IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF NEW MEXICO
No. CIV-82-1540M

THE PUEBLO OF ACOMA and THE PUEBLO OF LAGUNA, Plaintiff, v. CITY OF GRANTS, et al., Defendants.	DEPOSITION OF ROBERT J. BEHNKE

The deposition of ROBERT J. BEHNKE was taken by the Defendants in the home of Dr. Behnke at 3429 East Prospect Road, Fort Collins, Colorado, beginning at 10:30 a.m., Monday, December 15, 1986, pursuant to the Federal Rules of Civil Procedure, before BECKY S. JACKSON, Shorthand Reporter and Notary Public for the State of Colorado.

APPEARANCES:

STACEY A. JOHNSON, Attorney at Law, PAYNE & RANQUIST, P.C., United New Mexico Bank Building, Suite 1020, 200 Lomas Boulevard Northwest, Albuquerque, New Mexico 87102, appearing for the Pueblo of Acoma.

MS. KATHLEEN PRICE WATSON, Attorney at Law, POOLE, TINNIN & MARTIN, P.O. Box 1769, Albuquerque, New Mexico 87103, appearing on behalf of the City of Grants.

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ROBERT J. BEHNKE,

called as a witness, having been first duly sworn, was examined and testified as follows:

EXAMINATION

BY MS. WATSON:

Q. Dr. Behnke, this is a continuation of your deposition which was begun on September 9 of 1986. So, we were going to try and pick up where we left off last time.

The first thing I wanted to know is did you get a notice of the continuation of your deposition?

A. No.

Q. Okay. When was it that you learned of the continuation of your deposition?

A. I thought it was about five o'clock Friday.

Q. Okay. That would be three days ago?

A. Yes.

Q. Okay. And how were you informed of that?

A. Phone call from a secretary at Ortega's office in Albuquerque.

Q. All right. And, as a result of your schedule, we changed the site of the deposition from Denver to here at your home in Fort Collins to accommodate you; is that correct?

A. Right.

Q. All right. Now, some of the things I asked

you to bring in this notice of continuation of your deposition, which you did not receive, were anything that you had either supplied to you for this lawsuit relating to the subject matter, anything that you generated, and anything you referred to that you either did not bring with you to your first deposition or were supplied or you generated after the beginning of your deposition; that is, after September 9.

This morning you have produced some documents, have you not?

A. Well, as I said, these are not really directly related. There was nothing that was supplied since the September deposition. And I think these are sort of ancillary to some of the things we discussed at the September deposition that I didn't have at the time.

Q. Now, one of the things you brought with you is a paper by -- or a copy of a paper by Don Johnson and Richard Walsh entitled "Value of Alternative Fishery Management Practices."

A. Right.

Q. Did you refer to this in the course of writing your report?

A. When I wrote that report was, I think, three years ago. This was not available even in September. I had mentioned this as an example or type of fishery re-evaluation to derive, you know, maximum benefits from a fishery. And in

my report, I simply mentioned the common economic breakdown of fishermen into the three categories.

Q. Okay. And in your report, you had suggested that the tribe aim at a certain type of fisherman; is that correct?

A. Right.

Q. And this paper by Mr. Johnson and Mr. Walsh explains how an economic analysis of aiming at a certain type of fisherman is done?

A. It breaks down and gives quantitative value -- if the fish are a certain size, three additional inches are worth $3 for this type of fisherman. I think this is the first time you get some kind of quantitative evaluation.

Q. Okay. Will you be using this related to this case?

A. You mean if the case went to court?

Q. Yes.

A. Perhaps that would be, say, a documentation source to bolster the argument that a standard fisherman today can vary very greatly according to how you aim to select the clientele.

Q. Is this your only copy of this paper?

A. Yes, right now it is.

Q. I'd like to have this marked as Exhibit 19 to your deposition. Last time what we did was we went on and

marked your documents and had them copied and returned to you.

This time what I'd like to have done is the court reporter take the documents with her and mail them back to you; is that all right?

A. That's okay.

Q. This paper by Mr. Johnson and Mr. Walsh will be Exhibit 19 to your deposition.

(Behnke Exhibit 19 was marked for identification.)

Q. (By Ms. Watson) You also brought a document called "A Review Of Nutrient Dynamics In Unperturbed Stream Ecosystems," which is by Mr. Galat, dated August 1981. What is this document?

A. That's an example, I said, of how I go to get sources of expertise out beyond my own, where I lack formal education or training in. An example of a -- serving on graduate student committee, the student produces these.

This is part of what's called a preliminary examination, a written response so the student demonstrates his knowledge in the field.

Mr. Galat was a particularly brilliant student, knows much more about water quality and limnology than I do. So I refer to Mr. Galat often for his written document or for, say, specific information, call him on the

phone or write him.

And I had him review the part that was written -- the 1983 report, I guess, that you had on the Acoma Pueblo. I sent for review to Galat for comments.

Q. Okay. What was his response to your 1983 report in this case?

A. Oral communication, I think it was -- going back, I don't think -- it was nothing of -- no error of substance, and I think overall he was in agreement, since he's not personally familiar with it. But it sounded quite logical to him, my interpretation of the situation.

Q. And he himself had no data to use?

A. No, only what was in my report.

Q. All right. Now, this paper that you brought today that Mr. Galat did in August 1981, did you refer to this paper or use it in any way when writing your 1983 report in this case?

A. No.

Q. All right.

A. Except perhaps to review some general background information.

Q. So you may have used that for general background?

A. Yes, sort of like a textbook-type of reference.

Q. Okay. If this case were to go to trial and you were to testify, would you be reviewing that paper for purposes of your testimony?

A. I doubt it. If it was a point in this paper that was critical to a trial, I would recommend that they bring Mr. Galat in in person to testify.

Q. All right. Is this your only copy of this document also?

A. Yes.

Q. Do you mind if we have this marked as Exhibit 20, copied by the court reporter, and returned to you?

A. Okay.

(Behnke Deposition Exhibit 20 was marked for identification.)

Q. (By Ms. Watson) You also produced a third document, which -- Could you describe this document for me, please.

A. It was a response to FERC or Federal Energy Regulatory Commission's questions on a -- 1981 date -- a proposed water development project on the Yampa River in Colorado for the Juniper-Cross Mountain Project, on which I acted as a consultant to the Colorado Water Conservation District.

And I produced a report for that that was comparable to the Acomita report that was -- then the

attorney here took sections of the report and entered it into these responses to the FERC.

And I brought this along because the other attorney in our September deposition asked about this and how he could get copies or something. This is what I found in my files. And this is my example of doing previous type of work in this area.

Q. All right. I take it that you reviewed the attorney's recapitulation of what you submitted to him for this Juniper-Cross Mountain Project?

A. I see I made some -- penned in some corrections here, so evidently -- "eutrophication" spelled wrong. And I suspect I have.

But essentially, I guess these were my words interpreted through the attorney. I do have a question mark here that perhaps they got something wrong.

Q. Other than the spot where you have the question mark, can you say that the recapitulation on pages 7 through 19 of this document accurately reflects the results of your work on that project?

A. Offhand, I would say perhaps. I just pulled this out, and I really haven't read it over. It's been over five years, and I just say that I see where I have made corrections on it. One question mark was perhaps a misinterpretation that was made. But, otherwise, probably

much as I wrote it.

Q. All right. Is this your only copy of this document also?

A. It's the only one I could find of it. I was I was just looking through. I was talking on the phone the other day, and this is what I pulled out. I really don't know how relevant it is, but we discussed this as an example of some of the work I've done in the past.

Q. And Mr. Stein did request a copy of it?

A. I think he did.

Q. Yes, he did.

A. And this is not my entire report, but perhaps as far as relation of water quality and limnology goes, this section here is --

Q. Okay. Do you mind if we mark this as Exhibit 21, have the court reporter copy it, and return it to you?

A. Go ahead.

(Behnke Deposition Exhibit 21 was marked for identification.)

Q. (By Ms. Watson) While we're on the things that Mr. Stein requested, he also requested a copy of your report on the AMAX Project.

A. Oh, Clinton Reservoir. I don't have that. There was -- Let me see. How about the GCC report?

Q. These are the things that I have listed from

the first part of your deposition.

A. AMAX one was the Clinton Reservoir fishery which is mainly -- I think had -- must be water quality. Again, it was a fishery report, a new reservoir had been built.

There was water quality aspects of salt loading, put salt on the road and something like that. I have those at the office. But I don't think they're very relevant to this case, but we'll get them.

Q. He also asked for the report on the GCC project.

A. Yes. I had that here. Here it is. What I could find was a draft. This is on endangered species. This was my contribution. Essentially, most of this was written by me, except, again, rewritten by -- someone at the NUS Corporation wrote it.

And I believe there's nothing on water quality. It's mainly on flow habitat and endangered species requirements.

Again, this is a draft that -- You can see that it says I took something out here and am supposed to add something here. So it probably differs somewhat from the final report. Which, I think if I looked around enough, I could find a final report. But it's part of the public record.

Q. Do you mind if we mark this as Exhibit 22 and have the court reporter copy it and return it to you?

A. All right. Here's a page of citations.

(Behnke Deposition Exhibit 22 was marked for identification.)

Q. (By Ms. Watson) He also -- Mr. Stein also, at the first part of your deposition, requested any copies you have of papers or reports that you produced on -- in the course of your work on fisheries or rivers at the Mescalero Reservation, White River, and in the Truckee-Carson case.

A. Oh, okay. There was no written report except for the Mescalero was mentioned in another publication. There was a stocking of Snake River cutthroat. A student and I wrote a paper one time that used supplementary evidence of fishery on the Mescalero Reservation.

The Truckee-Carson case, I recently published this paper in this popular journal, a historical account of very large trout that once lived in the lake.

Q. Was this article here in Volume 13, No. 1, of the American Fisher, entitled "Pyramid Lake And Its Cutthroat Trout," developed as a result of your work on Truckee-Carson?

A. No, this was sort of an -- I guess fun-type of article. I had a lot of historical information that was not widely known to the public, and it was put together from that

point of view. It's not a strictly scientific article, although it has a lot of factual material in there. The point I was making is the world's biggest cutthroat trout was at Pyramid Lake, and it became extinct.

Q. All right. I think we'll have a copy of this article marked as Exhibit 23.

(Behnke Deposition Exhibit 23 was marked for identification.)

A. Those are some beautiful paintings done by probably the world's greatest trout artist around the turn of the century. And the paintings were in the Smithsonian and had never been published before. That's why I agreed to write this article, if they would get those paintings out and show them.

Q. Did you produce a written report, other than this article you just showed me, in the Truckee-Carson case?

A. Yes, okay, I did. You should have read these over the phone to me. That was the 1974 report for the Pyramid Lake Tribe versus the Bureau of Reclamation, at that time, documenting the decline and extinction of their fish. As I said, that paper, when I developed all that material, essentially came out in here.

Q. In Exhibit 23?

A. Yes. But I can get a copy of the original

1974 report, but it's much easier reading in this article than it is in the whole report.

Q. Do you have that available at your office, the 1974 report?

A. Right.

Q. And you also have the Clinton Reservoir Fishery Reservoir report at your office?

A. Right.

Q. With Mescalero, you did not write a specific written report for Mescalero?

A. No. That was sort of a quick trip a student and I took to sample the fishes in Dulce Lake and Stone Lake on the reservation, to compare the differences in different species of trout, how they were doing.

Q. I had understood that Dulce Lake was on the Jicarilla Apache reservation.

A. That's right. I don't think I was ever on the Mescalero then.

Q. You said you wrote no specific report for that?

A. I think the only research for that was in a published paper in 1974, in the tracts (Transactions) of the American Fishery Society, about the different performance of cutthroat trout versus rainbow trout in, I think, Stone Lake, the larger lake on the reservation.

Q. At the first part of your deposition you brought a copy of your resume or vitae with some publications listed in it.

A. Yes. You can find it here and copy it out.

Q. Would you please find it in your vitae?

A. This paper here (indicating). J. B. Trojnar, T-r-o-j-n-a-r, and R. B. Beekie.

Q. So that's on page 4 of your vitae, Management Implications of Ecological Segregation Between Two Introduced Populations Of Cutthroat Trout --

A. Right.

Q. -- In A Small Colorado Lake?

A. Right.

Q. So you conducted your work on the Jicarilla?

A. The Jicarilla was like a one- or two-sentence reference in that paper to the different survival of the trout in the Jicarilla lake.

Q. Okay. So have you done any work on the Mescalero Reservation in New Mexico?

A. I don't believe so. I must have confused Mescalero and Jicarilla.

Q. And you also mentioned some work you did at White River?

A. Hold on a minute. I was never on the Mescalero. Frank Halfmoon one time, I believe, was on the

Mescalero Reservation, collected some trout from a place called Indian Creek, I think. Comes off Mount Blanca there, goes down in the sand dunes area. And there was cutthroat trout in a creek. And he wanted me to identify it. So I examined the specimens. And I wrote a report for Frank Halfmoon, which was on the Mescalero.

Q. What was -- What were you looking for?

A. They wanted to know what the trout was. Was it a true, pure Rio Grande cutthroat trout? And, if so, how did it get there? Because the creek goes out from the mountain and goes in the desert. And how did it get there.

Q. Did it have anything to do with the water quality or their habitat?

A. No, it was strictly an identification-type of project.

Q. Okay. And Mr. Halfmoon would have that report anyway?

A. Yes.

Q. Then you mentioned at the first part of your deposition some work you did at White River?

A. Oh, that's on the Apache trout. Again, there's nothing on water quality. That was strictly an identification project to identify the streams on the White River Reservation that had the Salmo Apache trout.

Q. Did you analyze their habitat?

A. No. I think there would be almost nothing on it, except to comment on the size, elevation, and that of the streams.

Q. Okay. So we've narrowed it down then -- At your office, if we are able to take a break today, you might be able to find the Clinton Reservoir fishery report?

A. Yeah.

Q. And the 1974 report for the Pyramid Lake Tribe?

A. Right.

Q. Okay. Now, were you, since the time of your last deposition, supplied with any further documents or data related to your work with Acoma Fisheries in the Rio San Jose and Acomita Lake?

A. No. Since I left you on September 9, 1986, I had not heard a word, except the return of the documents that were borrowed at that time.

Q. So basically, you've had no contact with the Pueblo of Acoma's attorneys at all?

A. No.

Q. Since September 9.

A. Until I met Mr. Johnson this morning.

Q. Okay. And did you talk with anyone else, like Mr. Frank Halfmoon or any other people, other than the Pueblo's attorneys, about this project after September 9?

A. No, I'm quite sure I haven't.

Q. What was the purpose of your meeting with Mr. Johnson this morning?

A. To brief me on -- I was curious what the deposition would be about this morning, because I thought we completed it in September. And he was briefing me about the deposition of Dr. Armstrong.

Q. All right. What did he tell you about Dr. Armstrong's deposition?

MR. JOHNSON: I would object to that, and instruct him not to answer. It's attorney work product, and it's definitely the result of my thought process.

Q. (By Ms. Watson) Have you been asked to analyze what Dr. Armstrong has testified to and will testify to related to this case?

A. No. Only, when you came, I have received -- I had time only this morning, I say, for about an hour before you arrived, to briefly look over or start to look over Dr. Armstrong's deposition.

Q. You have a copy of the transcript of the deposition?

A. If that's what it is.

MR. JOHNSON: Um-hum.

A. I have this material here, and I believe it is several different fragments, you might say. Perhaps this is

it here.

MS. WATSON: I haven't received my copy. I was wondering how you got your copy. Obviously, you have a draft of it.

MR. JOHNSON: That's right.

MS. WATSON: Must be nice having an office across from the court reporter.

Q. (By Mr. Watson) You have copies of the exhibits to Dr. Armstrong's deposition?

A. I don't know what I have here. I haven't had a chance to look at them.

Q. All right. Have you been informed that we do have a trial date in this case?

A. No.

Q. All right. Have you been asked yet to be a witness at trial in this case?

A. No.

Q. Have you been asked to do any further work related to this case?

A. No.

Q. Then why were you given a copy of Dr. Armstrong's deposition?

A. I don't know, except I asked what was the -- to try to find out what the deposition this morning would be about. And my impression was that it was something in Dr.

Armstrong's deposition, it was brought up, that I would be asked about. So I tried to familiarize myself with what had taken place in the meantime, since our last deposition, that maybe wasn't known then.

Q. And with what did you familiarize yourself that was not known by you on September 9?

A. I believe Dr. Armstrong's deposition was taken since then.

Q. Okay.

A. So what he developed for his deposition was not known to me at that time. It wasn't available.

Q. So that's the only new information you have in this case?

A. I believe so, but, I said, I haven't had a chance to read it yet.

Q. Okay. All right. So this stack of documents over here is all new to you today?

A. Right.

Q. And let's see. May I look at them?

THE WITNESS: Is it okay to share? It's public record, I would imagine.

MR. JOHNSON: Sure.

A. Some of this is just a repeat of information that evidently Dr. Armstrong used.

Q. (By Ms. Watson) Okay. So it appears that you

have copies of what were marked as exhibits to Dr. Armstrong's depositions, some copies of some articles that Dr. Armstrong brought with him to his deposition and were copied, but not made part of the record, with some exhibits attached to those. And what is this last?

A. Oh, that was just another -- it goes with Galat -- this was another example, we had a student do a similar thing to Galat's about water. I believe that related to river regulation, perhaps.

I just grabbed that with Galat's paper. It's probably not that pertinent or relevant, except as an example of working with students who develop expertise beyond your own.

Q. This is a preliminary exam by Mr. Thomas Chart dated April 1985, called "A Review Of Stream Regulation In North America." Obviously, you didn't rely on this in writing your 1984 --

A. No.

Q. Did you discuss with Mr. Chart anything related to your 1983 report?

A. No, I don't believe so. That was a master's examination paper where Galat was a PhD, and Galat's is much more an authoritative-type of document. This is just, again, an example of how -- say, a learning process.

Q. All right. And is Mr. Chart one of those

people you would call if you had a question in his area of expertise?

A. Not likely.

Q. Okay. What is his area of expertise?

A. It was an endangered species, building a dam on the White River and what would happen to the endangered fish.

Q. Below the dam?

A. Yeah.

Q. Is this a reasonably good work on the topic?

A. I would say it's average of what you might expect from a master's student, but I wouldn't. Except for use in maybe bibliographic sources in there, he just doesn't have the expertise to do an interpretive synthesis of the quality I would use. It's not comparable to Galat's paper.

Q. All right. Then we won't mark this as an exhibit.

In your last deposition you mentioned a 1979 report that you did called "Monograph Of The Native Trouts Of The Genus Salma Of Western North America"?

A. Yes.

Q. Do you have a copy of that at your office?

A. Yes. In fact, I have a revision in 1981. And then just last week the editor for American Fishery Society was here, and we finalized the arrangements to revise it

again and publish it, perhaps next year, as a monograph in the American Fishery Society series. But both the 1975 and 1981 documents are at my office.

Q. May we obtain copies of those?

A. They're pretty bulky.

Q. We don't need to make them exhibits to the deposition, but we would like to obtain copies of them.

A. Okay. The 1981, the one I'm working from is my only copy. You might take a title page, so we could xerox a title page from it.

Q. We can make arrangements about that at the time of the break.

A. Okay.

Q. So have we exhausted the documents you brought with you today?

A. I believe so.

Q. And my understanding then is until this morning you had done no further work in this case since September 9; is that correct?

A. That's correct.

Q. I'd like to discuss with you the portion of your report on the fishery in the Rio San Jose itself. That portion of your report begins on page 3. Do you have your report in front of you?

A. No.

Q. Okay.

A. Remember last time I didn't have it then either. We made one, though, and I should have it at the office. I thought that was the end of the case.

Q. Well, I'll loan you my copy of your -- the first part of your deposition, which has your 1983 report attached as Exhibit 1 to the deposition.

On page 4 in the second paragraph you refer to the November 1981 sampling done by Mr. Halfmoon; is that correct?

A. Right.

Q. All right. You say that only 3,430 feet of the river -- of the stream was sampled; which is 13. -- but a total of the river on the reservation is 13.8 miles; is that correct?

A. That's what I have here. I took it from reports.

Q. Now, that 13.8 miles is from the western boundary to the eastern boundary of the reservation?

A. I suspect that's what it refers to.

Q. Okay. Now, looking at the proportion of the feet of stream sampled with the total feet of stream on the reservation, only 4.7 percent of the river was sampled in 1981 by Mr. Halfmoon; isn't that correct?

A. Right.

Q. All right. Is that amount of the river an adequate sample for estimating the population of the fish present?

A. No, you would not get a very good estimate from that, because you don't know how -- Was it truly a representative random sample? Did they sample all types of strata in the river, types of habitat? This would obviously not be -- I wouldn't make any authoritative claims on fish populations based on that sampling.

Q. What about of sampling would you want to have to give a proper estimate of the fish population?

A. I would go to a statistician and get their advice on something like that.

But this is a very rapidly changing field on fish and wildlife sampling. At CSU, we happen to have some of the world authorities on the subject, and they point out almost everything that was done in the past leaves too much room for it to be acceptable.

They are constantly developing new formulas, new techniques. If we wanted to get a valid sampling, I would go to these people and get them to design it.

Q. So, in your opinion, the sampling done by Mr. Halfmoon in November 1981 was not a valid type of sampling?

A. The sampling itself is valid. It's just, you would not make an issue over any type of validity on the

estimates.

Q. So you can't rely on the validity of the estimates?

A. I don't rely so much on the sampling itself as my examination of the stream, which was fairly submarginal habitat for trout at the time when I reviewed it in 1983.

Q. All right. So, as far as you know, it's possible that a lot of surviving fish were missed by Mr. Halfmoon's sampling?

A. Undoubtedly some were missed. But, as I point out, survival -- what is the circumstantial evidence that has, one, my observations on the stream, and, two, the fact that no one reported seeing any trout or catching any. If there were a lot of trout in that relatively small stream like that, it would have been well known to the people who live there.

Q. All right. Are the people who live there required to report seeing trout in that river?

A. No. Just that according to -- I think it was Frank Halfmoon and the tribal people I talked to, that the -- people living in Acoma just didn't consider that there were fish there. And so -- But, as I said, the word would certainly get around if someone started catching a lot of big trout.

Q. Now, there were a lot of phreatophytes and

other types of vegetation along the Rio San Jose within Acoma Pueblo, aren't there?

A. Certain areas.

Q. So that the areas in which tribal members have access to the stream are limited, are they not?

A. You mean for fishing? No, that would not really bother the fishing, because you can wade in the river to get around the brush or any barrier along the shore line.

Q. Did you observe anyone fishing or attempting to fish in the Rio San Jose when you made your tour of the Rio San Jose?

A. Not when I was there. I believe it was generally considered there wasn't any fish. I think the people were perhaps -- the water quality was such that maybe they wouldn't eat the fish.

I don't know what their past history was, but I think they mainly would fish in Acomita Lake, I believe. Although the Rio San Jose, they didn't allow nontribal members to use it originally, so I guess they did fish it themselves.

Q. But you're saying you relied on the fact no one reported trout. But if they had given up on it as a fishery, why would anybody report trout?

A. If someone would see a trout, they would get their fishing rod and catch it. If there were thousands in

there, they would catch more and more. The word would get around pretty fast. I don't think you would keep it a secret.

Frank Halfmoon didn't live there, and perhaps he only visited it a few times a year. My experience in these type of fish, you could not keep it quiet.

Q. Did you also meet Alex Laweka?

A. I recall the name. I wouldn't personally recognize him.

Q. So you don't know who he is?

A. No.

Q. What is the habitat of brown trout in a river like the Rio San Jose? Describe the characteristics of it.

A. Simply, is you need water, and the water should have this optimum types of depths and velocity and cover.

And it's highly variable. You can make -- There are models made to predict habitat of brown trout. They don't work very well. But, I said, the best type of description would be to observe a knowledgeable and experienced angler, watch where he fishes.

In other words, they are not randomly distributed. They are an aggregate that can be expressed in depth, velocity, and cover. But not in a truly authoritative and predictive fashion.

Q. Well, so you cannot describe the habitat of the brown trout in terms of depth?

A. Usually depths of one foot or more are preferred over depths of less than a foot.

Q. What about velocity?

A. Velocity, there's no real preference there. What they prefer is low or zero velocity. But the velocity is necessary to carry their food. It comes with the drift. The drift needs current velocity to transport it to the feeding fish.

So the main factor of velocity, current velocity, is the food transport mechanism.

The major factor would be for reproduction. If you spawn, the eggs need a certain velocity to clean the gravel, to keep the oxygen supply high for the gravel.

Q. And what is that velocity they need for reproduction?

A. It depends quite a bit on the river. They can actually spawn on the lake bottom, if the water is perfectly clear without sediment, and current movement in the lake is enough for them to spawn.

But a river usually carries a sediment load. Rio San Jose was not adequate for spawning because the sediment load was so high.

Usually at least about one foot per second

velocity is needed to get high survival and hatching of the eggs in the nest.

Q. Could you repeat that figure for me?

A. I say, usually about one foot per second. But there's no magical number there. It can be almost zero to three.

Q. Are there different preferred depths depending on what stage of life the brown trout is in?

A. Yes. The younger fish -- tricky to use the word "preferred." They'll be found in the more shallow depths, because the larger fish are in the deeper depths. So if you take the larger fish out, the small fish will move into deeper water.

But, typically, in a stream that has all different age classes and size, you find the smaller fish along the edge of the stream and in shallow water and the larger fish in the deeper water.

Q. Is that also true of rainbow trout?

A. Pretty much all trout respond the same.

Q. When you observed the Rio San Jose, what areas actually had depths that would support brown and rainbow trout?

A. Most of the places we looked at within, say, take 100 yard, 100 meter random sampling, within that hundred meters, the pool riffle ratio was good. The physical habitat

was good for trout.

Q. Are you speaking in terms of depth now?

A. Depth. There would be -- Every bend of the river would be -- You don't need a large proportion. Even if 1 percent within your hundred-meter section had depths of one foot, it would be adequate to aggregate your trout in.

Q. How about the velocities that you observed on the reservation?

A. At the time I was there, I'd say they were adequate. Thinking what the flow was. This was below Horace Spring. And I saw no problems with velocity.

As I said, trout don't need velocity except to carry food to them. Even in the relatively small stream they get half or more of their food from the terrestrial environment. You need a certain amount of flow. The bigger the depth, the more velocity.

Q. What rate of flow do they need then?

A. You mean for the Rio San Jose?

Q. Yes.

A. Usually, I'd say you ideally probably want to keep that river channel which was historically created by -- I don't know what the average flow in there was. I think the average -- the Ojo del Gallo Spring, I think -- so that was figured 19,000 acre-feet, I recall, of volume, if you put that in cfs.

Anyway, if I was -- off the top of my head, you could demand any flow necessary, I would probably suggest you keep a minimum flow of about 50 percent of what the historical average flow was.

Q. And so by the historical average flow, you are meaning including what originally came down Blue Water Creek before the dam?

A. Yeah, the virgin flow that created the river channel. And, I say, as a general rule, optimum trout habitat is maintained at about 50 percent of the virgin flow, unless you have a problem with flushing sediment or things like that for spawning, you would change your recommendations. But as to maintain habitat characteristics of adult fish.

Q. All right. Have you looked at the Rio San Jose to determine what amount would be necessary for the tribe to maintain a trout fishery in the Rio San Jose?

A. No. I think Mr. Halfmoon did one time. He was looking at some in-stream flow figures and was talking about doing an in-stream flow analysis. I don't know if that was ever done.

Q. From your observation of the river, based on what you know, was the flow on the river at the time that you observed it 50 percent of that virgin flow in the Rio San Jose?

A. It was -- I don't know what it was. It was less than that. But, as I said, at least in the low gradient sections, it was adequate to maintain good physical habitat as far as depth and cover went.

Q. How about the food supply to the trout in the Rio San Jose when you observed it?

A. I certainly didn't do any quantitative analysis, merely lifted up macrophyte vegetation, looked at the bottom. There was an abundance of invertebrate organisms.

Q. What types of organisms constitute food of the trout?

A. As I mentioned, as I recall it, probably amphipod crustacean. I say, crustaceans and insects were the main food or potential food. I don't know if I mentioned that in this report. As I recall, it was amphipod crustaceans and chirononid larvae. Insect and crustacean were potential main food sources.

Q. At the Rio San Jose?

A. Yes.

Q. And you said that appeared to be adequate or actually abundant?

A. Yes, I think the stream was greatly enriched, and that was reflected in the food supply.

Q. What freshened the cross-section of the river

should have cover available to be considered adequate for brown trout?

A. How much?

Q. Of the cross-section.

A. Cover, actually, say, depths one foot or more. Depths and current velocity, rippling the surface, that acts as cover itself. The cover merely pertains to the fact the fish in the stream would be invisible or protected against visual observation from above the stream.

So it can -- The most typical type of cover would be like in weed beds or under the bank, where the stream cuts under the bank. There's a great variety, a log falling in the stream, in back of a large boulder.

The same stream section could have cover at one flow and not cover at another flow. That's the problem.

Q. From what you observed of the Rio San Jose, were there areas of the river that you observed on the reservation that did not have adequate cover?

A. Oh, obviously. I'd say having a shallow riffle, there would lack cover for adult trout. Or in your food-producing area.

Q. What do you mean by food-producing areas?

A. Most of the invertebrates, the insects that the fish eat, are produced in their habitat as the shallow riffles, most high velocity riffle areas, in the deeper water

below these riffles or sometimes back of a log or a rock.

Q. How much of the stream did you observe when you were on the reservation?

A. I say only relatively small. I certainly didn't cover the whole 13.8 miles. I think we started from Horace Springs and went down to the irrigation diversion takeout. And then later I remember stopping at McCarty's it was called. It was the highway rest stop area, I believe.

Q. So approximately how many feet of the river did you observe on the reservation?

A. Altogether maybe perhaps, a cursory examination, maybe two or three miles of stream.

Q. All right. What percentage of that area had adequate cover for trout?

A. I really couldn't say. Except that the water quality, I said, the Rio San Jose could be, I think, a very excellent trout stream.

Q. Right. And I'm trying to get you to quantify what you observed as establishing a good trout stream.

A. As far as my qualitative observations, if I had all the elements of a good physical habitat, the depths, the velocity, the cover. But I didn't have any quantification. It was a very superficial -- It was like a fisherman who fishes that river that says, "This looks like a good river to fish," without quantifying why it's good.

Q. Okay. So of the two to three miles that you saw, they weren't a constant to two to three miles either, were they?

A. No.

Q. So the spots you observed looked good, but you can't say anything about the whole stretch of the river, can you?

A. It was a monotonous and repeatable type of habitat, because I think the gradient was constant. I think the gradient changed at McCarty's, and it became a higher velocity stream, perhaps with poor habitat after McCarty's. But I didn't examine it in any detail there, except to notice the higher velocity and perhaps increased gradient. But most of the places you could see the stream, it was fairly repeatable type of habitat.

Q. Okay. Now, when you were making your report, but were you considering a trout fishery below McCarty's?

A. Is that on the reservation there? I mean, how to develop the fishery on the reservation. You'd have to use -- they have 13.8 miles, supposedly. And so the concern was that any kind of improvement or relation to the fishery would pertain to only what was on the reservation.

Q. Right. And there is a stretch of the river below McCarty's.

A. So that would be part of the potential fishery

then.

Q. So you didn't observe any conditions below McCarty's?

A. No, only at the rest stop area there was a much higher current velocity, which suggested the stream was changing gradient there.

Q. I'd like you to assume that there are several points of irrigation diversion beyond what you observed downstream.

A. As I recall, the flow at McCarty's was higher than it was upstream. So perhaps some irrigation return flow was coming in or something. I don't recall.

But I do recall it looked like there was more flow at McCarty's than, say, it was up by Horace Springs that day. Or it may have been the following day. But it was obvious that the river is regulated or influenced quite a bit by irrigation.

Q. Assuming that you were considering a trout fishery below points of diversion for irrigation, what effect would diversions for irrigation have on that trout fishery?

A. Depended on how much irrigation diversion there was. Does it take all the water out of the stream or just a small percent. You can actually improve a fishery by diverting water at the highest flows, and certainly ruin it by diverting too much at the lower flows.

Q. So you've made no study at all to determine what effect irrigation diversion would have on trout fishery at the Rio San Jose?

A. No. I think in my report I perhaps made the point that the tribe themselves, if they wanted to get a really high value fishery on the reservation, they would also have to develop a water budget plan that would -- You schedule your irrigation to least conflict or even benefit the fishery. I think this had not been thought of in the past, not only the regulation of the river, but also Acomita Lake.

Q. Well, to determine the actual effect of -- well, the actual alleged effect, I'll say, of any effluent from the Grants Sewage Treatment Plant on the fishery in the Rio San Jose, you would need to know the effect of irrigation diversion, wouldn't you?

A. Irrigation diversion could be, I think, easily determined, if you have the USGS flow records. For example, if you see that the diversion takes all of the water out of that stream below that point, there would be essentially no chance for a fishery. You wouldn't predict there would be a fishery there unless you knew there was Anzak Spring coming in there.

Q. But you were not presented with any data on spring flow or gauging station?

A. I don't recall analyzing any flow data for the Rio San Jose, except what was the virgin volume and then the historical change with, I guess, Blue Water Creek, the cessation of flow in Ojo del Gallo. Mostly superficial information like that.

Q. And spotty data?

A. Yeah.

Q. And none of it had to do with the effect of irrigation diversions, correct?

A. I recognized the problems. I think I did point out if I was going to be put in charge of the tribe recreational enterprise, or something, I would integrate it with their agricultural enterprise, how that water would be used, when and why to divert, perhaps storage, and so forth, even to develop a beneficial impact on a fishery.

Q. So the purpose of the report you did was not really to assess any alleged damage by effluent from the sewage treatment plant on Rio San Jose and Acomita Lake?

A. I'd have to go back and read the report again. I think after my visit there, the point of this, I saw an opportunity they could have it, with better water quality could develop a very high-value recreational fishery.

Q. So you recall that as being the point of your paper?

A. Yes, at least that's what sticks in my mind,

is that they had evidently -- had not realized in the past how important recreational income could be, but at the present time it wasn't really feasible because of the water quality.

Q. Now, what water quality data did you have at the time you did your report?

A. At that time it was, I believe, Walter Hines' group had only the first sampling that year, but we visited the Grants Sewage Treatment Plant, and followed the Rio San Jose down along the road and railroad tracks off and on from the Grants STP to Horace Springs.

And what I saw, I think I brought out at the last deposition, was the previous day the plant had malfunctioned, and there was this tremendous slug of black, foul effluent going down the river. And one look at that would show how horrible it would be with that kind of water coming in, even if it only happened once a year.

Worse, I think, the reputation you would have. Once, say, the people from Albuquerque -- or you were trying to bring in this elite clientele to have an excellent trout fishery, and once that happened, that's the water that's coming onto the reservation that your fishery is based on, you could say it's not high-class. You would not get -- it's more of a sociological and psychological problem of the people's perception of a fishery.

Q. But there have been years of water quality data gathered on this stream. You did not examine any of it, did you?

A. Yes, I did. I wouldn't put much faith in it, because it was highly erratic. It was obviously the people -- the equipment was malfunctioning, or they were taking it at the wrong time or place. I don't know what.

You could get -- the nitrogen phosphate would go all over the place. It was the type of data I didn't think would hold up in court.

Q. Whose data was that?

A. I don't know if it was the New Mexico Health Department or Indian Reservation data or not. But the pages of data I looked at, it was not -- a systematic monitoring program had not taken place.

Q. Was the data among the documents you provided at your last deposition?

A. No, it would be something that was in there, you know, that was used. Probably -- I don't know if any of it is in here or not.

Q. What I'm trying to say is the water quality data you are now referring to, you had copies of?

A. I would have had it down there at the Denver deposition.

Q. All right. I'll show you what you brought to

your Denver deposition. Could you please point out to me what data you're referring to.

A. Probably this here, something from Aqua Science. But I don't recall, except that it was just -- My impression was that the river had lacked the water quality, that it lacked, really, a systematic monitoring basis.

Q. And you're referring to Exhibits 8 and 9 to the first part of your deposition?

A. Probably.

Q. All right. And you've been supplied no further water quality data since then?

A. No, I don't believe I have.

Q. What quantitative data would you need to determine the suitability of the entire reach of the Rio San Jose as a trout fishery on Acoma Pueblo?

A. Mainly I would prefer to use, like, empirical data, just to put the fish stock in and see what happens. Do they thrive? Do they reproduce?

Especially running water, you can have sometimes very high levels of nitrates and phosphates. You would run into the problems, when you put into a lake, you're going to get oxygen deficiency at the bottom. Running water, you're not likely to get that.

I think I pointed out here, especially ammonia. But you could probably maintain, you know, at least

a put-and-take, put the fish in, not expect them to reproduce perhaps.

If you go to a fish hatchery, the conditions, the water quality way exceeds EPA and State standards. It has to be treated before it's put back in the river. Quite high levels of ammonia, nitrates, and phosphates, waste product of the fish, high density. But as long as high oxygenated cold water is flowing through, trout can thrive in very poor water quality.

Q. What empirical data would a test provide you about habitat?

A. Not so much habitat, but the water quality. Is the water quality sufficient for the fish to live there.

Q. And at the same time, you would need to have other kinds of tests besides just the live well test to determine what the actual source of that water quality was, wouldn't you?

A. If you wanted to see if it was going to be a fishery, you'd have to leave the fish in for one or two years to see if it's going to be a viable, self-sustaining population. And the only way to determine that is to put the fish in and see.

Q. Right. And that gives you the effect on the fish. But it doesn't tell you the source of the water quality.

A. No, if the fish die, then this would be a variety of circumstance, then you would go back and look was component kill, most likely, is the lethal effect.

Q. So you would need at the same time as the live well data, at the same time you would need water quality data?

A. Yeah, there certainly should be water quality data. I believe this is what Walter Hines was doing was to develop a systematic water quality monitoring project on the Rio San Jose.

Q. Okay. And would you need the water quality monitored by Mr. Hines at each live well site?

A. Not necessarily. If you have the data of below or below -- for example, if fish are killed -- lethal below sewage treatment plants, the first thing come to my mind would be chlorine, and next, ammonia as the most likely intoxicants.

So if you see fish dead in the live box, and you have the water quality data perhaps taken the day before or during -- you collect and you see chlorine, detectable chlorine level, it would be fairly obvious of what killed the fish.

Q. But you need water quality data that is related both temporally and geographically, correct?

A. Yes. You have a problem with fish kills in

rivers because, especially like in a sewage plant effluent, you can get a toxic chemical that comes in, say, from an industrial user. It's a very ephemeral, sporadic event.

That's why often the live box with fish are used, because they are constantly exposed to it that you would not pick up on a daily sampling basis. It could come through and be there in that particular section for perhaps a few minutes, kill the fish. You would sample before or after, you would not pick that toxic compound up.

Q. Are you aware of any industrial contributors to the discharge from the Grants Sewage Treatment Plant?

A. I don't believe so. I know there was uranium mining in the area at one time. I think that is probably no longer in existence. The main problem I see was typical of most sewage effluent, was chlorine, ammonia, and organic matter.

Q. So water quality data relating to those would have to be temporally related to data from a live well testing, wouldn't it?

A. Yes, I would think you'd have to have -- Except with the point with the live well test would let you know the day I was there, I told you, that great black slug of undigested mass moving down the stream, water quality tested the day before and day after, wouldn't detect that.

But fish in a live box, you'd say, "Something

happened here yesterday. Something happened here." Would let you know that. So, I said, the biomonitoring, as it's called, gives you a constant monitoring effect; whereas, the checking for water quality parameters, you only do it on a daily basis, you could still miss a lot.

Q. All right. Now, what about quantitative data on the habitat suitability? How would you obtain that?

A. I'd just look at my familiarity with trout streams. The Rio San Jose, actually, is much better than average trout habitat, as I say, depth, velocity, cover, the potential food supply.

Q. You told me that was qualitative. I'm talking about quantitative.

A. Quantitative? I said, U.S. Fish and Wildlife Service has data on quantifying brown trout habitat. It's probably the state of the art and best you can do, but it is still not predictive.

Q. Meaning?

A. Meaning that you cannot take it to a stream, use it. You can get a quantitative habitat rating system, but that rating system bears little relationship to the actual numbers of biomass to the actual numbers in these streams wherever it has been tried. It's disappointing trying to quantify brown trout habitat. And that species has been worked on probably more than any other fish species.

Q. Is the same true for rainbow trout?

A. Yes, there's very little difference between them.

Q. All right. In your opinion, would the presence of treatment plant effluent, regardless of the level of its treatment, have tainted a trout fishery downstream of the Grants Sewage Treatment Plant?

A. A tainted fishery? From what?

Q. Well, you, in your report, have, based on your observations, but not water quality data you saw, have basically eliminated any other cause for a decline in that fishery.

A. The major limitation is, I think, that the water quality that comes in. And it's a high suspended organic matter in the water. So that water, even at relatively low flows, has a grayish-green cast to it, an unhealthy look. A fisherman wouldn't like it.

But also it simply inhibits trout feeding. Trout are sight feeders. You just cannot, no matter how good the habitat is and flow conditions, and food supply, it is just not feasible to expect a good trout fishery from, say, turbid water that a trout cannot see the food.

Q. And you base that on what you observed on your trip?

A. Right.

Q. Now, as part of your proposal for a high-class fishery to attract big spenders, you stated that the fishery should not be affected by an effluent?

A. Right.

Q. Now, were you talking about tainting the flesh of the fish?

A. No, it's a psychological perception of the fisherman. You can grow -- Like in secondary treated sewage effluents, you can grow trout very well, if the water is clear and you don't have oxygen problems.

In fact, I think I cite in here someplace about the AuSable River in Grayling, Michigan, that the quality, compared to Rio San Jose where all the flow below Grants was from the sewage treatment plant. There was a relatively small input of the City of about 1500 people there. It averaged 100 cubic feet per second. But it stimulated production, and the trout grew better and were more abundant than when they cleaned up the sewage and the trout fishery declined.

But the people there demanded that they clean it up, because it had the appearance of fishing, boating, recreating, in sewage effluent which was offensive to people.

In the Rio San Jose, the situation was a little bit as good, but too much was not good, where the water is, I say, tainted with this organic matter. It has a

sickly look about it. You could not sell it as a high quality fishery, even if you could grow big fish in it.

Q. And that was based on your observations only on that trip?

A. Right.

Q. Did you consider what other sources of turbidity there were?

A. Yes, yes, I did. I don't know if I have it in the report or not, but perhaps I brought it out at the last deposition.

But I think I made it clear to Frank Halfmoon or Hines or tribal people I talked with that to get this kind of fishery, like goal, the aim would be -- is we need this holistic management of the reservation, to integrate recreation with agriculture.

Look for sources of erosion on return irrigation flow, livestock grazing. Are they problems? You'd have to analyze the whole watershed there. If you've got better quality water quality coming down the Rio San Jose from Grants Sewage Treatment Plant, then what can the reservation do to make sure it's maintained high quality? I pointed this out. I didn't analyze this situation. I suspect return irrigation flow would be one obvious point to look at, and livestock grazing is another.

Q. Is livestock grazing a source of turbidity?

A. Well, livestock can reduce -- like the riparian vegetation, the banks cave in. It's mainly a habitat problem.

Q. Okay. Is it also a source of nutrients for the river?

A. Not significant. The livestock manure stays on the land. It fixes pretty rapidly. In all the studies I've seen, it's very minor for a small stream like that, unless you go to a feedlot.

Q. But you're assuming livestock do not have access to the river.

A. No, I assume they do. But I didn't analyze the circumstance. This was part of my telling them in the future if you've got better water quality coming down, these are some of the things you want to look at, your livestock management program, your irrigation management program.

Q. So the livestock have to do with the habitat itself?

A. Yeah, the negative impact you get from overgrazing is the destruction of the riparian stream edge, the effect of the reduction of the cover on the fish.

Q. Now, return flows from irrigation, how would they negatively impact?

A. Mainly, it's according to how you irrigate. If you're not careful, flooding your top soil, actually

bringing the sediment back in the river, this can be very harmful.

Q. That's harmful for spawning?

A. It can reduce spawning. My vision here was a clean, good water quality stream that would attract people willing to pay big money to fish for big trout in this type of environment. And you don't want to have muddy water coming down.

Q. So you're speaking of just sediment, as far as looks goes?

A. Probably. Mainly you'd negatively impact anything spawning below this. But, I said, again, I did not examine the irrigation system. I do not know what the irrigation return flows are. Do they have this problem. I said this is something you have to look at, really, for future management.

Q. Okay. Well, what I'm trying to understand is irrigation return flows would be a source of turbidity then?

A. Yes, sediment load. Possible source of sediment.

Q. They would be a possible source of nutrients for the river?

A. Yes, especially if the fields are fertilized.

Q. All right. Even if they aren't fertilized?

A. You'd get some type leaching according to the

type of soil. Your big problem would be heavily fertilized fields. If you're not careful, you could abuse the water with poor irrigation practice.

Q. Okay. So you did no quantification of that?

A. No.

Q. No study of their irrigation practices or how that would affect the fishery?

A. No. Merely pointed out that to get the type of fishery I was talking about, you have to really, say, holistically integrate a recreation plan for that water with an agricultural plan, take all this into account.

(A recess was taken.)

Q. (By Ms. Watson) All right. Now, getting back to your contention about big-spender fishermen having this psychological --

A. Perception.

Q. -- perception that the fishery would be tainted by sewage effluent in the flow, would those big spenders want to fish in waters affected by any effluent, regardless of the treatment level?

A. It wouldn't be obvious to them if the water was clear. It just looked healthy, and the fish were nice and healthy. There would be no question of where the nutrients came from that grew the fish.

I think most people realize in this day and

age almost all water in river systems downstream from cities are effluents which are being treated, and water is being recycled. People don't think about it until they see something that looks offensive to them.

I said, in the AuSable River in the Michigan case, there was actually, biologically, a healthy condition. There was great bacteria beds of suratlis, which breaks down sewage. That, in turn, fed a lot of insects, and the vegetation grew lushly. But people who lived along the river found it offensive.

Q. And that was a case where the effluent was clear?

A. I don't know how clear it was. But the manifestation of it, they claimed that it had a bad smell to it. So I think all they had there was a sewage oxidation pond that overflowed into the river.

Q. All right. So the things that you think would taint a fishery in the Rio San Jose as far as big spenders are concerned would be what the water looks like and what it smells like?

A. Right.

Q. Okay. Now, you stated that you expected a thousand-pound-a-year production level from a trout fishery in the Rio San Jose?

A. I don't know how I expressed that. Usually I

would express it pounds per acre of stream. 13.8 miles. There's usually -- I forget, maybe did I figure 30, 40, acres of water or something in there. 50 acres?

Q. On page 6 of your report, the last paragraph, you state that the Rio San Jose flows through 13.8 miles of Acoma lands and consists of about 20 surface acres, with clean water, adequate flows, and stream improvements, a yield of about a thousand pounds of trout per year should be possible.

A. For every mile of river, if the average width is eight-and-a-half feet, you have one acre. And the -- that would be -- the Rio San Jose would be averaging only about 14 feet wide, I guess -- no, 12 or 13 feet wide to get -- should be more than -- well, I don't know.

It would be 20 acres. So I come up with 50 pounds per acre, and a thousand pound per year. Yes, it would be -- that would be a very conservative estimate, probably both in surface acres and production.

Q. All right. Do you know what the average width of the Rio San Jose is on Acoma Pueblo?

A. No. Maybe I had that when I came up with a figure of about 20 surface acres, which would make it only about 12 or 13 feet in average width. I think wider than that, I believe.

Q. Assuming that 12 to 13 width is correct,

therefore, making your other figures correct, would that thousand pounds per year be a conservative figure again?

A. Yes, that would be only 50 pounds per acre, and you would expect that from even low nutrient water.

Q. Okay. Now, would the amount of food organisms you observed available to trout in the Rio San Jose, would that be adequate to sustain a thousand pounds per year reproduction?

A. Oh, yes. The only way -- you'd have to put them in and see. But we're talking about 50 pounds per acre, which is a very minimal figure. Because that is what we get in, say, Rocky Mountain trout streams of very low nutrient levels.

At higher nutrient levels, like some springs and creeks in Wyoming, probably the most directly applicable, like Horace Springs and Anzak Springs, feed where they have 1,000 pounds per acre of brown trout, so I took 50 pound per acre as a very low conservative figure. But I would really expect more like in the area of somewhere between 200 and 500 pound per acre.

Q. At that level 200 to 500 pound per acre, was the amount of food organisms that you observed at the Rio San Jose sufficient to support that production?

A. From my casual observations, the food densities was much higher than you find in a typical trout

stream. But there's no way to make that kind of statement, because it would take a long-term study. How -- I suspect half of the food would be coming from the terrestrial environment, grasshoppers, ants, things like that. That's why I say you can get high production even in almost like distilled water quality.

But with the natural enrichment in that stream, even without the sewage treatment influence, that stream is a relatively rich stream. And just based on that, in comparison with other trout streams, I would expect a high productive trout fishery.

Q. Considering it's a highly enriched stream naturally, without the sewage treatment plant, what effect does that have on your contention regarding DO levels?

A. That is only a problem in Acomita Lake, unless it's possible to kill fish in a river with low oxygen levels due to over-enrichment and during periods of very low flows when the trout would be congregated in deep pools. And you get almost like a miniture lake situation there.

But I think mainly my concern was when you take the water and put it in Acomita Lake, then you're going to run into the problems of dissolved oxygen problem, ammonia problems.

Q. Are you saying that the nutrients added to the Rio San Jose by the Grants Sewage Treatment Plant do not

cause a problem with DO, ammonia in the Rio San Jose?

A. There, I don't know what -- I suspect it would be ammonia, but also I think they'd have a problem in sewage effluent water with bacteria. You have enormous production of bacteria, many pathogenic forms, ulcers. It just makes an environment that's very conducive for disease in fish.

Q. You didn't look at that effect?

A. No, this is just a general statement you can make about sewage effluent in general. Where it's high organic matter, you're going to get high bacteria level, which is good. But there's a lot of bacteria that are pathogens. Typically, you'll find fish that are ulcerated, wounds on their body, incidence of parasitism goes up. It's not a healthy condition.

Q. What others can you cite?

A. Like in our own Poudre River, right down the road here in back of my house, there's a large sewage treatment plant that actually puts out a good effluent. There are actually a few trout live there. It's mainly suckers and carp.

During the summer months, when most of the flow in the river is from the sewage plant, you'll find a high incidence of ulcers on the fish and parasites.

There's a monitoring program that's been going on several years here, that Kodak has been sponsoring, that

has this kind of information documented. But as a general, there are, like, impacts on aquatic biology, a truism enough to be called a general paradigm type. There's no need to go through another PhD study to demonstrate you have a problem.

Q. Okay. So you're making your statement about the Rio San Jose just based on this information?

A. Right.

Q. Are racoons natural predators of trout in the Rio San Jose?

A. I would say, more likely, racoons would take fish that have recently died. They would certainly eat live fish if they could catch them, but they're not -- say, contrasted with the mink or otter, they don't really get in the water and swim and catch them. They have to lay in wait. So usually racoons are not a major predator on live fish. They certainly would be, if they could catch them.

It's like aquatic mammals are not adapted, so most of their diet might be carrion, the fish has recently died. That's why you wouldn't find dead fish on the bank, because a racoon would pick it up during the night and go off with it.

Q. All right. Looking at Lake Acomita, Mr. Halfmoon reported that rainbow trout, Snake River cutthroat trout, channel catfish, brown trout, and other fish were present in Lake Acomita.

What are the ranges of temperatures and dissolved oxygen in which each of those fish can survive?

A. Again relates to the temperature itself, but trout can get by, at least for short periods of time, even if the oxygen gets below 3 parts per million, if the water is cold, say less than 40 degrees Fahrenheit. They mainly -- They need at least 6 parts per million to function more optimally.

Channel catfish can get down to 1 part per million, at least for a short period of time, unless the water is like 85 degrees Fahrenheit.

But fish are cold blooded animals, and their oxygen demand pretty much depends on the external temperature. So the higher the temperature, the greater the demand for oxygen, and vice versa.

So you can't get a certain value except typically trout would need 6 parts per million for optimum functioning, especially at the higher temperatures, say over 50 degrees Fahrenheit. And channel trout would probably demand about 3 parts per million, and would run into stressful situations below 1. And trout would start to be stressful say about 3.

Q. According to the Fish and Wildlife Service, brown trout can live in water up to 78 degrees Fahrenheit. Do you agree with that?

A. They can live in water up to 83 degrees for about two hours. They can live in 78-degree water for perhaps two weeks. They might starve to death before they die of heat shock, because they usually cease feeding at 77 or 78. In other words, they cannot continue indefinitely.

Q. All right. So you're saying that they can -- You agree with the Fish and Wildlife Service in that they can feed in water up to 78 degrees Fahrenheit?

A. These are laboratory tests, and as far as how valid they are in natural conditions would be questionable. But trout raised under laboratory conditions, both rainbow, brown, at about 77 Fahrenheit the feeding ceases. I discovered a form of trout one time that fed at higher temperatures. They were actually feeding in 83 degree water.

Q. Okay. In your earlier deposition, you indicated that brown trout could survive and feed up to 86 or 87 degrees.

A. No, I don't believe I ever stated that figure. I said, again, the upper lethal temperature of almost all trout that have ever been tested in about two-hour time period gets about 83. But the maximum of brown trout often are better than rainbow trout or cutthroat trout in that as you approach the lethal temperature, they're still able to function, they don't get into stress so readily.

That's why often brown trout is the major

trout you'll find in the lower reaches of rivers where it gets warmer, and submarginal conditions.

Q. Okay. Now, in figure 1 to your report --

A. Oh, that was a lake, okay.

Q. -- you, in essence, say that a temperature of 21 degree centigrade is limiting to trout.

A. For continued existence. In other words, for viable population. It has to get much colder than that for spawning.

But, essentially if you had a tank, you could maintain them. You could maintain them indefinitely feeding at that -- You're going to introduce disease problems, but essentially 21 degrees. 70 degrees you could maintain a pretty viable population at that. It's way above optimal, but there's not going to -- They'll avoid it if they can, but they're not going to be highly stressed if subjected to it.

Q. So they'll continue to feed and thrive, but for bacteria?

A. They won't thrive so much. I would say the intake of food versus expenditure of energy is about neutral. They can maintain themselves -- I would say maybe maintain themselves indefinitely at that temperature. Except it would greatly shorten their life span because of a greatly increased metabolic rate and susceptibility to disease.

But that's a general -- again, a paradigm of

trout biology of about 21 C or 70 Fahrenheit as a temperature that's tolerable.

Q. Did you ever examine data from the Fish and Wildlife Service about the water column in Acomita Lake?

A. No, I don't believe -- As I said, the problem was there was never a systematic water sampling program on the reservation. I think the most, you might say, insightful information was comments in their reports about when they opened the gates and the terrible stench that would come out, which would be hydrogen sulfide, which would be an anaerobic condition, was building up on the bottom.

I would suspect the lake was about ready to kill all the fish, and at the right time they would open up the gate and flush out the water. And it essentially saved the fishery.

As I understand it, over the years they never had a complete or massive fish kill. It was amazing they didn't, but I think it was that by opportunely opening the gate. Or a windstorm could do the same, a very big intensive wind action could turn the lake over and oxygenate it and prevent the massive fish kill.

Q. Wouldn't you expect that any water released from the bottom of a lake would smell like hydrogen sulfide?

A. No, unless there's anaerobic decomposition going on. That's the smell of anaerobic decomposition going

on. In a clear lake that has a vegetation and it's photosynthesizing from the bottom, that doesn't take place, because there's aerobic conditions going on.

Q. Even without a contribution from the Grants Sewage Treatment Plant, weren't there anaerobic conditions on the bottom of Lake Acomita?

A. I would say that Lake Acomita, the lake stratification, the water would have been enriched enough there would have been anaerobic conditions.

Q. How do you know that lake was stratified?

A. When you open the gate and the stench comes out and you don't smell the stench on the surface, you know the lake is stratified and it is contained below the thermocline or stratified layer.

Q. So you're going basically on the smell itself?

A. Just from the comments. And it's just very, very -- again, a paradigm of limnology is that when you put water in a standing body, it will stratify by temperature. There's not free exchange of gasses between the layers, the temperature stratification. In turn, then your anaerobic decomposition process on the bottom without oxygen, hydrogen sulfide is one of the products given off, and because of that, sewage-like smell.

Q. Now, you had data available to you at the time you wrote the report about the temperature in the water

column, didn't you?

A. I don't recall if it was in the reports that you have. If IT was in the reports you have there, I've got to see it. Again, it was very sporadic. I would imagine the Acomita Lake was -- would have had marginal temperatures during the hottest part of the summer.

Q. What do you mean by "marginal temperatures"?

A. I said before -- going back to my figure 1, the marginal area is where the oxygen would be 4 parts per million or less and the temperature more than 21 centigrade or 70 Fahrenheit. But I believe, at least in the shallow water of Acomita Lake, you could get 80 degree Fahrenheit temperatures in the hottest part of the summer.

Q. Well, I'd like you to look at Exhibit 6 to the first part of your deposition, which you testified was data supplied to you by Mr. Halfmoon from Fish and Wildlife. And there is a water column profile data from various years.

A. There's one for April 14 and March 9 there.

Q. Does that have any effect on your stratification theory?

A. No, the lake is not stratified at this time of year.

Q. Why don't you look through the rest of that and see if there are -- What months are you wanting to look at?

A. July and August. As I recall, that was sporadic, of such a nature that it was not very useful to me. I just had to, I said, looking at the lake, the elevation, the climate of the region, made my own summary analysis.

Even here, even if you do a one-shot deal, it's not -- you don't know whether the day before a violent windstorm would turn that lake over and oxygenate it. It would be lethal the day before and look fine the next day. You have to have a long-term systematic monitoring program to make a good interpretation.

Q. So, basically, you base your theory of stratification on the observations in Fish and Wildlife narratives on the theory of hydrogen sulfide as water is released?

A. Yes. And I see no way that a lake that has the characteristics of Acomita Lake, that morphometry, especially when there's not a high flow-through of water, that's not going to stratify in the summer months. In the summer months it will stratify, almost certainly, unless it is a shallow, saucer-like lake with good flow-through.

Q. Doesn't the Fish and Wildlife Service in a lake like that have a regular turnover in the water by having planned releases and new in-flows?

A. I think that was the point I made in the report. This is a part of what I've been talking about, my

integration of a recreation program with an agriculture program.

It looks like in the past they would -- without planning, they would often make those releases just at the right time to flush the, I say, the foul water out of the lake and refill it with a better water quality water, at least, much less organic matter had been built up in the lake.

I said why not have a monitoring program set up if you want a fishery. It was like a time-bomb effect that could cause a fish kill. That when certain combination of temperatures and oxygen -- you'd open the gate and let the water out and refill it.

So there's a possibility of working a management plan of a fishery to integrate it with an agriculture plan to meet your water demand at the right time that would optimize your fishery benefits.

Q. In your opinion, there was not such a well-integrated management plan at Lake Acomita?

A. No, my impression was that the lake was managed for agriculture, it was irrigation water. I don't know how frequent this was done during the summer months of the irrigation season, but probably frequent enough that it avoided a massive fish kill.

Q. But that was just by chance?

A. It was by chance, but it was probably on a weekly -- or just about the time enough, say, the oxygen problem would come to where you might cause a fish kill, out would go the water, and it was avoided.

Q. But you don't know of any -- you were provided no records of releases, were you?

A. No, I don't think anybody really has those records.

Q. So how do you know it was on a weekly basis?

A. It probably varied from month to month, year to year.

Q. And you didn't do that?

A. I don't know. It could be done. Maybe the Laguna downstream -- pueblo -- somebody could call up and somebody would open the gate. I'm sure no record was kept. You'd have to talk to the people who worked the gates.

Q. So it's your impression, again, from reading what was provided to you, that Lake Acomita wasn't really managed as a fishery anyway?

A. No, it's an irrigation reservoir, and that happened to provide an excellent fishery in the early years.

Q. And for it to continue to be an excellent fishery, it would have to be managed on some other basis than as an irrigation lake, wouldn't it?

A. No, it could be certainly managed as an

irrigation lake. It just is what I call a water budget would have to be developed. You'd have to plan ahead your demands on the water, the in-flow and out-flow characteristics to optimize the fishery values.

Q. Okay. So in order to maintain those early years of excellent fishery, they would have had to have had a well-integrated system of managing that lake for both irrigation and fishery purposes?

A. Well, during the early years, at least, the lake had the overall environmental quality that must have been such so that it tolerated some wide fluctuation. There was no fish kill and the fish were doing very well, the survival and growth was excellent, according to the old reports. So things were working out very well, even though it wasn't planned that way, you might say. Fishery was really sort of an afterthought of making -- the reservoir was not made to be a fishery.

Q. Okay. So basically you don't have any data about what they did with those lakes in the early years, except from the Fish and Wildlife. You don't have any data on how they managed the releases for irrigation purposes; is that right?

A. No.

Q. Now, your figure 1 to your report on the stratification is merely a paradigm, correct?

A. Yes. This was taken from a variety of sources. And so it's a paradigm of about what you'll expect.

Q. So it's not an accurate picture of Lake Acomita, is it?

A. Probably that was -- had Lake Acomita in mind when I put it together, so I suspect it wasn't quite too different from how Acomita operated, how it functioned, how it looked in an oxygen profile, temperature profile, at least during the stressful times.

Q. But you had no data?

A. No. For example, I have all the organic sediment -- I think I brought this out at the September deposition -- I had no -- I called it organic sediment, but it may be mainly inorganic, but that is a minor point, because there would certainly be enough organic matter in there to release nutrients.

But the point was that the lake had lost a lot of its volume over the years and it reduces the area, I say, the volume of the anaerobic conditions. The larger it is, the longer it will take to ruin your fishery.

Q. So another contributing factor here was how the volume in the lake was managed?

A. Well, it's not management of the volume. The volume is the result of the filling of the reservoir with inorganic and organic sediment. That's where the volume is

lost.

Q. It's not uncommon for fish kills to occur immediately after stocking, is it?

A. No, especially if you transfer the fish from a hatchery into waters, like, with high pH, high zinc levels, or something like that, that they need a time, acclimation time. If you put them into very different water, it can cause fairly high mortalities.

Q. Okay. So did you do any comparison between stocking times, fish kills, and hydrogen sulfide?

A. No, it's very difficult to find much about fish kills. It would be just random comments in those old reports. About so-and-so would find some dead fish.

It seemed to increase in recent years, and then even comments of catfish dying. And, there again, they thought the only condition they found was aramonus bacteria. As I said, conditions had obviously deteriorated over the years, because the fish they were stocking were not doing as well as they had in the previous years. They were not growing and surviving as well after two, three, four years after stocking.

Obviously, that's just circumstantial evidence. I wouldn't argue with it. They wouldn't have continued to stock the small fingerling-sized trout they were getting by with.

Q. When you say two, three, or four years after stocking, you're basing that on --

A. The creel, c-r-e-e-l, census sampling size. In the early years, you'll notice 24, 25 inches. You could follow a stocking over the next following year, the year after, and then the 24-, 25-inch fish would be about three years, four years after the initial stocking of those fish. That wasn't occurring in later years.

Q. Did you actually see the creel census reports?

A. Only what's in the -- I think what you have.

Q. Within the exhibits that you --

A. Right.

Q. Wouldn't increased fishing pressure have something to do with the size of the fish being caught?

A. It would, except fishing pressure decreased over those years.

Q. And that's according to?

A. According to their use estimates, their number of permit sales. And I also had some personal communication on this from Terry Merkel, who was the biologist in charge there before Frank Halfmoon.

Q. And what did Terry say?

A. Well, I also sent him a copy of the report. He agreed with it, and said, yes, that obviously they didn't have -- they didn't have the long-term monitoring data on

water quality, but it was obvious they could not get the -- over the years, the fishery kept declining. They could not get the survival and growth of the young trout, and it got to be a put-and-take stocking of catchable trout. And it became very expensive, and then we went to catfish.

Q. And when did he say they went to put-and-take?

A. It may have been after he left, but it was, like, in the early to mid-70s, I believe. About '75, '76, in there. I'm not sure.

Q. And you base that purely on what Mr. Merkel said?

A. Well, it's reflected in the creel census data and any other kind of comments you find in the Fish and Wildlife Service reports.

Q. What was the stocking rate at Lake Acomita?

A. I don't know. It varied quite a bit. And, again, in those reports you have there, it was several years ago when I saw them, but it depended on the size of the fish. If the fish was smaller, they would stock more of them. Probably depended on the availability of the Fish and Wildlife Service, the federal hatcheries where they got them, the fishing pressure. The higher the fishing pressure, the more fish they would put in. But I don't think there's no standard policy or even standardization of stocking in that lake.

Q. Is that reasonable in managing a fishery in a lake like Lake Acomita?

A. Yes, it's a -- you might say a state-of-the-art-type situation where you just get an experienced biologist like Frank Halfmoon, Terry Merkel, Jack Dean before him, knowing those people, they had a lot of experience and they just sort of -- rule of thumb, they knew what to do. So the stocking was probably reasonable as far as the results they got.

Q. What do you mean by as far as the results they got?

A. Well, they could modify over the years. So they would stock -- in the early years stock in fingerling fish, and I would say 2-, 3-, 4-inch size, young fish. They would survive and grow very well. And they provided a very good fishery. And it was a cost-effective fishery, based on how many pounds you put in and how many pounds are caught out.

But over the years, assumed the water quality changed, they could not get those kind of results. So they started stocking larger and larger trout, trying different species of trout to try to overcome it.

And, I said, this is just a typical way a fishery would be managed by an experienced biologist. He doesn't have factual data. He's going on experience from

other situations. And, I said, I could find no fault, really, with the management -- the way Acomita Lake was managed or its stocking.

Q. So you could find no fault with either the management or the stocking; is that what you're saying?

A. Yes, I think the Fish and Wildlife Service biologist are doing the best job they could with the time they had to devote to that. They had a large area, many lakes. But they had a lot of experience. I'd say, overall, they were doing a good job. I think the water quality problem got beyond their control.

Q. Okay. And you attribute the water quality problem entirely to the Grants Sewage Treatment Plant?

A. I wouldn't say entirely. I would say maybe the straw that breaks the camel's back here. Grants, particularly in the summer months, outside of a flash flood or heavy rainstorm, the entire flow is coming from the Grants Sewage Treatment Plant.

And this is where the most sensitive time for the fish in the lake are, during the summer, where you're going to have your problem.

So, I said, I don't know exactly what percentage of the nutrient loading that was responsible for the eutrophication, for the anaerobic conditions in the lake, came from Grants. But even if it was only 10 percent, it

would have been too much. Maybe 10 percent reduction could have allowed that fishery to continue in excellent condition.

Q. So you're saying that without the Grants Sewage Treatment Plant, with just the nutrient loading from natural sources, there would have been no problem whatsoever with Lake Acomita?

A. There's always going to be a potential problem with a lake. Something can always happen. So I would never say there would be no problem, except the early years of that lake, it was an excellent trout fishery, based on the survival and growth of the small trout stock.

Q. And you're assuming that the sewage got to Lake Acomita when?

A. I don't know. You'd have to go and review the whole chronology of the events again. But I think it was -- I don't know when that sewage treatment plant came on-line. I forget now. It was in the 1960s or whenever.

Q. All right. And you're assuming that when it came on-line, the effluent from the sewage treatment plant always reached Horace Springs?

A. Not always. I don't know what the population of Grants was, what the volume was of the plant on a daily, monthly, annual basis, how it fluctuated, what their chlorination schedule was. Perhaps the plant worked better in former times, had a lighter load. There is no way I could

say what you're asking.

Q. Okay. But I'm trying to get down to you say in the early '60s it was an excellent fishery. When was it that, in your opinion, the Grants Sewage Treatment Plant broke the camel's back?

A. I don't know. All I can say is that, according to the Fish and Wildlife Service reports and their personal communication, it was, like, in the mid-to-late 1970s they were no longer getting the results they got, that they had back, I guess, starting in the 1950s or whenever they started their stocking program. So that was the time period.

And it looked like it was not a sudden event. In other words, you could point your finger and say, "On April 1, 1960, was the start." It was a cumulative, gradual impact that over the years it was being impacted to a point where it reached -- the point where it was no longer an excellent trout fishery. It was no longer a good cost benefit trout fishery.

Q. That's based on accumulations?

A. Based on accumulations over the year.

Q. Of what?

A. The water quality deterioration was not a sudden, dramatic event. The water quality -- the water going into that lake was probably increasingly impacted by the

Grants Sewage Treatment Plant in later years.

Q. For that to have occurred, would there have had to have been perennial flows from the Grants Sewage Treatment Plant to Horace Springs beginning in the 1960s?

A. No.

Q. The early 1960s?

A. No. We went along the river below the sewage treatment plant to Horace Springs. And there was a tremendous deposition of sewage sludge or organic matter along the Rio San Jose. And you could see, like, a flash flood could dislodge it and put it into, might say, suspension, transport it, during these periods. So even without continual flow, the products, detrimental products, were building up in the stream bed waiting for this transport during the periods of high flow.

Q. Now, are you of the opinion that the sediments that you saw that day were all from the sewage treatment plant?

A. Yes, I think -- I don't think all of it. But it was very, very obvious that along the Rio San Jose, the beds of organic black muck along the banks and bottom is not characteristic of arid land streams that have very little plant material in the watershed. So it's just a typical situation. Where you see high organic content, like in Rio San Jose, it's almost got to be of human-induced effluent,

sewage plants.

Q. And you're speaking of the whole stretch?

A. From the STP down to Horace Springs.

Q. All right. Do you know of any data about the content of that sediment?

A. No, just what I personally saw. And it was beds of black organic muck.

Q. Did you see how deep they were? Did you test them?

A. Poked a stick in them, and there were some quite large -- considering the size of that stream, there were some large deposits of organic matter.

Q. If there were no input from the Grants Sewage Treatment Plant and you just had natural contribution from sediments and nutrients from the watershed and from the Rio San Jose, irrigation return flows, without the Grants Sewage Treatment Plant, would the people who managed a fishery in Acomita Lake have to regularly change the water in the lake by opening it up for out-flow and bringing in in-flow?

A. I can't say that, because if it was a lake that was managed strictly for the fisheries, you could probably get almost enough water, you know, to fill the lake from the watershed runoff down the arroyo, and you wouldn't have to depend on bringing the Rio San Jose water in, except just occasionally. Under these conditions I would see no

problem whatsoever to maintain a high water quality for trout fishery.

Q. Are there any lakes on other reservations in New Mexico, to your knowledge, that stopped being what you would call a good trout fishery that don't receive waste discharges?

A. Well, one, I think, Stone Lake on the Jicarilla Reservation seems to be a good trout fishery because carp got in there. I also think the water level dropped. Perhaps it depended on the surface runoff from surrounding areas, and, during years of low precipitation, the lake level would drop. This is natural. But I think the main impact on Stone Lake was the introduction of carp.

Q. Did Stone Lake have any rooted vegetation problems?

A. Yes, as I recall, there was a lot of vegetation there.

Q. What were the carp introduced for?

A. I wouldn't know. I couldn't see anybody deliberately introducing them. I suspect they may have been stocked years ago as a food fish.

Q. Okay. What was the source of the rooted vegetation problems in Stone Lake?

A. Well, I say, Stone Lake was a dead-end lake, so all the nutrients going in -- so there was no flow-

through. I can't recall any values. I don't know if I've ever seen them, but it was obviously -- was a eutrophic lake, it was a rich lake. It also had an excellent trout fishery, very big, fast-growing trout.

Q. What were the DO levels like in Stone Lake?

A. I don't know.

Q. Any other lakes in New Mexico that you're familiar with on Indian reservations?

A. No. If you could name a few.

Q. Well, you mentioned Dulce.

A. That's a very small lake. Again, I think a rich lake, had good vegetation and grew good trout.

Q. Did it have any problems?

A. I think it had problems, perhaps again with water. The Jicarilla Reservation is almost in a desert-like area, and I guess it was just the years above normal precipitation to get trout fishery. Other years it would get too warm.

Q. What was the source of the richness of the lake?

A. Again, like Stone Lake, it was a desiccating lake where there was no flow-through. There was a lot of nutrients brought in which would stay there.

Q. What was the DO level in the Dulce Lake?

A. I don't know.

Q. Are those the only two lakes on reservations in New Mexico you're familiar with?

A. Again, it was like 15 years ago or more since I've been on some of the reservations there. If you could name a few, I might recall.

Q. Did Dulce have a problem with rooted vegetation?

A. Yes, there was vegetation in Dulce Lake.

Q. Were any herbicides or poisons added to Lake Acomita?

A. I don't know. If they got in the water on the Rio San Jose, if they were in the water when the lake was transferred to Lake Acomita, they should be in Lake Acomita. But I don't believe -- seeing any references or mentions of that in the old reports.

Q. Okay. What's the use of toxaphene in lake fishery?

A. In a lake reclamation project, you want to eradicate all the fish in a lake, you apply toxaphene. I believe rotenone is the chemical agent that kills the fish. And then you restock the fish. Say, if you want to get rid of the carp in Stone Lake, you apply toxaphene.

Q. Where in the lake would the toxaphene reside?

A. Usually it breaks down in about 30 days. In recent years usually a chemical called antimycin is used,

which breaks down in about 24 hours.

Q. What do you mean by "it breaks down"?

A. It becomes nonlethal. toxaphene, if it has a rotenone base, would be essentially lethal for about 30 days. If the lake was not flushed out, it would be toxic to fish for, say, 30 days, usually.

Q. At what point is it toxic to fish?

A. What do you mean "point"?

Q. What levels.

A. Usually the recommended dose is -- it's according to what percent toxaphene you have, but use of rotenone as the active agent, about -- well, some say 5 percent or one-half of 1 percent, .5 percent.

Q. How many parts per whatever?

A. Like 5 parts per million, I think, of rotenone would be lethal. 5 parts per million rotenone is usually the recommended dosage.

Q. Does rotenone sorb on to any organic particles?

A. Probably does. It's an organic compound. But I couldn't tell you the chemistry of it.

Q. If it does sorb on to organic particles, would catfish consuming those organic particles also ingest it?

A. I've never heard of a fish toxin getting back in the food chain and causing a problem like that. In fact,

the lethal characteristics of it is it constricts the gill filaments and it affects respiration. Taken internally, I don't think it's that's lethal.

Q. Do you know of any other toxicants that are added to get rid of unwanted fish?

A. Yes, usually the two major ones are rotenone, which also is some of the toxaphene, and the major one used now is called antimycin, a-n-t-i-m-y-c-i-n, because it becomes nontoxic much more rapidly.

Q. Does that also affect gills, or does it work internally?

A. Yes, it's essentially the same. It suppresses respiration.

Q. By affecting the gills?

A. Right.

Q. So you don't know if it is getting back into the food chain in any way?

A. No. I said I doubt -- they're not very toxic if taken internally. I've never heard of any secondary or recycling type of problem with fish toxicants through the food chain.

Q. Okay. How about chemicals added to get rid of weeds, rooted vegetation?

A. Often they're copper based, and copper can be quite lethal, toxic to fish. Copper sulfate is probably the

most common or cheap weed-control agent.

Q. Okay. If it is added, at what levels does it become lethal to fish?

A. I'm not sure. I believe the EPA standards of copper are very low, either like 1 part per million or 10 parts per billion. It's very toxic, at least in its ionic form, is very toxic to fish.

Q. Chemically, what happens to it in the lake?

A. That can be in your bottom for many years, and it can be incorporated into food chains.

Q. What do you mean by "for many years"?

A. Well, if it's bound in the bottom sediment, and you keep getting sedimentation on the lake, you'll have -- say you make a core sample that's a foot below the surface, you might, say, find copper down there that came in 20 or 30 years ago perhaps.

Q. How can it be incorporated into the food chain?

A. Well, first to primary production of plant material, if the plants -- if copper is a trace element that's used, when you add it like that as a surplus, the copper in the plants can be transferred to insects, to vertebrates, and then into fish.

I'm not familiar with a problem of that, because usually a copper kills if it's in that kind of

concentration. The effect is very sudden and dramatic. You get a fish kill right away.

Q. I take it from your previous testimony that you did no analysis of data from the Fish and Wildlife Service on Lake Acomita to determine what toxicants were added to that lake and what their effect was?

A. They had a weed problem there, and I know they put stocked crayfish in the lake to eat the weeds. Before and after that, they may have used copper sulfate solution to try to control the weeds around the shoreline area. I wasn't familiar with that. I don't recall reading anything in the reports that this was done.

Q. Okay. Does concentration of copper in organic tissues increase as it goes up the food chain?

A. I'm not sure if copper is a biomagnifier or not. Most heavy metals are not. Some certainly are.

It's according to if it's stored in the fatty tissue, then it accumulates and is passed on. Usually the main problem I'm familiar with in, like, a trout fishery, is the fish accumulates it over his life. So the longer the life of the fish is, the accumulation builds up. And it can reach lethal levels or chronic levels where their growth is impaired.

So most of what I'm familiar with is copper, zinc, cadmium, these kind of heavy metals in the liver and

kidneys, over a period of time. It's directly -- the fish are getting it directly in the water and not through the food chain.

Q. Are trout more sensitive to copper than catfish?

A. As is a general rule, trout are more sensitive than catfish, especially -- but not to all -- this is a thing I would call an expert and ask his advice.

But, as a general rule, trout are more sensitive, but I believe catfish are more sensitive to things like chlorine or some of the products like chlorimines. It's difficult to make a flat statement, except that, in general, trout are more sensitive to toxicants than catfish, but not to all.

Q. So for catfish, you said chlorine?

A. Yeah, I believe there was a recent paper I remember reading that actually catfish were killed before rainbow trout with some of the by-products of chlorine.

Q. Anything else that catfish are more sensitive to?

A. I'm sure there is, but I'm not a, you know, toxicologist specialist. I would get on the phone and call someone if you really wanted to know.

Q. Okay. With a stocking program, what are the considerations that you have to take into account in

devising, setting up a stocking program?

A. Well, mainly you want to maximize your value. You know, how many fish are stocked versus how many come back to the fishery, especially in pounds. It's like a business. You want to invest your money to guess the highest -- maximize your return.

Q. In other words, pounds put in yielding pounds put out?

A. Right. In small fingerling, to stock you can get 50. With a catchable trout stock, called a put-and-take fishery, you're getting about -- for every 10 pound you put in, you might get 7 or 8 pounds back, so it's a losing proposition.

Q. Any other considerations?

A. Well, the size of the fish. As I said when I was talking about the high value fishery, I thought was big fish, and have the fish grow to a large size in a relatively short time.

Q. So that means you're taking into consideration what?

A. Well, the food supply in the lake, the length of the growing season. I said, Acomita Lake did produce very rapidly growing trout, about an inch a month they were growing.

Q. So far, from what I can tell, you've named

three considerations. The yield of pound taken out from the pound put in?

A. Right.

Q. The food supply and the length of the growing season.

A. Yeah, that relates to essentially the survival and growth of the fish.

Q. Any other considerations?

A. I said, this high value fishery I had in mind, we want big fish. And also I would prefer a more elitist fish, instead of a common rainbow trout or common brown fish. We would use, like, cutthroat trout like the Pyramid Lake cutthroat trout. It would be a much more unique fishery to allow fishing for native cutthroat trout, especially of large size. Would probably be the only large fishery in New Mexico, at least readily available.

Q. For this more attractive kind of fish, what do you need?

A. What do you need to make it attractive?

Q. Yeah, what has to be different?

A. Well, it looks different. And also you'd need the proper publicity. So the media on television programs, in newspapers, to let people know that Acomita Lake has a fishery for native cutthroat trout, and explain why this is so very special.

Q. But I mean in food supply, type habitat.

A. Not very many. Any water that grows trout, you could grow cutthroat trout in, if you didn't have the other trout.

Q. So you're just speaking of assuming that the water quality were improved -- that is, not turbid, doesn't stink -- and the habitat in the Rio San Jose is good, as you say, then all you'd need to do is just not put in rainbow and not put in brown?

A. Right. Since they're not there now, they wouldn't get there unless they are stocked, so just don't stock them. We would stock the native cutthroat trout.

Q. And their needs as to temperature are no different?

A. A little more sensitive, but, I said, so long as there are no other trout there, they can do quite well. But, I said, they are not as hardy a fish as brown or rainbow trout. They are more sensitive. So you would need better water quality for cutthroat native trout than you would for brown or rainbow trout.

Q. What kind of water quality do they need?

A. It's about the same stipulations you have if you want to -- have oxygen or temperature for brown and rainbow would probably be about the same, except that it's a subtle difference. In other words, it's a long-term chronic

condition. They probably have exactly the same short-term, acute, lethal limits of the oxygen, temperature, and things like that. But they just don't do well in competition with brown trout and rainbow trout in most streams today. But I suspect there's very little differences. As long as you had only Rio Grande cutthroat. If brown and rainbow trout could live there.

Q. Why can you not have rainbow and brown with cutthroat?

A. I think it's just the evidence we have that the Rio Grande cutthroat trout once lived all over the drainage from the Rocky Mountains to Albuquerque, all the tributaries, including the Rio San Jose. And the brown trout and rainbow were stocked, and the cutthroat disappeared.

So the empirical evidence is that it doesn't work. You just don't.

Q. Why, though?

A. You cannot -- There's no quantified way to say it. With rainbow trout, they hybridize. You can't maintain them with rainbows because of the hybridization.

Brown trout have an advantage, probably, in warmer water, more turbid water. Brown trouts' vision is more highly adapted to see in dimmer light. Perhaps as streams became more impacted with sediment, more turbidity, you favor brown trout over the cutthroat trout. There's no

way to document that in a quantified experimental basis.

Q. Well, brown and rainbow are not predators of Rio Grande cutthroat?

A. They could be, but the predation is not a major problem. I said, another thing the Rio San Jose has is a Rio Grande sucker that is now extinct in Colorado. And it's been replaced by a nonnative sucker, the white sucker. And suckers are not predatious fish. And exactly why the white sucker replaces the Rio Grande sucker, we don't know, except that the competition for a life history stage for a common habitat. But the Rio Grande sucker does not get along with the white sucker.

Also, in New Mexico, this effect is going to be seen. And, I said, the Rio San Jose may become a refuge area for Rio Grande sucker, because it's one of the few waters that lacks the white sucker.

Q. What management expertise would be needed to maintain --

A. Anyone that would know enough not to stock rainbow trout or brown trout with them.

Q. Anything else?

A. The amount of sophistication is that -- I said, if you handle a trout fishery like Acomita Lake, that you could put baby rainbow trout and have them grow and survive like they did in the early years, you could do the

same with Rio Grande cutthroat trout.

Q. And you are advocating putting Rio Grande cutthroat trout in both Rio San Jose and Lake Acomita?

A. Yes. If the Rio San Jose could be cleaned enough to have natural reproduction, then I would definitely urge the tribe to try to restore the original cutthroat trout. Many of the Indian tribes are doing this now, trying to restore their native fish and fawna.

Q. And by cleaning it up enough to support natural reproduction in the Rio San Jose, are you saying getting rid of sediments?

A. You'd have to greatly reduce sediment loads, particularly the organic sediment which would be lethal to eggs buried in the gravel.

Q. From whatever source?

A. Whatever source.

Q. And as for Lake Acomita?

A. Lake Acomita could be managed anyway, because you're not going to expect trout to spawn there. They don't spawn in that lake. And the question of -- Well, if you put rainbow trout in the lake, could they get back out into the river. Say, if you had managed the river for a native cutthroat trout initially, the question would be could the rainbow get from the lake to the river. If they could, we would manage the lake as a cutthroat trout fishery.

Q. Did you have any conversations with Frank Halfmoon about the role of the Acoma Pueblo members themselves in the operation of Lake Acomita as a fishery?

A. No. I may have suggested to him or someone I talked with one time that ultimately the tribe should have its own resident biologist or recreational manager who has been trained through a course at the university here, majored in fish and wildlife management or something like that, so they could have a resident manager on hand, keep some kind of continuity going in a program.

Q. Okay. Did he ever complain to you about the Acomas as managers of the fishery in Lake Acomita?

A. No, I never heard no comments about their role in the fishery. As far as I know, it was just supplied by the Fish and Wildlife Service. And I guess -- I think the tribal members maybe did creel census work, and that was about all.

Q. That's your understanding of their role?

A. Yeah.

Q. All right. Halfmoon states in his 1984 report, which you received a copy of after you did your report, that annual plants of catchable trouts varied from 24,000 to 74,000 a year since 1969.

A. Did he say "catchable"? That means about 8 inches or more in size.

Q. He said "catchable." Now, what is that -- What are those numbers on a per-surface-acre basis?

A. I think the reservoir is about 730 surface acres, so maybe up to a thousand per acre, perhaps.

Q. That's at the 74,000 level?

A. Yeah.

Q. What would it be at the 24,000 level?

A. Well, about 300, 250. Yeah, about 300 eggs.

Q. Is this a normal rate of trout stocking?

A. It's very heavy. I think that's probably due to the use demand from being near Albuquerque.

Q. Okay. What's the normal stocking rate in fish per acre per year of channel catfish?

A. That would vary enormously. Like in Acomita Lake, where it would be stocked to maintain a fishery like in July and August, two or three summer months when the trout weren't biting, you might say, it would be like a rule-of-thumb situation. Evidently, the experienced biologist would estimate how many they'd need, how many people come through to fish, how many catfish to supply them with. You might look at one per day or two per day or something like that. You have -- If they estimated 5,000 people would come in July and August, you might submit 5,000 catfish.

Q. So you don't do it on a fish per acre per year basis?

A. No, in these kind of stockings, you're talking about catchable-sized fish, they're not stocked, really, to grow and survive in the lake. It's a put-and-take fishery to maintain an immediate demand. So the normal lake biology situation just doesn't apply.

Q. Is that true for rainbow trout?

A. Catchable trout it is. I said, in the early days when they were stocking fingerling fish, then they were taking advantage of the water quality conditions, the food supplied to produce a cost-effective fishery.

When you go over to the catchable fishery, there's no way you're going to get more pounds out than you put in. It's an expensive operation to maintain.

Q. What about when you put in fingerlings?

A. Fingerlings are usually stocked at the rate of, again, according to the richness of the water. Anywhere, I'd say, from 200 to a thousand fingerlings per acre.

Q. Per year?

A. Per year.

Q. And that's both rainbow and brown?

A. Yes. Usually that would be totally, even if you use more than one species in combination.

Q. How about with cutthroat?

A. If I was managing it for trophy-sized fish, I would reduce the stocking rate to maybe a hundred per year

per acre to try to maximize growth.

Q. But, otherwise, if you weren't trying to maximize growth, you would use the same rate?

A. Yeah. Really, the trout species are pretty much interchangeable for these purposes.

Q. And this is all -- the rainbow, brown, and cutthroat -- those fish per acre per year figures I gave were for fingerlings?

A. That's a fingerling, yeah. You'd only use the higher level if you had excellent growth conditions, and also heavy fishing pressure, because we assume a lot of those are going to be caught within a year.

Q. What consideration, if any, should be given to the carrying capacity of Lake Acomita for a put-and-take fishery?

A. Put-and-take fishery, you could use a bathtub. It's just put-and-take, catch, fishery has no relevance or bearing on the -- As long as they can live in the water, the temperature, oxygen conditions, they can live in it. They're not going to be there that long to enter into the ecosystem. Simply, you could do it by putting up a swimming pool and putting them in and let the fishermen come and take them out.

Q. But you do consider carrying capacity?

A. Yes. You have to consider the carrying capacity.

Q. Now, how does that -- how do you define "carrying capacity"?

A. I'd say the potential of the body of water -- What's the maximum amount of biomass of that species that could support at any given time of the year? It would vary, but it would be at the maximum level of the carrying capacity.

Q. Can you determine that for Lake Acomita for trout?

A. No. But in the past I would suspect there would probably be at least a hundred pound per surface acre. I know a similar lake in Arizona called Becker Lake had maintained about 300 pound per acre of trout, stocking small fingerling trout, letting them grow in the lake. They reached almost 300 pounds per acre, which we might call carrying capacity.

Q. Okay. In table 4 in Halfmoon's 1984 report, he shows that an average of 11,450 fishermen -- fish were caught per year from 1964 to 1982. That's about 163 fish per acre per year.

A. What was the average size of the fish?

Q. Let's see.

A. Let's say a half a pound. Probably about 10, 11 inches, I would suspect, average. So they were catching maybe 80 pound per acre, which, if, indeed, these were from

fingerling plants, that would suggest a carrying capacity of over a hundred pounds per acre.

Q. Okay. But is the catch rate of 163 fish per acre per year higher or lower than that experienced elsewhere?

A. That's a very high rate. But, I said, I couldn't tell -- How many was that? If they're all from fingerling plants or how many came from catchable plants. But, in any event, it would be a good fishery.

Q. Catchable.

A. If they're catchable. That really doesn't tell anything about carrying capacity. You could have that catch rate at 10,000 an acre, just keep dumping them in and people keep lining up and pulling them out.

Q. But isn't it still from 1969 to 1982 a very high catch rate?

A. I would say from talking about average fishing waters, you know, public water, that's a good catch rate. But, I said, it has really no meaning if it's based on catchable trout. Doesn't tell you anything about the quality of the environment to grow trout or carrying capacity.

Q. The report that you did on fisheries at the Pueblo of Acoma in 1983, do you consider that to be of publishable quality?

A. No. That was just -- there was nothing -- if

you were to publish it, you would have to have something new or original. This is a synthesis of a review of known information. If I discovered a new species there or something like that that's noteworthy, then it too would be publishable.

Q. Wouldn't you also have to have some data?

A. Yes, this is a typical consulting-type report.

MS. WATSON: I've got no further questions.

MR. JOHNSON: Let's see how short I can make mine.

EXAMINATION

BY MR. JOHNSON:

Q. When Miss Watson called you to discuss your deposition, did she discuss with you documents that she was requesting that you bring?

A. No, I don't believe she mentioned any documents.

Q. Did she discuss general categories of documents?

A. Who is Miss Watson? Is that your secretary?

MS. WATSON: It's me.

A. Oh, I was thinking of your secretary.

Q. (By Mr. Johnson) No.

A. What I have here is what came to mind from

what you suggested. So I don't think -- you didn't specify the things I don't have here. If you had asked for them, I would have had them.

Q. So these that you did produce were pursuant to her discussion of what she expected?

A. Yes, from what my impression was.

MS. WATSON: Assuming I discussed with him everything I expected. However, I was dealing with your expert witness.

A. It wasn't a great conversation we had. It was about two minutes or so.

Q. (By Mr. Johnson) In talking about the stream that -- the portions of the stream that Frank Halfmoon surveyed and sampled, we saw that he surveyed about 5 percent of the stream.

Do you know in what specific reaches of the stream his sampling was conducted?

A. He took me there where -- like most of the trout that we covered and I think the stocking site and then he pointed out some of the other downstream areas.

Q. Do you know if that was concentrated in the region above McCarty's?

A. I think it was all in the region above McCarty's.

Q. What is the comparative distance of the region

above McCarty's compared with the regions that he sampled? Would it be significantly more than the 5 percent of the 13 miles of the stream?

A. Where does McCarty's come into the 13 miles? I think everything was above McCarty's, the place that was stocked. He may have done some sampling below McCarty's, but, as I recall, the recovery of those trout a year later were almost all concentrated in the upper two sections. I think he had eight or ten sampling stations, but the place where he found the trout was just below where they were stocked.

Q. Then would the validity of the samplings depend on the percentage of that stream segment above McCarty's that was actually sampled, as well as the percentage of the entire stream length?

A. I guess you would make it a little more effective, you might say, as far as the validity goes. There's no doubt in my mind that there had not been great survival of that trout in that stream. I was surprised that any had survived over a year, but some had.

Q. When you observed the fishery, pretty much was your study of the stream concentrated between the sewage treatment plant and McCarty's also?

A. One day we toured the stream from the sewage treatment plant down to Horace Springs. And then I think

another day it was from Horace Springs through the reservation down to McCarty's.

Q. Did you observe the depth and the cover and the flow in those regions as you walked that stretch of the stream?

A. Just as qualitative impressions in my mind, much like an angler would. I said, this is a physical habitat and the stream was good as far as the gradient, the depths, the pool, and the riffles that cover, especially the in-stream vegetation, usually a mark of excellent trout. If you have macrophyte vegetations in a river, typically you have an excellent habitat.

Q. Okay. When you walked along the stretch of the Rio San Jose above Horace Springs and below the sewage treatment plant, did you notice if there was any other course -- or any other source that could have caused that grayish-green turbidity in the water?

A. There's no other in-flow into the -- into the San Jose, but the big spring, the Ojo del Gallo, had not started running again. It had been dry for some years. So I think until you got to Horace Spring there was no in-flow into the creek.

Q. So even though livestock grazing or sediment in-flow or all those other things may cause turbidity, you did not observe any of that to be the cause of the turbidity

that you observed in the water?

A. The turbidity we saw that day was obviously because the sewage treatment plant had malfunctioned the previous day and had bypassed a whole set of untreated effluence, and that's what we were looking at downstream from the plant.

Q. Okay.

MR. JOHNSON: I don't have any other questions.

MS. WATSON: I have no others. I will just write you a letter about those three items.

THE WITNESS: Okay.

MS. WATSON: I think there were three, maybe four. I think there were three categories. And you can just send copies.

THE REPORTER: Do you want a copy?

MR. JOHNSON: Yes.

(The deposition was concluded at 2:15 p.m.)

CERTIFICATE OF WITNESS

STATE OF COLORADO)
) ss.
COUNTY _____)

I, ROBERT J. BEHNKE, the witness in the above deposition, do hereby acknowledge that I have read the foregoing transcript of my testimony, and state under oath that it, together with any attached amendment to the deposition, constitutes my sworn testimony.

I ( ) have ( ) have not made corrections on the attached amendment to the deposition form.

_____
ROBERT J. BEHNKE

SUBSCRIBED AND SWORN to before me this _____ day of _____, 1986.

My commission expires _____

_____
Notary Public, State of _____
Street Address _____
City and State _____

REPORTER'S CERTIFICATE

STATE OF COLORADO)
)ss.
CITY AND COUNTY OF DENVER)

I, BECKY S. JACKSON, a Court Reporter and Notary Public within and for the State of Colorado, duly commissioned to administer oaths, do hereby certify that, previous to the commencement of the examination, the witness was duly sworn by me to testify to the truth in relation to the matters in controversy between the said parties; that the said deposition was taken in stenotypy by me at the time and place aforesaid, and was thereafter reduced to typewritten form by me; that the foregoing is a true and correct transcript of my stenotype notes thereof;

That I am not attorney nor counsel, nor in any way connected with any attorney or counsel for any of the parties to said action, nor otherwise interested in the outcome of this action.

In witness whereof, I have affixed my signature and seal this 12th day of January, 1987.

My Commission expires September 21, 1987.

Becky S. Jackson

Becky S. Jackson, Notary Public
210 Clayton Street, Suite Three
Denver, Colorado 80206

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VALUE OF ALTERNATIVE FISHERY MANAGEMENT PRACTICES

Donn M. Johnson and Richard G. Walsh*

ABSTRACT

Understanding the value of alternative fishery management practices can help managers improve the effectiveness of programs. This paper provides preliminary results on the value of alternative practices to distinct user groups. We apply the contingent valuation method, recommended by the U.S. Water Resources Council, in a pilot study of recreation users of the cold water fishery in parks and forests of the Rocky Mountains, Colorado. Empirical willingness to pay functions are presented for the number and size of fish caught. These and related values are shown to vary by skill level of fishermen.

INTRODUCTION

That the quality of fishing contributes to the value of the recreation experience is well known. The pioneering economic work on the subject was by Stevens (1966). Managers increasingly face important problems of evaluating fishing opportunities in a way that will allow comparisons with their economic costs. The problem is especially acute at many parks and forest recreation sites, where it is not enough to know how many users value fishing. It is necessary to determine how much various user groups value specific levels of fishing quality in order to make managerial decisions relating values to costs of alternative fishery management practices.

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The contingent valuation method is by far the most important tool that we have to decide these questions. The approach was recently recommended as providing an acceptable measure of the economic value of recreation opportunities and resources. The U. S. Water Resources Council (1979 and 1983) authorized use of the contingent valuation method and established procedures for its application to recreation and environmental quality problems. In this approach, a sample of the affected population is asked to report their maximum willingness to pay, contingent on hypothetical changes in recreation opportunities or resources. The approach has been successfully applied to a number of recreation valuation problems since its initial proposal by Davis (1963).

The purpose of this study is to apply the contingent valuation method to measure the effect of fishing quality on willingness to pay for the experience. The primary objective is to develop empirical value functions for the number and size of fish caught. These and related values are shown to vary with the skill level of fishermen.

STUDY DESIGN

The basic data used in this pilot study were obtained from on-site interviews with a sample of 32 cold-water fishermen at rivers and lakes in the northern front range of the Rocky Mountains, Colorado. Interviews were conducted on random days throughout the summer of 1985. Interviewing was initiated at the beginning of the day with the first person encountered at the study sites. Subsequent interviews were conducted with persons randomly selected throughout the day. The interviewer was identified as an employee of the University to establish the legitimate scientific purpose of the study. Less than 5 percent of those approached refused to participate in the survey (thus response bias should be insignificant).

The value questions were designed to be as realistic and credible as possible. Respondents were first asked to report the direct costs of their current trip. Then, they were asked to estimate the maximum amount they would be willing to pay rather than forego the recreation experience. Direct trip costs represent a generally accepted method of paying for recreation trips. This relatively neutral measure of value was selected over alternatives such as an entrance fee or tax in an effort to avoid emotional reaction and protest against the method of valuing fishing quality. As a result, protest responses, which were removed from the analysis, represented less than 7.0 percent of the sample, well within the Council's standard of 15.0 percent.

An iterative bidding technique, recommended by the Council, was used to encourage fishermen to report maximum values, representing the point of indifference between having the amount of income reported or the specific change in quality of the resource. The respondents were asked to react to a series of dollar values posed by the interviewer. Respondents answered "yes" or "no" to whether they were willing to pay the stated amount of money to obtain the increment in recreation opportunity or resource. The interviewer increased the dollar value by random amounts until the highest amount the respondent was willing to pay was identified.

The Council recommends net willingness to pay (consumer surplus) as an acceptable economic measure of the benefits of public recreation programs. These net benefits are measured as the area below a demand curve and above direct cost or price. We asked fishermen to report their maximum willingness to pay for the current or marginal trip. The response represents a direct estimate of one point on a demand curve in which change in willingness to pay is related to the change in number of trips. Integrating under this marginal

benefit function provided an estimate of total benefit. Subtracting direct travel costs from total benefits and dividing by number of days resulted in consumer surplus of $12.20 per day, with average catch of 6.1 fish, 9.4 inches in length.

From this starting point, respondents then were asked to report changes in net willingness to pay contingent on changes in the quality of fishing. Values were obtained from each individual for several changes in the number and size of fish caught. These observations trace out the representative individual fisherman's marginal benefit function for quality of the resource.

PRELIMINARY RESULTS

Following the usual procedure in the study of recreation values, least-squares statistical methods were used to estimate the relationship between willingness to pay and fishing quality.

Number of Fish

$$WTP = \underset{}{0.193} + \underset{(0.293)}{0.989Q} + \underset{(0.073)}{0.0206Q^2} \qquad R^2 = 0.189$$

Size of Fish

$$WTP = \underset{}{-0.467} + \underset{(0.716)}{1.563S} + \underset{(0.298)}{0.460S^2} \qquad R^2 = 0.235$$

Where WTP = change in willingness to pay per day; Q = change in number of fish caught; and S = change in size of fish caught (length in inches). Standard errors are shown in parentheses below the coefficients.

The number of observations was sufficient for statistically significant analysis of the relationship between value and change in the number and size of fish caught. The coefficients of determination, R^2, adjusted for degrees of freedom, indicates that 19 to 24 percent of the variation in willingness to pay was explained by the number and size of fish caught. This is considered a

satisfactory level of explanation with data from a cross-sectional survey of individual consumers. The regression coefficients for the number and size of fish were significantly different from zero at the 0.05 level, as indicated by the standard errors for the linear terms in the equations. Alternative forms of the equations were evaluated including linear, quadratic, semi-, and double logarithmic models. The quadratic form seems to provide the best fit of the relationship; although the squared terms for the number and size of fish caught are not statistically significant.

Figures 1 and 2 illustrate the shape of these willingness to pay functions. Figure 1 shows that willingness to pay for fishing increased by more than $1 per additional fish caught. It decreased by slightly more than $1 with each fewer fish. Figure 2 shows that willingness to pay for fishing increased by nearly $2 with a 1-inch increase in the size of fish caught. Apparently, willingness to pay is an increasing function of fish size. With a 4-inch increase in size, willingness to pay rose by more than $3 per inch to about $25, or more than double the average willingness to pay of $12.20 for 9.4 inch trout. This approaches the maximum increase in size possible given the biological constraints of the study sites.

Table 1 illustrates how fishing value functions may shift with participant skill level -- low, medium, and high. This classification was based on reviews of preference data from several fishing studies (Bergersen, et al., 1982; and Driver, et al., 1984). They suggest that skill level may be a reasonable proxy for the type of fishing opportunities produced by fishery management programs. Respondent reported skill levels were adjusted by the interviewer after observing their fishing practices.

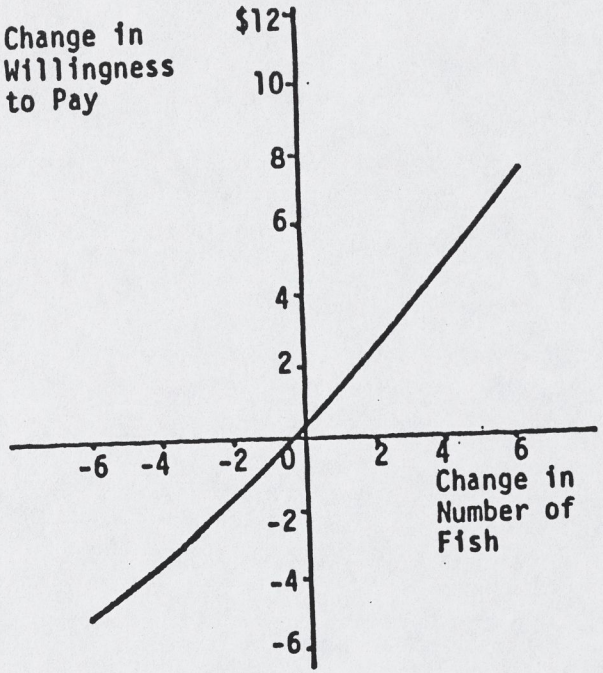

Figure 1. Effect of Change in the Number of Fish Caught on Willingness to Pay

Zero Point = 6.1 Fish
= $12.20 WTP

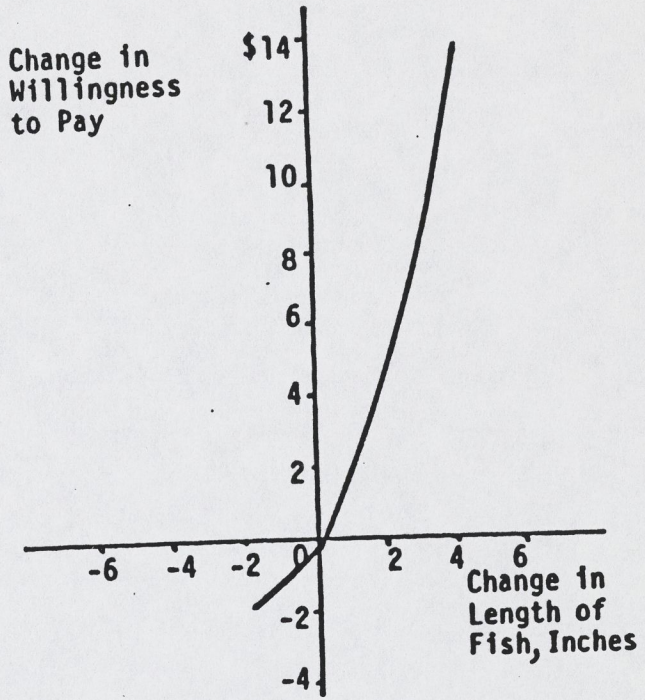

Figure 2. Effect of Change in the Size of Fish Caught on Willingness to Pay

Zero Point = 9.4 Inches
= $12.20 WTP

Table 1. Participant Skill Level and Fishing Values

Variable	Skill Level			
	Low	Medium	High	Total
Number of Cases	8	13	11	32
Annual days fished per year	15.50	18.15	34.27	23.03
Consumer surplus per day	$10.44	$10.78	$18.08	$12.20
Number of fish caught per day	1.88	4.85	10.64	6.09
Added days fished per added fish caught	0.54	0.70	0.28	0.48
Consumer surplus per added fish caught	$1.25	$1.40	$0.44	$0.93
Average size fish caught, inches in length	8.40	7.70	9.90	9.40
Added days fished per added inch	0.67	0.79	1.23	0.94
Consumer surplus per added inch	$1.25	$1.78	$2.02	$1.75
Added days with wild fish	0.25	0.69	1.55	0.88
Added consumer surplus per day with wild fish	$2.13	$2.62	$3.46	$2.78
Importance of method (1=Low, 5=High)	1.88	2.54	3.09	2.56
Percent of time:				
Bait fishing	42.50	47.54	15.91	35.41
Lure fishing	7.75	21.39	25.64	19.44
Fly fishing	49.75	31.46	58.46	45.32
Investment in equipment	$338.75	$440.00	$2219.09	$1026.25
Income	$37,500	$53,077	$26,364	$40,000

The relationships are suggestive of the possible true variation in values. Owing to the smallness of the pretest sample (32 cases), the differences in the cross-sectional mean values were in general not statistically significant. However, the results of this pilot study are suggestive of variations that are likely to prove significant with a larger sample. An additional 300 fishermen will be interviewed in the summer of 1986.

Table 1 shows that those with higher skill fished about twice as many days per year as those of lesser skill. Apparently, those with higher skill caught a larger number and size of fish and had more consumer surplus per day. High skill anglers placed greater value on: (1) size as compared to number of fish; (2) wild trout; and (3) had a greater preference for artificial lures and flies.

Fishermen of less skill often did not catch any fish and rarely caught very many. Thus, it should not be surprising that those with lower skill were more responsive to changes in the number of fish caught than those of higher skill. Those with less skill were more concerned with catching fish than the method; more used live bait. Also, they were less interested in catching wild trout.

COMPARATIVE STUDIES

Few previous studies have measured the effect of the number and size of fish caught on the value of fishing. Harris (1983) reported the data were not sufficient to estimate the effect of number of fish caught on the benefits of fishing in Colorado. Adamowicz and Phillips (1983) surveyed 272 resident fishermen in Alberta, Canada. The authors reported the marginal value of an additional fish ranged from $1.69 to $2.69 in 1976 Canadian dollars.

Sorg, et al. (1985) summarized the results of a telephone survey of resident and nonresident fishermen in Idaho. They caught an average of 5 fish on primary purpose trips and 7.4 fish on non-primary-purpose trips of 1.6 days. The authors reported an incremental value of $1.60 per each additional fish for primary purpose trips and $2.20 for non-primary-purpose trips. Benefits per trip increased by about $2 to $4 per added inch in length, holding number of fish constant.

Compared to these results, our study indicates that the value of catching additional fish may be somewhat less, particularly for participants with high skill who are already catching large numbers of fish. However, with regard to the value of catching larger fish, our results are consistent with the Idaho study, and we show that it increases with the level of skill.

CONCLUSIONS

The results of this pilot study should be viewed as tentative and a first approximation subject to improvement with further work. Much more research is needed before we will understand all of the relevant economic and noneconomic questions concerning the value of fishery management services in parks and forests of the United States. We estimated the empirical nature of willingness to pay functions for the number and size of fish caught, and explored the effect of participant skill levels. The results suggest that research on the value of fishing quality in the future should include participant skill as an independent variable in willingness to pay functions. Then the effects of participant skill can be held constant to develop value functions for management units with programs for a particular type of fishing experience.

There is a need for further research on the social costs of fishery management programs for different types of fishing experience. This would

allow managers to compare the benefits and costs of alternatives such as catch and release regulations, stocking catchable size fish, and habitat improvement measures.

The contingent valuation approach to the problem illustrated here appears to be sufficiently promising to indicate that it could be used to analyze the value of service in other types of outdoor recreation activities. We recommend further research to test its general application.

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