NEW MEXICO OIL CONSERVATION COMMISSION

COMMISSION HEARING

SANTA FE, NEW MEXICO

Hearing Date APRIL 22, 1985 Time: 9:00 A.M.

NAME	REPRESENTING	LOCATION
Jennifer Pruett	NM Environmental Improvement Div.	SFE
Kathleen Schwartz	Union	Farmington
Randy Rickford	Amoco	Farmington
Charles Boyce	Amoco	Denver
PAUL OLDAKER	AMOCO	DENVER
E.E. ELLY	UNION	OKLA. CITY
Wayne Wen	Petro-Lewis	Denver
William F. Carr	Campbell and Black	Santa Fe
Gary D. Miller	Northwest Pipeline Corp	Salt Lake City, UT
DALE BALLARD	EPNG	FARMINGTON
LORI KOMATAR	NORTHWEST PIPELINE	SALT LAKE CITY
THOMAS L. [illegible]	EPNG	EL PASO, TX
Gray Kaylor	EPNG	Farmington
A.R. Kendrick	Four Corners Gas Conservation Committee	Aztec
J.L. Calder	ARCO Oil + Gas Co	Denver
Bill Lorenz	[illegible]	[illegible]
J.A. Rush	Meridian Oil Inc	Englewood

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NAME	REPRESENTING	LOCATION
Douglas Earp	NMEID	Santa Fe
Patrick Longmire	NMEID	Santa Fe
Dave Boyer	NMOCD	" "
John F. Eichelmann	EPNG	santa fe
[illegible]	[illegible]	Santa Fe
[illegible]	GEOSCIENCECONSULTANTS, LTD	Albuquerque
Enid Busch	NMOCD	Aztec
[illegible]	COG	Artesia
C. TERRY Hobbs	Southland Royalty Co	FARMINGTON
GARY PAULSON	Amoco Production Co.	DENVER
Dennis McQuillan	NMEID	Santa Fe
Michael J. Videtich	Texaco Inc.	Cortez, Colo
OSCAR SIMPSON	F D WATER SUPPLY	SANTA FE
CHRIS SHUEY	SELF	ALBQ, NM
[illegible]	[illegible]	[illegible]
MARTY BUYS	Tenneco Oil	Denver
Masud Zand	Navajo Tribe	Window Rock, AZ
Stan Zygmunt	Delta H Engr.	Santa Fe

NEW MEXICO OIL CONSERVATION COMMISSION

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NAME	REPRESENTING	LOCATION
Robert Rea	NMERDI	Santa Fe
Gavino Perez Jr.	Tesoro Petroleum Corp.	San Antonio Tx
Ernest L. Padilla	ATTY AT LAW	Santa Fe
Thomas R. Schultz	El Paso Nat. Gas	Denver
W Perry Pearce	Meridian Oil Inc (Montgomery Andrews PA)	Santa Fe
Charles Sponberg	Union Texas Petroleum	Farmington
Greg Kander	EPNG	Farmington
DALE BACCARD	"	"
Charles Sponberg	Union Texas Petroleum	Farmington
Randall Hicks	Geoscience Consultants Ltd	Albuquerque
Edith Pierpont	League of Women Voters of New Mexico	Santa Fe

NEW MEXICO OIL CONSERVATION COMMISSION

COMMISSION HEARING

SANTA FE, NEW MEXICO

Hearing Date APRIL 22, 1985 Time: 9:00 A.M.

NAME	REPRESENTING	LOCATION

STATE OF NEW MEXICO
ENERGY AND MINERALS DEPARTMENT
OIL CONSERVATION DIVISION
STATE LAND OFFICE BUILDING
SANTA FE, NEW MEXICO

22 April 1985

COMMISSION HEARING

VOLUME I OF 2 VOLUMES

IN THE MATTER OF:

The hearing called by the Oil Conservation Commission on its own motion to define the vertical and areal extent of aquifers potentially vulnerable to contamination by the surface disposition of water produced in conjunction with the production of oil and gas in McKinley, Rio Arriba, Sandoval and San Juan Counties, New Mexico. CASE 8224

BEFORE: Richard L. Stamets, Chairman
Commissioner Ed Kelley

TRANSCRIPT OF HEARING

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For the Water Study Committee: Jeff Taylor
Attorney at Law
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A P P E A R A N C E S

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For EID:	Jennifer J. Pruett Attorney at Law P. O. Box 968 Santa Fe, New Mexico 87504-0968
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For BCO, Inc.:	Ernest L. Padilla Attorney at Law P. O. Box 2523 Santa Fe, New Mexico 87501

I N D E X

E X H I B I T S

MR. STAMETS: The hearing will please come to order.

We concluded last go-around with a witness for Mr. Pearce.

Mr. Pearce, do you have any additional testimony or witnesses?

MR. PEARCE: One very brief item, if I may, Mr. Chairman.

During the last hearing there were two requests made of us by additional documentation. I have that at this time, if I may.

What I have marked as Exhibit Number Two is a summary of calculations of benzene and toluene vaporization. There was some question. You may recall that Dr. Tom Schultz testified that he believed that the 50 percent flash volatilization number was a reasonable, conservative estimate, but there under some instances a higher percentage of benzene and toluene might vaporize.

We were asked to prepare a summary of calculations which led us to that opinion. Those calculations have been prepared by a professional engineer for El Paso Natural Gas Company who is not in attendance, but I have several copies of these which can be reviewed at everyone's leisure.

In addition to that, Mr. Chairman, we had a request at the last hearing for some ad

ditional information about sampling done relative to organic content of soils.

What I have marked as Exhibit Number Three is a summary of those tests. These tests were performed by an EPA certified lab by the name of Raba-Kistner. The physical reports are not here but we have summarized the data which they developed.

In addition to that, I have two sets of documents which I have not marked as exhibits. They are a more detailed record of how the soil samples were taken and from what locations those samples were taken.

I do not propose to make these exhibits. They contain a number of photographs. I propose to simply deliver them to the Commission and then the Commission's files will be open for anyone who wishes to inspect them.

So those two binders are not actually being tendered as exhibits.

With those introductory matters, Mr. Chairman, if I may, I would offer Exhibits One, parts one through five, and Two and Three into evidence.

MR. STAMETS: Are there objections to the admission of these exhibits?

MR. PRUETT: Is Mr. Miller -- Dr. Miller going to testify?

MR. PEARCE: Yes, that's Part Six of this, I'm sorry.

MR. STAMETS: If there is no objection, these exhibits will be admitted with the notation that Alfred J. Wessler put Exhibit Two together for El Paso Natural Gas Company and is not actually here to testify today.

All right, who shall be the next person?

Mr. Carr.

MR. CARR: May it please the Commission, my name is William F. Carr with the Campbell Law Firm in Santa Fe.

As the Commission will recall, on April the 3rd Dr. Tom Schultz testified about five mechanisms of attenutation. The five mechanisms are set forth on the easel that's before the Commission.

Today I'm going to call Dr. Gary Miller, who is going to testify about the sixth mechanism of attenuation, which is biodegradation.

At this time I will call Dr. Miller.

Mr. Stamets, the witness needs to be sworn.

(Witness sworn.)

MR. STAMETS: Mr. Carr, you may proceed.

DR. GARY DAVID MILLER,

being called as a witness and being duly sworn upon his oath, testified as follows, to-wit:

DIRECT EXAMINATION

BY MR. CARR:

Q Will you state your full name and place of residence?

A Gary David Miller. 428 Elmcrest, Norman, Oklahoma.

Q Dr. Miller, by whom are you employed and in what capacity?

A I'm employed by the University of Oklahoma as Assistant Professor in the School of Civil Engineering and Environmental Science, and today I'm here as a consultant for Northwest Pipeline Corporation.

Q Have you previously testified before this Commission and had your credentials accepted and made a matter of record?

A No, I have not.

Q Would you briefly summarize for the Commission your educational background?

A I have a Bachelor's of Science degree with a major in biology and a minor in chemistry from Oral Roberts University in 1972.

I have a Master's of Environmental Science degree with an emphasis in solid waste management

from the University of Oklahoma in 1974, and a PhD in Civil Engineering and Environmental Science from the University of Oklahoma in 1980.

Q Would you review your work history for the Commission, please?

A Since 1980 I have been Assistant Professor of Civil Engineering and Environmental Science at the University of Oklahoma. I have also been Assistant Co-Director of the Natural Center for Ground Water Research at the University of Oklahoma, which is a U. S. Environmental Protection Agency established center of excellence and is a consortium of the University of Oklahoma, Oklahoma State University, and Rice University.

I teach courses at the gradute level in solid -- or in ground water quality management and in ground water pollution control, and all these positions I've held since 1981.

Q Do you belong to any professional associations?

A Yes, I belong to several professional associations, including the American Society for Microbiology, the National Waterwell Association.

I am also a member of the EPA Peer Review Panel for Environmental Chemistry and Physics, and I've been a peer reviewer for several journals, including Analytical Chemistry and Ground Water Monitoring Review.

Q What does a peer reviewer actually do?

A When an article is submitted to a journal for possible publication, it is submitted -- it is then sent to other scientists that have a similar area of expertise for their review to see it is it acceptable for publication.

Q And you review to satisfy yourself and check to be sure it's being run in a technically sound fashion, is that one of the things you check?

A Yes, that's correct.

Q Would you briefly review some of the research that you've personally participated in which relates to the subject of today's hearing?

A Overall I've participated in more than 20 research projects but two of them I'd like to highlight that relate to this hearing.

One is I was principal investigator on a research project titled Microcosm Technology for Subsurface Environments between 1980 and 1983. It was funded by the U. S. Environmental Protection Agency and the project was to develop laboratory techniques and field sampling techniques for studying ground water microbiology.

Since then I have been co-principal investigator on a research project titled Determination of Subsurface Contaminant Transport Using Microcosm Systems, also sponsored by the U. S. Environmental Protection Agency, and it is funded at the level of $850,000 for three years and we are using the laboratory and field sampling techniques developed in the previous project to further study the

transport and fate of contaminants in the subsurface environment.

Q In carrying out these studies do you actually go into the field and take samples and bring them back to your lab and analyze them there?

A Right. That's exactly what we do. We go into the field, collect subsurface materials, bring them into the laboratory for analysis.

Q Have you written any books or portions of books which relate to the subject of today's hearing?

A Yes, I've been the author of three books, or co-author of three books, but one most relevant to this hearing is a book chapter with Dr. Larry Canter and myself titled "Trends in Research and Development: Implications for Managing Groundwater", which is in the book titled Groundwater Management: A Key Issue for the 80's, to be published by the American Academy for the Advancement of Science this year.

Q Have you had other papers published which relate to this subject?

A Yes. Three papers I'd like to mention.

One I co-authored with Dr. Larry Canter titled "Bio-degradation Studies of Selected Priority Pollutants".

The second one was by Dr. Joseph Suflita and myself, titled "The Microbial Metabolism of Xenobiotic Compounds in Groundwater Aquifers".

And a third, and the third paper was also co-authored with Dr. Joseph Suflita, titled "The Microbial Metabolism of Chlorophenolic Compounds in Groundwater Aquifers", which has been accepted to Environmental Toxicology and Chemistry.

Q And that will be published?

A This year in a special proceedings that will be coming out, special publication.

Q Dr. Miller, what were you asked to review and study in preparation for today's hearing?

A I was asked to review my research and related current research on microbiological degradation of organic chemicals in the subsurface.

MR. CARR: May it please the Commission, at this time we tender Dr. Miller as an expert witness in environmental biology and chemistry.

MR. STAMETS: Are there any questions as to his qualifications?

MR. TAYLOR: Mr. Chairman, I don't have an objection but I -- I'm sort of confused.

I thought that a paper that he'd written was in the exhibit from Meridian, yet he said he was testifying on behalf of Northwest Pipeline.

Can I be straightened out on that?

MR. PEARCE: Yes. The exhibit is entitled Meridian because my particular client is Meri-

dian Oil and we combined all of the exhibits together.

MR. TAYLOR: All right.

MR. PEARCE: Dr. Miller is correct that he is retained and appearing on behalf of Northwest Pipeline.

Other than combining exhibits and keeping from paying experts to testify on the same topics, that's really what we've got going on here.

MR. STAMETS: Being no objection, the witness is considered qualified.

Q Dr. Miller, are you familiar with the five mechanisms of attenutation that Dr. Schultz presented in this case at the April 3rd hearing?

A Yes, I am familiar with those. I was -- I was present at the April 3rd hearing and in fact several of those mechanisms we also addressed in my research because we are attempting to differentiate between those mechanisms and biodegradation processes that occur in subsurface material, but my testimony today will be primarily towards the biodegradation processes in the subsurface.

Q Would you turn to the first page after Tab No. 6 in Meridian Exhibit Number One and identify this and review it for the Commission?

A Yes. This first page is titled "Main Points About Biodegradation of Organics in the Subsurface."

This material behind Tab 6 in this exhibit was prepared by me for this hearing and this first page

just summarizes the six main points that I would like to make.

Q Would you now identify the second document in -- after Tab No. 6?

A Yes. The second document is titled "Biodegradation" and I believe it is about five pages in length, and it's a written narrative that summarizes my testimony today.

Q Does this report also have a bibliography attached to it?

A Yes. The attached bibliography, about two pages with twenty references, those references could be used by anybody who would like to go into this subject matter in greater depth.

Q Will you now refer to the first point you're going to present concerning biodegradation, state what it is, and review it for the Commission?

A Yes. The first point I'd like to make is that benzene and toluene are readily biodegradable by microorganisms, and as supporting documentation for this I have a paper several pages over, the first paper, titled "Biodegradability Studies with Organic Priority Pollutant Compounds", authored by Henry Tabak and others, who are researchers for the U. S. Environmental Protection Agency at their Cincinnati Laboratory.

Specifically I'd like to refer to Table 3 on Page 1509 of their paper and in that table, which is tit-

led "Biodegradability of benzene, toluene, and their derivatives evaluated by the static screening flask test method", we see in the lefthand column, titled "Test compound" that the first compound mentioned in benzene.

The second column is "Concentration of the test compound" and benzene was tested as 5 parts per million and 10 parts per million.

And the third column is -- is a performance summary. The "D" in that column refers to significant degradation of benzene was found with rapid adaptation of the micro-organisms.

The next column is titled "Original culture" and within one week between about 40-to-50 percent of the benzene had been degraded. A subculture was then taken of that first culture and within two weeks 95-to-100 percent of the benzene was degraded.

So benzene was significantly degraded and there was rapid adaptation of the micro-organisms to it.

Then further down, third from the bottom, is toluene. The same concentrations of toluene were tested. It was also found that there was significant degradation with rapid adaptation of the micro-organisms. In fact, it was more rapidly degraded than -- than the benzene, and within one week 100 percent of the toluene was biodegraded.

So -- so this table, then, indicates that benzene and toluene are readily biodegradable in the environment.

Q Toluene degraded in one week and benzene in two.

A Within about two weeks.

Q Are the authors of this report recognized authorities in this area?

A Yes, they are. They are active researchers with the U. S. Environmental Protection Agency.

Q And in what journal was this paper published?

A This paper was published in the Journal of the Water Control Federation, which is a highly recognized journal in this area.

Q Have you utilized their work in your research?

A Yes. I utilized their work and this paper in my own research.

Q And have you confirmed their conclusions in your own independent research?

A Yes. My research would agree with what their table has shown.

Q Would you now refer to your second point and review that for the Commission?

A The second point, then, is that micro-organisms exist in the subsurface and they are metabolically active, and this, this area is -- gets us to the new area. It was, perhaps, a misconception by some people in the past that micro-organisms did not exist in the subsurface

environment, and in the past about five or six years we have discovered that they do exist in the subsurface environment and they are metabolically active.

The next paper in this exhibit, which appeared in EOS, by Wilson and McNabb,

Q What is EOS?

A EOS is the title of a journal. Okay. And this article by Wilson and McNabb is titled "Biological Transformation of Organic Pollutants in Groundwater", which appeared in 1983, and in this paper they summarize what we had learned in about the four previous years about the occurrence and activity of micro-organisms in the subsurface environment.

In the first table on Page 505 of their paper, titled "Numbers of Organisms in the Subsurface Environment", we can see that there were several sites that aquifer material has been obtained. They used the same sampling technique that we used, that we developed in our previous research project, and they obtained aquifer material from two places in Oklahoma, from a place in Louisiana, from Conroe, Texas, and from a site in New York on Long Island, and there were various depths to the water table at these sites.

They sampled the subsoil. They -- they obtained material just above the water table, and they obtained aquifer material just below the water table, and in all of these sites they found that there was a surprisingly

uniformity to the numbers of micro-organisms that occur in the aquifer material.

The minimum amount that they discovered was approximately 300,000 micro-organisms per gram of dry weight of aquifer material.

The maximum number they found was 170,000,000 micro-organisms per gram of dry weight of aquifer material.

So everywhere they looked they found micro-organisms and to date everywhere we've looked we've found this relative -- in this range numbers of micro-organisms in subsurface environment.

Q Are you familiar with the sampling techniques employed in preparing this paper and doing this research?

A Yes. I helped develop those sampling techniques and participated in collecting some of these samples.

Q How does this information compare with the number of micro-organisms that are found at great depths?

A Some other researchers have collected some samples from depths exceeding 100 meters and have also found about 1,000,000 micro-organisms per gram of dry weight. So even at great depths these significant levels or organisms do occur.

Q How does this compare with the number of

organisms in surface soils?

A In surface soils we find about 10 to the 8, or -- or maybe about two orders of magnitude more organisms, about 10 to the 6, or a 1,000,000 micro-organisms per gram of dry weight; a still significant number of micro-organisms.

Q That's at the deeper depths.

A In the deeper depths, right.

Q And are there any differences that you've noted in these organisms?

A Yeah, the main difference we seem to have found in the subsurface micro-organisms is that they're used to what we might call a nutrient poor environment or in other words, they don't have a lot of food to eat in simple terms. They're not picky eaters and they will metabolize or eat, digest just about a wider range of chemicals that comes along than surface micro-organisms who have the luxury of, let's say, being picky eaters and can specialize in the types of things that they will metabolize.

Q At both levels do the organisms eat benzene and toluene?

A Yes. They metabolize benzene and toluene. In the subsurface environment it appears that they will metabolize benzene and toluene at lower concentrations and will metabolize them to lower concentrations below, say, levels of significant concern.

Q Are you ready now to go on to your third

point?

A Yes. The third point that I would like to make for the Commission is that aerobic biodegradation of benzene and toluene and related organic chemicals does occur in the subsurface environment.

Again, this is made in the article by Wilson and McNabb.

On the next page, Page 506 of their article in Table 2 they summarize the prospect for the biotransformaton of selected organic pollutants in water table aquifers, and if you look under the lefthand column titled "Class of Compounds" you'll see under alkylbenzenes that benzene and toluene are listed, and for the aerobic environment for benzene it is listed that it's probable that benzene will degrade at concentrations greater than 100 parts per billion or micrograms per liter, and possible that it will be degraded even at trace concentrations below 10 parts per billion.

The same thing is true of toluene, that it's probable that it degrades concentrations greater than 100 parts per billion and possible it degrades even at trace concentrations.

The reasons that these terms "probable" and "possible" were used is that everywhere we looked benzene and toluene was degradable, so we would predict that probably it would degrade at future sites.

Q On this table there is also a column for

an anaerobic water and it indicates "none".

A Right. At the --

Q Can you explain that?

A Sure. At the time that this article was written, that was what was thought to be true, that benzene and toluene would not be degradable under anaerobic conditions; however, since that time it has been found by some that under certain anaerobic conditions that benzene and toluene may be degradable, and I'll address that a little bit later.

Q Have you confirmed the conclusions set forth in Table 2 with your own research?

A Yes. In fact, some of this information that's in Table 2 is from my own research.

Q Will you now go to the report by Bouwer and McCarty?

A Yes. The next paper, which supports the aerobic degradation of these types of chemicals in the subsurface environment, is titled "Modeling of Trace Organic Biotransformation in the Subsurface", and it appeared in the Groundwater Journal.

And this, what I would like to refer to first of all is Table 1 of this paper and titled "Average Utilization of Substrates Fed Continuously to Aerobic and Methanogenic Biofilm Reactors After Acclimation."

And if you looked in the lefthand column titled "Substrate", there is a category called nonchlori-

nated aromatics. Benzene and toluene are there. Benzene and toluene are nonchlorinated aromatic chemicals.

And you see that -- that ethylbenzene, syurene, naphthalene, were removed at a rate of 99 percent or greater within a 20 minute detention time in their treatment study under aerobic conditions. So these were rapidly degraded under aerobic conditions.

Under anaerobic, or methanogenic conditions some of the nonchlorinated aromatics were also removed but at a much slower rate.

Then the next point I would like to make from this article is on Page 439. It's Figure 3. They reviewed the general figure on the degradation of different types of organic chemicals under different types of conditions and under aerobic heterotrophic respiration conditions they indicated that chlorinated benzenes and nonchlorinated aromatics were readily degradable, and they indicated that under the anaerobic environment that there was much less known about it, as indicated by the question mark under sulfate respiration, for example.

Q Dr. Miller, are you ready to go to your graph on toluene?

A Yes. The next evidence, or next exhibit is titled "Toluene", and it's just a graph from my own research that indicates a solid line and a dashed line and the solid line is from aquifer material that's collected from well within the -- the saturated zone a couple meters below

the top of the water table.

The dashed line is from right near the top of the water table but within the aquifer or within saturated material.

And we see that within about four weeks in the upper zone the toluene was completely degraded and in the lower aquifer material it was a slower rate of degradation but there was a significant degradation of toluene in my own research.

Q Dr. Miller, this information relates only -- depicts -- is information collected only below the water table.

A Yes.

Q Do you have information or could you plot information showing what happened above the water table?

A Yes. We also studied aquifer material collected in the unsaturated zone above the water table and the rate of degradation in that material was between 240 and 250 percent per week, and it would essentially coincide with the Y axis on this chart so we didn't include it, but very rapid degradation in the unsaturated material, and the rate of degradation in the saturated material was approximately 30 percent per week.

Q Would you now go to the fourth point?

A The fourth point about this is that -- that the aerobic degradation pathways of benzene and toluene lead to complete mineralization to carbon dioxide and water

with the formation of no metabolites formed that are of human health or environmental concern.

And I've taken this material from a report by the name of Perry. The author is Perry. It's number seventeen on my bibliographic list, from a book titled Petroleum Microbiology and the first illustration is for the aerobic pathway utilized by bacteria for the oxidation of benzene.

It's illustrated on the poster here. We see that benzene is degraded in the presence of bacteria and oxygen. A water molecule is added to the ring structure to form a dihydrobenzene.

That is then transformed to a catechol and then that catechol either undergoes ortho or meta fission to either a muconic acid or a semialdehyde and at that -- when the ring structure is broken at that point, then they -- it is completely metabolized to carbon dioxide and water under aerobic conditions and none of these metabolites are of any known human health or environmental concern, that I'm aware of.

The next illustration is titled "Two Aerobic Pathways for Toluene Biodegradation", taken from the same book, and there are two degradation pathways for -- under aerobic conditions for toluene.

On the lefthand side toluene is degraded to a dihydrotoluene and a methylcatechol, finally the ring -- it undergoes ring fission and is completely metabolized

to carbon dioxide and water.

Under the other degradation pathway on the righthand side the toluene is degraded to a benzyl alcohol, then a benzyl aldehyde, finally benzoic acid, and then also a catechol and then undergoes ring fission and complete mineralization to carbon dioxide and water.

Q And none of these intermediate compounds constitute a health or environmental hazard.

A They do not to my knowledge. That's correct.

Q Would you now go to point number five?

A Okay, the point -- the fifth point that I would like to make is that oxygen does occur at significant levels under most conditions in the subsurface, even in the deeper subsurface, and perhaps this is the second area of misconception, because many people believe that the subsurface environment is an anaerobic environment and we have found that that's -- that's generally not the case.

The subsurface environment is actually an oxygenated environment under most conditions.

It can be seen from the abstract of this paper that is given, titled "Deep Oxygenated Groundwater Anomaly or Common Occurrence?", and it's by two authors from the U. S. Geological Survey, Winograd and Robertson, in their Published in Science, which is a very reputable journal, and they indicate that significant levels of dissolved oxygen 2 to 8 milligrams per liter were present from waters

from a variety of deep aquifers in Nevada, Arizona, and in the Appalachians in Arkansas, even as deep as 100 to 1000 meters in depth.

And so generally, then, it would be expected that the subsurface is commonly an aerobic environment and would be expected to be aerobic except where there are large amounts of organic contamination.

Q Will you now review point six?

A Okay, the sixth point that I would like to make, then, is that recent studies indicate that toluene and possibly benzene may degrade under anaerobic conditions of such conditions do occur in the subsurface environment.

And for that I'd like to refer to a page titled "Abstracts of the Annual Meeting of the American Society for Microbiology" which occurred in March of this year, and under the section entitled "Environmental and General Applied Microbiology" the abstract numbered Q 5, which is titled "Biotransformation of Toluene in Methanogenic Subsurface Material", by Rees, Wilson and Wilson, they found that toluene was degradable under methanogenic, which is a type of anaerobic condition, in the subsurface environment at a slower rate than aerobic conditions but they did find anaerobic degradation.

The next paper by Reinhard and Goodman, titled "Occurrence and Distribution of Organic Chemicals in Two Landfill Leachate Plumes", which just recently appeared in Environmental and Science Technology, also there were in-

dications that benzene, toluene, and related compounds could be degraded under anaerobic conditions in the subsurface environment.

Thirdly, Dr. Rene Schwarzenbach from Switzerland, who works with some famous scientists over there, visited my lab last month and he indicated in his laboratory experiments he found anaerobic degradation of benzene, toluene, and related compounds under -- under anaerobic conditions given at rapid rates and especially after adaptation of the micro-organisms.

So very recent evidence does indicate that toluene and possibly benzene may degrade under anaerobic conditions in the subsurface environment.

Q And why do you think this informations has not been discovered prior to this time?

A Previously it was -- it was thought that micro-organisms did not occur in the subsurface environment so there were no biological processes down there.

We set out in the late seventies and early eighties to test that common belief and we developed sampling procedures for obtaining aquifer materials that was uncontaminated by surface micro-organisms and would only contain the indigenous micro-organisms that occur in the subsurface.

When we studied that material we also developed new laboratory techniques for identifying micro-organisms in aquifer materials and we were pleasantly sur-

prised to find out that there were micro-organisms that exist.

In fact, one of the researchers that -- that started this expected to have a one-year research project and go on to something and better and the something bigger and better turned out to be groundwater microbiology, and so we have continued to pursue that line of research.

Once we found out that there were micro-organisms that do occur in the subsurface environment, we found that they are metabolically active, and also there weren't -- it's very difficult to sample wellwater or groundwater for -- and analyze it for dissolved oxygen without introducing dissolved oxygen into the -- into the water, so the paper by Winograd and Robertson was an innovative technique for doing that, and so by that innovative technique they were able to document that the -- that subsurface groundwater does contain dissolved oxygen.

So it's been largely due to the development of analytical and field and laboratory techniques that we've been able to make these discoveries.

Q Would you summarize now for the Commission the conclusions you've reached as a result of your studies?

A Yes. I'd like to just refer back to the first page of Subsection 6 of this exhibit, which was titled "Main Points About Biodegradation of Organics in the Subsurface".

My first point was that benzene and toluene are readily degradable by micro-organisms in the environment.

Secondly, micro-organisms do exist in the subsurface and they are metabolically active.

The third point was that aerobic biodegradation of benzene and toluene and related organic chemicals does occur in the subsurface environment.

Fourth, the aerobic degradation pathways of benzene and toluene lead to complete mineralization, to carbon dioxide and water, with no metabolized forms that are of human health or environmental concern.

Fifth, oxygen occurs at significant levels under most conditions in the subsurface, even in the deeper aquifers.

And finally, recent studies indicate that toluene and possible benzene may degrade even under anaerobic conditions if they -- if such conditions do occur in the subsurface environment.

I think that biodegradation of organics in the subsurface is one of the most exciting scientific discoveries in recent years and combined with the other loses previously described by Dr. Schultz, there are several volatilization losses. There is two or three dimensional flow in the partially saturated zone, which can result in the dilution of any remaining chemicals.

Sorption, which for the types of soils in

the area of concern can result in a 5 to 50-fold delay or retardation of these chemicals.

Biodegradation results in the further disappearance and at a rate greater than 30 percent per week, and after adaptation, an even faster rate of disappearance will occur, and in fact, biodegradation and some of the dilution and and retardation mechanisms can work together to provide a greater residence time of these chemicals in the -- in the subsurface for biodegradation to occur.

And then the concentration of benzene and toluene will be reduced to less than 10 parts per billion, which is below current levels of regulatory concern.

Now most computer models that have been developed for predicting the fate of these types of chemicals in the subsurface have been formulated by hydrogeologists that originally used inorganic chemicals that do not degrade, and they used retardation factors to simulate the movement of organic chemicals, which, if the organic chemicals are biodegradable, we now know this is not an accurate way to model their transport and fate.

The U. S. Environmental Protection Agency has within the past year initiated at least two new research projects, one by myself, to develop mathematical models that will include more accurate simulation of microbiological processes in the subsurface.

When we consider that all these six re-

tardation and removal mechanisms for benzene and toluene, it is clear why they have not shown up in water supply wells in the area of concern, and I would not expect them to threaten fresh water supplies in the San Juan Basin.

Q Dr. Miller, were materials contained in Part 6 of Meridian Exhibit Number One prepared by you and compiled under your direction and supervision?

A Yes, they were.

Q And can, from your own experience and research, you testify as to the accuracy of the materials contained therein?

A Yes.

MR. CARR: At this time, Mr. Stamets, we would offer into evidence Part 6 of Meridian Exhibit Number One.

MR. STAMETS: Any objection to the entry of this portion of the exhibit?

It will be admitted.

MR. CARR: That concludes my direct examination of Dr. Miller and I tender the witness for cross examination.

MR. STAMETS: Are there questions of Dr. Miller?

MR. KELLAHIN: Yes, Mr. Chairman.

MR. STAMETS: Mr. Kellahin.

CROSS EXAMINATION

BY MR. KELLAHIN:

Q Dr. Miller, did you attend the Oil Conservation Commission hearing in this case on February 20th of 1985?

A No, I did not.

Q You were at the hearing we had on April 3rd, 1985, in this case?

A Yes, I was.

Q So you heard Mr. Schultz' testimony about the other mechanisms of attentuation.

A Yes, I did.

Q In preparing for your testimony today, Doctor, did you review any of the information that was in the transcript for the Februrary 20th hearing?

A No, I did not.

Q Doctor, what we're trying to determine here is whether or not there ought to be small volume exemptions in a vulnerable area of the San Juan Basin so that oil and gas wells, the produced water from which, can be placed in unlined pits, and whether that process poses a reasonable probability of contamination to the groundwater.

Within that context, then, I want to ask you some questions and your professional opinion on biodegradation.

Assume, if you will, for me, sir, that the prior testimony has provided evidence that a hydrologist

has made a simple dilution calculation and has assumed certain factors; that the produced water coming from the separator has been analyzed out of the separator directly and shows concentrations of benzene in the range of 20 milligrams per liter; that in addition there have been water samples taken out of the pit in which there are analyses showing that concentrations of benzene in the pit are about 3.5 milligrams per liter.

The hydrologist then does a simple dilution calculation assuming a vertical distance from the bottom of the pits to groundwater of about 25 feet and that the pit is subject to having water placed on it on a continuing basis at the rate of about five barrels a day.

It is also in the record that a number of these pits are in soil compositions that are gravel. They have big cobbles in them. They do not have fine grained soils.

Let's also assume that groundwater monitoring has occurred around this well and while it's been done appropriately, in accordance with the standards of a hydrologist, and the groundwate monitoring fails to detect benzene in concentrations in excess of the standard, my question, sir, in your opinion are there reasonable scientific explanations for the fact that benzene at 3.5 milligrams per liter is in the pit, and yet when you sample the groundwater around that pit you do not find benzene?

Do you have an opinion on that point?

A Yes. I -- I feel that our scientific evidence today would strongly indicate that these six removal mechanisms and dilution mechanisms would account for that.

Q In your opinion is it necessary for you to actually to go out to the San Juan Basin and look at these wells and study it yourself in order to reach the conclusion that the mechanisms, including the mechanism of biodegradation, is occurring in this type of soil and area?

A No, I don't think it's necessary. The preponderance of evidence everywhere we've looked is that biodegradation of these chemicals does occur in these types of materials, these types of environments, and would filly expect them to occur in the San Juan Basin.

Q Doctor, I'd like to ask your expert opinion on whether you agree or disagree with certain testimony of a prior witness, Mr. Dave Boyer, at the February 20th, 1985 hearing.

This testimony appearing on page 82 and 83 of that transcript, Mr. Boyer is discussing the mechanism of biodegradation and he concludes that it is not an important factor to consider when you're determining whether the benzene concentrations in the pit are reaching the groundwater, and he says:

"There are some mechanisms in the subsurface for containment and attenuation of these things. I'm going to discuss those briefly."

He then discusses briefly the first five and he gets down to the last, biodegradation, and defines biodegradation, and then he says:

"In an anaerobic environment it's a different story and degradation only occurs slowly in an aerobic environment, so if you have an aerobic environment down there, you probably don't have very much in the way of degradation."

That was his testimony. Do you agree or disagree with his opinion?

A I disagree. I think that that would have been commonly believed five or six years ago but the recent evidence indicates that that's not true.

Q You quoted to us awhile ago, doctor, and discussed for us the paper by Winograd and Robertson?

A Yes.

Q And it had to do with the presence of dissolved oxygen in the saturated zone?

A In groundwater is correct.

Q In the groundwater? And that that was one of the factors that allowed the biodegradation mechanism to work in this type of environment.

A Right. It would permit aerobic degradation.

Q I want to direct that kind of point to the San Juan Basin water area, doctor.

Would you anticipate that recently re-

charged water, which is common in the shallow, localized, recharged alluvial aquifers in the San Juan Basin, we're dealing with San Juan Basin that is continually and actively recharged. That's the type of aquifer we have. If you'll assume that, my question is whether or not in your opinion there would be higher or lower percentages of dissolved oxygen than in the deep groundwater discussed in the Winograd and Robertson reports and studies?

A They indicated a range of dissolved oxygen from 2 to 8 milligrams per liter.

I would expect the dissolved oxygen to fall within that range in the San Juan River Basin; perhaps towards the upper end of that. But 8 milligrams per liter, depending upon the temperature of water, is getting near the saturation point for dissolved oxygen, so it probably wouldn't occur much higher than that.

Q Is that range of dissolved oxygen in the water an adequate range to create an environment for the biodegradation to take place?

A The only -- the only way that it could be limiting is if it was overwhelmed by organic chemicals.

Q And when we talk about the concentrations of benzene that I described earlier, when they come out of the separator and were in that 20 milligrams per liter range, by the time we're in the pit we're down to the 3 and 4 milligram range, in your opinion would that be a concentration that would overwhelm the mechanism of biodegrada-

tion?

A In my opinion it would not be high enough to overwhelm it.

The cases where I have seen it overwhelmed have been much, much higher concentrations of benzene and toluene and related compounds.

Q Let's assume also, sir, as I discussed with you earlier, that the facts are that the pit is subject to a rate, a volume of water, produced water in the pit, of 5 barrels a day or less, would that be a volume of water in the pit that would overwhelm the mechanism of biodegradation, using a concentration in the pit of 5 -- 3.5 milligrams per liter?

A It -- it appears to me from my research and the research of others that that concentration and volume should not overwhelm the capacity of the subsurface to degrade these chemicals, although I haven't performed, you know, detailed studies of that or mathematical modeling of it, because we're still developing the mathematical model for that, but I would say that -- that there is ample opportunity for adaptation of the micro-organisms within the pit and in the subsurface immediately below the pit to rapidly degrade these chemicals, and the presence of benzene and toluene and related chemicals in the water environment provides for, you know, adequate micro-organisms to exist that can degrade those chemicals.

Q All right, let's assume that the poten-

tial contaminants in the pit, that there is some level that reaches the groundwater and they're subject in this area to rapid dilution.

Will biodegradation continue in an atmosphere where we have the contaminants diluted and we have highly oxygenated water?

A Right. Biodegradation will occur. I've studied in the -- at the -- in the neighborhood of 100 parts per billion biodegradation occurred. I've studied at about 10 to 20 parts per billion and biodegradation of these chemicals occurs at those trace levels, also, and usually when we're getting below, say, 10 parts per billion, we're getting below levels of regulatory concern.

Q In the scheme of trying to determine the effects of the different mechanisms of attenuation, can you give us a general range of magnitude of the effects of biodegradation in the fact situation I've given you? Does it play a mojor part, a minor part, or can you attempt to determine how important that factor is in relation to the other five factors that Mr. Schultz discussed?

A I think biodegradation plays a major role. I think that it works in concert with some of the other factors, like sorption, to -- to provide for what we might call a treatment zone, an area of active degradation beneath the pit that I would anticipate occurred there.

We've observed what we might call treatment zones and other sites we've investigated around the

country where there was an area of active degradation that was maybe a foot or so in length, and we found significant concentrations on one side, within a foot disappearance to below measurable levels in subsurface material.

So I would -- I would -- it would be my judgment that there are this kind of a treatment zone beneath these pits.

Q At the April 3rd hearing Commissioner Stamets gave Mr. Schultz an example and asked Mr. Schultz whether that was adequate and an example characterized what is happening in the unlined pit area in relation to groundwater, and the example was this, sir: That -- the expert was asked whether or not this is like the carbon filter you might have on your tap water in the house, and that after a period of time if you did not change your filter by running the tap water through the filter the filter becomes full and eventually you're going to have a glass of water that's got contaminants or pollutants in it.

With regards to the mechanism of biodegradation and the other factors of attenuation, would that be a fair example of the type of a situation we have when we're dealing with the unlined pits in the San Juan Basin?

A I would say that would only be fair if the system was overloaded with a gross amount of contamination or deposition of pollutants, that there was kind of bulk flow of pollutants, but in this case, where we're talking about 20 parts per million concentration and, say, 5

barrels per day, or so, of liquid, I wouldn't think that that would be accurate because the system would not be overloaded and the biodegradation mechanisms would result in disappearance or complete metabolism of these chemicals.

Q I just want to make sure we're dealing with the same numbers, doctor.

A Okay.

Q The example I gave to you and the fact situation is we're dealing with 3.5 milligrams per liter.

A Right.

Q And we're dealing with 5 barrels a day in the pits.

Witnesses are continuing to change the mathematics on me and I am barely comfortable with milligrams per liter, and if you could keep in that form it would help me a lot.

A I'll try.

Q You just made reference to 20 parts per billion.

A I meant to say 20 parts per million but I was in that range.

Q I'm still not with you.

A Right.

Q 20 parts per million is --

A Is 20 milligrams per liter, approximately.

Q All right.

A Right.

Q In your opinion, then, with regards to the unlined pits, are we dealing with a statis carbon filter type environment there or do we have a dynamic regenerating system that continues to have the mechanism of attenuation work on these contaminants and not only delay them but remove them from -- from the system?

A All right. I'd say in these concentration ranges and levels of input that it is a dynamic system where there is a capacity for regeneration.

Q Up to this point, doctor, we have been talking about the unsaturated zone and the effects of biodegradation on that zone.

Let's have you shift gears now, sir, and talk about what happens, if anything happens, with regards to the treatment of contaminants in the saturated zone, or saturated environmenta.

A Our experiment, our experimentation to date indicates that biodegradation continues in the saturated zone, perhaps at a somewhat reduced rate, but still occurs there at significantly rapid rate. It would -- we estimate in the range of about 30 percent per week rate of degradation in the saturated zone. So if benzene and toluene and related chemicals reach a groundwater there would continue to be biodegradation even in a saturated zone.

Q So if in the vulnerable area of the San Juan Basin we have unsaturated zones and also saturated

zones, in your opinion are the mechanism of biodegradation still active and functioning in both the saturated and unsaturated environment?

A Yes.

Q Talking again in the small volume concentrations that we've just discussed.

A That's correct.

Q Thank you, sir.

MR. STAMETS: Are there other questions of the witness?

Ms. Pruett?

CROSS EXAMINATION

BY MS. PRUETT:

Q Sir, you were at the last hearing and you heard Mr. Pearce telling the Commission his experts were going, I believe he said, to discuss the read world geology and hydrology, and your essay is titled "Main Points About Biodegradation of Organics in the Subsurface."

And your first point is that benzene and toluene are readily biodegradable by micro-organisms and you cite the Tabak article for that proposition, but the Tabak study was not a real world study, was it?

A No, he used real world micro-organisms he collected from the environment but it was the surface environment and only indicates the potential for benzene and toluene to --

Q Right.

A -- degrade by micro-organisms.

Q That article reflects --

MR. PEARCE: Excuse me, let's don't interrupt the witness, please.

A Right, I wanted to -- and therefore I went on to the next five points and showed that first of all, you know, by the Tabak article that benzene and toluene are degradable.

Then the next points indicated that they're degradable in the subsurface environment.

Q Right, but the Tabak article was based on tests done in controlled laboratory situations, in laboratory culture samples.

A Sure, with micro-organisms from the environment.

Q And they were injected, those flasks were injected with yeast extract and settled domestic waste water.

A That's correct.

Q And produced waste water, which is the subject of this hearing, doesn't contain yeast extract or settled domestic waste.

A No, I wouldn't expect it to.

Q Okay. Now, also in the Tabak article on page 1506, the authors point out that the minimum sensitivity of the gas chromotography -- chromotographical proce-

dures is .1 milligrams per liter and he states that. quote, the indication of 100 percent biodegradation in the tabular data should not be interpreted as zero residual of the individual priority pollutant, end quote.

So even though Tabak's charts show 100 percent degradation, that may not, in fact, be the case. There could be some residual under .1 milligrams per liter that just -- their instruments were incapable of picking up.

A Right. We can only say that there's degradation to the point of limits of detection. We can't state below that.

Q Right. And that point of detection is in fact ten times greater than the New Mexico health standard for benzene.

A In his studies, yes. In my studies, probably my limit of detection was in the about one part -- or about a tenth of a part per billion. Okay, so that would be much below the Tabak's.

Q Tabak also stated that, on page 1517, the priority pollutants that were observed not to exhibit significant degradation under the conditions of the static-culture-flask methodology cannot be presumed to be completely recalcitrant to microbial action. Unquote.

Isn't the reverse also true, just because degradation occurred in these controlled flask conditions, that one cannot presume that under environmental conditions they would necessarily degrade?

A Yes, and that's exactly why I presented evidence to show that it would occur in the subsurface environment.

Q Now, on your third point citing Wilson and McNabb and Bouwer and McCarty, they said aerobic biodegradation of benzene, toluene, and related organic chemicals, occurs in the subsurface, again in an attempt to convince us that you have looked at real world subsurface conditions, but in fact, the Bouwer and McCarty article did not study benzene and toluene in the subsurface here, did it?

A Right, they -- they studied it under methanogenic type conditions that could possibly occur in the subsurface, but in the others, all the other studies we've done, we've collected aquifer material and subsurface material from the environment and used that for all of our studies.

Q But the Bouwer and McCarty article, which you cited for this proposition, involved a situation where they actually studied ethylbenzene and styrene in a biofilm reactor again in a controlled laboratory situation.

A Yes, that's correct. In that article they were looking at that type of experimental set-up and part of the reason for that was because it's difficult to obtain those type of conditions. We now can do it, but the only way to set up those kinds of anaerobic conditions was by the technique that they used.

Since then we have found methanogenic

conditions in the environment using -- using actual aquifer material, and it confirms their results.

Q And Boywer and McCarty used acetate as their primary substrate to support bacterial growth in their biofilm reactor.

A Yes.

Q And acetate isn't usually found in produced water, is it?

A Not to my knowledge. It's just an organic substrate similar to the other organic chemicals that are in produced water.

Q And it seems to be that Wilson and McNabb's references to benzene degradation ranged in the solids. I believe they --

MR. CARR: I'm going to object. This is argumentative. If the counsel would like to make a closing statement or call a witness to testify she certainly may do that, but her opinion is not appropriate. She may cross examine the witness and reserve here comments for an appropriate time.

MS. PRUETT: Sir, this witness has made what I believe are overstatements and I'm trying to pin him down to exactly where he got his information and to point out inconsistencies within the material he himself has cited.

MR. CARR: These are argumentative questions. When counsel stands up and says, "I don't

believe this ..." and starts arguing with the witness her line of questioning is inappropriate, and I'm objecting to it and requesting that you rule so that she will cease from further questions of this nature.

MS. PRUETT: I would be happy to remove my own statements and my interpretation and I will rephrase my question (inaudible.)

MR. STAMETS: Ms. Pruett, if you would rephrase your questions that certainly would help.

MS. PRUETT: All right.

Q Isn't it true that Wilson and McNabb have stated in their bulletin here that their references to benzene degradation are, quote, the authors' opinion, unquote, and were based on, quote, cautious extrapolation from the behavior of these compounds, and, quote, from the authors' admittedly limited experience with their behavior in the subsurface environment, unquote?

A Yes. They said that because we have not sampled everywhere in the world and there's only a limited number of places that we've sampled.

They cited at that time, I would say, what, one, two, three, four, five different sites throughout the country. Since then we've sampled four or five other places to confirm their -- their studies.

It -- we've only looked at a limited number of concentrations, but we've looked at concentrations that are in the range of concern for this hearing.

We also almost, I would say all of the aquifer material that they did study was similar in nature. It was all sandy, low organic carbon content, from river alluvial type deposits, very similar to the San Juan Basin here.

So they were saying that they can extrapolate this to all subsurface environments because there's -- there are many different types of subsurface materials and environments but fortunately, the types of materials that they used for their studies is very similar to the types of materials of concern here.

So it's highly extrapolative. You can extrapolate it very easily, I think.

Q Also their exact words were "cautious".

A Right.

Q In the Winograd and Robertson article they cite examples for the proposition that aerobic conditions and microbial metabolism would be expected in the unsaturated zone as well as ground levels.

Didn't they end their abstract with the caveat that these assumptions must be tested on a, quote, case-by-case basis, unquote?

A Yes, and everywhere we've looked in the shallower subsurface in our own studies, we've found dissolved oxygen concentrations at least two milligrams per liter, typically four or five milligrams per liter.

We haven't done something similar to them

in the deeper subsurface but everywhere in the shallower subsurface and in alluvial type material we found similar dissolved oxygen concentrations.

Q Now the Reinhard and Goodman study, benzene wasn't observed to be biodegradable, was it?

A No, I don't believe so.

Q And in the Reinhard and Goodman study, indeed, wasn't the adsorptive capacity of the aquifer for benzene exhausted in that study?

A I don't think that he stated it was totally exhausted but that that was one possible interpretation to some of his data.

Q Didn't they state in that article that the only observable attenuation mechanism for benzene that appeared to be operating was hydrodynamic dispersion?

A I don't recall that specific statement from his article, but I recall other statements from his article that he did indicate that biodegradation of some of these chemicals was one possible interpretation of his results.

Q For the other compounds but not necessarily for benzene.

A Not necessarily. I don't recall that statement in there.

Q Now in your article on -- on the last paragraph of page 1, you state, quote, in fact, degradation of these two organic chemicals, benzene and toluene, has oc-

curred every time they have been tested with subsurface material, close quote.

But isn't it true that one of the references you submitted (not clearly understood) showed that there was no significant biodegradation of benzene in alluvium from the flood plain of the South Canadian River?

A That -- I'll have to turn to that and look, although I'll have to say that -- that -- that Barbara Wilson is one of my students and in verbal communication from her, she has found anaerobic biodegradation of benzene but it hasn't been published yet.

MS. PRUETT: Mr. Chairman, I would suggest that that remark be stricken as hearsay.

MR. STAMETS: The Commission will recognize the remark as hearsay.

MR. KELLAHIN: Mr. Chairman, I might point that there's a well recognized exception to the hearsay rule; that an expert witness may rely upon hearsay evidence upon which he may reach a conclusion and, in fact, that's what Dr. Miller has done today. That's what all the other experts do before this Commission, because they don't go out and do all the actual research themselves.

It's a well documented exception to the hearsay rule and we believe his comment is appropriate.

MR. ELMER: Counsel, doesn't that refer to printed materials which the expert utilizes in

preparing his expert testimony and not to oral statements made?

MR. KELLAHIN: I believe it's broad enough to include oral statements made to this expert. It's the custom and practice of this Commission of broaden that exception to include not only documented evidence upon which he relies but the verbal testimony or evidence he receives verbally or orally from others.

It would be a significant departure from the practice of this Commission to now exclude that type of evidence.

MR. ELMER: Well, I can only make my recommendation to the Commission that oral testimony relied upon by an expert be excluded, because the affiant is not before the Commission for examination and that the Commission should limit its admission as to the written materials which the expert relied upon in forming his testimony.

MR. KELLAHIN: That's a difference without being a significant distinction, Mr. Chairman, because the written testimony or report from someone else, that person is not here to document it, either.

MR. STAMETS: No sense in protracted legal argument here. We will allow the answer to remain in the record and we will take it for what it's worth.

Q Aside from any hearsay or oral testimony, the reason I asked that question is this quote in the Rees

abstract, quote, toluene degradation was apparent after 6 weeks; after 11 months the toluene concentration was reduced at least an order of magnitude. There was no significant degradation of the other aromatic hydrocarbons. Close quote.

Benzene is an aromatic hydrocarbon.

A Right. That -- that's a good point. I was going -- intended to add to that is that's where you have to be really careful in -- in looking at information about the anaerobic degradation of these compounds because what happens when the aquifer material and the microorganisms under anaerobic conditions have been experienced and been exposed to these types of chemicals, there is a long adaptation period and typically we find the adaptation period, we would expect it to be six months, maybe a year.

So many researchers have studied these chemicals under anaerobic conditions, studied them for a month, said they didn't go away, so we give up, they don't degrade.

More recently we have been taking the approach let's study them for longer periods of time. When we initially expected it would take nine months, a year, maybe a year and a half before we'd see something happen, when degradation does occur under anaerobic conditions, it's usually very rapid, and I would say that most of the researchers I've talked to, including my (coughing, not audible) has

been surprised that the period of adaptation under the anaerobic conditions was much shorter than he expected. And so when we say that benzene didn't degrade in this experiment, it only pertains to the period of time that they studied it. The next month the adaptation period for those micro-organisms may have, you know, occurred and degradation occurred rapidly.

So there are time consuming difficult experiments under anaerobic conditions, and so when degradation does occur, then that's pretty positive evidence, but when it doesn't occur, that doesn't mean it won't occur.

Q The next thing I wanted to look at was reference Figure 17, reference (17), the J. J. Perry exhibit.

A Uh-huh.

Q And I didn't find where that reference fit in your -- in your summary article. I imagine it's someplace on page 2 and I think perhaps the second full paragraph, before (16) is cited and after (17) (18) is cited.

Well, could you tell me exactly where (17) fits in there?

A Fits in there? It really fits in the paragraph "The aerobic degradation pathways. . ." that starts out that way.

Q That second full paragraph, okay.

A Yes.

Q Okay. I have a copy of this article which I'd like you to take a look at in the Petroleum Microbiology book.

Is this the article you were referring to?

A Yes. I believe that -- this is the book where the degradation pathways were taken from.

Q Could you read the title of that for me?

A "Microbial Metabolism of Cyclic Alkanes".

Q Are benzene and toluene cyclic alkanes?

A No, they are not. They are aromatics.

Q Can I direct your attention to the next article in that textbook, which is marked (not understood)?

Would you read the title of that one?

A "Microbial Transformation of Aromatic Hydrocarbons."

Q Would you just flip through that and take a look at it, because I've looked at both of those very carefully and I wonder if that Cerniglia (sic) article is the one that you were actually citing? I think I recognize a few of the pictures in there and the references they used having your Figures 1, 2, and 3.

A Yes, I believe you're right. You're right. It was from the Cerniglia (sic) article.

Q And not --

A And not Perry. That is a mistake, right. But the information is still the same. It's just an improper citation.

Q Yes. Well, we would correct that in the record. The author of that article is C. E. Cerniglia, C-E-R-N-I-G-L-I-A.

MR. CARR: Mr. Stamets, we'll certainly stipulate that if we've got the incorrect citation to that chart, that that can be corrected.

MR. STAMETS: We'd appreciate it if before the hearing concludes that be corrected in our copies of the exhibit.

Q And those Figures 1, 2, and 3 attached to your essay, they come from that article?

A I'm not sure which figures you're referring to.

Q Figures 1, 2, and 3, the aerobic pathways of toluene.

Figure 1 I think you said came from your own research.

A Yes, Figure 1 --

Q The other two --

A -- is my research, right.

The other two are directly from that.

Q Isn't it true, then, in Cerniglia's conclusions, he states, quote, little is known if these reactions occur under environmental conditions?

A Yes. By his research most of this information is from laboratory studies and they're well known degradation pathways, but it is another matter to extrapolate

this specifically to the subsurface environment, or to the environment in general. It's very difficult because these metabolites often occur at levels that are below our capability of detection under environmental conditions. So that's why we have to do it in the laboratory.

Q With the caveat that they may or may not occur environ -- under environmental conditions.

A Right. We would -- we would expect that and we have -- we're attempting to document that but we haven't been able to document that these are the pathways that actually occur in our samples. Right, that's one of the subjects of our current research.

Q In your references (19) and (20) and the evidence for anaerobic degradation, isn't it true, however, that in both of these studies benzene was not observed to be degraded significantly, if at all?

A Yes, I believe so, in both of those studies it was not observed to be significant. Again I'd have to refer to the communication of my student and the fact that there's a long adaptation time under anaerobic conditions.

MS. PRUETT: We would make the same objection to this communication with the student.

MR. STAMETS: If you did, we'd make the same ruling.

Q In reference number (20) it was demonstrated that sometimes microbial transformation (not under

stood. Isn't that true?

A Yes, that could be true.

Q Okay. In the last paragraph of your abstract you state that the rate of degradation of benzene and toluene and other organic pollutants is quite rapid, but in fact you've presented no data other than the special laboratory situations showing the rapid degradation of benzene and toluene, isn't that correct?

A Yes. I didn't present any field evidence in my studies. The rest of the, you know, I could talk about other studies that have shown rapid degradation but I didn't show -- present that in this exhibit.

Q And the authors of your only real life study, the Reinhard and Goodman study, advocated a site by site analysis of the effects of biodegradation.

A Well, I would -- I would not agree that they are the only real life study. I --

Q Do you know --

A -- think all these are real life.

Q -- I'm sorry.

A Because they all use -- well, most of these, if not all of the articles, use actual aquifer material, real environmental micro-organisms that do occur showing --

Q Yes, but the only one, the only study that was done in field conditions.

A Right. So state your question again.

Q The authors of the only field study, Reinhard and Goodman, advocated site by site analysis before predicting the effects of biodegradation.

A I would say that they're not the only one that was a field study because in many of these we go out and we -- in the field and collect material, so it's field and laboratory combined study, and theirs was probably the only one that was totally conducted in the field.

Q And did they not advocate site by site analysis? I would direct you --

A Okay.

Q -- to their --

A Before I say they did, I'd like to see it.

Q -- to their first sentence on the lateral distribution paragraph on page 955 where they state, the principal attenuating processes for an organic compound, dispersive dilution, sorption, and biological degradation cannot be evaluated individually in the absence of mass balance data, indicating both dissolved and sorbed concentration as a function of time.

On the basis of water concentrations alone, data interpretation is ambiguous...

A I still didn't see where you read that from.

Q Page 959.

A 959, I'm sorry. Okay. All right. They

indicated on the -- only in the absence of mass balance data, right, that that would be true.

Q I wanted to turn back to your comments on Dr. Rene Schwartzman.

A Schwarzenbach.

Q Schwarzenbach, thank you. I remembered Switzerland.

Did you discuss with Dr. Schwartzman the method of sampling used?

A Yes.

Q I'm a little confused about Mr. Kellahin's quotes from Dave Boyer on the aerobic, anaerobic environment. Was that from page 84? Because I want to ask -- reread that and see if you agree with his statement starting a little earlier than Mr. Kellahin started, and I'm starting at line 20.

Degradation, but, in other words, usually bacteria can act on this stuff in an aerobic environment.

A Right.

Would you agree with that?

But then at line 24 he states, in an anaerobic environment it's a different story and degradation occurs, only occurs slowly in anaerobic environment.

Would you agree with that statement?

A I would agree initially that that's true until adaptation occurs and then it's very rapid, and in this type of a case, if anaerobic conditions were to occur

in the -- in the pit area, I would expect that there would be a period of acclimation certainly less than a year, I would expect, and then there would be rapid degradation of these compounds.

Q You were asked whether a concentration of 3.5 milligrams per liter I think of benzene at 5 barrels per day appeared not to be enough to overwhelm micro-organisms. Can I assume from your statement that a higher concentration might?

A The only times I've seen where it has has been much, much higher. Most of the cases I'm aware of where there has been an overwhelming, it's been a spill of gasoline or -- or large amounts of hydrocarbons, like several hundred gallons, or thousands of gallons. In that case, it would overwhelm the system.

Q Produced water contains not only benzene but many other chemicals that could work on the depletion of oxygen.

A That's true.

Q So a volume exemption without site specific information on concentration and numbers of chemicals present may not in fact provide site conditions where micro-organisms are overwhelmed.

A I would say that from what we know, that it seems that there is a reasonable level that we should be able to arrive at where there would be a volume that at the given concentrations that's low enough, and without evidence

that the system has been overwhelmed, I don't see how we can, you know, it seems to me that the preponderance of the scientific information is that -- that these mechanisms do attenuate and are adequate to protect the environment.

Q But without evidence of the concentration level, you can't say that for a -- for a fact.

A Well, we do know what the concentration levels are, so I don't know exactly what you mean.

Q We do in specific cases, site studies, but we don't know every produced water pit in the San Juan Basin.

A That's true. Nobody has gone out and studied every pit, to my knowledge.

Q Thank you.

MS. PRUETT: That's all.

MR. STAMETS: Other questions?

Mr. Chavez.

QUESTIONS BY MR. CHAVEZ:

Q Dr. Miller, were the static flask tests that were used on benzene and toluene biodegradation similar to the hydrologic conditions in the San Juan Basin?

A No, not at all. They only indicate the potential for degradation of benzene and toluene but the types of studies that -- that we have conducted and were cited in the other materials would be similar to the conditions that would occur in the Basin.

Q I beg your pardon, the last part you said, what would be similar to what occurs in the San Juan Basin?

A The other types of studies that were mentioned point -- point three, mainly point three, aerobic degradation of benzene and toluene and related organic chemicals occurs in the subsurface.

Q Dr. Miller, in the type of inductive reasoning that's used when going from laboratory conditions to actual environmental conditions, isn't there a rationale that would dictate or demand that some site specific data be available before you would deduce from laboratory experimentation?

A If it was purely a laboratory study, yes. In our studies we took material from the field, brought it into the laboratory. Of course --

Q From the San Juan Basin?

A Not from the San Juan Basin, from throughout the country.

Q Do you believe that nine samples throughout the United States would be significant enough to give you a better than ninety percent chance of certainty or correlation with the San Juan Basin?

A I would say when all the studies indicate the same thing that that's pretty strong evidence. We don't have evidence to the, you know, contrary. If it was 50/50, then that would be different, but these -- these experiments

are very time consuming and costly. Like I said, my own study funded at -- at $850,000 alone. So, you know, in the time that we've had.

The Tabak report, if I get the dates on it correctly, occurred in 1981, so only in 1981 were we really starting to address the question are these chemicals degradable in the environment.

So it's only been since 1981 that we've had time to go out and do these experiments, and at all the sites we've looked at since that time we found consistent results.

Q So the experiments that Tabak did, would that be more relative to, say, the single chemical, or say, benzene spills, than it would be to the continual condition of benzene in the system?

A I don't know if I'd say more relevant. How I used this paper is to indicate the potential for biodegradation of these contaminants in the environment, and then the need is to go to more, you know, the particular type of environment that you're concerned with to examine those chemicals in that environment, and that's what I tried to show in the remainder of the points that I made; that we did indicate the potential for the biodegradation of these things and then went to actual subsurface material to demonstrate that it occurs in the subsurface.

Q In a single discharge incident but not in a continual charging incident.

A We -- I used both static and column experiments and mixtures of chemicals, as well as chemicals singly experimented.

Q Would there be a point at which the stabilization would be reached that all the microbes would be eating all the benzene that they could and yet there'd be benzene bypassing them to a certain extent?

A I think that that's -- that's possible, yes.

Q Are you familiar with any incidents where there is or has been benzene and toluene or any other petroleum products polluting groundwater?

A Yes.

Q Under those situations would there be conditions existing that did not allow the biodegradation to take place over a certain period of time?

A The only cases that I'm aware of where that has occurred is when there was large volumes and rapid release of pollutants in usually pretty highly concentrated forms, much higher than anything we're talking about here.

Q We've been hearing a lot of words like "rapidly", "large amounts", and "certain periods of time", is that the study you're working right now to develop the idea of quantification of times, strengths of biodegradation of these materials?

A That's true. We're further -- further identifying the rates and the quantities, but what I mean by

large amounts, I'm talking about large spills, like -- like gasoline storage tanks, thousands of gallons released in a matter of hours; most cases where the system is overwhelmed.

Other cases where gasoline storage tanks appear to be leaking pure gasoline, let's say, five or ten gallons per day of gasoline itself, then -- then the system can become overwhelmed.

Q Do you have any comments as to the biodegradation that may have taken place in shallow oil reservoirs that are located 100 feet, shallow, would they be subject to biodegradation?

A It appears that in those -- there is a potential for some biodegradation there, although it appears that in that case the concentrations are limiting and the environmental factors are limiting to biodegradation, and -- but there's a lot of discussion on that matter.

Q What happens to the oxygen that you say is in the ground once the materials start entering the ground and start the biodegradation process?

A It's one of the -- it's utilized in the biodegradation process under aerobic conditions.

Q So after a time period, then, the oxygen would be eliminated?

A I would be eliminated if there's no further addition of oxygen and the concentration of the organics is in excess of the available oxygen.

Q Are you familiar enough with the hydrol-

ogy in the San Juan Basin to say whether or not there would be additions of oxygen to the system?

A I would think that, yes, the groundwater recharging the area would -- would most probably contain additional oxygen, although that recharge rate is probably fairly -- fairly slow, and then the oxygen contained, or the water from the pits would also contain oxygen and promote an aerobic environment generally.

Q Would there be conditions existing -- well, let me put it this way.

What conditions would have to exist before you would recommend that, say, Northwest Pipeline, your client, not install an unlined pit in proximity to a water well?

A Well, I haven't -- that's really not my -- my task to make that kind of recommendation here.

Q No, but what criteria would you consider should you be asked a question like that, hypothetically.

A Well, hypothetically, if you press me on it, I would say first of all there needs to be direct evidence that -- that there is contamination of water wells and secondly, that -- that the water wells are in very close proximity to the pits. I hesitate to say exactly what I mean by "close" but I would say that if the water well is more than 100 yards, I would think that that is likely to be a pretty good safety factor.

Q In your recommendation with regard to

pollution under direct examination you said you thought that small -- discharges of small amounts of produced water posed no danger to groundwater.

Is that conditioned upon your knowledge of the depth of groundwater in the San Juan Basin?

A I don't know what you mean by conditioned upon that.

Q Well, I'm trying to get --

A From what I know about it, yes.

Q I'm trying to get back to my previous question.

Before you would recommend that a pit not be installed or a well not be drilled, would you have to know how much water, produced water, was being discharged to the pit, the amount of benzene, toluene, other constituents, the depth of the groundwater, the microbiological analysis of the soil beneath the pit, and this type thing before you would recommend that a well be drilled or not be drilled near a pit?

MR. PEARCE: Excuse me, just a minute, I apologize, I did not understand that question.

Are we talking about him recommending whether or not to drill a water well?

MR. CHAVEZ: Drill a water well or install a pit, either one.

What type of pit?

MR. PEARCE: Well, you're ask-

ing the question. You choose.

MR. CHAVEZ: Okay.

Q If your client wanted to drill a water well in proximity to a pit, for water production, would you evaluate the distance to the depth, the distance of the well from the depth of the groundwater and the type of microbes, do a microbial analysis of the ground before you would make the recommendation to him?

A I don't think it would be necessary to evaluate the types of micro-organisms that were there.

I think if the pit was in the groundwater that might be of concern, but if -- if it's not intercepting the water table, then I don't think that that -- I think that degradation processes that occur in the unsaturated zone, that continue to occur in the saturated zone, would provide adequate safety.

Q Even if the pit was -- had 10 barrels of water a day put into it at the --

A Well, I'm talking about, yeah, again, the types of concentrations that, you know, we've been hearing about and the -- in the range of let's say 5 barrels per day.

You know, just -- not scientific opinion, but my own just personal judgment, I would say that that seems reasonable.

Q Even if the water table was one foot below the bottom of the pit?

A There would be a very active zone of degradation there that possibly might be adequate; that's difficult to say 1 foot, you know, give or take an inch.

But if it was -- I would say it would be of concern if it intercepted the pit.

Q What conclusions do you draw about the effects of biodegradation from the evidence that was presented in the last hearing by Dr. Zaman?

A You mean the excavation that he undertook?

I don't -- I don't see anything that contradicts in what he said because he didn't demonstrate that there was contamination from the pits, in my opinion.

Q But there was benzene, toluene in the groundwater a distance from the pits.

A He -- he presented -- he did not use good sampling techniques or sample handling techniques in collecting those samples and in transporting them to the laboratory and the method of excavation, the contamination could have occurred during the method of excavation, if you want to, you know, press me on that, so I -- I can't say that the benzene and toluene came from the pit. It could have come from his backhoe. It could have come from some other source in the area.

So it's difficult to draw conclusions from that.

Q If it came from any other source besides

being introduced by the backhoe, what conclusion would you draw?

A I can't draw any particular conclusions because I wouldn't know the concentration that it was being introduced and from some other source, and I wouldn't know what rate it was being introduced.

MR. CHAVEZ: That's all the questions I have.

MR. STAMETS: Any other questions of the witness?

Mr. Taylor.

CROSS EXAMINATION

BY MR. TAYLOR:

Q I just have a few questions for you, Dr. Miller.

Starting out with your first page of Part 6 of the exhibit, your first paragraph says that benzene and toluene are readily biodegradable by micro-organisms.

Are they equally biodegradable?

A Well, by looking at the Tabak paper, it appears that the -- in his study, that the, as I indicated, that toluene is more readily degradable under aerobic conditions than benzene.

Q In the article by Tabak was the degradation of benzene and toluene considered aerobic type degradation?

A Yes, I believe he considered it to be aerobic.

Q Then would you consider the results to be reflective of what would occur in anaerobic conditions, especially with the rate of degradation?

A No, I didn't try to say that it would be.

Q In the article by Wilson it was maintained that aerobic degradation occurs in the groundwater. Does this degradation rely on a monod or Michaelis-Menten type of rate relationship with respect to oxygen, and given a constant nutrient source, such as benzene, and a limited supply of oxygen, would the degradation rate deline over time?

A I could ask you to explain it, but their information doesn't address kinetics.

We're -- that's the subject of our current research to define your question.

Okay, they just measured the rate of disappearance but they didn't define the kinetics and you're trying to ask which type of kinetics it was and that hasn't been defined.

Q Would you care to comment -- I don't know since your answer wasn't really yes or no -- but do you care to comment on the magnitude that aerobic degradation would have in a saturated zone where a pit would supply large amounts of benzene or toluene to the saturated zone daily but only small amounts of oxygen?

A Well, that's a hypothetical case that -- that if that were to occur, then -- then it is possible that the degradation possibly could exceed the oxygen concentration, but we must keep in mind that the transport in most subsurface environments is very slow, so there's a long residence time, and there is a consortium of micro-organisms that exist.

So -- so that's a hypothetical situation I'm not sure exists.

Q Do you know what the transport time is in the San Juan basin?

A No, I don't, haven't measured it.

Q Could it be that if the transport time in the San Juan Basin is faster than the average -- or faster than most, at least, in the example that you cited, that these models would not hold?

A We -- I studied similar type material with rapid, fairly rapid transport, and found rapid degradation within a matter of 18 inches in my laboratory columns, so essentially complete degradation within about 18 inches under fairly rapid transport rates of about 2 inches per day transport, so I -- even in the saturated zone I would expect pretty rapid degradation even under fairly rapid transport rates.

Q Would the micro-organisms have a preference for straight chain compounds over aromatic compounds, and how about a preference for phenols over benzene?

A Some micro-organisms might, but I would expect that, yeah, they would have some preferences for, like for example, phenol is very rapidly hydrolized and biodegraded in the subsurface environment.

Q Then if the produced water had large quantities of straight chain compounds or phenols the rate of benzene degradation would be decreased.

A Not necessarily because there is the process called secondary utilization or secondary metabolism where actually the combination of chemicals can -- can result in an increased rate of metabolism versus if there's only one compound that exists.

So it's not necessarily the case.

Q But it could be the case.

A I've never -- I don't think I've observed that. I'm not sure of anybody -- of any evidence of that.

More commonly there's the secondary metabolism or secondary utilization, the co-metabolism concept that occurs.

Q Have you actually done any rate modeling on discharges of 5 barrels per day with 20 parts per million benzene concentrations with respect to biodegradation, and if you have, have you compared these to actual field data or to the studies that you've cited?

A That was the last point in my testimony that I was making, is that the models do not exist to accurately do that; that we are trying to develop those.

The models that exist don't accurately account for biodegradation in the subsurface and we're trying to modify some models and incorporate accurate microbiological processes at this time.

Q You mentioned that adaptation to anaerobic conditions is required. Does this mean that during this period of adaptation biodegradation does not occur or at least is not a major contributor to attenuation?

A I would -- I would -- that's hard to say. I don't know that there's enough evidence to say one way or the other on that.

I would -- I would speculate that there would still be some small rate of degradation that would occur, but it's hard to say what that rate would be.

Q How long does this adaptation period take?

A It can take anywhere from a couple of weeks to -- to multiple months; maybe a year in some cases, although, as I said before, that we've been surprised to date that the acclimation period was less than what we would have predicted by our surface microbiological studies.

Q What happens to benzene and other organic hydrocarbons during this period of adaptation?

A Well, the other attenuation mechanisms will continue to play an effect and there may still be uptake by micro-organisms and not degraded, but we're still studying that.

Q Say we go back to our example of 5 barrels a day every day, and we're in an anaerobic environment, what's going to happen during the ten or eleven months that it takes for that environment to come around to those 5 barrels a day --

A Well, you're assuming an anaerobic environment and I'm not sure --

Q Yes, I am, and I want to know what's going to happen in that -- in that environment during that time.

A Well, I'm not sure that an anaerobic environment would exist so I don't think it's --

Q Do you think there --

A -- necessarily pertinent to this.

Q Do you think there may be no such thing as an anaerobic environment?

A Sure there is, but not under these conditions necessarily.

Q Let's see, if long adaptation times are required for anaerobic bugs to be established, what effects would changing conditions have on the time to get anaerobic organisms established to survive?

A I don't understand the question.

Q Well, let me give you an example of a changing condition to be high flow of produced waters during one part of the year and not during other parts of the year; high flow during the summer and then no flow during the win-

ter, very small flow.

A We're studying a landfill site that exactly exhibits that and once the organisms have been adapted, they've been exposed to pollutants during one season, they've adapted, the next season comes along, they've readily adapted in a matter of days.

So their adaptation rate in subsequent seasons is very rapid under anaerobic conditions.

Q So you don't think this would have detrimental effects? I don't understand these organisms, but for instance, if there were a lot of them that adapted during the summer season and then there was no produced water coming through, or very little, during the winter season, they wouldn't die off or disappear?

A That's right. They seem to undergo maintenance, you might say, during that time, and to very rapidly reactivate their metabolism.

Q So there would be no period the next year of having to re-establish.

A It would be a much shorter period, very short period, from all the evidence we have to date.

Q Could a combination of these various conditions we've been talking about prevent degradation from occuring under the optimum conditions presented on your models?

A Under the optimum conditions presented.

Q While you're --

A It is conceivable that something could happen to --

Q Right. I mean your models seem to say that there's -- essentially you said during the last part of your direct examination that there is -- we don't have to worry.

MR. KELLAHIN: Mr. Chairman, I'm going to object to that question. I've resisted for some time and I can resist no longer.

An expert is not -- it's not appropriate to address a question that calls for this expert to speculate.

He is to be addressed questions on the reasonable probability of occurrence of some given facts or circumstances.

Mr. Taylor has asked this witness whether something might possibly happen under some conceivable set of circumstances which Mr. Taylor is unable or unwilling to describe. That calls for a speculative answer by this expert and it is not appropriate it.

We object to it.

MR. STAMETS: Mr. Taylor, will you be more specific?

MR. TAYLOR: Mr. Chairman, I don't think I was speculating. I was asking the witness if the models that he has presented to us are always going to work and whether that's speculation or not. I don't know.

but he's saying that he's got this model and under various situations degradation is going to make it such that benzene and other organic hydrocarbons are not going to reach the water table, and I'm just asking him if under all situations this was going to work.

He has not told us what specific situations it is going to work under, but I'd like to know if it's always going to work.

MR. KELLAHIN: That is my exact objection. This witness does not have to testify that a model will work under all situations.

He needs to be asked the question what are the situations in which the model is tailored and what is the reasonable probability of that model working to some reasonable degree of accuracy in a given fact situation.

We're still speculating.

MR. TAYLOR: Mr. Chairman, I guess we don't need to argue about this because my whole point is that we really don't know. These models are merely laboratory models and what we want to know is about the real world in the San Juan Basin and what's going to happen, so I'll withdraw that question.

MR. ELMER: I don't think the Chair has made a ruling yet.

MR. STAMETS: Since the question was withdrawn, we won't.

MR. TAYLOR: I think that's all the questions I have.

CROSS EXAMINATION

BY MR. STAMETS:

Q Dr. Miller, you have used the words "may degrade" and I presume "may degrade" also implies may not.

A I'm not sure which exact context you're referring to.

Q Well, many, many times in here you've talked about benzene may degrade under anaerobic conditions. Toluene may degrade under anaerobic conditions.

You have not said it will degrade and I'm concerned about that, whether or not may implies that it may not.

A There is a limited implication there but what I -- the reason I've said "may" is because -- because we have had limited experience with that. The techniques have only recently been developed for studying anaerobic conditions in subsurface material.

Okay, as I said, we only started addressing this about 1980 and we've concentrated most of our efforts on the aerobic environment until about the last year, and under anaerobic conditions there is mounting, increasing evidence that these types of chemicals are degradable, but we haven't studied a wide variety of aquifer material from across the country and -- but some of the material we have

studied from alluvial aquifer material in a landfill in Norman would indicate that these are degradable under hathanogenic and other anaerobic conditions, given, you know, the micro-organisms appear to be adaptable to them over actually a shorter period of time than we initially expected them to be, and so there is some indications that -- that degradation of these can occur under anaerobic conditions but there's a lot more research needs to be -- be done to say, yes, it will occur in all cases.

Q Can I paraphrase that by saying this is an area of science which is immature and there are fewer certainties?

A And there -- what was the last part?

Q Fewer certainties?

A Fewer certainties? Fewer certainties than the aerobic, yes.

Q I believe that the record does indicate that we have had one, at least one case in the Flora Vista area where a municipal well was contaminated by benzenes and other organics. There doesn't seem to be a whole lot of cases in an area as large as the San Juan Basin, but do you believe that that does indicate that it can happen?

A I don't know enough about it to say. There may be multiple sources. Maybe not at these pits, but other possible sources. In that case, I've seen cases where a person changing oil on their driveway lets the oil run off and it contaminated their own well, and so without direct

evidence it was from a pit, it's hard to say, and I don't know enough about that case to say that that's evidence that these pits contaminate drinking water supply wells.

Q Conversely, do we need that degree of evidence to prove that these pits are not a problem?

A Are you saying do we need to have evidence that there's contamination before we -- or --

Q Oh, now, I think that in the case I cited that you indicated a lot of things could have happened there and we just don't have enough information to say that that is for sure the reason that this well was contaminated, and what I'm asking you is, is the reverse true? Do -- do we need some empirical demonstration that in fact in the San Juan Basin the organics that are being produced with fresh water, with the produced waters there, are being catalyzed, converted, are not a problem?

A I think that the preponderance of the scientific evidence is that when we consider all these six mechanisms, that I would, you know, not expect there to be a problem from these pits unless there was for some reason, you know, specific evidence that indicated otherwise.

Q Dr. Miller, would it be possible to take some selected sites in the San Juan Basin and do some empirical studies to determine whether or not organics are being converted, catalyzed before they could reach usable groundwater?

A What do you mean by emperical studies?

Q What I'm talking about is taking a pit and drilling a well downstream from it, taking samples, both of the produced water and then groundwater samples throughout?

A Sure, that would be possible. We have the technology to do that.

Q Would that be better than -- than the last study?

A That would be, yeah, that would be desirable to have some of that, too. It's not -- that's a major amount of effort involved, but that -- that would be additional evidence.

Q In a situation where we have groundwater occurring from depths of just a few feet, maybe four feet, perhaps even less, to fifty feet in the vulnerable area, would several such studies need to be done to sort of run the whole gamut of possibilities?

A It depends on -- I would, if I were designing this study, I guess I would design it in stages and depending on the results of the first study, might indicate whether further studies are needed.

I would investigate the -- in what we might say the worst case conditions first and then if there was any evidence of problems in the worst case condition, then we could go to the -- to the next level of concern.

Q I believe you heard Mr. Kellahin discuss the real crux of the -- of the argument at this point is

this so-called small volume exemption. How much, what is the minimum amount that can be allowed to be produced and disposed of on the surface?

Do you have some recommendation as to a minimum disposal volume?

A Well, I hate to make a recommendation but I would state that from what I've studied and from my own research that it just seems reasonable in my opinion that at these concentrations and at 5 barrels per day, it seems reasonable.

In the absence of any contradictory, specific evidence showing, you know, direct contamination or widespread contamination, it seems like a reasonable small volume exemption to make.

Q Let's talk about the adaptation of the micro-organisms.

Let me ask you if this is what you're talking about. We've got a group of micro-organisms here that are used to eating McDonalds and they live on McDonalds, and some day a truck drives up and is full of -- well, let's -- Long John Silver's fish, and these micro-organisms initially don't much care for Long John Silver's but they begin to develop a taste for it, and given a length of time they will be able to eat both McDonalds and Long John Silver's?

A I think that would be, yeah, one example of a type of adaptation.

Q We keep hearing the phrase "the real world", "the real world", "the real world". What is the extent of your study of the San Juan Basin, its hydrology and formations and soil types?

A Only from reading about it. I have not ever collected a sample in the Basin or drilled a well myself in the Basin.

Q So based on your testimony, do we have in the record a real world analysis of what is happening in the San Juan Basin?

A I think we do in the sense that we studied the same types of material and same types of chemicals of similar concentrations. We used actual aquifer material. We didn't use, you know, sand or we didn't use soil material or some synthetic material. We used actual aquifer material, similar composition as would occur in the San Juan River Basin, and the same types of chemicals.

So I think it's about as real world as you can get without actually going out, you know, to the San Juan Basin and doing it, but I would expect the same types of results. I don't have any reason to believe that we wouldn't see the same thing.

Q If we had this theoretical pit out there which was receiving 5 barrels of produced water per day, let's just say that the groundwater was at 5 feet, how long a time would it take before we would have a real world demonstration that in fact the theories put forth here today

are working in the San Juan Basin?

A You mean if we went out and actually collected samples and did some research?

Q Yes.

A I would -- I would say that based on my current research that it would be something like eighteen months of field and laboratory work.

Q How many dollars?

A Well, my current research, that would constitute about half my current effort, so it would be in the neighborhood of $400,000 to $500,000, for one site.

MR. STAMETS: Any other questions for this witness?

Mr. Chavez.

QUESTIONS BY MR. CHAVEZ:

Q Dr. Miller, can you state that your client's wells are not introducing benzene and toluene into the groundwater in the San Juan Basin?

A I cannot state that with certainty, but what I can state, that even if some is getting to the groundwater, that degradation of those chemicals is most probably occurring even in the groundwater.

Q But you cannot say --

A With certainty that there is none anywhere, because I haven't sampled them all.

MR. CHAVEZ: I have nothing

more.

MR. STAMETS: We'll take about a fifteen minute recess.

(Thereupon a recess was taken.)

MR. STAMETS: Any other questions of this witness?

Mr. Shuey.

QUESTIONS BY MR. SHUEY:

Q Thank you, Mr. Chairman.

Dr. Miller, for give me if I mis-heard or let's say you mentioned during the establishment of your credentials you were calling off things you've done.

I'm interested in the studies you repeatedly said during your testimony and cross examination, you called "we" or "our" studies, and I took that to mean those which you said you had done yourself.

I'm wondering if we go to your bibliography of your testimony here, I see one reference in that list of twenty references, Number (7), that has a G. D. Miller. Is that you?

A Yes.

Q Are there any other references in your list which you apparently overtly participated in and by that I mean that which has your name in it?

A My name is not listed as the author of several of these but I participated in the research of several of these, collaborated with several of these researchers.

For example, the first one, the second one, third one, sixth one, seventh one, the eleventh one, thirteenth one, fifteenth one, sixteenth one, nineteenth one. I've worked with those researchers and collaborate with them.

Q If we were to go and obtain some of these documents, would we find any reference to you having participated in them?

A No, I didn't help write those.

Q Okay. Correct me if I'm wrong, but I believe you said in connection with the Wilson and McNabb paper that you had helped collect some of the samples?

A Yes.

Q Okay, and then I believe that on your reference (7) that was one of the references in which you say in the second paragraph of your paper that activities of subsurface micro-organisms have been detected, so I gather that you looked at some subsurface material and the little bugs inside it.

A Yes.

Q Okay. Now, on Wilson and McNabb you helped collect those samples, correct?

A Yes.

Q Okay. Did you help perform any of the analyses?

A Yes.

Q All right, now which ones did you --

A I have studied -- my work has been primarily at the Pickett, Oklahoma site and the Lula, Oklahoma site.

Q Is there any place in this article by Wilson and McNabb in which your participation in the study is documented other than where we have your name?

A No, they didn't document it in this report. Specifically I've looked at the chlorobenzenes. It was my research they used in Table 2 for the chlorobenzenes and the phenol and alkyl phenols and the chlorophenols.

The reason --

Q Your research did not include the alkylbenzenes.

A My own specific research included toluene. It hasn't included benzene. It has included styrene.

Q Thank you.

I believe you testified a couple of times that the materials that Wilson and McNabb and yourself worked with in these studies, and partacularly the Wilson - McNabb study, were similar in composition or physical characteristics to those in the aquifer that the Committee has described, is that true?

A Right, it's alluvial material of relatively shallow water table and low organic carbon contents.

Q Is there any information in the Wilson - McNabb article that indicates that composition?

A I don't recall if they did that, they included that. It may be in there.

Q If did not have your testimony here today how would I be able to tell what kind of materials those gentlemen sampled?

A It's published in some other reports that I didn't bring with me but I could furnish those.

Q Have you conducted a -- any field study of -- let me drop that.

I believe in Wilson - McNabb's article it says in the second column on the first page, talked about the core material from several shallow water-table aquifers and associated material from the vadose zone, and I just believe that you have said that you worked at the Pickett site and the Lula site.

Could you just -- could you describe what those materials actually looked like or what their composition was?

A It's a fairly uniform, sandy, brown sandy material. At the Pickett site there's a little bit of gravelly material associated with it. It's predominantly just a brown, sandy, medium-grained sand, with a small, you know, trace amounts of clay and organic carbon content, but pre-

dominantly just a sand material.

Q Now you said that you think that the material in the San Juan River Valley is similar to that material you've described.

A What I would expect in an alluvial river basin.

Q You expect; do you have any direct knowledge?

A I've never been to the river basin to see it, right.

Q Have you ever conducted a study on the properties of these bugs being able to degrade or eat benzene and toluene under a pit in the San Juan Basin?

A No.

Q I believe you testified that you -- that a foot of material under a pit, you had characterized that as the treatment zone or active zone of treatment.

How -- have you ever taken some of that material that is under, typically under the pits that we're talking about, and done the same kind of laboratory tests these authors and yourself did to determine if these bugs eat these benzenes and toluenes?

A I just said I've never done it at those pits, so I answered the question, I think.

Q Okay, so the active zone of treatment, the treatment zone, has occurred in some of the research, but you don't know if it's occurring under one of these

pits.

A We have observed it at field sites, under field studies. By "we" I mean myself and my fellow researchers at the National Center for Groundwater Research.

We've observed it at field sites, okay, active zones of degradation that were the length of about a foot or maybe a foot and a half in length, where there was, you know, almost complete degradation of everything across that zone, and it was a similar type material, but I don't know of anybody that's gone out to this basin and done that.

Q Under pits, is that what you were just talking about?

A Yes, it was under a creosote pit in this case.

Q A creosote pit.

A Right, same types of compounds.

Q You were -- I believe Mr. Chavez asked you some questions about Mr. Zaman's study. You were here for --

A For his testimony, yes, on April the 3rd.

Q You said that his study to you didn't demonstrate as to any effect from the pit around which he dug the test holes or not, but there's any number of different factors that would cause you concern.

At least you mentioned the backhoe. What -- why would the backhoe have been of any concern in that study?

A Just oil and grease that could either be on the backhoe itself or leaking from the backhoe.

Q Uh-huh, did you hear Mr. Zaman's testimony regarding his inspection of the backhoe?

A I don't recall what he said. I heard his testimony.

Q You said that there could be a whole range of different sources for those kinds of materials in that area. What -- what could those have been?

A Could have been anything. Could have been somebody's gasoline tank that was leaking from their car. I mean you can speculate anything.

Q Okay. All right. Now I'm going to ask you your professional opinion. I'll do it the same way that Mr. Kellahin did.

Let's assume for instance that we have a pit that's sitting there, okay, and it does receive one to two barrels a day and the benzene concentrations are typical of those that we've seen in this hearing in the evidence, and that this particular well, oil well that received the produced water did not a reserve pit or mud pit next to it, and there are no --no cars have been in the area to be leaking gas, and that the tractors involved did not have leaking oil or leaking hydraulics, and if someone went out and dug several test pits and found benzene and styrene at distances from 45 to 235 feet from the produced water pit, if there were no other sources for those materials, where could they

have come from?

A That's exactly the difficulty with doing field work, because you cannot eliminate other possible sources, and so there -- that's a hypothetical case that we can't -- can't ever say whatever occurred.

Q Then I'm puzzled about how the Commission may make a decision in this case, because I believe you testified earlier that you needed -- the field investigations would be an important way of determining the effects of this pits.

A I said that it would be added evidence.

Q Added evidence. And I believe you said that in relation to a question by Mr. Chavez, you said there may -- I quote, I wrote it down here, "There needs to be direct evidence of contamination of water wells."

With all these uncertainties involved, how could we ever obtain that direct evidence?

A It would require going out at a -- in the field, okay, and doing a series of sampling from a pit, all the way to, let's say, where there would be completely disappearance, you know, no evidence of any contamination, under very controlled conditions.

But on top of that, you know, we'd need to survey all the other possible sources in the area and indicate that if we found any evidence of benzene and toluene that was actually from that pit, not from any other pit, we'd need very good, accurate hydrogeological studies of the

area to show that any contamination, if it was found there, hadn't migrated from some other source, and ideally maybe some tracer studies.

So you're talking in that case more than half a million dollars in eighteen months for a good study.

Q But you as an expert, if you conducted that study and have eliminated all other sources and did your tracer test and came -- could you come to the conclusion, all other sources had been eliminated, could you come to the conclusion that the pit was the source of contamination?

A I guess, yes, if you eliminate all other possibilities and there was contamination, but it's purely hypothetical.

Q I believe when Mr. Stamets was asking you questions you, one of you or both of you, characterized what you did describe for me as a worst case, is that correct?

A I'm talking about a worst case being something where, let's say, the pit was in the groundwater. We might start examining those first. That to me would be the worst case, and high volumes and high concentrations.

Q The type of study you described for me, though, half a million dollars, in your experience as a researcher, government contract, Federal government contract, is that a level of -- is that a level of money that involves -- well, how often is that amount of money provided to researchers such as yourself, or researchers such the experts

for the industry or for the OCD?

A Very rarely. I'd say that my research project is one of the largest in this area in the country. There's only one that just started that's larger than that, and it's looking at the transport and fate of one chemical in a field monitoring study.

That's a multi-million dollar research project.

Q Would it be reasonable to, in your opinion, would it be reasonable to expect that an organization like the Oil Conservation Division could, or for that matter, any agency of State government in Mexico to be able to afford a $500,000 study?

MR. KELLAHIN: Objection, Mr. Chairman, there's no proper foundation laid to show that this witness is capable of answering that question.

MR. SHUEY: Well, Mr. Chairman, I think he has testified that that's his estimate of what it would cost. I'm asking him his experienced opinion given that he's gotten grants from the Federal government if that -- if that level of funding is capable for State government.

MR. STAMETS: I think that, Mr. Shuey, we'll allow the newspapers relative to the last Legislative session to answer that question and not require this witness to.

Q All right, thank you.

You said -- you testified earlier, as I

remember, in response to a question by Mr. Stamets that you thought that 5 barrels a day sounded like a reasonable regulatory level. Why is that reasonable?

A I think it's reasonable because of the -- all the scientific, you know, testimony that's been presented; that there are retardation, attenutation, dilution and degradation mechanisms in place that will, you know, be what we might call safety factors for these in the subsurface environment, and there hasn't been a preponderance of evidence that is an actual problem in drinking water wells.

Q Has there been evidence that those factors, contrary to your opinion, may be not as important, the retardation and biodegradation and those avenues that you and Dr. Schultz have testified to are (not understood) maybe made just like the -- just like the mechanisms that Mr. Boyer described, or (not clearly understood.)?

A I think on the contrary, that they're very well established mechanisms and widely -- well, there is wide recognition of these among the researchers in this area and the recognition of these, especially I'm referring to biodegradation is growing rapidly throughout -- throughout multiple scientific disciplines.

The geophysical -- the geohydrologists had a convention in California just recently, had a whole session devoted to this subject.

The American Society for Microbiology just had a whole session devoted to biodegradation of these

things in the subsurface environment.

So the recognition is coming very rapidly in a wide range of disciplines.

Q But there's still a large degree of uncertainty involved in all this, isn't that true?

A Well, I -- yeah, there's a large degree but there's also a large degree of certainty.

Q Okay, one final question is a hypothetical question, too.

I believe you testified that -- that, oh, yoiu thought that if a water well was 100 yards away or more that that would -- from a pit, an unlined pit, that that would not bother you.

Let's assume that this water well, let's assume that this pit is unlined that we talked to -- or talked about, and let's assume that the groundwater level was five feet below the pit and this groundwater level extends for -- over an area much greater than 100 yards from the pit.

If -- let's say someone came in and wanted to drill that water well and they could only afford a water well that was screened to take advantage of the shallow water table. They had no other source of water.

Let's further assume that that was your well that you wanted to drill and you wanted to use that water for drinking water. Would you drill that well and drink it?

A Yes, I would.

Q Thank you.

MR. STAMETS: Any other questions of this witness?

Let me ask one, Mr. Carr, before you do some redirect.

MR. CARR: Okay.

RECROSS EXAMNATION

BY MR. STAMETS:

Q Dr. Miller, it concerns me that -- that it's going to cost half a million dollars in your opinion to prove anything about this. I know it's not this simple, but if I was -- if I raised chickens and if I saw the roosters out there with the chickens and eggs and chickens come out of the eggs and I could say that's a chicken.

But the way you're talking, if I walked out in the country and saw a chicken that I had not raised, I couldn't be sure that that was a chicken.

Now I know that that's an oversimplification of the whole thing. I know lots of other things can happen in an area as complex as this. But it seems to me that you've seen some things out there in the testimony that look an awful lot like chickens and I keep hearing you tell me that you don't know all the facts and so that chicken may not really be a chicken.

It seems to me that there's got to be

some logical place between a $500,000 study and being able to accept what we have seen out in the field, and I'm not sure that I've even asked you a question.

Let me rephrase that. Aren't there things that can be done out in the field to make reasonable analysis, analysis that a reasonable man could use to make decisions in a matter of this case that are going to cost much, much less than $500,000?

A Well, I'll answer that two ways.

One is I would change your chicken analogy slightly. I didn't deny they were chickens but if you didn't personally raise them, you couldn't say who actually raised them, and that's really what I'm trying to say, is we don't know where that chicken came from; could have been, you know, any number of farmers in the area.

Q But secondly, I would say that if a coring and sampling project would -- at various distances from some of the pits would be possible, using accepted EPA guidelines for doing that, so far that hasn't been done by anybody that's been presented while I've been here, anyway, okay, so using EPA coring and sampling techniques just to look for the disappearance of benzene and toluene and these chemicals of concern with distance, could be done.

I'm -- that's not my direct area of expertise and I'd have a hard time saying what that would cost, but I would say half of that, half of a half a million, a quarter of a million or so. I would say it would be

in excess of $100,000, though, to do it right. Okay.

Q That is still almost like Mission Impossible. I have a hard time -- I have a hard time dealing with that.

MR. STAMETS: Mr. Carr, you had some additional questions.

MR. CARR: Mr. Stamets, your chicken analogy has sort of thrown me. It seems to me that story would be more like someone going out and looking around and not being able to find any chickens but still deciding to shoot all the foxes. I think that's maybe more what we have before you today.

REDIRECT EXAMINATION

BY MR. CARR:

Q Dr. Miller, you've talked about some very expensive figures for some studies that might shed some light in the field on whether biodegradation is taking place under certain pits. To be sure I understand that, and in response to what I think Mr. Stamets was really going for with that, the figures you were quoting, were they not for the cost that would be incurred in doing some detailed studies of biodegradation?

A Including the field sampling and the laboratory biodegradation studies, correct.

Q So aside from the biodegradation question itself, there might be some other things that could

be done at least cost.

A Right, like I said, doing the coring with distance from a pit under accepted procedures.

Q Now based on your knowledge and experience in testing and sampling water supplies, would you recommend that the Oil Conservation Division sample and analyze and study data on each pit in the San Juan Basin before prohibiting disposal of produced water in them?

A I think that would be, you know, excessive to try to do that and out of line. It's very costly to just do the analysis, much less physical sampling, but once you bring it back the analysis is very expensive for these kinds of things.

Q Do you believe there is data available in the general sense that would make that sort of testing unnecessary?

A I think so, based on the studies that we presented here.

Q Now if I understand your testimony today, biodegradation, at least as it works in the subsurface, is a relatively new area or an area now that is only being understood, is that a fair statement?

A Yes, for the subsurface environment we've only recently began addressing that, the last four or five years.

Q Now here today as part of your testimony, you've presented a number of papers. As to each of these

papers are they prepared by the leading authorities in the area on each of these subjects?

A I would say, yeah, each of these are among the leading authorities in these areas, yes.

Q Are these papers that are commonly relied upon by microbiologists such as yourself?

A Yes, and as I mentioned a little bit ago, the American Society for Microbiology just held a session devoted to this subject matter and Perry McCarty, one of the authors of one of these papers presented a keynote address, specifically on his research on this before that meeting.

Q Have you personally relied upon each of these papers that you've presented?

A Yes, I rely upon them for guidance in my research.

Q As to the conclusions that you've presented here today, have you confirmed all of these conclusions in this research with your own independent work and research?

A I would say that there's nothing in my research to counter -- you know, to counter-indicate this.

Q Now, there's been quite a bit of discussion lab studies versus field studies.

Have you discovered anything in any of your work in any of your lab studies that would indicate that the conclusions that you have reached and the information you have obtained would not apply equally in the field?

A That's right. We've observed degradation and these processes in the field environment so that the things that we've observed in the laboratory do occur in the field also.

Q Why do you -- why do you conduct these studies in the lab as opposed to in the field?

A Main reason, there are several reasons. One is it's a lot cheaper to do it in the laboratory because you can bring the material into your lab and you don't have to keep running out to some remote field site and these are quite often daily samplings and daily -- daily maintenance of the material.

We can also control the conditions in the laboratory environment. We can't controll the conditions in the field environment and accidents happen; things, you know, temperature varies all over the place. We can control the conditions in the laboratory. We have readily access and once the acceptable techniques are developed it's less costly to do the laboratory work than the field work.

But we don't rely just on laboratory studies. We also try to go out in the field and confirm in the field what we observed in the laboratory.

Q Based on your research, your study of similar situations, and your understanding of the San Juan Basin, would you just state what your conclusions -- what conclusions you've reached?

A My conclusion is that based on the

mechanisms for attenuation that we've presented and it's just clear to me why these chemicals, benzene and toluene, and related ones, haven't shown up in the water supply wells in the region, and that I wouldn't expect these pits to threaten water supply wells in the region.

MR. CARR: Nothing further.

MR. STAMETS: Any other questions of this witness?

Mr. Chavez.

QUESTIONS BY MR. CHAVEZ:

Q Dr. Miller, according to your testimony, then, actually an operator could dig an unlined pit that exposed groundwater and dump into that pit because the mechanism of biodegradation is available to not allow the pollutants to leave a certain area of the pit, is that correct?

A It's correct that those mechanisms would still be in place even in a pit that intercepts the water table.

Q Okay, then reasoning on further, we could actually dispose of these produced waters into a well drilled into the aquifer, couldn't we?

A You could do that. That would -- that would present a more immediate transport directly to the water table and as I indicated there's a very active degradation in the vadose zone and I would think it would be important to preserve that vadose zone between a pit and the

water table where possible and the direct introduction of these into the drinking water would -- would really take away that safety margin.

Q In the time constraint that you talked about in one -- one of your statements was that in one experiment the benzene was degraded within a week. I'm sorry, I don't recall the exact test that was done but --

A You might be referring to the Tabak paper where I said two weeks for benzene and one week for toluene.

Q If the water was reached, if the produced water containing benzene and toluene reached the water table within a matter of hours because of the saturated zone, not a vadose zone, I'm talking about a saturated zone below the vadose zone, then would travel, even though these mechanisms of degradation still exist, wouldn't the benzene and toluene exist out to a certain distance from the pit?

A They could, but remember that -- that we, in the sorption testimony, Dr. Schultz said -- indicated that he expected there would be a five to fifty-fold retardation for benzene and toluene in this type of material, so being retarded it wouldn't flow as rapidly as the water itself.

Q He also said there would be some kind of saturation point experienced, also.

A There could be for sorption, but if there's biodegradation in conjunction with sorption, then -- then that, let's say, that capacity for sorption would be

increased by the biodegradation.

Q How much?

A I don't know the answer to that.

MR. CHAVEZ: That's all I have.

MR. STAMETS: Ms. Pruett.

MS. PRUETT: One question.

CROSS EXAMINATION

BY MS. PRUETT:

Q I think you just said that all the things you have found in your laboratory studies you have backed up with field studies.

A We have -- we have conducted some field studies to back that up, correct.

Q Do you have any field studies which back up that toluene was 100 percent biodegraded in one week and benzene was 100 percent biodrgraded in two weeks?

A Let me think. I'd have to look at the creosote site to say for certainty that it was that rate of degradation at that field site.

Q Could you make that available to us?

A Sure. Sure.

MR. STAMETS: Any other questions of this witness? He may be excused.

We'll recess the hearing until 1:15.

(Thereupon the noon recess was taken.)

STATE OF NEW MEXICO
ENERGY AND MINERALS DEPARTMENT
OIL CONSERVATION DIVISION
STATE LAND OFFICE BUILDING
SANTA FE, NEW MEXICO

22 April 1985

COMMISSION HEARING

VOLUME 2 OF 2 VOLUMES

IN THE MATTER OF:

The hearing called by the Oil Conservation Commission on its own motion to define the vertical and areal extent of aquifers potentially vulnerable to contamination by the surface disposition of water produced in conjunction with the production of oil and gas in McKinley, Rio Arriba, Sandoval and San Juan Counties, New Mexico.

CASE 8224

BEFORE: Richard L. Stamets, Chairman
Commissioner Ed Kelley

TRANSCRIPT OF HEARING

A P P E A R A N C E S

For the Oil Conservation Division: Marx M. Elmer
Attorney at Law
Energy and Minerals Department
Santa Fe, New Mexico 87501

For the Water Study Committee: Jeff Taylor
Attorney at Law
Legal Counsel to the Division
State Land Office Bldg.
Santa Fe, New Mexico 87501

(Thereafter, at the hour of 1:15 o'clock p.m. the hearing was again called to order and the following proceedings were had, to-wit:)

MR. STAMETS: The hearing will please come to order.

Do you have any other witnesse, Mr. Carr?

MR. CARR: No, that concludes our direct testimony in this case, Mr. Stamets.

MR. STAMETS: Mr. Kellahin.

MR. KELLAHIN: Yes, sir.

Mr. Chairman, we'll call at this time Mr. Randy Hicks.

For the record, Mr. Chairman, Mr. Hicks was sworn as a witness at the hearing on April 3rd. He's in attendance today. Do you desire he be re-sworn?

MR. STAMETS: No, any person who's been previously sworn in any of the hearings to date in this case continue to be sworn.

RANDALL T. HICKS,

being called as a witness and being duly sworn upon his oath, testified as follows, to-wit:

DIRECT EXAMINATION

BY MR. KELLAHIN:

Q Mr. Hicks, for the record would you please state your name and occupation?

A My name is Randall Thackerey Hicks and I am Vice President and Director of Technical Services for Geoscience Consultants, Limited.

Q Geoscience Consultants does business in what city, Mr. Hicks?

A Albuquerque, New Mexico.

Q Do you hold any professional degrees in geology or hydrology?

A Yes, I do.

Q Would you describe for the Commission when and where you obtained your degree and the type of degree you received?

A In 1975 I received a Bachelor of Science from Beloit College and majored in geology.

And in 1980 I received a Master's degree in geology from the University of New Mexico.

Additionally I have done some studies in hydrology beyond my Master's degree.

Q What was your Master's thesis in, Mr.

Hicks?

A My Master's thesis was in the -- it dealt with the interactions between and water in terms of the chemical reactions between the two.

Q Would you describe for us what other additional educational studies you have undertaken subsequent to receiving a Master's degree?

A While working for the Enivronmental Improvement Division I assisted with many of their studies on the impact to groundwater from discharges from various industries, as well as site specific industries or industrial facilities.

I was in a -- I took a number of different courses with respect to contaminant hydrogeology and hydrogeology in general.

Q Would you describe for us what has been your employment experience with the New Mexico Environmental Improvement Division?

A With the NMEID I was a Senior Hydrologist or a Water Resource Specialist III for several years there, and the my primary responsibilities were to evaluate the impact to groundwater from discharges from industrial facilities, agricultural facilities and municipal facilities, all sorts of discharges which may have an adverse impact to groundwater.

Q Would you describe for us what has been your experience in regulatory development and implementa-

tion?

A While with the Environmental Improvement Division, along with Mr. Boyer, I co-authored the Underground Injection Control Section of the Water Quality Control Commission Regulations, that's Section 5.

Mr. Boyer and myself spent approximately one year in regulatory development toward designing a set of regulations for underground injection control in New Mexico.

Q For what period of time were you employed by the New Mexico EID?

A From 1981 to 83.

Q What was your next work experience in the field of geology or geohydrology, Mr. Hicks, after the EID employment?

A After the EID I joined Geoscience Consultants.

Q What is it that you do for Geoscience Consultants?

A I prepare and -- I supervise and prepare regulatory or rather permits, regulatory permit documents, which evaluate the potential impacts to groundwater from discharges and also make recommendations to my clients as to how to prevent any degradation of groundwater from those discharges.

Additionally we, Geoscience Consultants will evaluate certain soil or groundwater contamination cases, or potential cases, and determine how to mitigate the

situations if, in fact, they do require any sort of mitigation.

MR. KELLAHIN: Mr. Chairman, at this time we tender Mr. Hicks as an expert geohydrologist.

MR. STAMETS: Any questions as to the witness' qualifications?

He is considered qualified.

Q Mr. Hicks, you said that you were familiar with and had in fact worked in the area of administering the New Mexico Water Quality Control Commission regulations with regards to discharge plans while at EID.

A That's correct.

Q Are you familiar with the administration and implementation of those regulations concerning the levels of contamination that can be discharged onto the surface with an approved disposal or discharge plan?

A Yes, sir.

Q Would you give us a summary, sir, of how the EID Discharge Plan Approval system works with regards to the levels of contamination that a discharger might place upon the surface in relation to New Mexico Ground Water Quality Standards?

A Certainly. The bottom line of the regulation is that a discharge cannot, any kind of discharge, whether it be from an injection well or a surface impoundment, cannot cause an exceedence of the ground water standards at any place of reasonable, foreseeable future use. It

is the burden of the discharger to show the Environmental Improvement Division that the activities which the discharger conducts will not result in contamination above the standards beyond their property line.

The area of reasonable foreseeable future use has been defined by policy as the property line of the facility.

Q Under the EID administration of the Water Quality Control Commission regulations is a discharger limited to discharging only distilled, uncontaminated water?

A Absolutely not. There is, in fact, the Environmental Improvement Division will allow dilution to occur between the source of input and the property line. This has been a matter of policy and also regulation.

The -- and so the level of contaminants which can enter groundwater at any given point is in fact a function of the hydrologic regime of the area or the way it's produced.

Q In terms of obtaining a discharge permit under the process, Mr. Hicks, if an applicant or a discharger has a simple dilution calculation as one approach for the application and also has a computer model done in a way that's consistent with the methods of your science and discipline, and finally has actual groundwater monitoring, would you describe as a former regulator what the significance is of each of those types of criteria of data submitted for approval of a discharge plan?

A Typically the Environmental Improvement Division will go through three levels of review with respect to a potential discharge.

The first level of review will involve a dilution calculation similar to what Mr. Boyer presented in his testimony. It's a very simplistic dilution calculation and gives the worst case scenarios for potential discharges. It involves no decay. It permits no -- no dilution or dispersion, if you will, past the point of discharge, and if, in fact, a discharge, volumes which do enter groundwater, permit or the dilution calculation shows that it meets standards, the plan will typically be approved.

The second, if the dilution calculation, the simple dilution calculation fails, oftentimes the Environmental Improvement Division will go to a more sophisticated modeling technique, using computer models, such as random walk or others which are available, and if -- and then they take into consideration dispersion and the distance to the property line.

Other factors may or may not be considered in the computer modeling.

If at the property line the computer model demonstrates that groundwater will not be contaminated, in many instances the plan will be approved at that point.

The third line of evaluation may involve the installation of groundwater monitoring wells.

Therefore, if the evaluation test fails the dilution calculation, additionally if it fails the groundwater modeling evaluation, yet groundwater monitoring wells are put in and it passes, if you will, it demonstrates that the standards are not being exceeded, then indeed the plan would be approved. This would apply specifically for discharges which had been in operation for awhile, where the groundwater conditions would be representative of -- of what is going on in the subsurface as opposed to a brand new discharge or brand new process, one that is not fully understood, may require additional evaluation, but certainly for well understood processes or where the processes have been going on for a long period of time, this has been typically the type of evaluation which has been pursued.

Q Let me direct your attention now to the vulnerable area of the San Juan Basin under consideration by the Commission, and I want to ask you whether or not you have an opinion as to what would constitute an adequate study upon which rules and regulations can be formulated in the vulnerable area under investigation by the Oil Commission concerning the potential groundwater contamination due to disposal of produced water in unlined surface pits.

Do you have such an opinion?

A Yes, I do. There are steps which should be taken for an adequate study.

Q Have you prepared those steps in the form of an exhibit?

A Yes, I have.

Q Mr. Hicks, I show you what we have marked as Tenneco Exhibit Number One and ask you if you prepared this tabulation of requirements for an adequate study?

A Yes, I did.

Q All right, sir, would you describe for us what in your opinion would constitute an adequate study in terms and for the purposes of within the vulnerable area determining the appropriateness of a small volume blanket exemption for five barrels a day, or less, of produced water into unlined pits?

A Certainly. The first step of the requirements is to inventory the water wells and the oil and gas wells in the area to determine what is actually there, how many, where they are.

The second step is to map the areas of vulnerable groundwater that are based upon the criteria which has been well established in the literature and in hydrogeologic science, looking at the depth to groundwater, the lithology of the unsaturated zone and the transmissivity and hydraulic conductivity of the aquifer. All of these are important considerations when evaluating the vulnerability of groundwater.

The third step would be to within the vulnerable area perform a statistically accurate sampling of well sites. You need to do this in order to adequately characterize the waste that is being produced, the type of

waste, and the type of disposal practices, and there are a number of factors you may wish to gather, a number of data you may wish to gather with respect to this sampling.

Certainly I would evaluate each of the well sites, not only for the depth to groundwater, the lithology and the transmissivity, but I'd look at the chemistry of the produced water and the volume of water that is produced.

I would then analyze the data that was collected from this initial field study to determine if there are certain populations or certain groupings, categories which you can break out from this random sampling.

Then, as point number six illustrates, I would select several sites that are based upon these groupings to perform detailed field studies on. I would install monitor wells and what not.

The things that I would look at in this detailed study would be the history of the site. At each one of these individual sites I would want to know where the produced water pit is, where there may be buried pits, where there may be other sources of contamination other than the produced water pit, since we're trying to focus on the impact of produced water pits.

I'd want to look at some long term monitoring of the volume of water that has been produced at each one of these sites.

I'd want to look at some long term moni-

toring of the chemistry of produced water from these specific sites.

I would install the groundwater monitoring network that I mentioned just previously.

I would perform -- I would also install unsaturated zone monitoring network.

I would perform chemical analyses of the groundwater and any fluid from the unsaturated zone and these steps would, in fact, help me define, or they would define, the hydrogeologic site conditions in the saturated and the unsaturated zone.

And based upon the data collected from these sites and in this random sampling from which we selected these sites, I'd perform computer modeling to determine the potential impacts to groundwater and to reduce the number of field studies. What I'm trying to do here is I've selected a random sampling. I've gone out and I've visited the sites and I've collected this information. I've chosen several sites to perform some detailed investigations on, including groundwater monitoring, and then using these selected sites I would then model a larger number of sites in order to insure that we're dealing with a representative sample.

I would calibrate this computer model of many different sites with the actual field data that I had collected during my site specific studies. If the data -- if the field data permit calibration of the model, it should

include the considerations of many -- the consideration of many of the aspects that we have talked about earlier in this hearing, including attenutation, volatilization, and biodegradation.

From this data base we would then have -- it would -- then it would be sufficient to produce a order.

Q Were you present on February 20th, 1985, when the Commission conducted the first hearing in this case?

A Yes, I was.

Q And you heard the testimony of Mr. Boyer?

A Yes, did.

Q Have you had an opportunity to review his exhibits and review the transcript in that case?

A Yes, I did.

Q Do you have an opinion, Mr. Hicks, as to whether or not at this point the Oil Conservation Division has conducted an adequate study, as you've outlined for us?

A No, they have not. They have not followed these -- all of the nine steps of what I consider the requirements for an adequate study, and what would be considered the requirements of an adequate study by professional hydrogeologists and regulatory -- and people in regulatory development.

They have begun. They have conducted several -- several steps in this study.

Q With reference to the Oil Conservation

Division study, what, if any, of these steps do you believe that they have completed?

A The inventory of water wells and oil and gas wells is complete.

The areas of vulnerable groundwater have been mapped to a degree that needs to be refined further.

They have not conducted a statistically accurate sampling of the well sites, although they have sampled some well sites.

The data for the chemistry of the produced water and the volume of produced water has been, from their limited sampling, has been evaluated.

And that's basically where they stopped, is in number --number four.

Q Mr. Boyer has done some simple dilution calculations that have been discussed in the prior hearing. You're aware of those, are you not, sir?

A Yes, I am.

Q Based upon those dilution calculations, Mr. Hicks, can you form an opinion as to whether or not you believe that's an adequate basis upon which the Commission can enter an order that would ban the use of unlined surface pits in the vulnerable area for small producing rates of five barrels a day or less?

A Well, as I outlined, the mechanism that the Environmental Improvement Division follows for discharge plan approval, I believe should be followed here, as well.

What Mr. Boyer has conducted is the first cut of absolute worst case scenarios using higher levels of benzene than actually occur in the pits, for example, and it does represent the absolute worst case theoretical that could possible exist, and I do not believe after my investigation in the San Juan Basin vulnerable area, that that is in fact representative of what is actually occurring.

Q Were you here at the hearing on April 3rd, 1985, when Mr. Zaman testified about his groundwater monitoring around the Duncan Oil Field and specifically I believe he monitored around the Duncan Well 6-11.

A Yes.

Q Were you here present for that hearing?

A Yes, I was.

Q All right. With regards to Mr. Zaman's work at the Duncan site, can you form an opinion as an expert hydrologist as to whether or not that study is an adequate basis upon which to form an order that would ban the use of small volume unlined surface pits of five barrels a day or less in the vulnerable area?

A It is not sufficient evidence.

Q Can you give us the reasons why you believe that that study is not sufficient?

A The data that was presented was -- had some problems with it with respect to sampling procedures and methods of sample collection, which are not standard methods. The method of sample collection with preservation

with an organic is not standard methods.

The method of collection in Mason jars, I believe is what they employed, is not standard methods.

There are some discrepancies in the data, as I reviewed it, which showed that initially when they -- they did two sets of samplings, I'm sure people remember.

The first set of sampling showed some levels of benzene that were above the standards and these samples were collected in less than ideal situations, as Mr. Zaman admitted.

The second set of samples, which were collected without organic preservatives, indeed showed no detectable levels of benzene and so I'm a little bit confused as to which set of numbers or values to believe based on the evidence that was presented.

Additionally there is really -- it's difficult to imagine drawing a hydrologic gradient map or hydraulic gradient map of the water table in such a flat area where the water table is indeed relatively flat without an accurate survey by a professional surveyor, or at least someone who is very adept in surveying with instruments.

Q In your opinion is the water monitoring study data information, whatever, filed by Mr. Zaman on this one site, an adequate basis by which to determine the fate of the 1300 oil and gas wells in the vulnerable area?

A Absolutely not.

Q Mr. Hicks, you've described for us what

in your opinion would constitute an adequate study. There was -- we discussed it earlier today on the Zaman study before I leave that, could you identify for us what the possible sources of contamination may have been with regards to that study, other than the potential for contamination from disposal in unlined surface pits?

A There are numerous sources that can exist at any given site.

One such source would be the reserve pit at a well site.

Another source would be surface contamination which had occurred during the testing of the well.

Another source of contamination can be pipeline leaks, the pipeline casing leaks or pipeline leaks which may occur between the storage tank and the wellhead itself or between the -- any one of the subsurface connections.

Additionally there is a potential contamination from the -- the separator itself due to surface spills, but in this particular case with Duncan, I believe that they mentioned there was a buried separator, which was -- could not observe, and that may be another source in this case.

Those would be a partial list.

Q Mr. Zaman had a photograph of a backhoe cut in which there was an obvious dark stain some feet below the surface, to which he attributed that oil stain -- attri-

buted that stain to an oil stain and concluded that that was an indication of contamination by the use of an unlined surface pit.

Do you share that opinion?

A Well, that point is very interesting for two reasons.

First of all, I don't share that opinion. The oil stained material that Mr. Zaman showed in his slides, I would be very hard pressed as a hydrogeologist, and especially in that environment, to understand how such an apparently viscous material would be able to flow hundreds of feet from the produced water pit.

I would offer an alternative explanation for that and perhaps offer an alternative explanation for some of the high benzene readings which he may have obtained from that individual pit.

Surface contamination, as I mentioned, at well sites is not -- surface soil contamination is not uncommon due to changing of oil from the rig, the testing of the wells, and indeed, soil can become oil contaminated, not necessarily oil saturated, but stained with hydrocarbons.

This material then may be buried to prevent washing of the material, for whatever reason, and then in his excavation he may have dug through such a surface contamination and in fact contaminated his equipment on the way down and resulted in higher levels of benzene due to improper isolation of this surface contamination with that of

groundwater.

Q Mr. Hicks, it has been discussed earlier that the Flora Vista site may or may not be an example of groundwater contamination from the use of an unlined surface pit and no one knows at this point.

I would like to direct your attention, sir, to the transcript of hearing on the February 20th date, and to Mr. Boyer's testimony beginning approximately on page 115, continues over 116. If you'll take a moment and review those pages of the transcript, I'd like to ask you a few questions about the Flora Vista well.

A Yes, I see that section that you're referring to and I've read it.

Q All right, sir. With regards to the information that you have reviewed, not only in the transcript but testimony of Mr. Boyer about Flora Vista, do you have an opinion as a geohydrologist as to whether or not the source of potential contamination of groundwater in this area can be attributed to an unlined surface pit from the Manana Gas Well as discussed at the prior hearing?

A The contamination of the Flora Vist well, as I understand it and as is reflected in the transcript, is -- I'll just read it again for the benefit of the audience. The information I have is a copy of a table that I received from the Environmental Improvement Division listing a sample date of August '83 and at that time the biggest contamination was 32 milligrams per liter, almost 33 milligrams per

liter of oil and grease. It had a concentration of 0.4 phenols and a detected aromatic purgables, but there's no quantification limit given. It's less than .01 for aromatics and as most of the audience is probably aware, benzene is an aromatic.

Q Tell us poor little chicken farmers what that means in plain English. Is that an indication of contamination by the disposal of produced water from the Manana Well into an unlined surface pit?

A No, it is not.

Q Why not?

A It is not because the phenols and oil and grease can come from numerous sources and in fact may or may not be a constitutent in produced water at all.

Oil and grease would be a contaminant which I would look at in terms of a turbine pump if it was installed at the well initially. I would look at contamination due to how it was drilled, perhaps what it drilled through. It may have drilled through an old surface disposal pit. It may have drilled through an old reserve pit. Somebody may have been changing their oil and dumped it in the well. I mean there are numerous sources which you could attribute this kind of contamination.

Q In your studies of the San Juan Basin area, Mr. Hicks, have you come across or are you aware of any confirmed case of groundwater contamination by the use of unlined surface pits for the produced water from oil and

gas wells?

A I personally know of no cases.

Q You discussed with us earlier on Exhibit One a list of requirements that you would consider be necessary to form an adequate study.

A Yes.

Q Have you and has Geoscience Consultants completed such a study with regards to the unlined surface pit use in the vulnerable area on behalf of Tenneco Oil Company?

A In terms of the requirements for this study, with the exception of the installation of groundwater monitor -- I mean unsaturated zone monitoring network, we have completed such a study.

Q Mr. Hicks, I have placed on the blackboard what is marked as Tenneco Exhibit Number Two and ask you, sir, if you'll identify the map for us before we discuss what it shows. Would you identify that, please?

A Yes. That is the map of the vulnerable area which has been displayed earlier, where the vulnerable area has been outlined along the river valleys of the San Juan, La Plata, and Animas Rivers.

Q All right, sir, would you identify for us the three sites that are indicated with the red dots?

A Those are the three sites where Geoscience Consultants and Tenneco conducted groundwater monitoring. They are the McCoy D-1 on the Animas River; the

Eaton A-1-E on the San Juan River; and the Paine A-1-E on the San Juan River.

Q In terms of evaluating the vulnerable area with regards to the continued practice of allowing small volume produced rates in unlined pits, would you give the Commission the benenfit of telling us what you've done with regards to the compiling and gathering of the data?

A Certainly. The first step that we went through with out study is we assumed that -- and I'd like to refer to the requirements for an adequate study.

We assumed that number one had been done and indeed had been completed by the OCD and the Short Term Study Committee.

Number two, map the areas of vulnerable groundwater based upon the accepted criteria, that also had been done and the results of that study are shown on that map of the vulnerable area.

Within the vulnerable area there had been a statistically accurate sample of well sites conducted and what we did initially is we went out, I went out and Geoscience went out to perform site evaluations of a number of different wells. I mean we took 21 wells initially and examined them for their hydrogeologic character -- characteristics, the characteristics of the volume of water produced, the sizes of the pit and various other parameters were investigated.

From these 21 sites we chose three for a

detailed site study. These three were chosen because we felt that they were, based on the 21 sites that we had examined, were representative of the vulnerable area. They were representative of the worst case scenario that we could foresee, which was the Eaton A-1-E, and a worst case scenario again with the Paine A-1-E, and a more realistic scenario with the McCoy D-1.

After choose -- after selecting these three sites for detailed studies, we installed monitor wells at all three sites using strict EPA criteria.

We installed dry points at these sites due to our initial investigations demonstrated that drilling with a hollow stem auger, for example, or many other kinds of drilling apparatus, which are also acceptable, would be rather difficult due to the lithologic conditions of the sites, so we chose dry points.

We steam cleaned the dry points totally prior to installation.

Lithologic data were collected at each one of the sites employing a backhoe. The backhoe was used, was fully steam cleaned, as well, and used to dig trenches in areas where we could examine the unsaturated zone and in many instances the saturated zone, as well.

We collected samples from the separator and the pit for chemical analysis.

During the -- after the installation of the groundwater wells, again using -- emphasizing that I'm

using strict EPA guidelines for this, we collected samples again using standard methods which applyl to hazardous waste sites or any type of discharge that EPA would be monitoring.

We used strict chain of custody, clean vials for volatile organic analysis, similar, exactly the same as those which Mr. Boyer used in collecting his samples.

Additionally, we had the results of the analyses which we received back from the laboratory verified by another independent lab, so we used two labs for verification.

The -- and that is the process that we went through to collect our data.

Incidentally, I might emphasis additionally that all of the wells -- the wells installed were supervised by a certified professional hydrogeologist -- certified professional geologist. I am a certified professional geologist and I supervised the installation of all the wells.

For all but two of the wells I was present on site during every step of the installation process and made all the decisions regarding the -- the installation.

Q In terms of the 1200 or 1300 oil and gas wells in the vulnerable area, Mr. Hicks, would you give us an approximation of the number of wells that you have seen the sites of in order to determine whether or not there is

any way to categorize the types of wells we see in the vulnerable area?

A I'd like to move ahead a little bit with respect to how we conducted our study after the analyses came back from the laboratory.

We felt that as looking at 21 sites we did -- and spanning the vulnerable area in terms of a driving tour and a walking tour, we did feel that these three sites were representative of what was the actual situation in the vulnerable area.

In order to insure that that was the case, we used a -- we had a data base of approximately 300 wells from these 1300. Those are the wells of Amoco and Tenneco, where we knew the volume of produced water, the location of the wells, the elevation of the wells, and the anticipated depth to groundwater. Many other factors were known from this data base.

From that initial sample of 300 wells, using a random number generator, we selected an additional 50 wells, or rather we selected from that 50, well, 60 wells, I'm sorry. We selected 60 wells to perform on site hydrogeologic studies of each one of these 60 wells.

I personally went out and visited each one of these -- well, I take that back. I personally visited 50 of these wells. Time did not permit all -- visiting all 60. I visited 50 of these wells from this random sample.

Additionally, as people who have been in the San Juan Basin fully understand, these wells are very close together. I could go to a site where there is one, one wellhead or one numbered well, whereas there are in fact three wellheads at that given site, so I should say that I visited 50 sites that represent a minimum of 50 wells, and performed a hydrogeologic evaluation of each one of these well sites; therefore the total number of wells that I have seen is in excess of -- and that I've actually performed a hydrogeologic investigation of, is in excess of 75 well sites.

Q In your opinion have you studied an adequate number of wells and well sites from which to get a representative indication to you as a geohydologist of the varying kinds of or types of wells in the vulnerable area?

A Absolutely. In fact we called in a statistical consultant, a PhD, Dr. Francis Wall, who has a PhD in statistics and has performed numerous investigations for many companies with regards to statistical analysis of data, and I wanted to confirm with him that this random number generation, that looking at the sample of 300 was sufficient; that looking at -- that based on this -- this number of 300 and moving on down to 50 that that would in fact be an adequate sample.

We plotted out where these wells fell, these 300 wells, and indeed they were fully representative of the Animas and the San Juan River.

Q Did you and Dr. Wall -- did you and Dr. Wall as the statistician come to any agreement upon the adequacy of the sampling and the groundwater monitoring of these wells in terms of categorizing the well population in the vulnerable area?

A Yes, we did.

Q In your opinion, Mr. Hicks, is it necessary in order to either develop an exemption on a blanket basis for small volumes of produced water, 5 barrels a day or less, in unlined pits, is it necessary either to develop the exemption in those terms or in the alternative for the Division to ban entirely the use of the unlined pits in the vulnerable area?

A Based on the data that we have collected, I would --

Q My question, sir, is whether or not it's necessary for you to have site by site data at all of the 1200 wells in order to come to some hydrogeologically supported conclusions about how to handle those type of pits?

A That's not necessary.

Q What is necessary?

A What's necessary is to go and find out by a random sampling technique what types of wells exist in the vulnerable area. Then to field test these types, these populations, and calibrate these tests with actual field data; perform computer modeling on these populations to determine whether there is in fact a threat to groundwater.

Q Based upon your study, Mr. Hicks, are you able to categorize the well population in the vulnerable area into certain categories?

A Yes.

Q Would you describe for us generally what are the criteria or factors that identify the various types of well populations from a hydrologist's point of view in the vulnerable area?

A Based on my study, I have broken out the types of wells into four different categories, four different populations, with several sub-populations in two of them.

Q Before you go into detail about --

A Okay.

Q -- doing that, I'm trying to get a general feel for the types of studies you made and what conclusions you can draw from them.

A The types of studies that were made, I investigated the hydrogeologic conditions at each one of the -- at each one of the sites that I visited in order to categorize them into different populations.

I investigated the type of water produced; the type of well.

Q Mr. Hicks, I show you what is marked as Tenneco Exhibit Number Three.

All right, sir, if you'll turn to the first page of -- let me ask you to identify Exhibit Number

Three.

A Okay.

Q What is it?

A Exhibit Three is a report summarizing our field investigations of the vulnerable area in the San Juan Basin, New Mexico.

Q All right, sir, let me have you turn then to -- after the title page, if you'll turn to the first page of the exhibit and if you'll take us through the study and explain to us the exhibits as we come to them.

A Yes, sir.

Using the form that you find after the listing, where it says "Well Site Evaluation", there are certain criteria that were used in order to break down the individual wells into sub-populations. The title of the -- well, "Well Site Evaluations", those are the data that were used along with my own observations in the field as a professional geologist.

And we broke, we were able to break down the wells in the vulnerable into certain populations.

We broke them down initially into the San Juan River, or rather the river valley, river flood plain cases, which include the San Juan River, where the gradient of the -- the hydraulic gradient is equal to that of the river. In the case of the San Juan it's .002 to .003, as Mr. Boyer brought out in his earlier testimony.

We broke these out into three different

categories, high hydraulic conductivity cases, medium hydraulic conductivity cases, and low hydraulic conductivity cases. There were based on our site evaluation of the type of material which existed in the saturated zone, as well as the well testing which had been done at our sites, which we -- where we conducted a drilling program, as well as published information with regards to the hydraulic parameters and characteristics, the hydaulic characteristics of the flood plain.

The Animas River, according to our random sample, broke down into one category in that there was high hydraulic conductivity cases. We observed no medium hydraulic conductivity cases or no low hydraulic conductivity cases in the Animan River.

So the flood plains area breakdown, the flood plain population breaks down into three different categories, high, low, and medium transmissivity, or hydraulic conductivity.

The second population which exists are those of the valley side slopes and the tributaries that are away from the active flood plain of the major rivers in the system.

Those, too, broke down into three different sub-populations, high, medium, and low hydraulic conductivity cases.

The third population that we identified from our field investigations were those of bedrock mesas.

These are where the produced water pits lie on bedrock of sandstone or shale and where, in our professional opinion, produced water will not enter the groundwater system that is being used as an aquifer.

The fourth case, the fourth population that was brought out was the Pictured Cliffs wells, which in fact have no production equipment or generally have no production equipment on them. In fact, all of the wells which we investigated and that we have shown here as Pictured Cliffs did not have any production equipment on them whatsoever. They do not have produced water pits. They do not have a separator. The well flows directly into the pipeline and initially these are -- the other well sites which were not visited as far as the random sample are also listed as specific well locations that we went to in the course of our previous investigation. You'll notice that there are not 21 sites there. That's mainly -- that is because several of the 21 sites which we investigated in a random sample also are -- the sites which we visited, the 21 sites, some of them fell within our random sampling, so they are shown in the -- broken out into the different populations.

Q When you talk about the well population being placed into various categories, what type of category would typify the McCoy gas well that's indicated on Exhibit Number Two?

A That's a high transmissivity case in the flood plain.

Q Would you describe for us what the hydrogeologic characteristics are of that type of well?

A In the Animas River an examination of the riverbed itself and indeed the materials which have been deposited in the active flood plain show that it is indeed very coarse grained material, cobbles, boulders, and generally are -- well, are very high conductivity. That is also demonstrated by well tests in the area; that it is indeed high conductivity, and if you can turn to the following page after Well Site Evaluation, there is a chart which shows hydraulic conductivity values based on the type of material in unconsolidated deposits, and that's what we're talking about here, is unconsolidated deposits.

In the McCoy area we're dealing with very coarse grained gravel and very clean sand, and it falls within the range which has been tested by the McMann No. 1 Well, which has been marked on this chart. The McMann No. 1 Well was used in many of the calculations which Mr. Boyer conducted in this exhibit. This is a well which is in the Animas River Valley and correlates quite handily with the McCoy situation.

Q When we talk about the Eaton site, the A-1-E groundwater monitoring site, would you describe for us generally in hydraulic parameters what type of well will it have?

A The Eaton site falls within the valley side slopes and it is -- it is very fine grained. It was

not part of our random sample.

It is a fine grained unit which has been deposited on the side of a valley slope, the side of a valley, and it's important to understand why it's fine grained in this area.

It is fine grained basically because the contribution of sediments from the tributaries of the San Juan River have caused a find grained deposition due to the materials that it's eroding. So it is a fine grained case. It is on the side slopes of the valley and the hydraulic gradient is indeed greater than .01.

Q When we look at the Paine site, Mr. Hicks, describe for us the type of site we're seeing at that well.

A The Paine site is, the Paine location was actually drilled in the river itself. It had to be swampy area on the side of the river. It had to built up so that the well equipment would be stabilized. It is on a platform which lies four to five feet above the swamp level in the side of the river, and so it is in a river valley case. It is part of the flood plain and it is in a low to medium conductivity range. It's in the -- it's in the low hydraulic conductivity case of the San Juan.

Q Would you turn now to that portion of Exhibit Number Three that has the foldouts?

A Certainly.

Q It starts with this first one. Unfolded

this is part of Mr. Stamets' chicken ranch. What is this?

A This is the surficial geology map of the vulnerable area. It was -- the following pages give the full reference. It's unfortunately Xeroxed into three different sections so it would fit into the -- our exhibit here.

But it was done by Charles Hunt in 1977. It's the New Mexico Mining -- or it's a Geologic Map No. 43, GM 43 by the --

Q What's the purpose of that map?

A The purpose of the map is to show the surficial geology of the state of in this particular case, the Northwest Quadrant of the State of New Mexico, what rock units are exposed, what alluvial units are exposed, and the type of units that they are.

Q What use have you made of that map?

A I used this map to check to make certain that the cases that we investigated with respect to grouping it into these populations that we discussed before isn't -- isn't a function of chance, that there is indeed an explanation can be made why we can break this into certain populations, what geological reasoning there is.

And indeed throughout --through the careful study of this map you can -- you can tell that the Animas River, for example, and the San Juan River, share approximately the same density of side tributaries coming in.

Evaluation of the map will also show that

these side tributaries erode and drain the same type of bedrock material.

You can also see from this map that the San Juan River and the Animas River have their sources in Colorado in the San Juan Mountains of Colorado. They have, then, similar sources. They have, then, a similar network of tributaries which drain into them. They have, then, a similar flux of material that is sediment from the side tributaries and also from the San Juan River itself, and as a result, you can -- and after the site investigation that I performed throughout this area, it was demonstrated to me by my site investigations that indeed we can fall into two major populations of river flood plain material and side slopes.

The river flood plain material contains the -- is dominated, the lithology of these units is dominated by that which is transported by the San Juan River.

The side slopes, or the valley slopes, is dominated -- the lithology of the material is dominated by that which is contributed by the dry -- the tributaries to the San Juan River, which indeed are the same, the same bedrock material, the same source material, whether you're looking at the Animas or the San Juan or the La Plata, for that matter.

And so we have two distinct geologic populations here. Where we have one population the material and the nature of the material is controlled by the major

rivers. The other population, where the hydraulic parameters and the lithology is controlled by the side canyon contribution of sediment.

Q In your opinion is each of those well populations represented by either the McCoy Well or the Eaton Well?

A Yes, they are. The McCoy Well and the Paine Well reflect the flood plain population and indeed the Eaton A-1-E reflects the side slope population.

Q Can you give us an approximation now, sir, of the number or percentage of wells in the 12-or-1300 wells in the vulnerable area population, what portion falls either in the McCoy or the Eaton categories?

A Well, the bulk of the wells that we're looking at, it's well reflected, in fact, and the audience and the Commission can draw its own conclusions with respect to our random sampling.

We see here that we investigated a total of -- like discounting the bedrock mesa cases, because we have -- we are discounting those with this particular topic of discussion, and discounting the Pictured Cliffs, we have approximately 32, 30 sites here, of which we have the distribution as shown in this chart.

Q All right, sir, if you'll turn now to the general soil map that's in Exhibit Number Three and explain the purpose of that --

A Certainly.

Q -- portion of the exhibit.

A In addition to looking at the surficial geology map of Hunt, I looked at the soils map to determine -- to corroborate, if you will, the information upon -- is -- are we in fact looking at representative areas? Can they be broken down? Is the -- can the geology be broken down into populations?

And indeed the Soil Conservation Service has broken it down into different soil types and an investigation or evaluation of this map shows that the San Juan River Basin and the Animas River Basin show generally the same, or show exactly the same, soil types throughout in fact the vulnerable area, and indeed, if you look carefully at the sites as well, you'll see that the soils which line the vulnerable area in each case are similar between the San Juan and the -- or similar, they're exactly the same, between the San Juan and the Animas River.

Q All right, sir, let's go to that portion of Exhibit Number Three that addresses the groundwater monitoring at the Paine Well.

A Okay.

Q That's the next foldout, I think, in Exhibit Number Three.

A The Paine Well is a foldout which folds out legal size, is representative of the valley flood plain area.

This area was of most concern. The val-

ley flood plain area was of most concern to the Commission at the initial two hearings. We investigated this site and looking at the water in the pit, we also performed chemical analyses of surface water and ground water.

And now looking at this map, where it says "Water Table Elevation in Feet", the southwest corner, or actually the westernmost extremity of the produced water pit, shows a value of 5473.2. That is the level of water in the pit. It is perched above the groundwater which is represented by the level in the -- the well point No. 1, which we installed at 5471.2, which is in fact the same level as the surface water, 5471.2, which is a survey point directly below the -- where it says "swamp area".

Q Are all these elevations surveyed in, Mr. Hicks?

A These are surveyed by a professional surveyor.

Q And the arrow indicates what, sir?

A The arrow is an indication of the groundwater gradient, how it would be moving from the pit toward areas of lower groundwater elevation. It is the direction which groundwater flows.

Q We now have the table showing the elevations, the direction of the hydraulic gradient. Did you, consistent with the disciplines of your profession, take samples and preserve them in accordance with standards the water at the different monitoring sites?

A Yes, on the next page it shows that, where we did take samples from the well point which was installed and let me emphasis that the well points were installed so that the screen was in the uppermost portion of the uppermost aquifer.

The screen of these well points, which was 36 inches in length, sampled the top 36 inches of the aquifer.

The surface water sample, which is represented here by the survey point below "swamp area" was collected pursuant to strict EPA guidelines, as was the groundwater monitoring well.

Q This next page is captioned "Benzene Concentration PPB".

A That's correct.

Q Why have you selected benzene as the contaminant or the chemical in which to test?

A There's two primary reasons for the selection of benzene.

One of the most critical areas that you can -- one of the most critical concerns that we wanted to look at was to find out what is -- what was the impact from produced water itself. Many people have brought up other parameters which may be used but benzene is a parameter which is not found naturally in groundwater and we knew that we could use it as an adequate conservative tracer for groundwater studies.

The other aspect for the reasoning why we chose benzene is because it was of particular concern to the Oil Conservation Commission and we wanted to investigate the levels of benzene further in actual field studies to determine whether there was a problem with benzene itself.

Q Were your samples taken in the method approved by the EID?

A Absolutely.

Q And who conducted the analysis of -- from those water samples?

A ASSAIGAI Analytical Laboratories in Albuquerque, New Mexico, with cross checks by Rocky Mountain Analytical Laboratories in Denver.

Q Are those laboratories recognized as being competent laboratories to conduct this type of analysis?

A Yes, they are.

Q And what were the results of the analysis, Mr. Hicks?

A The results for the analysis by ASSAIGAI Analytical Laboratories are presented in this map.

The cross check with benzene -- for benzene levels was performed on three samples and the data from Rocky Mountain Analytical corroborated the levels that ASSAIGAI produced.

And for the sake of consistency, these maps reflect the data from ASSAIGAI Analytical, and what it

shows is in terms of PPB from the well, from the produced water itself, from the separator, that we have a -- we have a concentration in -- from the separator of 53,010 milligrams -- I'm sorry, PPB benzene from the separator.

In groundwater itself, it was below the limit of detection.

Q All right, sir, let's go on to the next wellsite that was the subject of your groundwater monitoring and my book shows the McCoy site as being the next one.

A That's correct.

Q All right, sir, if you'll explain to us the water table elevation method.

A Using groundwater as expressed in the swamp area, the swamp area was in fact free standing water, using the Animas River as a line source for groundwater and our three groundwater monitoring wells, in addition to the water levels in the blowdown pit and in the produced water pit, we established the configuration of groundwater shown here.

The -- all of these groundwater elevations were surveyed by a professional surveyor.

The pits at the McCoy site, both the blowdown pit and the produced water pit itself, are in fact hand-dug wells. They are constructed and excavated into groundwater and the levels in the pits themselves do in fact reflect groundwater elevations; therefore, this site has very good control with respect to the direction and the gra-

dient of groundwater in the area and it correlates quite well with what you would expect from the Animas River. You'll remember that Mr. Boyer's general hydraulic gradient was .004. We are off the river slightly and we show .007, which is well within expected ranges.

Q In your opinion have the monitoring wells been located at appropriate places so that if there is a plume of contamination from produced water in the unlined pit it would have been detected with the groundwater monitoring at these locations?

A What we have here is a situation where we look at the gradient at a point in time and we need to understand that tne gradient will vary slightly in this area, very slightly, with respect to fluctuations in the river.

We located the groundwater monitoring wells down gradient from the pit and in fact I believe that they are fully representative of material which could have entered groundwater from the pit itself.

Q Sir, if we turn now to the benzene concentration map for the McCoy Well and have you describe that for us.

A The separator from the McCoy Well discharged directly into the produced water pit which was in fact excavated into groundwater and we saw that the pit itself had a concentration of benzene of two parts per billion.

The well that was installed immediately adjacent to the pit itself, as close as the fenceline would allow, as shown by this figure, also showed two parts per billion.

And the --

Q So we're straight on our map here, what is the groundwater standard in New Mexico in PPB for benzene?

A Twenty. Ten.

Q Ten.

A Ten.

Q Ten, right?

A Ten.

Q And show us what you found in the monitor wells.

A The Monitor Well No. 1 showed a direct influence from the pit itself. Indeed, it was the exact same concentration of benzene in this well.

So we are -- we are confident that this well has been affected by the discharge from the pit, albeit significantly below standards.

The down gradient wells, the wells which are directly down gradient from Well No. 1 and the pit, show less than the limit of detection for benzene in these two wells.

Q All right, sir, let's turn now to the Eaton Well site and have you describe the groundwater moni-

toring at Eaton site and the water table elevation there.

A The Eaton site was also fully evaluated with respect to wells. You can see that at this site there are seven groundwater piezometers for the determination of the elevation of groundwater. All of these points again were surveyed by a professional engineer.

The groundwater levels were measured by a professional geologist.

The -- this -- this shows an interesting relationship here in that the produced water pit appears to have a mounding effect with respect to groundwater; that there has indeed been an input of ground -- of produced water into the groundwater system here, as evidenced by this mounding near the pit. The actual gradient which is exhibited away from the pit is perhaps best reflected by the contours to the north and to the west.

So we had excellent control in this area with respect to groundwater gradients.

Q All right, sir, let's turn now to the benzene concentration map that goes with the Eaton study.

A Certainly. The Eaton site was extremely interesting because it contained a high volume of produced water. There was four barrels per day entering this pit, which was larger than -- than any site that I had personally visited with the initial 21 investigations and indeed subsequent investigations, as well.

This was a large contribution of produced

water into an unlined pit.

The concentration of benzene in the produced water itself from the separator, not in the pit, from the separator, was 10,800 PPB.

Immediately adjacent to the pit, again, as close to the pit as the fenceline would allow, we intalled Monitor Well No. 2. This well showed 11 parts per billion benzene, a significant reduction.

The wells which were down gradient from the source of potential contamination, if you will, the produced water pit, showed levels below the limit of detection; again, a significant reduction from the 11 PPB that was noticed in the -- that was analyzed in Well No. 2.

Q If the Oil Conservation Commission applies the EID method of approving discharge permits to the Eaton, McCoy, and Paine well sites, would those wells receive a discharge permit?

A They would all be approved.

Q Why?

A Because in terms of the excedence of groundwater standards at a place of reasonable foreseeable future use, monitoring evidence has demonstrated that excedence of standards is not occurring at these sites.

Q Let me show you what I've marked as Exhibit Number Four, Mr. Hicks.

All right, sir, would you identify Exhibit Number Four?

A This is a result -- this is a compilation of OCD data and Geoscience Consultants, Limited, data with respect to the concentration of benzene in the separators from -- rather from water that is immediately discharged from the separators, as compared to the concentration of benzene which is observed in the produced water pits themselves.

Q Do you recall how Mr. Boyer made his dilution calculation in order to come up with an average of the benzene concentration that he used in that calculation?

A Yes, I believe he used on the order between 12 and 16 miligrams per liter. The exact figure was 14.5, I believe.

Q In your opinion is it appropriate for the dilution calculation to use a benzene concentration at that level?

A Based on Oil Conservation Division data I certainly wouldn't use that. I think that's too high of a source term based on what's actually in the pits.

Q What source term concentration for benzene would you use in the calculation?

A Well, in terms of -- if I was to calculate the simple dilution method where I would actually inject, if you will, water from a produced water pit into the groundwater, I would use 3.5 milligrams per liter -- sorry, 3.5 (not understood) terms of milligrams per liter benzene. That's the number I would use.

MR. KELLAHIN: Mr. Chairman, it might be appropriate to note on Exhibit Number Four that all these values are in milligrams per liter so that we don't use something else.

Q After conducting the field studies, Mr. Hicks, what conclusions can you draw with regards to your studies of the vulnerable area in terms of a small volume blanket exemption of 5 barrels per day of produced water into unlined pits in terms, first of all, of the potential contamination of groundwater by benzene?

A First I might -- my first conclusion would be that the data presented here in Table 1 with respect to the separators and pits shows that the initial calculations that were done by NMOCD exaggerate the nature of the problem.

There is apparently and obviously, and it's demonstrated in these examples, that there are mechanisms working in the pits themselves, which significantly reduce the source term for benzene in the pits.

My second conclusion would be that we have -- we have gone out to the field. We have performed field investigations of what can be considered a worst case scenario in the terms of the Paine site; in terms of the Eaton site, and found that in areas where effluent coming from the separators is extremely high, such as in the Paine site, that -- and where groundwater is very close, such as in the Paine site, that based on this field investigation

there is not a problem in these areas.

At the Eaton site we show that there is a significant reduction in benzene concentrations between the pit and groundwater and there is not a problem with benzene concentrations in groundwater from these populations and indeed the McCoy site, which is more representative of the entire vulnerable area, we find that there, again, is not a problem with respect to benzene concentrations from these populations of wells.

And my final conclusion is that we have taken a random sample of the wells in the vulnerable area. We have found that a significant number of those wells contain no production equipment. We found that a significant number of those wells lie on bedrock and pose no threat to groundwater.

We found that in the river valley scenario, that there is not a significant problem with respect to benzene concentrations in groundwater, and in the valley side slope population there is not a significant problem with respect to benzene in groundwater.

And it appears to me, based on my field observations and field studies, that indeed the evidence concerning a small volume exemption appears to be quite favorable, that indeed the volumes that we looked at show that there is not a threat to groundwater.

Q Based upon your study of the vulnerable area, Mr. Hicks, do you have an opinion as to whether the

McCoy, Eaton, and Paine groundwater monitoring studies around those types of wells have given you an adequate basis upon which to determine whether or not the balance of the well population falls into one of those categories, excluding for a moment the Pictured Cliffs wells and the wells on bedrock?

A We -- we determined from this study that in a detailed site investigation that these wells are representative of what is actually in the vulnerable area, and these wells do represent the vast majority of wells and in fact are representative of all the wells in the -- in the San Juan Basin in terms of field studies.

Q In the vulnerable area.

A In the vulnerable area, yes.

Q And for each of those three well sites the actual groundwater monitoring and the field data that you've gotten on the sites and have had evaluated for benzene concentrations leads you to what conclusion about potential benzene contamination from the use of unlined production pits?

A Based on the data, I don't see a danger to groundwater contamination based on benzene input to groundwater from these wells, from these produced water pits.

We see significant degradation of benzene in the pits and we see significant degradation of benzene in the unsaturated zone and significant degradation of benzene

in the -- in the wells themselves, or rather between the wells and the unsaturated zone.

It's simply not a threat to groundwater based on these field studies.

Q How comfortable are you, Mr. Hicks, with your conclusions about these wells and the way they represent the well populations in determining whether or not the conclusions you have reached are going to apply to wells located a half mile away from these sites or in fact at the other end of the vulnerable area?

A I investigated sites from Bloomfield to Navajo Dam to within sight of the Colorado border, and the populations that we have developed here based on sound hydrogeologic data bear out in all cases.

The side slopes in the San Juan Basin near Bloomfield are equivalent to the side slope scenarios in the Animas River, are equivalent to the side slopes up near the Navajo Dam. The geology, the surficial geology map demonstrates this. The soils map demonstrates this. And the field -- my own field observations demonstrate that there are these categories -- these -- these populations and they are consistent throughout the vulnerable area.

Q In your opinion is it appropriate to limit the investigation of the water chemistry to the benzene constituent?

A I think that there are other parameters of concern. Benzene certainly is the most critical, in my

opinion.

There is, in fact, as Mr. Boyer brought out in his testimony earlier, a concern with respect to TDS and I may bring out that determining the TDS content and its input to groundwater from produced water is going to be very, very difficult for several reasons.

First of all, as anybody who has examined the vulnerable area will attest to, the salt concentration, the evaporative powers, if you will, acting upon the -- in the -- in the area are such that thick salt deposits can occur along the sides of the rivers themselves, which would add considerable noise to any study of TDS.

Additionally, as in all agricultural areas, where agriculture is intensified there is a loss of water due to evapotransporation on the concentration of salts in the soils themselves. Periodically these concentrations of salts need to be flushed into groundwater in order for agriculture to continue to operate.

Therefore, throughout areas, whether you're in the Rio Grande Valley, near Las Cruces, where there is no produced water; whether up in Farmington, or whether you're anywhere in areas of intense agricultural activity, you'll find high levels of TDS, not necessarily naturally occurring, but certainly occurring as a result of agriculture.

In the case of the San Juan Basin vulnerable area, we have two processes acting upon the aquifer to

raise the natural level of TDS, and that is natural evaporation, as I discussed, where the salt deposits occur along the river banks, as well as agriculture, and it's interesting to note that TDS does not appear to be a problem at all, based on actual data from published reports, which Mr. Boyer also referenced in his earlier testimony.

Q In your opinion if we are to select a good diagnostic parameter by which to judge the oil and gas operation using produced water in unlined pits, would the selection of benzene be the appropriate parameter to select?

A I believe it would be. I believe it would be because of its -- its level of concern that has been expressed by the OCC, due to the fact that it is a constituent which can be -- which is generally mobile. It's not like many other organic compounds that become fixed in a soil. It can be transported and it is indeed found in the pits themselves, and so it would be a representative indicator parameter, absolutely.

Q When we talk about benzene in the three groundwater monitoring areas, you told us that you have found low concentrations of benzene that are well within the standards for groundwater in New Mexico.

A That's correct.

Q Do you have any reason to believe that the method of groundwater monitoring that you conducted at these sites was such that you simply missed it?

A I would find that very, very difficult to

believe.

We installed these wells down gradient from potential sources, immediately down gradient from the potential sources.

In the case of Eaton we had excellent control for the groundwater gradient. We screened the well within the uppermost portion of the aquifer where we would in fact see, first see, any contribution of contamination from the pit.

In the case of Eaton we actually monitored the mound, the groundwater mound which is evidenced from leakage from the pit itself.

In the case of McCoy, we demonstrated that number -- Well No. 1 was -- excuse me, let me reference that correctly, make certain it's Well No. 1 at McCoy.

The well which is immediately adjacent to the pit at McCoy, it is No. 1, that showed an influence, a direct influence from the well itself. The other two wells were directly down gradient from this area of influence, and let me emphasize the scale of these maps. One inch equals 50 feet on these scales. These maps are on the order of 25 feet, 50 feet, from the potential source of contamination and the Paine site, as well, we monitored within 15 feet, 20 feet of the potential source of contamination, again directly down gradient from the source; again in the areas of uppermost aquifers.

I find it very difficult to believe that

we would miss any source of contamination.

Q Mr. Hicks, you live and work in Albuquerque. You're a New Mexico hydrologist. You consult for lots of different people, and the Commission wants your own judgment about whether or not the Commission ought to continue the practice of allowing small volumes of produced water in the range of 5 barrels a day or less being placed in unlined production pits and ancillary pits at well sites in the vulnerable area.

Do you have any reservations about that practice continuing based upon the study that you have conducted?

A Let me preface my answer by two statements.

First of all, for two and a half years I worked for the Environmental Improvement Division as an advocate, if you will, of clean water.

My role as Technical Services Director for Geoscience Consultants also puts me in an advocate role for clean water.

Water pollution is a liability for my clients. It is not something that anybody will willfully do. If discovered, it -- and if it does occur and it harms somebody, it is a tremendous liability.

It's my responsibility to my clients to minimize that liability as much as possible and if there is a liability, point that out to my clients.

I did the same thing for the Environmental Improvement Division in a different capacity. I pointed out to the dischargers by disapproving plans or asking for more information with respect to what needs to be done in order to protect groundwater; in a sense to limit the State's liability for improper disposal of produced -- of water, waste water.

In this case I would have no qualms in recommending to the OCC that based on the data that we have today, the 5 barrels per day exemption would not influence the liability of my clients nor the liability of the State in terms of -- of degrading groundwater.

I have no qualms about making that recommendation based on the field evidence that I've collected.

MR. KELLAHIN: That concludes our direct examination of Mr. Hicks.

We move the introduction of Exhibits One through Four.

MR. STAMETS: Without objection these exhibits will be admitted.

MR. STAMETS: I've got a few questions of Mr. Hicks that I would like to ask before we take a break.

CROSS EXAMINATION

BY MR. STAMETS:

Q Mr. Hicks, if I interpret the work that you've done shown in Exhibit Three, this does show, does it not, that water which enters the pit is migrating out of the pit into the groundwater.

A That's correct.

Q All right. I think it does two other things. Tell me if I'm correct or if I'm wrong.

It seems to me that you've demonstrated as to the benzene levels, confirmed the theories that Dr. Miller testified to earlier today.

A It certainly seems to support his -- his testimony. It seems to be the field evidence that he had talked about.

Q Now, Mr. Hicks, it also seems to me that it confirms Mr. Boyer's testimony that a potential exists for pollution from produced waters migrating into the underground waters in the area, and let me kind of go ahead and explain what I'm talking about.

Let's say that we do have a TDS water, 30,000 TDS. That water could migrate vertically into the fresh water and could cause fresh water to exceed TDS levels. Is that correct?

A That's correct.

Q Okay. Now, in discussing Mr. Zaman's work and also in talking about Flora Vista, it seems to me

that you were indicating that you did not believe that produced water was the problem; that you did not believe that the levels of hydrocarbons, soluble hydrocarbons in the produced water was sufficient to have caused the problems that were observed.

A I don't think that that would be a fully accurate interpretation. I think that perhaps, if I may clarify --

Q Please do.

A -- that the study that was done at the Duncan site, as well as the potential contamination or the documented contamination at Flora Vista, the data that were presented, or the data that are known about these sites is not sufficient by any means to narrow the source to a produced water pit.

There are indeed other, numerous other sources. I'm not denying that there's a problem or that there's a potential problem at these sites. Obviously, Flora Vista, for example, has high phenols and high oil and grease. There's a problem there, but what it -- what you can tie it back to, you need to study it more, in terms of the Duncan site, as well.

Q Well, let me interrupt. I felt that I heard in your testimony that -- that you seem to believe that it was crude oil or -- or distillate which had gotten onto the surface directly as opposed to dissolved hydrocarbons in the produced water; that that was more likely the

source in your own mind than any dissolved hydrocarbons in the produced water.

A Especially, yes, I would say that that is especially true for the Duncan site where they actually dug through oil stained material. That is my opinion based upon the evidence that was presented.

In terms of Flora Vista that would also be true, that based upon the evidence presented it appears to be a different kind of hydrocarbon that you expect due to oil and grease contamination, yes.

Q In the three sites that you did the investigating on at the end of Exhibit Three, if one were to go out there and put six inches of distillate in that pit, do you believe that you would see benzene levels at much higher concentrations in the -- in the test holes that you have out there?

A I think I can direct you to the table that shows that, Table 1, Benzene Concentrations in Produced Water. Also the foldout of benzene concentration for the Paine site, which is foldout number two of our exhibit, and it shows --

Q Let me -- is that foldout number two of the last series?

A Yes, it is.

Q Okay. Okay.

A Benzene concentration PPB.

Q I've got it.

A If you look at what's actually entering the pit at the Paine site, we have an extremely high level of benzene entering the pit, yet on the far edge of the pit, if you'll -- if you'll notice here, there's a dot where we took the water level elevation and the water -- it's in the westernmost corner, okay?

The analyses, and you can plot this and I would recommend that you would plot this on your map itself, the analyses that we have under the Geoscience Consultants field data from Table 1 from Paine, the .002 figure can in fact be plotted at that point.

This shows that there is a significant reduction of benzene in this pit, and I may add that the levels of benzene that were seen here for 53 PPM is extremely high in terms of answering your question directly, based on these data, and the other data that I've seen, my feeling is that the distillate entering the pit by itself would not cause a significant elevation of benzene levels in groundwater.

Q Well, I'm not clear. I think I heard your answer but I'm not sure that I understand it, and it seems to conflict with some of the points you made during the testimony, again relative to the Flora Vista and what Mr. Zaman did. I felt that I heard you say that discharges of hydrocarbons themselves could be the cause of that and my point is to say suppose you've got an upset at one of these pits and you discharge a lot of distillate to that pit, and

you've got fairly high transmissivity.

A Uh-huh.

Q You've got, at least in one of these cases, you've got the pit directly in the water table. Is that the kind of situation that Dr. Miller was talking about where the microbes could be overwhelmed and benzene could be moving away from the pit and reading in much higher concentrations than you show here where you've been able to monitor and you know there's nothing going in there but produced water?

A If there is a problem at a site where condensate is entering the pit at these levels that we see, or higher, I can't testify with respect to whether that would be overwhelmed or not, but certainly it would be higher concentrations of benzene than -- than we have seen in our investigation, and if I may clarify with respect to the Duncan site, where I felt that the source of contamination at the Duncan site may be crude or surface contamination, I may refresh your memory with respect as to how those samples were obtained, where they actually dug through what appeared to be oil stain, and in fact there was a jar of material that was brought in as an exhibit for this oil stained material.

I cannot testify to the sample collection methods, as to whether this particular material that dropped into the pit itself of groundwater was the culprit or whether there was certain extenuating circumstances with re-

gards to sampling that occurred.

Based on what we've seen in the -- in the field itself, based upon our groundwater monitoring, the discharge, the surface discharges that may exist at the Duncan site would not cause contamination of groundwater unless it was introduced to groundwater and perhaps even sampled as part of the groundwater sample.

My feeling is that maybe, and I don't know, I can't testify with respect to how exactly it was sampled, I was not there, but that would certainly be one thing that I would want to do at this site, is we have values of groundwater, or we have samples that would show that there's benzene in groundwater, I think it would be appropriate to perform a study at the site pursuant to the strict EPA guidelines to see whether that is the case or whether it indeed falls into what we have demonstrated in the field and that there is no contamination.

Q Let me ask you the question this way. I'm wondering if perhaps as to organic contamination, if the Commission should be more concerned about accidental discharges of hydrocarbons directly, to the surface than to produced water.

A Absolutely, without a doubt.

Q Now you had quite a bit of testimony in here relating to a discharge plan process.

Are you suggesting that discharge plan procedures should be adopted for discharges to produced

water pits in this area?

A The discussion with respect to the Water Quality Control Commission regulations and discharge plans was used as an example to show that the cases that we have investigated here, which are fully representative of the vulnerable area, would in fact be approved under a discharge plan process.

We feel, and I believe that many, especially industries that desire to locate in New Mexico, will testify that the discharge plan process is indeed strict and does indeed consider many kinds of -- of potential contamination sources, and using this strict guideline, we applied it to these sites to see whether it would pass this strict test, these sites that are representative of the vulnerable area, and indeed it did.

So it was used for illustrative purposes only and certainly not a recommendation to the Oil Conservation Commission to move toward a discharge plan process.

Q Mr. Hicks, you probably are not the one to ask this question, but I would like to --

A Don't ask it.

Q I would like to have some indication today or shortly after this hearing if these monitor wells that have been installed would be available for a cooperative sampling effort which would involve the companies that own wells and -- and the Oil Conservation Division.

A You're fully correct, I'm not the one to

answer that question.

Q Today or sometime fairly soon.

MR. STAMETS: We'll take about a fifteen minute recess.

(Thereupon a recess was taken.)

MR. STAMETS: The hearing will please come to order.

Are there other questions of this witness?

Mr. Chavez.

QUESTIONS BY MR. CHAVEZ:

Q Mr. Hicks, in your testimony you said that the EID permits dilution of a discharge in order to meet certain requirements. Is this dilution at the surface before it's discharged or are you counting dilution in the ground after discharge?

A Dilution in the ground after discharge, between the discharge point and the property line or the place of reasonable foreseeable future use.

Q Where did you get the quantity of volume of water produced for your study?

A From Tenneco and Amoco recent records.

Q Did you monitor the volumes yourself personally at these wells to determine that these volumes are

correct?

A Visually we noticed or insured that in fact the wells were -- the separators were discharging.

At the Eaton site, for example, we did in fact witness a steady discharge. I'm not saying constant but consistent.

At the Paine site while we were -- in order to take the sample from the separator we had to -- you're probably familiar with tripping the separator -- we did that, and indeed water, produced -- produced water was produced from the separator.

Q So the volumes you used on your exhibit then are not from your own measurements.

A They're not from my own measurements.

Q In your water table elevation map for the McCoy Gas Com "D" No. 1 you showed that sampling point number one is upgraded from the produced water pit yet your benzene concentration map that follows shows the similar benzene level. Would you explain that?

A Yes. As -- as you are aware, in the river valleys there are seasonal fluctuations with respect to groundwater elevations and the absolute direction of flow in groundwater will change slightly throughout the course of a year or throughout time.

With respect to the -- I might also draw your attention to the fact that the gradient is rather low in this area.

And so we could have two mechanisms working with respect to obtaining the concentrations of benzene in Well No. 1.

The first is that the water table fluctuates slightly such that during periods of the year it is in fact directly down gradient from the pit.

The second mechanism that can be operating is dilution or dispersion and mixing in the saturated zone itself. The water is moving very slowly in this -- or the gradient is rather -- relatively low, and you can get diffusion away from the pit, such that the area of influence is much larger than the pit itself, and indeed, that's what I believe we are seeing in this case, is that the area of influence is larger than the pit itself and therefore it has affected Well No. 1.

That's my explanation.

Q You heard Dr. Miller testify earlier that he thought it would take over a year and quite a bit of money to do a test on one well, yet you have done a test in a short period of time on three wells.

Do you think that your data is adequate in that case, considering Dr. Miller's testimony, to -- for the Division to make a finding or do you feel that there is still more testing that needs to be done?

A Based on the data that we have gotten to date, I would feel comfortable with a ruling.

In terms of what Dr. Miller had indicated

with respect to a study, I believe he referred mainly to quantifying the biodegradation process at a site, which may involve considerably more effort than simply quantifying what the actual field data are.

And so, you know, at the present time, I feel quite comfortable with the study that we've done and feel quite comfortable with the results and not having to spend a year in doing it.

Q Was it the, for my own recollection, was it the McCoy Well that had standing groundwater?

A That's correct.

Q Then it would not be unusual to find dilution of benzene in that pit upon the separator dumping into it, would it?

A That's absolutely correct.

Q In areas where dilution may not be sufficient within a certain proximity of the pit, would you consider perhaps adding water to the produced water, say, unpolluted water to the produced water before it goes into the pit for immediate dilution?

A That is, in fact, done in cases of other industrial discharges where the contaminants are -- are diluted prior to discharge. That occurs.

Whether or not it would be recommended in the case of produced water, I don't think it's necessary.

Q But it is a recognized technique used to put discharges within certain technical limits?

A There are better mechanisms. I feel that the dilution of contaminants is -- is really a last resort.

Generally the first resort that you would look for is natural, natural protection, natural degradation. If that's not the case, industries will generally go to a treatment system. If the treatment system still cannot protect groundwater, in that case, and in those extreme cases, there would in fact be a cause for advocating dilution, but as a consultant I have never advocated dilution of effluent for any long term -- long term waste disposal practice.

Q Why is that?

A I think it's a waste of water.

Q Is it a waste of groundwater?

A Yes, sir.

Q Is it a waste of groundwater to rely on natural dilution by introducing produced water into it?

A I don't believe so, because in this particular instance we see that the natural processes, which are acting upon produced water, actually clean up or treat, as was used -- the word "treatment" was used earlier, in a treatment zone. There actually are natural treatment zones which rehabilitate the water to usable concentrations and therefore I don't see that we are degrading groundwater by the use of unlined pits.

Q I don't understand that. Are you saying that your study shows that the natural processes of degrada-

tion are at work, not dilution?

A Apparently so, especially based on the Eaton site. As -- as you'll remember from my testimony, I talked about a groundwater mound that had developed around the Eaton site, and my feeling is, based on that groundwater data, is that the Well No. 1, I'm sorry, Well No. 2, which is located immediately adjacent to the pit, is actually located in that mound of produced water or water that's generated, recharges, if you will, from the pit itself, and based on those data, I feel that there is -- there are processes acting in the unsaturated zone that reduce the level of benzene from 3.5, 3.8, that area, in the pit to .11, I believe that's the number, to the number that I see in the monitor well.

Q Do your dilution calculations indicate that there are other processes at work besides dilution that would give you these values?

A I'm sorry.

Q Do your calculations of dilution show that there are other processes at work besides dilution to give you these values of benzene?

A Yes, they do. If you were to use the dilution calculation of Mr. Boyer, which he fully explained in his exhibits earlier, where -- if you were to use the input term, if you were to crunch through, if you will, the equation for the input terms that he used for 3.5 milligrams per liter, you couldn't result -- the end result would not be 11

PPB in that well by dilution alone.

There indeed have to be other mechanisms acting upon the source to reduce the benzene concentrations. Dilution alone does not give you 11 PPB from 3500 PPB.

Q Did you do any calculations which may indicate that the absorption of benzene to the alluvium beneath the pit may or may not have reached stabilization?

A We didn't do any calculations with respect to that, but it was considered in choosing the sites.

If you'll look for Eaton, you'll see that it was -- the spud date, or the turn-on date, if you will, the number used, the turn-on date is 1981 and of course we sampled in 1985. Throughout this period of time it was producing 4 barrels of produced water a day and we felt that if ever there was going to be a case for overloading with respect to sorption, this was going to be it, because a very, very large volume of water, if, you know, neglecting evaporation, the potential for a very large volume of water could pass through this column, if you will, of unsaturated zone, and therefore we chose this location because we felt that there was sorption going on, that it would have been fully saturated with respect to sorption if there weren't other processes.

I might also bring out that the depth to groundwater in this area is on the order of 13 feet and the depth of the pit is on the order of 6 feet, which will give us 9 feet. Hopefully my in-head subtraction is correct. 9

feet of saturated -- unsaturated zone, or 9 feet of column.

So we did consider the sorption processes in our site selection, but, no, we did not do any calculations with respect to sorption.

Q So you don't know for sure then. It was just an estimate that you made as far as whether or not sorption increased degradation?

A That's correct.

MR. CHAVEZ: That's all the questions I have.

RECROSS EXAMINATION

BY MR. STAMETS:

Q Mr. Hicks, relative to that last series of questions, I noticed that the McCoy Well dates back to 1965 and that one again seems to indicate that you've demonstrated that Dr. Miller's theories are working even on a well that's been around for, oh, about ten years.

A Well, that's -- that is, in fact, one of the primary -- twenty years.

Q My math's as good as yours.

A That's, in fact, one of the reasons why we chose this site, is because it had been around for so long and we felt that there was indeed a twenty year history of produced water disposal at this site, and if there was going to be a problem with our quote average well throughout the long term, this was going to be it.

MR. STAMETS: Other questions of this witness?

Ms. Pruett.

CROSS EXAMINATION

BY MS. PRUETT:

Q As a former regulator and co-author of the --

MR. STAMETS: Ms. Pruett, could you speak up?

MS. PRUETT: Sure.

MR. STAMETS: I can't hear you.

Q As a former regulator and a co-author of the UIC regulations, did you do a study similar to the one you discuss in your exhibit at that time?

A In that particular instance a study was not necessary because it had been conducted and numerous hearings throughout a very, very long process had been conducted by the U. S. Environmental Improvement Agency throughout the nation.

These sets of regulations were developed throughout -- by looking at case histories. A lot of -- a substantial amount of data had been collected with respect to underground injection control, and was used in the regulatory development by the U. S. EPA, using industry and governmental staff.

What Mr. Boyer and I did was use these

regulations as the basis, a basis that had been fully accepted in the nation as a standard by which industry and government had established a standard, and we used that to write the UIC regulations.

Q So those sorts of nine steps were performed by somebody, it just wasn't you.

A Although I can't testify to that specifically because I don't know which studies, but if you look at the documentation with respect to underground injection control, indeed you would find, I would say, numerous stacks of technical arguments and papers on underground injection control from which the regulations were developed.

Q Did you do any monitoring other than at the three wells you've identified here?

A Groundwater monitoring?

Q Right.

A No.

Q The hydrogeologic investigation that you did on the fifty or sixty wells, I don't remember your exact number --

A Yes.

Q -- what did each investigation entail?

A The investigation for well site evaluation is shown on -- in my exhibit here, and basically it also entailed, under comments, my own professional opinion of what the site hydrogeologic characteristics were.

It's more than -- it's certainly more

than just making little checks on this piece of paper. It is an investigation that was done by myself, a certified professional geologist, where I can take into consideration not only these individual factors but locational factors, geomorphic factors, geologic factors, which are considered in this.

Q At the site itself did you do anything other than a visual inspection or from your -- from your own experience did you decide that was not necessary?

A We took photographs. I took photographs of each one of the sites. I got into the pits in numerous sites for a grain size evaluation, which has been of the exposed -- the exposed subsurface.

There were no sieve tests performed. The grain size evaluation was visual.

All of the examination was, except for the field -- the detailed sites, all of the examinations were visual.

Q You say the grain size evaluation was in the pit itself. How -- how deep? How (inaudible)?

A That depended -- that depended upon the site, of course, and the location. If there were -- generally the pits are five or six feet deep, so you can tell what's going on in the upper portions of the -- of the subsurface. Obviously, you can tell what's going on, or I can tell what's going on on the surface just by kicking around the dirt and seeing that.

I also in the course of the evaluation, if there was some question as to whether the materials changed significantly between the surface and the groundwater, I would look in arroyos and road cuts and other areas around the particular site so that I could make a professional determination as to whether it was significantly different below what I could see.

Q Are those judgments reflected on your forms and would you make those available to us, copies of those data forms?

A I believe I can, yes.

Q Are they going to tell us anything? I mean are there things reflected there or just calculations you did in your head?

A Well, much of it was -- much of it was done in my head. Much of it was done as a -- much of it was not written down with respect to that. Much of it is, in fact, reflected in some of the other maps and things which -- which explain the situation further.

So the forms, in terms of your -- your request, forms may be of -- of limited use to you but certainly they're available.

Q How did you determine the hydraulic conductivity for the purposes of breaking down the fifty or sixty wells into this rated population?

A The next page of the exhibit shows a chart from Freeze and Cherry, which correlates grain size

distribution of unconsolidated deposits with the typical values for hydraulic conductivity.

These values have been, oh, they've been corroborated in the field through the use of the pump test data from McMann No. 1, which was a pump test conducted by the U. S. Geological Survey, that showed that in the gravel lenses that we're talking about for the Animas River, we're talking about in this case 10 to the minus third meters per second.

Normally what I did is, I would look at the site. I would determine where it fell within this category, and I would reduce it by an order of magnitude to be conservative.

Q But you didn't actually do any pump tests yourself?

A On the field sites that we did, we did not do any pump tests. We did observe recovery of the wells to determine its relative hydraulic conductivity in order to determine whether our estimates based on our visual examinations would be correct, and the recovery data that we got from our own site investigations and indeed the pump test data which the U. S. Geological Survey has conducted, corroborate what we felt to be accurate hydraulic conductivity values.

Q Again, most of these corroboration mechanisms are visual.

A Well, the corroboration methods weren't.

Most of my -- most of the data that I collected in my well site investigation was visual.

The corroboration was with actual testing.

Q Do you have any field notes or well logs that you could make available to us that we could look at more specifically on what you based your (inaudible)?

A I think that the photographs, perhaps, would be useful, as would the -- in conjunction with the maps showing where these are, as well as my field points.

Q And you'll make all those -- I realize the photographs will be in the Commission's files, but will you make those --

A I believe I can make those available.

Q Thank you.

Other than benzene, you didn't look at any other constituents of produced water even (inaudible).

A That's correct.

Q Now the Eaton Well, and correct me if I'm mistaking what you said, but my recollection is that you stated that when people applied for a discharge permit from EID, one would probably be granted on the basis of the information.

A That's correct.

Q But actually EID would require data on many other components other than benzene, isn't that correct?

A Yes, that is correct.

Q They'd certainly, require some information or more information, general information.

A Absolutely.

Q Do you have any data on heavy metals in produced water and whether it -- whether heavy metals are present or were traveling?

A I haven't presented any. I've seen some, and I think I can make it available. I think Mr. Boyer took some, as well, I think. I believe that they're in NMOCD exhibits, but I didn't look at heavy metals.

Q And you can't say for certain that other components, such as heavy metals or chlorides, would behave in the same manner that benzene behaves.

A I can speak toward heavy metals to a -- to a degree. My Master's thesis dealt specifically with uranium and the relationship between heavy metals and groundwater, and in most instances they can be sorbed onto the soil relatively rapidly, in many instances, especially in the presence of some organic matter.

They may be, in this environment they may be mobile. If they're present in the produced water it would be logical to look at heavy metals. We decided to look at benzene because of the reasons I discussed earlier.

Q The statement you made about the volume going into the pits, over what period of time of these records did you study?

A I was given data from Amoco and Tenneco. I don't -- I can't verify how long they did their particular studies or made their estimates with respect to the water produced. That data can be made available to you because I am convinced that there is a time span that they've looked at it.

Q I think it would be helpful for us to see whether that's an average of what time period and what -- we'd appreciate it if you would make that available.

A Sure.

Q The three wells that you mentioned, were they dry gas wells?

A They were -- dry gas meaning no condensate produced?

Q Meaning fewer hydrocarbons in the form of liquids.

A I am not an oil -- petroleum engineer or a production person. I can testify to the fact that at each one of these sites there were production tanks to store condensate and in the cases of Paine and Eaton, where there were two tanks because there were two different formations that they were producing from, but there were tanks present, there's condensate being produced.

And I believe the OCD would have records in terms of how much condensate.

Q Did you measure the specific production from any of these wells?

A I didn't personally, no.

Q So without any specific production measurement or any quarry testing you would still recommend five barrels per day for them?

A Based on benzene, yes.

Q But you can't say --

A Now, let me -- in terms of -- based on the benzene values we've seen I would recommend the five barrel a day. We haven't done the work, or the work hasn't been done with respect to TDS and it, in fact, would be relatively straightforward to do.

Q Right, and for the fact that you haven't done that, you can't say that five barrels a day exemption would protect groundwater from TDS or chlorides.

A No, I couldn't say that.

Q And you can't say that whatever it is that was operating at the time you did your investigation will continue to operate indefinitely.

A With respect to benzene? I think that it's been operating for twenty years at the McCoy site.

I think that it's been operating for many years at the Paine and again I'm not -- I'm not the expert to talk about how long these processes go on, but based on the testimony of Dr. Miller, it seems to me that it is a -- it is a constant regenerating type of mechanism, so based on that testimony I would say it would continue to go on, but again, I need to qualify that.

Q But in the event of an accidental discharge of liquid hydrocarbons of significant volume, you can't say whether what you observed might not be completely changed.

A I can't say that.

Q Thank you.

MR. STAMETS: Other questions of this witness?

MR. TAYLOR: I have some.

CROSS EXAMINATION

BY MR. TAYLOR:

Q Mr. Hicks, excuse me if my questions don't make sense. I think Mr. Stamets' chickens may have been at work here.

You said essentially that you agreed with Dr. Miller that the effects of attenuation tend to degrade the benzene and, I suppose, other organic hydrocarbons.

To what extent do you agree with him? If I could, I'd characterize his testimony as saying really don't worry about this, or it's not a big problem.

Just how do you feel about that?

A Well, to characterize it in terms of benzene on that same level, if we -- if we make the assumption that Dr. Miller said it's not a problem, that there are natural conditions existing and don't worry about it, it appears as though the field data corroborated that, and so

with respect to benzene, it appears not to be a problem.

Q If that's true, though, how do we account for those instances where we have found those contaminants in an aquifer or in other situations?

A In other situations outside of the vulnerable area, let's say --

Q Right.

A -- in the State of New Mexico?

Q Say in the southeast.

A Okay. Well, I'm not familiar with the southeast in terms of what you're speaking of, but let me -- I am familiar with several sources of benzene contamination in groundwater where product, such as gasoline, unleaded gasoline, for example, or leaded gasoline, has leaked consistently from a tank or gasoline trucks or tank cars have lost their integrity or been punctured overturned, such that a large insult to groundwater has occurred due to very, very high concentrations of benzene over a very localized period -- localized area.

Those are the cases that I'm aware of, of benzene concentration, concentrations in groundwater busting standards, where you've got either a constant source of pure product or a large insult due to on the order of tank cars being ruptured.

Q This is more or less what we might relate to a spill --

A A spill, that's correct. That's where I

have been -- a spill and constant leak of product is where I am familiar with benzene contamination in groundwater.

Q Would you go into the parameters you utilized in selecting the location of your monitoring wells a little bit for me? I didn't get to look at your exhibit and I don't know if that information is contained in it. How did you actually determine what parameters to look at in terms of --

A Initially what we did is we felt that by looking at hydrogeologic maps and water table maps in any alluvial valley, you'll -- one can recognize that the water table generally follows the contours of the land surface.

We assumed that this was going to be the case and we implaced (sic) groundwater monitoring wells down slope from the produced water pit itself.

In the case of -- of Eaton, I mean that was in the case of Eaton.

In the case of McCoy and in the case of Paine, the river was within sight. There was a swampy area within sight of both and based on the gradient of the river, we chose a down gradient direction.

If a survey, then we performed a survey and did water level elevations so that we can accurately determine the gradient.

And in the case of Eaton we went back in and put in more wells so that we would insure that we were directly down gradient from the source.

And so it was a two-step process. One step involved field observations. The next step, in the case of Eaton, involved looking at the water level contours and then putting in more groundwater monitoring wells to insure that we were absolutely down gradient.

Q On the same subject, how, looking at the 1200 wells in the northwest, did you decide which -- which wells to (almost inaudible.)

A In consultation with Dr. Francis Wall, we looked at the distribution of the 1200 wells in the -- in the vulnerable area, just by looking at an API map showing the locations.

We had a sub-population of 300 wells for which we had data from Amoco and Tenneco. Those wells were located in the Animas River and in the La Plata.

So from the 1200 we had 300 in two -- two areas of the river.

We looked at those, the geographic distribution of those 300 wells with respect to the other wells that are in the area and they, from a visual observation they appeared to agree with the distribution that was shown in the API map.

So from this 300-set of -- or from this 1200-set of data, we then reduced it to 300 that we had data on that we thought were representative.

From that 300 then we went -- we numbered each one of those and using a random number generator we

generated 60 sites within that 300 sub-set population and we feel, after looking at the distribution of the 1200, after looking at the distribution of the 300, and after looking at the distribution of the 60, that these 60 sites are indeed representative of the Animas and the San Juan River in terms of their distribution.

So we did a statistically valid sampling and a random selection of wells, strictly based on how the data was presented to us, which was alphabetical.

Q I don't quite understand. How did you get down to the three --

A Oh, that's how we got to the 60. For the three wells, you'll -- you'll remember that initially we went out and we looked at 21 sites and we, again using our hydrologic reasoning, we -- and based on these 21 sites, we chose 3 sites which we felt were representative of the 21 that we saw, and that's -- and we tried to choose the worst case scenarios.

We chose one case where we had low transmissivity, low hydraulic conductivity with a large volume of produced water.

We chose one that had been around for twenty years where in fact we were discharging straight into groundwater.

And we chose another location where surface water was all around it and felt that this also reflected a threat to surface water as well as groundwater.

So what we tried to do is, in our heads we chose these three sites based on what we though was the worst case scenario of the populations that we saw, which were side slopes and valley situations.

Then to insure, it was only after we put in the wells, to insure that these wells were representative, that's when we did the statistical analysis.

So the statistical analysis of the 60 was done after the selection of those first 3 and indeed the statistical analysis corroborated our initial feelings, if you will, that two populations exist.

Q You were here for Mr. Boyer's testimony, weren't you?

A That's correct.

Q He talked about when he did his model for the dangers of allowing pits, he had three ranges of permeability --

A That's correct.

Q 25, I guess that's feet a day, I'm not sure, 25, 250, and 2500, and he said there are actual cases in the alluvial river valleys of water moving 500 feet a day.

How did your situations around your monitor wells compare to -- to those numbers?

Do you have any idea?

A Well, yeah, I do have an idea.

The McMann No. 1 Well, if you'll look at

the exhibit, it shows the estimated the hydraulic conductivities as a relationship to grain size. You'll see the McMann Well is pointed out there as 10 to the minus 3 meters per second. That's a little bit -- that -- that is approximately, I believe, if you trot off the calculations, you'll see that that is approximately 2500 feet per day.

Mr. Boyer, for his high transmissivity zone, or Mr. Boyer, in his calculations of his high key case, or high conductivity case, again field calibrated it with actual data from McMann, which was 10 to the minus 3, which is, or actually, I guess was more approximately 10 to the minus 4 gallons per feet per day. It's in that range that you see presented there.

That is, in fact, what our -- our high hydraulic conductivities are in our -- in the data that we -- how we broke it out. The high is what Mr. Boyer used. The medium is, in fact, his medium, and the low is what his low is. They're very compatible. They correspond except for the conversion factors you're going to get are slightly different; they're not exact, but they're -- they correlate very well.

Q You said on -- I believe you said that your monitor wells, or in some cases the limited detection of benzene, benzene was not detected. What was the limit that your tests show?

A One PPB.

Q And what is the State standard?

A 10 PPB.

Q What's your experience been with regard to the amount of time for an applicant to prepare and for a staff to evaluate discharge plan applications?

A It depends upon the complexity of the plan and the nature of the discharge and where it is. It's different for each one, but I can make some broad characterizations, if you wish.

Q Sure.

A For a sewage treatment plant where the constitutents are well known, they've been around for quite awhile, and the methods of disposal are for -- for effluent are well known, my guess is that it would take on the order of three and a half to four months, or less, for such a situation.

For an injection well, for example, I'll give you the other side of the range. For an injection well for waste disposal where there are -- well, at least a year ago there weren't any fully permitted in the state, there may one or two now, but an injection well, where it is a process that is not fully familiar with the State of New Mexico, the aquifers have not been fully tested with respect to how an injection well may react, it may take as long as a year and a half to two years to get a permit for an injection well.

A uranium mill would probably be along the same -- same lines, due to the complexity of the situa-

tion and a large volume discharge.

So, basically, we vary from three to four months to perhaps as much as two years.

That's been my experience.

Q If the Commission adopts some kind of a no-pit order and allows exemptions, what were your -- what are your feelings on a discharge plan type process for allowing those?

I don't know, you were talking about discharge plans a lot and I couldn't figure out whether you were meaning that there should be something like that or --

A Okay. Well, do you want my opinion as to what I would do for exemptions or that kind of a case?

Q Sure.

A I certainly wouldn't go to the discharge plan process per se, mainly because we group these into different populations here. We know -- we can see that certain things behave similarly.

So for a site-by-site basis I certainly wouldn't say that would be required at all.

Additionally, I think the discharge plan process per se would overwhelm unnecessarily the regulatory agency and I believe that some sort of an administrative rule would be far more appropriate. Individuals have brought up -- well, my feeling is that benzene may not be a problem or benzene is not a problem in this area. There may be some other parameters that would be of concern, but

they're much more easily monitored, such as TDS. There can be, just as in the same method that you can have a low volume exemption, like the BLM does, you can tie that to a certain TDS limit and you can go through the calculations to show that if you've got X volume produced and the volume is a certain TDS, that, you know, you've got to have a lined pit.

Now that wouldn't be site-by-site. That would in fact be an administrative rule, very similar to a low volume exemption.

That's the process that I would go through and in order to deal with those parameters such as TDS as opposed to a site-by-site basis.

Q Again what parameters would you consider -- do you remember Mr. Boyer's testimony when he was talking about the -- what exemptions he would -- or what he recommended for exemption, and he talked about permeability of the soil?

A Yes. Yes, I do remember that. That would be -- in fact, if you look at the, oh, let's see, Well Sites Investigated report, the first two pages, or I'm sorry, the third page, where it says Bedrock Mesa Cases? I firmly believe that these bedrock mesa cases are in fact the cases that are very similar to the cases that Mr. Boyer was talking about where we have a produced water pit located on low permeability rock, where it would not enter groundwater from these unlined pits.

Those certainly would be exempted or approved or administratively handled in an effective manner in the same way that we can devise a nomegram (sic) or a chart or something to deal with some of the other parameters that may be of more concern now than initially benzene waS, such as TDS.

Q Are all of these wells in the bedrock mesa cases category in the vulnerable area?

A Yes, they are.

Q Now you talked about the fact that in order to make any rule on this matter there were nine steps that you thought the Committee or someone should go through.

A Yes.

Q Are you aware that when this committee was set up there was a charge to them by the Oil Conservation Commission which was --

A I'm not aware of that. I've read the -- I've read the Produced Water Committee reports in terms of The charge made as to whAt it was supposed to do. I don't -- perhaps I jumped the gun in answering my question.

I'm not aware of any step-by-step process they should have gone through in terms of this study. Maybe you'd like to direct that question to --

Q I just essentially wanted to point out that they, you know, were not mandated to go through a study process to do this.

A Oh, yeah.

Q How many of the 1200 wells in the vulnerable area produce more than 5 barrels of water a day, do you know?

A I really don't have any idea.

Q And your recommendation is for no more than a 5 barrel exemption.

A Well, my recommendation would be that based on the data that I have seen to date with respect to benzene, that 5 barrels a day entering the groundwater, which is what the BLM uses for a standard and what I'm told that other states use as a standard, would be -- would be adequate to protect the environment. It would be consistent with the rest of the nation and indeed consistent with the field data that we've shown here with respect to benzene.

Q Are you familiar with whether either the States of Texas or Oklahoma have no-pit rules, or what rules they have in regard to this?

A I don't know. I honestly don't know. I'm aware of the rule in the southeast portion of the state and I'm aware of the -- of what the BLM requires.

Q You already said, however, that your recommendation does not consider heavy metals or TDS or any other constituents in produced water and that those should affect what the determination should be on exemptions.

A That's correct. My understanding was that heavy metals and TDS were much less of a problem than benzene when we first started this investigation. That's

why we chose benzene for the parameter of most concern.

But we did not investigate the mobility of -- we did not investigate the concentration of heavy metals in produced water pits, nor did we investigate the total dissolved solids content of produced water pits.

We restricted our -- our study to benzene.

Q Dr. Miller, I believe, stated that he inspected the cost of a study just on one well, I think, to be about $500,000. Could you speak to that figure? Do you have any thoughts of your own?

A Well, in reference to the kind of study that he would conduct that may be the case. If you want to quantify the types of micro-organisms, if you want to quantify where microbiological degradation is occurring, that's in a one foot zone, how much occurs in two feet, you're talking about many, many examples from a site. You're talking about expensive analyses to quantify how much biodegradation occurs at given slices.

But I don't think the Division or the Commission is really interested as to what -- how much biodegradation occurs at any given site. I think what is more appropriate is are there mechanisms that do exist that would reduce the concentration of benzene between the produced water pit and place of reasonable foreseeable future use, and if that would be a goal of the study, it would certainly cost significantly less than half a million, a quarter of

million, or a tenth of a million, or certainly for one well site I couldn't give you the exact cost, but I know that -- I know that the seven wells at Eaton site, for example, you're dealing with standard stainless steel screens, and you can use Environmental Improvement Division's hollow stem auger to put it down in that particular area because there isn't the high cobbles, and -- or you could use PVC. There's a number of different methods. You could cut down that cost tremendously.

Q Could you tell us approximately what the testing portion of your -- the study you did cost to drill monitor wells and have -- not the whole part of it, just drilling the wells and have samples tested and --

A Well, let's see. Let's -- I'd have to figure it out, if you can bear with me.

Q Just a ballpark figure.

A We've got a day of rig time. If you want to contract that out, that would be $800 with a hollow stem.

You've got -- well, you better say three days for the seven wells, so multiply three times 800.

Then you'd have the price of the materials. In this case I would use, if I was interested in heavy metals, TDS, and --

MR. KELLAHIN: Mr. Chairman, I'm going to object to the costs of doing this kind of work.

I'm sure Mr. Hicks would be more than happy to put a bid out if the Oil Commission would

like to hire him to prepare evidence so they could support their case.

But the question of what this cost and what was involved here I don't think is moving us along in this process.

MR. TAYLOR: It may not be moving us along but I thought it might be of interest to the Commission, but we'll move along.

Q As to the fifty or sixty wells you checked out, what levels of water were discharged, range and average?

A Oh, boy. We had, I would say that they ranged from reported to be zero, and that's not Pictured Cliffs, I mean actual Dakota cases or Chacra or Pictured -- not Pictured Cliffs -- Mesaverde wells. They were reported to be zero. We went to the pit site and in many instances, several instances where it was reported to be zero there was standing water in the pit. There obviously was a discharge there.

So it was, all I can say, it would be very low, maybe on the order of an eighth of a barrel a day or less to as much as four to six barrels a day, and I'd say that, I would feel comfortable with giving you that range.

Q On the well site evaluation form in your exhibit, which I think is this.

A Yes.

Q I've got several questions about it and

the first one is were the produced water rates on that those that were reported or were they actually measured?

A Those were reported. Well, let me take that back.

That was a list that was given to me by Amoco and Tenneco. With respect to what they were measured or how they arrived at that I can't testify, but I know that many of the wells, many of the separators were in fact tested or calibrated, if you will, to the pumper's estimate. The pumper is the individual that goes around to wells to check them out. He checks out how much condensate is produced to make sure that everything is operating smoothly.

He had a -- he gave an estimate of what the produced water would be, and I believe that in several cases it was calibrated with counters, but I really can't testify fully.

Q It wasn't done as part of your --

A No, it was not.

Q -- work?

A It was not.

Q How were the hydraulic gradient values and conductivity values determined at the site?

A Again they were my visual observations, where I would correlate the -- what I believed, based on my experience as a hydrogeologist and the observations at the site, what I believed to be the lithologic material below the -- below the pit, and then I correlated that lithologic

material with hydraulic conductivity values that were given on the following chart from Freeze and Cherry, and I reduced it by an order of magnitude and if I can go through an example, at the -- at the McCoy site, for example, it was entirely gravel. There was very -- there was some fine sand mixed in but the matrix, what held that site together was gravel. It was not clasts of large material floating in a sand matrix. What held that site together was gravel.

So you could categorize that in the middle of the gravel category.

Then you cross over and you see that it's 10 to the minus 2 meters per second. I would then reduce that by order of magnitude that would more correlate with the field data and also to be conservative, and I would arrive at 10 to the minus 3 meters per second or 10 to the 4th gallons per day per foot squared as hydraulic conductivity.

So it was a lithologic evaluation correlated by this chart.

Q How did you estimate the depth to groundwater? How did you determine it?

A In many cases I couldn't fill that in from my field investigation. In many of the river valleys I was able to because I could actually witness groundwater in some of the pits or in -- by the river level being close by.

In order to determine what the level of groundwater is in the valley slope cases, for example, I had to go back after I visited the site, I'd come back to the

office. I would look at the Kelly elevation, or the elevation of the well site and then the elevation of the river. I would look at the slope and hopefully I would find some -- some groundwater data from some of the published sources so that I could estimate what the hydraulic gradient was and then I would give my estimate of the depth to groundwater.

I might add, that task isn't fully completed at the present time, but there are blanks in the data that can be readily filled in with respect to the depth of the groundwater.

Q Did you do any drilling other than the monitoring wells?

A No.

Q Let's see, in reference to the Bureau of Mines map, which I don't remember which it is.

A This one?

Q I think so. Let me ask the question and we'll know.

A Okay.

Q Did you use it or did you intend it to be used for soils evaluation or did you (not understood)?

A I used this map when I -- when I was out in the field I recognized that there were striking similarities between the populations based on my visual investigation and I was curious as to how the side slope environment or the side slope population could correlate so well between Bloomfield and up near the Colorado border north of Cedar

Hill.

At that time I pulled this map out and indeed found that there were reasons for that and that was, the reasons were the density of the -- the density of the drainages and the types of material that these drainages provided in terms of sediment load to the valleys.

So that's how I used this map. I used it after the fact to corroborate what I was actually seeing in the field.

In terms of the soils investigation map, I believe it's just further evidence that you can break these down and they do fall into specific -- that's it's no great surprise, in other words, that we can divide these into two populations.

Q Let me see, I don't know if I can talk about this or not, but for a monitor well site did you obtain or calculate volumes discharged, frequency of discharge, hydraulic conductivity, those other items?

A Hydraulic conductivity at the sites with the wells was estimated based on the recovery rate of the wells after sampling and my visual inspection.

In terms of the water produced, again that was Tenneco and Amoco data.

Was there a third?

Q Let's see. Let's see, years of discharge, volumes of discharge.

A Well, in terms of total volume of dis-

charge, you could take -- for the field sites we knew what date they came on line; it would just be a matter of multiplication to determine how much water had been discharged and we did not, I haven't performed that multiplication.

Q How comfortable are you that the gradient values are accurate, not seasonally influenced?

A In the case of Eaton I feel pretty good about that. I feel real good about that, that it is -- it's a little perplexing because it -- the gradient is actually up stream from the -- it actually flows up -- up -- not uphill, but it flows to the -- well, the San Juan River flows down to the east, or west, I'm sorry, the San Juan River flows to the west, whereas at the Eaton site the groundwater flow is more toward the northeast, and that may be influenced due to some recharge contributions from the canyon. I feel pretty good about that.

I feel real good about it, that that will not be influenced by seasonal fluctuations.

With respect to the McCoy Well and with respect to the Paine Well, I believe that those would be influenced by fluctuations.

Q Okay. With respect to the study plan in your Exhibit One, given 1200 oil and/or gas wells in the area, do you have any idea as to the number of sites that would have to be examined in order to obtain a 95 percent level competence?

A I haven't done that statistical analysis.

Q You mentioned hydrogeologic studies were done on at least 75 oil and gas wells. Does this include chemical analysis of groundwater at the sites?

A Well site evaluations, hydrologic well site evaluations, perhaps, is what was done in about -- was actually done at -- the forms were completed on approximately 50 to 55 wells.

Then we did the three -- three detailed sites, so again about 58 in there.

Then there's a list that shows other wells that I visited in the same area and did a mental evaluation of them, if you will.

So in terms of sampling the pits or groundwater, no, that has only been done on three sites, three wells that we -- well, let me take that back.

Pits, of course, and separators were sampled by OCD and I believe as well as ourselves, and I believe the data base shown here in Table 1, and with respect to groundwater monitoring, we're doing with these three sites.

Q Given the subject matter of the hearing, isn't a chemical analysis of groundwater at more sites necessary to come up with a valid --

A You know, I think that if we really had some high levels of benzene, I mean I'm talking strictly about benzene here, if we talked -- if we had some significant differences and some significant variations with

respect to the benzene concentrations, or if indeed we were close to standards after you moved 20 feet away from the well, indeed I would be the first to recommend more sites to be studied, but the consistency of the data that we have here shows that in a mere -- in a wide range of hydrogeologic conditions we come up with the same result with respect to benzene and therefore I am comfortable, I would be comfortable doing more sites and I would be comfortable not doing any more.

Q But essentially from what I get, you only tested three sites and the rest were paper analysis or there was not testing done at the other 60 or 75 sites.

A Well, I think that in terms of -- there was testing done at other sites as reflected by Table 1 with respect to the degradation that occurred between the separators and the pits.

Indeed, that data, those data are consistent and they also agree with what we see in groundwater. It's just interesting that we've got this degradation occurring consistently in the pits and also in the groundwater and I feel -- I feel comfortable with respect to benzene at the present time based on these three sites, and again let me say that I would be comfortable putting some more -- doing some more sites; perhaps even doing a statistical analysis with respect to -- I wouldn't be comfortable doing it, perhaps OCD would be comfortable doing it -- with respect to looking at the representative numbers so that they

can be assured of corroborating even these data, because I think it will.

Q Thank you.

MR. TAYLOR: That's all the questions I have.

MR. STAMETS: Other questions?

Mr. Chavez.

QUESTIONS BY MR. CHAVEZ:

Q Mr. Hicks, I want to go back to the volume of waters reported produced from the well.

You said that of the 50 wells that you surveyed or visited some had reported zero water production, however, there was water in the pits.

Where did you get those volumes?

A They were provided to me by the companies.

Q It seems like the volume of water may be significant in the calculations, especially if we're looking at dilution and biodegradation.

If the volume of water produced instead of being four barrels a day would, say, be one-fourth of a barrel a day, how much difference would that make in your calculations of dilution to see whether or not biodegradation was or was not taking place, or if there were other factors?

A We based our calibrations on the data

that was presented in terms of our dilution versus biodegradation that I talked about earlier.

If you reduce the volume of water that was entered into the pits that again could potentially enter groundwater, dilution might be, might be more of a factor and it might not be. It would depend upon -- it would depend upon the actual data.

If we look at the sites, if we assume that the sites that we visited were -- did not vary significantly, i.e., we report 4 barrels, if we assume that it's not 40 and it's not .4, it might be 3-1/2, it might be 3, it might be 6, we've got a test case where we have a relatively high volume of water that shows no degradation of groundwater beyond 20 feet away from the pit.

Then we have another case of McCoy where we've got a low volume entered into the pit and again we have no degradation, so I can't say that the volume produced is really going to have a significant effect, whether it's dilution or whether it's biodegradation. I think we seem to be coming up with the same, same numbers despite the volume produced. That's just -- that's my feeling based on the data.

Q Assuming that -- you're assuming that the produced volume is exactly as was reported to you, is that correct?

A That's what I used in my mixing calculation.

Q But you still didn't answer the question. What significance would there be had the volume been 1/4th of a barrel, say, instead of 4?

A Let's use the Eaton site. I think that's what you -- in terms of 4 was reported, what would happen if it was 1, or 1/4? We would perform the mixing calculations and perhaps we would not have to -- have to call on as much biodegradation. Dilution would be a mechanism that we could call on to account for the values that we saw in groundwater.

It certainly is the first mechanism that I tried to use to determine how we got from 3.5 milligrams per liter in the pit to .11. I'm -- let me -- from 3500 PPB in the pit to 11 PPB in the closest well to lower limit of detection in the well at 20 feet away. Dilution wouldn't account for that. In this case at 4 I didn't run through the calculation for 1/4 but, you know, it may show that dilution would account for more of it, but I seriously doubt whether it would account for all of it, because what we're dealing with here is a large -- we're still dealing with a large source term relative to the standards. We're dealing with 3500 PPB in the source term and 10 PPB for the standard, or 11 PPB in our actual result.

I don't think that the underflow at this site would permit a quart a barrel. I can't say that for a fact but I could trot through the calculations, or Mr. Boyer could trot through the calculations to determine -- deter-

mine the answer to your question with respect to how much dilution would be occurring at a quarter barrel and how much we would get -- how low we could get standards calling only on dilution if it's a quarter barrel, an eighth of a barrel.

Did I answer your question?

Q No, but thanks a lot.

Is one of the criteria used for picking these wells that they were representative by produced water volume?

A The wells that we studied for the monitor wells?

Q Yes.

A I don't think that they were representative or necessarily representative with respect to produced water.

For the Eaton site we wanted to choose one where we knew we had a high volume and so we skewed it, if you will, to the worst case.

In the -- in the Paine site we again tried to pick a relatively high producer. It's -- our report showed that it was one barrel per day, and indeed the pit was, was not only a large pit but it did indeed have significant volumes of water in it.

And so again it was -- we tried to skew it to a worst case scenario.

In the McCoy case it was perhaps more representative and so we did not use produced water as a cri-

teria for representativeness. We used the geologic and hydrologic criteria for representativeness and then tried to take what we believed was going to be the worst case for these kinds of populations.

Q In your exhibit you showed the McCoy Well uses one quarter of a barrel a day but it's a 20-year old well.

The other two wells produced more water per day but they are newer wells.

Did you try to make a determination over the life of the well whether or not they were similar in regard to the amount of produced water that was put in the pits?

A No, we did not.

Q In your work with the EID are you familiar with other cases of benzene in groundwater such as had occurred in Prewitt, New Mexico?

A I'm vaguely familiar with the Prewitt case.

Q In that case are you aware whether there is or is not benzene in the groundwater?

A I believe it is benzene in the groundwater.

Q Do you recall how long that benzene had been there?

MR. KELLAHIN: I'm going to object to this line of questioning. He's talking about the

Prewitt case, which I believe has nothing to do with an unlined surface pit disposal and is not the subject matter in this hearing.

MR. STAMETS: I'm sorry, I was conferring with our lawyer.

Mr. Chavez, what did you ask him?

MR. CHAVEZ: My question concerned the benzene in the groundwater at Prewitt, New Mexico, his familiarity with it.

I was trying to make the point of the dilution and degradation of benzene that has been there in that groundwater; trying to draw some analogies. It is within District III.

MR. KELLAHIN: Is that contamination from produced water being put into an unlined surface pit?

MR. CHAVEZ: We don't know. There is a produced water pit there.

MR. STAMETS: I hate to --

MR. KELLAHIN: Is this in the vulnerable area?

MR. STAMETS: I hate to muddy this record any further and so I believe that we should leave the refinery out the testimony.

Q Mr. Stamets earlier mentioned that our concern should also include spills and upsets as well as

produced water.

What sort of protection do the unlined pits provide in the event of these occurrences?

A They'll contain a spill of the magnitude that the -- the volume of the pit and permit that kind of containment until you can get a vacuum truck or a pumper there to clean it up. That would be my answer.

Q Should some contingency planning be required since spills and upsets may be equal or of greater import than a small volume of produced water?

A I think there's an economic incentive to do so by the producers. Keep in mind that the pumpers are going to the wells on a daily or almost every other day basis. If there's condensate going into the pit people are losing money and there's an economic incentive to get a truck out there, A, first to fix the problem; B, to get a truck out there to recover what you've got.

Q Mr. Hicks, based on your study have you come up with any idea or thought of what an upper limit might be for allowing the discharges into unlined pits in the vulnerable area?

A Based on our study of benzene, benzene being what we believed to most the critical parameter, it appears as though 5 barrels of day being consistent with the other orders of the -- that I'm aware of, would be an upper limit.

MR. CHAVEZ: No further ques-

tions.

RECROSS EXAMINATION

BY MR. STAMETS:

Q Mr. Hicks, earlier I believe you indicated that there was to your knowledge no contamination of drinking water in the San Juan Basin from produced water, is that correct?

A That's correct.

Q And that was not necessarily counting the Flora Vista site, which -- it's not counting Flora Vista --

A I --

Q -- and I'm not asking you to say that Flora Vista's produced water, but if we dismissed that one from consideration, there is no site?

A None that I -- none that I am aware of.

MR. STAMETS: Mr. Chavez, even though you're not under oath, from your experience as director and supervisor of that District Office, does that square with your recollection of the situation there?

MR. CHAVEZ: Yes, sir.

Q Mr. Hicks, how much could rainfall affect the figures that you show on these -- on Exhibit Three, as far as dilution is concerned?

A Rainfall falling in the pit, for example?

Q Yes, right.

A We've got a volume of fluid in many of

these pits -- well, I guess it would depend on how much volume is in the pit to begin with. If we got an inch rain and there's only a half inch of fluids standing in the pit, the rainfall would be a significant factor in sampling the pits.

If in fact there is 4 feet of standing water in the pits and we get a half inch of rainfall the impact would be much less significant.

Q Would it be possible to make a calculation, not today, but sometime before a decision is rendered in this case, relative to one of these facilities based on only a quarter of a barrel instead of 4 barrels and what the effect would be of rainfall?

A A theoretical --

Q Yes.

A --mixing model --

Q Yes.

A -- that would consider a quarter barrel a day and the input of rainfall into the pit. Do we then consider evaporation as well?

Q Yes.

A Do we give any consideration to volatilization of benzene?

I don't -- we've got some -- I hate to simplify this thing to two or three things when we do have some -- some complex mechanisms acting.

Q Whatever you'ld like to throw in.

A It can be done.

Q Are your clients willing to pay for it?

A Don't ask me that.

MR. BUYS: Yes.

MR. STAMETS: Very good. We'd be appreciative if you could supply us with that information at an early date.

Q Mr. Hicks, I'm trying to figure out how we could handle some of these things.

I'm wondering if this would be a reasonable, practical was to do it, to require, say, a pit registration in the vulnerable area, where the owner would put his name down, put the location of the pit down, give us some specifics as to pit size and depth, the volume of water that goes to that pit, and then the water analysis, which would perhaps include TDS and Water Quality Control Commission standards. I'm not sure which standards ought to be used, surface water standards or groundwater standards, and require a ban, automatic ban if volume is over 5 barrels a day, or if any of these standards are exceeded.

A In the -- in the pit itself?

Q In the water going to the pit.

A Oh, I don't -- I don't think that would be representative. I think that would be -- I don't think it would work that way because we -- we're talking about several mechanisms in the pit itself that reduce certain constituents; additionally there's only certain constituents that would be of concern, and I think the representa-

tive, perhaps a more representative sampling with respect to some of the concerns that the EID has brought forth with respect to heavy metals or bringing that data to light.

We've recognized that the water going to the pit is considerably higher in benzene, for example, than the water that's in the pit itself.

We've also shown that benzene may not be, or according to the field studies is not a concern with respect ot groundwater degradation.

Perhaps --

Q I'm thinking more in terms of arsenic and chlorides, those type constituents.

A I think that --

Q If we have a produced water which exceeds the level of arsenic by 2, should that be allowed to be disposed of in an unlined pit?

A I think that what can be done is that, too, can be calibrated similar to what we've done to benzene.

As we found that benzene is not a problem with respect to groundwater, perhaps the same is true for arsenic. There may be some parameters that are of concern. There may be some parameters that need to be further investigated.

One of the things that I could -- I could foresee would be a pit registration similar to what you're talking about where the volume of water is produced and then

the specific conductants of that -- the specific conductants, of course, can be related to TDS. The specific conductants of that fluid in the pit itself would then also be submitted to the OCD so that a calculation with respect to TDS may be permitted and you would be able to draw your order from that. With respect to the heavy metals, perhaps that needs some investigation for field corroboration or some theoretical aspects which I don't believe have been brought out in this -- in this hearing at all, with respect to the mobility and the potential effect of heavy metals.

Q Is such a registration also reasonable to contain a spill or upset contingency plan?

A I think that a standard plan for the entire Basin would apply. For the vulnerable area, rather.

MR. STAMETS: Any other questions of this witness?

You may be excused.

At the last go-round when we asked who all was going to testify, it seemed like half the audience stood up.

How many more witnesses do you have at this point?

MR. KELLAHIN: Mr. Chairman, we might be able to figure out what to do about the balance of our case in the evening hours. I can't guess for you on the number of witnesses just now.

We need to talk about Mr.

Hicks' testimony and determine if we are going to put on additional witnesses. We could have as many as four. We could have as few as one. We need to talk about that.

MR. STAMETS: We're certainly planning on going home right away.

I'm trying to figure out whether to tell my fellow commissioner here that maybe he needs to plan on staying late, but we can work on that tomorrow.

We do need to finish this thing up tomorrow. I don't want to restrict anybody's testimony but we have a record that some sort of order can be based on and not just go on and on and on arguing the same points over and over again.

MR. KELLAHIN: Well, from the point of view of the producers, I believe we could finish tomorrow but I do not know what additional witnesses the Division's calling or whether EID proposes to call a witness.

MR. STAMETS: Ms. Pruett, at this point do you have any idea of putting on additional testimony?

MS. PRUETT: We have one additional witness that we're holding in the wings and at this point we don't plan to have him testify but we don't know what will happen tomorrow.

MR. STAMETS: Mr. Taylor.

MR. TAYLOR: Mr. Chairman, we

have, I think, one rebuttal witness who will take just a few minutes time.

MR. STAMETS: We'll recess this hearing until 8:30 tomorrow morning.

(Thereupon the hearing was recessed until the following morning, being 23 April, 1985.)

C E R T I F I C A T E

I, SALLY W. BOYD, C.S.R., DO HEREBY CERTIFY that the foregoing Transcript of Hearing before the Oil Conservation Division was reported by me; that the said transcript is a full, true, and correct record of the hearing, prepared by me to the best of my ability.

Sally W. Boyd CSR