came up with our recommendation, is that you would enormously increase the recreational area, because you would create a lake two miles long that would have excellent fishing, whereas the stream as it is now isn't worth a darn.

Q That was a pretty easy one, at least insofar as the stream?

A Yes, this is correct, it sure was.

But to answer your question more specifically, and it's very hypothetical, it would depend on the individual stream, how big it is, how good the trout fishing was, what it was worth in dollars and cents, whether you could take out ten or twenty percent without damaging the usefulness of the stream to the general public.

Q How would you go about determining that?

A First of all, I would set up a team, and one of the first things we would do would be to run shocking experiments on the river to see what sort of fish were there. And then we would walk the river very carefully with a team, and find out the relative percentage between riffle and holes.

And then we would work on the bottom fauna, to see what sort of bottom fauna was there.

And if it looks as though taking out ten percent would not damage what we had, then, it's possible we may recommend that they would take out ten percent.

Q How would you be --

A But your question is so hypothetical, and so much depends on the stream, you see, that I can't answer it one way or another.

Q Would it not -- I think I will be repeating

a question I asked before, in that situation -- would it not be useful to have detailed information as to what changes in stream flow parameters, such as velocity and depth, would occur at different flow levels, if they took out ten percent, what a change that would make?

A We would certainly have a hydrologist in on the team, but I don't think we would have the hydrologist make thousands of measurements and run the whole thing through the computer in order to come out with our results. I think we could tell long before that.

Q Are you really qualified to say?

A No, you asked for my opinion.

Q Okay. What may be necessary to --

A Again, it depends on the stream.

Now, the Big Elk Creek is nothing but a tremendously long series of riffles, there are no pools in it, which makes it one kind of a situation, you see? Taking out ten percent of the water wouldn't harm anything. In fact, that's probably what they are doing right now.

Q Is that the situation you gave, the one where you started with zero fish in the first place?

A That's right.

Q I can see why it wouldn't make any difference.

A Absolutely. That's why I say it depends on the situation.

On the other hand, if you went up to Henry's Fork, perhaps the most single national fishing, trout fishing area in the western United States, and, say, take out ten percent of the water, I would say, "For heaven's sake, no, don't take out anything."

Q Why do you know it would have an impact?

A It's a large stream that has a constant flow, and constant level. If you take out ten percent, immediately you lower it. And it's now a trophy fishing area, so let's not change it.

Q You may have given us now two easy cases, one where the impact is obviously zero, and one where it is obviously proportional to the change in flow.

A That's why I say you must know the stream.

Q How about the Red River? A rather more complicated situation, is it?

A We want to take out ten percent of the water?

Q Okay.

A I don't think it would harm the stream.

Q How can you say that? How do you know anything about what would happen to the hydraulics of that stream?

A You asked for my opinion, and this is my opinion. It is based on observing many, many, many kinds of streams, and the flows, and droughts, and so on.

Q Well, I think where we disagree is not in whether or not it would be useful to know something in more detail about the hydraulic changes, depth and velocity --

A That's fine; send the hydrologists in and let them tinker with it as much as they want to.

Q And you wouldn't really second-guess their judgment as to what nature and level of effort --

A As to hydrology, absolutely not.

Q -- as may be based in making these predictions? You accept their view of what must be done to generate that output for you?

A All right.

Q Your problem, then, and that's -- am I correct, is it your understanding that that essentially is the hydraulic part of this --

A Yes.

Q -- instream flow approach?

A Yes.

Q Okay. And with that, you have no quarrel?

A Right.

MR. GREENBERG: I am now lost. I don't know what you are agreeing to. I don't even know if Mr. Estes knows what he is asking.

I think the witness has already said that he would not ask a hydrologist to make thousands of samples and play with his computer, unless somebody told him that they wanted to throw away their money.

So, you know, if that is, in fact, what we have done here -- and I think that's exactly what Doctor Pennak thinks has been done here -- he would quarrel with the use of that kind of resource for that kind of project.

On the other hand, if he was putting together a team, and there was a hydrologist on that team, then, he would defer to the hydrologist in the sense of what the hydrologist wanted to do.

Is that --

THE WITNESS: Essentially all of the impact statements that I have been associated with had a hydrologist, but they have measured the general flow regime, inflows, outflows, loss through groundwater, gains through groundwater, and so on. It has not involved the sort of details that the Inflow people have.

Now, again, don't misunderstand me. I think

it is a scientific contribution for them to go ahead and do this tremendous series of measurements on a stream, because it is a contribution to knowledge; don't misunderstand me for a moment. But let's be very careful about trying to use only hydrological criteria for determining the ecology of the salmonidae, because it is a much more complicated thing than merely hydrological details.

MR. ESTES: Okay. Thank you.

MR. KURY: I have no questions.

MR. GREENBERG: No questions.

(THEREUPON, the witness was excused.)