RAS 4921

Official Transcript of Proceedings

NUCLEAR REGULATORY COMMISSION

Title: Private Fuel Storage, LLC

Docket Number: 72-22-ISFSI; ASLBP No. 97-732-02-ISFSI

Location: Rockville, Maryland

Date: Thursday, June 17, 2002

Work Order No.: NRC-428 Pages 10811-11080

NEAL R. GROSS AND CO., INC.
Court Reporters and Transcribers
1323 Rhode Island Avenue, N.W.
Washington, D.C. 20005
(202) 234-4433

Template = SECY-032

SECY-02

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

In the Matter of:	)
PRIVATE FUEL STORAGE, LLC,	) Docket No. 72-22
(Independent Spent Fuel	) ASLBP No.
Storage Installation)	) 97-732-02-ISFSI

ASLBP Hearing Room
Third Floor
Two White Flint North Building
11545 Rockville Pike
Rockville, Maryland

June 17, 2002

The above-entitled matter came on for hearing, pursuant to notice, at 9:00 a.m. before:

MICHAEL C. FARRAR, CHAIRMAN
Administrative Judge
U. S. Nuclear Regulatory Commission

DR. JERRY R. KLINE
Administrative Judge
U. S. Nuclear Regulatory Commission

DR. PETER S. LAM
Administrative Judge
U. S. Nuclear Regulatory Commission

A P P E A R A N C E S

FOR THE STATE OF UTAH:
Denise Chancellor, Esq.
Connie Nakahara, Esq.
ASSISTANT ATTORNEY GENERAL
Office of the Attorney General
160 East 300 South, 5th Floor
P. O. Box 140873
Salt Lake City, Utah 84114

FOR PRIVATE FUEL STORAGE, LLC:
Jay Silberg, Esq.
Sean Barnett, Esq.
Paul Gaukler, Esq.
SHAW PITTMAN
Attorneys at Law
2300 N Street, N.W.
Washington, D.C. 20037

FOR THE SKULL VALLEY BAND OF GOSHUTE INDIANS:
Timothy Vollmann, Esq.
Attorney at Law

FOR THE U.S. NUCLEAR REGULATORY COMMISSION:
Sherwin E. Turk, Esq.
Catherine Marco, Esq.
Office of the General Counsel
Mail Stop - 0-15 B18
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

FOR THE SOUTHERN UTAH WILDERNESS ALLIANCE:
Joro Walker
Director, Utah Office
Land and Water Fund of the Rockies
1473 South 1100 East, Suite F
Salt Lake City, Utah 84105

I-N-D-E-X

EXHIBITS

NUMBER	DESCRIPTION	MARK	RECD
Applicant			
GGG	Soil Cement Mixes	10835	10837
HHH	ACI Report	10836	10837
III	Mitchell Deposition	10836	10837
JJJ	PFS Safety Analysis	10836	10837
State			
212	Enlargement of PFS SAR Fig. 4.2-7	10867	10990
213	AGEC Test Results	10877	10990
105	James Mitchell CV	11035	11035
106	PFS SAR Sect. 2.6.4.11	11035	11035
108	Trudeau Deposition	11035	11035
109	Wissa Deposition	11035	11035
PFS			
228	Mitchell Deposition	11046	
228A	Mitchell Deposition w/corrections	11052	
229	Soil Cement Mixes	11068	

P-R-O-C-E-E-D-I-N-G-S

9:32 a.m.

CHAIRMAN FARRAR: Good morning, everyone. We said we would try to start at 9:30 if the moving in problems didn't cause you too much delays. Is everyone ready to go? I will talk slowly while you get organized.

I want to welcome everyone to the Licensing Board's hearing room at the NRC headquarters in Rockville, Maryland. We've conducted six weeks of hearings in Salt Lake City, four of them on seismic issues.

We are here today to begin two weeks of additional hearings on seismic matters. For the benefit of the Court Reporters, could you all introduce yourselves briefly?

MR. GAULKER: Paul Gaulker, Counsel for Applicant, Private Fuel Storage.

MR. TRAVIESO-DIAZ: Matias Travieso Diaz, Counsel for PFS.

MR. SILBERG: Jay Silberg, also counsel for PFS. We are all from the Washington law firm of Shaw Pittman.

CHAIRMAN FARRAR: For the State of Utah?

MS. CHANCELLOR: Denise Chancellor, State of Utah, Connie Nakahara, State of Utah. On my right is Dr. Steven Bartlett, and on my left is Dr. James Mitchell, who will be witnesses in this Proceeding.

CHAIRMAN FARRAR: For the Staff?

MR. O'NEILL: Martin O'Neill, Counsel for the NRC Staff.

MS. MARCO: Catherine Marco, Counsel for NRC.

MR. TURK: Sherwin Turk, with the same office.

CHAIRMAN FARRAR: Good to see you all here again. Let's go off the record for a moment to discuss some logistical matters.

(Whereupon, the above-entitled matter went off the record at 9:34 a.m. and went back on the record at 9:35 a.m.)

CHAIRMAN FARRAR: Are there any preliminary matters before we start with the Applicant's witnesses?

MR. GAULKER: Yes, Your Honor, there is one preliminary matter, to update the Board on the latest discussions we've had among the parties for the schedule for these two weeks of seismic hearings.

As discussed we are starting out with the start soil witnesses, today and tomorrow. We will be starting with Dr. Bartlett, the cross examination of Dr. Bartlett, and any rebuttal that Staff may have with respect to the Sandia report, on Wednesday.

We've set that as to the exact time we will start on that. And I believe there was some discussion to the extent we have time on Tuesday afternoon, available, we have two options.

One is to try to do his rebuttal testimony on Section D, which we didn't get to in Salt Lake City, or potentially start soils, whichever one works out the best.

CHAIRMAN FARRAR: Okay.

MR. GAULKER: Then Thursday we would go to the soils part of section C, and do that Thursday, and complete that on Friday.

MS. CHANCELLOR: Your Honor, I might add that the State does not necessarily agree that we should start Dr. Luke on Wednesday, but that may be a moot point, depending on what happens with soil cement.

And I agree with Mr. Gaulker, we haven't decided yet how we will fill the afternoon on Tuesday.

MR. TRAVIESO-DIAZ: We will need to get a notice as to which way the State prefers to go, so that we can have the paperwork ready.

MR. TURK: May I note, before we move to the second week, that Dr. Luke will be available this week. He is flying out on Tuesday, he will be here Tuesday night. So for that reason we proposed the cross examination of Dr. Bartlett, with respect to his rebuttal testimony concerning Dr. Luke's report, to commence Wednesday morning.

CHAIRMAN FARRAR: And you need Dr. Luke here to do that, is that the --

MR. TURK: Correct. It is for that reason that we discussed with the other parties the need, if we do need to fill Tuesday afternoon, we would do that with the Trudeau rebuttals, or some of the soils testimony.

CHAIRMAN FARRAR: Now, do you envision, then, that Dr. Luke would provide rebuttal testimony?

MR. TURK: Yes.

CHAIRMAN FARRAR: And we would have to fit that into the same time?

MR. TURK: That would come in on Wednesday, and I don't see any problem with that, because if we start with Dr. Bartlett's cross examination, I don't imagine that will go more than a few hours at the most. We would have time for Dr. Luke's rebuttal.

CHAIRMAN FARRAR: All right. Before we go to the second week, as planned, we will be recessing at 2 p.m. on Friday, and then you will be working with Judge Bullwork on the electronic information exchange for about an hour or so, and then be free to go.

MR. TRAVIESO-DIAZ: And the understanding is that we will start early on Friday?

CHAIRMAN FARRAR: Yes, 8 o'clock on Friday. And we will be at 9 every day the rest of this week, and our contemplation is to do the same thing that we did in Salt Lake City, go from 9 to 12:30, 12:30 to 1:30 lunch, 1:30 to 5 to complete, but we would be willing to stay if it is necessary to complete a particular witness, or an important phase.

Mr. Gaulker, you were going to tell us about the second week?

MR. GAULKER: Yes, the second week --

MS. CHANCELLOR: What about the first week and the Holtec report?

MR. TRAVIESO-DIAZ: We will talk about in a moment.

MS. CHANCELLOR: Okay.

MR. GAULKER: The second week we had originally discussed not having a hearing on Monday, but the parties have discussed, and believe that we should have hearing on Monday. And we will start, we propose to start with the radiation dose consequences of Section E, because of the weekend, and travel, Counsel would like to start at 10 o'clock on Monday, if we could.

CHAIRMAN FARRAR: That is fine.

MR. GAULKER: We would have radiation dose consequences, we expect that to take two to three days. We would definitely start with the cross examination of Dr. Bartlett on Section E, on Thursday.

To the extent that we have some time on Wednesday, because radiation dose consequences may get done earlier, we would have the rebuttal testimony of John Stamatakos, I believe is what we had discussed, on Section E.

And then we would have Dr. Bartlett's direct testimony on Section E on Thursday, and we will have any rebuttal on Section E, we envision some small rebuttal ourselves, on Friday.

And to the extent we didn't get to Dr. Stamatakos on Wednesday, then his rebuttal would be on Friday.

CHAIRMAN FARRAR: And under that schedule we finish in two weeks?

MR. GAULKER: Yes.

MS. CHANCELLOR: All being well.

CHAIRMAN FARRAR: That would make a total of six weeks on seismic?

MS. CHANCELLOR: I might add with the rebuttal on Dr. Stamatakos, Mr. Turk sent me a draft that arrived after hours on Friday. So Dr. Aravas hasn't had a chance to look at that.

There is the potential that we may need to tie Dr. Aravas in by video conference.

CHAIRMAN FARRAR: We can arrange that if necessary.

MS. CHANCELLOR: And I need to check on his availability.

CHAIRMAN FARRAR: All right. He is at the university?

MS. CHANCELLOR: That is correct.

CHAIRMAN FARRAR: And that is where we did the video facilities last time?

MS. CHANCELLOR: Yes, the broadcast center, that is correct. And Dr. Bartlett will be going back on the weekend, so that is the reason why we are starting him at a date certain on Thursday.

CHAIRMAN FARRAR: All right. Again, the Board wants to commend the parties for working together on witness scheduling, in an issue on which you have 21 panels the witnesses, this is certainly a better way to do it than us trying to direct traffic, so we appreciate your help.

Any other preliminary matters?

MR. TRAVIESO-DIAZ: Yes, Your Honor.

CHAIRMAN FARRAR: Okay.

MR. TRAVIESO-DIAZ: Two more. First, the more general of the two. If I recall, the Board commended the parties to attempt to expedite, or facilitate the rebuttal process, which as we saw in Salt Lake City, can be convoluted.

In an effort to do that, we have tentatively agreed that this discussion with the State, I don't think we ever had a chance to talk about this with the Staff, that to the extent feasible, we would try to have a witness present, for his direct testimony, and any rebuttal that he may have to other parties' testimony at the same time.

In an effort to achieve that, I circulated late last night, and I apologize for the lateness, but the witnesses were traveling, and they didn't get here until late.

A rebuttal testimony by Mr. Trudeau and Dr. Wissa, to the testimony of Dr. Bartlett and Dr. Mitchell, and our view, the witnesses will be available to answer questions on that rebuttal at the same time they give their direct testimony.

However, the State may feel that they need more time to review it, and in this instance, it is possible that they may want to have, revert to the procedure that we used in Salt Lake City for these witnesses.

But our view is that the better practice, if at all possible, would be to have what we intended, which is to have this witness address direct and rebuttal at the same time, be the way we go.

With the understanding, of course, that we may need to have additional oral rebuttal based on the testimony that the other parties give.

CHAIRMAN FARRAR: We appreciate that offer. When we had gotten your rebuttal that question crossed our minds, if it wouldn't be more efficient to do both at once, rather than what we did in Salt Lake City.

But certainly efficiency takes second place to fairness, so the -- it would have to be either by the State's ability, at least in this instance, given the lateness of the filing, to proceed in that fashion.

MR. O'NEILL: I would note that we haven't received a copy of that yet, so we would certainly request some additional time to review it.

MR. TURK: Could we hear from the State?

MS. CHANCELLOR: Yes. We received a copy around about midnight last night, and the two witnesses here have only just had a chance to look at it first thing this morning.

So I think in this instance it would be more efficient if we did it as part of the overall rebuttal, rather than part of direct.

CHAIRMAN FARRAR: All right.

MR. TURK: May I address it also, Your Honor?

CHAIRMAN FARRAR: Go ahead, Mr. Turk.

MR. TURK: We received it electronically, I saw it on my machine this morning. But we didn't understand that, upon receiving it, that it was intended to be presented first thing this morning.

So we have not had a chance to review it ourselves, yet. I think with respect to that piece of rebuttal testimony, we are probably best served by doing it in the normal course of doing the other witnesses, then coming to the rebuttal.

But with respect to other testimony, if we get it in time, we don't have a problem with the

Applicant's suggestion.

CHAIRMAN FARRAR: That would be our thought, that to the extent that can be done in future instances, it is certainly a time saving procedure. In this instance we appreciate the offer, but it sounds like it would be better not to do it this time.

MR. TRAVIESO-DIAZ: One other preliminary matter. As it will become apparent, in the discussions on the soil cement issue, there is a concern raised by the State that moisture may accumulate under the cement treated soil, in the soil directly underneath, and weaken the soil.

And I'm not trying to characterize their position, but just give you background for what I'm going to say.

Our position to the contrary is that for a number of reasons this is not going to happen. One of the reasons we claim this is not going to happen, is that the waste storage casks, that sit on the pad, in addition to being radioactively hot, they also are at a fairly elevated temperature, and they release heat.

That heat goes through the pad, through the cement treated soil, and ultimately into the soil beneath, driving moisture away. To demonstrate that we have prepared, and we sent to the State last week, a calculation that Holtec did, intending to demonstrate that in fact how the heat transfer process occurs, and that there is a positive temperature gradient going from the cement treated soil, to the top layer of the subsoil.

Therefore --

CHAIRMAN FARRAR: Now, you touched on this conceptually in your testimony?

MR. TRAVIESO-DIAZ: Correct. And the State wishes to cross examine on that issue. And they want to cross examine the author of the report, the person who is going to sponsor this, Dr. Singh.

MS. CHANCELLOR: Could we just establish that this is part of rebuttal, and not part of direct testimony? Because it wasn't introduced as part of the direct prefiled testimony.

MR. TRAVIESO-DIAZ: That is correct. And -- but the reason we are raising all this at this point is that the State feels that they need to have Dr. Bartlett present when that examination takes place.

We have suggested to do it next week, because Dr. Singh will be participating here with the radiation release panel. However, the state feels that they want to have Dr. Bartlett available for that examination he won't be here.

Well, we accommodate the State --

CHAIRMAN FARRAR: I thought he was coming back Monday?

MS. CHANCELLOR: No, he is coming back Thursday. I think the main point is that this is part of soil cement testimony, it is not part of radiation dose testimony.

And in addition I need the experts here. It is a bit of a crossover. There are some radiation issues with respect to the amount of heat transfer. But it is presented in the context of soil cement, and that is why I felt like it should be this week when we are doing soils this week.

MR. TRAVIESO-DIAZ: The reason why I bring it up this before you now, is that we think the only way this can be done, effectively, is by tying Dr. Singh by radioconferencing tomorrow, given that time, so that he can be examined on that issue without having to come here, given that it is rather narrow.

And I think the State is agreeable to that procedure, is that correct?

MS. CHANCELLOR: Yes, that is correct.

CHAIRMAN FARRAR: Where will he be?

MR. GAULKER: He will be at his offices up in New Jersey. They do have videoconferencing capabilities, is my understanding, Holtec does.

MR. TRAVIESO-DIAZ: So what we need to do is establish a time certain tomorrow, in which that videoconference can take place, and make the necessary arrangements.

CHAIRMAN FARRAR: Hold on a minute.

(Pause.)

JUDGE LAM: Mr. Travieso-Diaz?

MR. TRAVIESO-DIAZ: Yes.

JUDGE LAM: What do you intend to demonstrate with this new thermal calculation by Dr. Singh?

MR. TRAVIESO-DIAZ: Well, intuitively the principle is well understood. If the cask emits heat, that heat may in fact find its because the heat will tend to die mostly away. And, in fact, it will stay in the soil.

However, that is just in principle. We have actually quantified that principle and demonstrated that there is such a gradient of a number of degrees Fahrenheit.

So at all times the top layer of the subsoil will be warmer than the area underneath it, therefore moisture will be migrating away from the area underneath the pad, as opposed to into it.

So it is a quantification of what I think we understand to be a physical principle.

MS. CHANCELLOR: Your Honor, I guess it is a question of what it is rebutting.

MR. TRAVIESO-DIAZ: Excuse me?

MS. CHANCELLOR: I mean, it is being offered as rebuttal testimony, correct?

MR. TRAVIESO-DIAZ: Yes.

MS. CHANCELLOR: So it is a question of what that rebuttal testimony is rebutting.

MR. TRAVIESO-DIAZ: It is rebutting the claim that is made by the State witnesses, that one of the potential concerns with the use of soil cement, is that the subsoil underneath the soil cement will be -- that moisture will be trapped by having, essentially, a concrete pad above that doesn't let the normal traffic, if you will, of moisture to go in and out. That is part of their testimony.

And we have a number of answers to it. One of them is that it simply is not going to happen, because moisture will not gather underneath the pads, and the soil cement, because the heat that migrates downwards will prevent it.

I can refer you specifically to --

MS. CHANCELLOR: No, it is fine, I don't want to get into an argument.

CHAIRMAN FARRAR: Well, before we make the effort to set up the videoconference for Dr. Singh, Ms. Chancellor, if you have an argument that this is improper rebuttal, then we ought to hear it at some point before we make the arrangements.

Do you want to do that at some later time today?

MS. CHANCELLOR: Could we do that after lunch?

CHAIRMAN FARRAR: Fine. If assuming that argument does not prevail, what time do you want to do Dr. Singh on Tuesday? And the reason I ask is we have to arrange through headquarters videoconferencing people.

MR. TRAVIESO-DIAZ: Could we make that the first order of business after lunch tomorrow? And that way we know it is going to be like 1:30.

CHAIRMAN FARRAR: All right. Why don't we set that for 1:30 on Tuesday. We will check now to see if we can arrange that, and then we will hear argument later on whether this is appropriate rebuttal.

MR. TRAVIESO-DIAZ: Thank you.

CHAIRMAN FARRAR: Is that all the preliminary matters?

MR. TRAVIESO-DIAZ: Yes, sir.

CHAIRMAN FARRAR: Then the Applicant was going to present its testimony on soil cement?

MR. TRAVIESO-DIAZ: That is correct.

CHAIRMAN FARRAR: Go ahead.

MS. CHANCELLOR: Your Honor, did you receive a copy of my cross examination plan? If you didn't I have a hard copy with me.

CHAIRMAN FARRAR: Yes, we have that.

MS. CHANCELLOR: Okay.

CHAIRMAN FARRAR: Thank you. For the benefit of Counsel, if we have a situation where you need to go over and show the witnesses something, there is a hand held microphone which you can use, if you are away from your desk.

Whereupon,

PETER TRUDEAU

was called as a witness by counsel for the Applicant and, having been previously duly sworn, assumed the witness stand, was examined and testified as follows:

Whereupon,

ANWAR WISSA

was called as a witness by counsel for the Applicant and, having been duly sworn, assumed the witness stand, was examined and testified as follows:

DIRECT EXAMINATION

MR. TRAVIESO-DIAZ: Gentlemen, would you state your name for the record, please?

MR. TRUDEAU: Good morning. My name is Paul J. Trudeau.

DR. WISSA: Anwar Wissa.

MR. TRAVIESO-DIAZ: Do you both have in front of you a document bearing the caption of this Proceeding, dated April 1st, 2002, and entitled: Joint Testimony of Paul J. Trudeau, and Anwar Ez Wissa, on Section C of Unified Content Utah L-QQ?

DR. WISSA: Yes.

MR. TRUDEAU: Yes.

MR. TRAVIESO-DIAZ: Are there any corrections you wish to make to that testimony?

MR. TRUDEAU: I have one correction that I would like to make to the response on page 17, which is A-23.

In the last line of that paragraph I had indicated, at that time, that -- excuse me, let me back up. The stress controlled tests were performed by PFS showed very little defamation, indicating no significant reduction in shear strength, even after 500 cycles of loading.

And then parenthetically it says: Versus about 8 to 15 for the PFS design earthquake. I would like to change the 8 to 15 to say 7 to 11, which is consistent with the numbers that I'm using in my rebuttal testimony on part D.

I was advised by Dr. Robert Young last week that when we include directivity effects 7 to 11 are the appropriate numbers for this site, and directivity of the earthquake is a significant well-known issue for the site.

So it is appropriate to use the 7 to 11 in that case, instead of the 8 to 15 that I had originally included.

MR. TRAVIESO-DIAZ: Did you both prepare this testimony, or was it prepared under your direct supervision and control?

MR. TRUDEAU: Yes.

DR. WISSA: Yes.

MR. TRAVIESO-DIAZ: With the correction that you noted, Mr. Trudeau, is that testimony true and correct to the best of your knowledge?

MR. TRUDEAU: Yes.

MR. TRAVIESO-DIAZ: I would like to, Dr. Wissa, is it true and correct?

DR. WISSA: Yes.

MR. TRAVIESO-DIAZ: I would like to move to have this testimony admitted into evidence, and incorporated into the record.

CHAIRMAN FARRAR: Any objection?

MS. CHANCELLOR: No objection, Your Honor.

MR. O'NEILL: No objection, Your Honor.

CHAIRMAN FARRAR: All right, then the testimony of this panel will be bound into the record at this point, as if read.

(Insert prefiled testimony of Dr. Trudeau and Dr. Wissa here.)

April 1, 2002

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of	)	
	)	
PRIVATE FUEL STORAGE L.L.C.	)	**Docket No. 72-22**
	)	
(Private Fuel Storage Facility)	)	**ASLBP No. 97-732-02-ISFSI**

JOINT TESTIMONY OF PAUL J. TRUDEAU AND ANWAR E. Z. WISSA ON SECTION C OF UNIFIED CONTENTION UTAH L/QQ

I. WITNESSES

A. Paul J. Trudeau ("PJT")

Q1. Please state your full name.

A1. Paul J. Trudeau.

Q2. By whom are you employed and what is your position?

A2. I am a Senior Lead Geotechnical Engineer at Stone & Webster, Inc., a Shaw Group Company ("S&W") in Stoughton, Massachusetts.

Q3. Please summarize your educational and professional qualifications.

A3. My professional and educational experience is described in the *Curriculum Vitae* attached to the testimony I am filing simultaneously herewith with respect to Section D of Unified Contention Utah L/QQ ("the Unified Contention.") As indicated there, I have twenty-nine years of experience in geotechnical engineering, including the performance of subsurface soil investigations; the performance and supervision of the analysis of foundations in support of the design of structures; the performance of laboratory tests of soils including index property tests, consolidation tests, static and dynamic triaxial tests, and other tests; the performance of analyses of the performance of soils and structures under static and dynamic conditions; the development of geotechnical design criteria for other engineering disciplines, such as Structural, Environmental, Engineering Mechanics, and Electrical; and the preparation of the geotechnical sections of Preliminary and Final Safety Analyses Reports and Environmental Reports.

Q4. What is the basis of your familiarity with the Private Fuel Storage Facility?

A4. S&W is the Architect/Engineer for the Private Fuel Storage Facility ("PFSF") under contract with Private Fuel Storage, L.L.C. ("PFS" or "Applicant"). As such, it coordinates the facility design activities, including the studies needed to characterize the PFSF site and establish its suitability. My particular areas of concentration on the PFSF project are the analysis of soils – settlement, bearing capacity, and stability of foundations – as well as the conduct of soils investigations, laboratory testing of soils to measure static and dynamic properties, and the performance of computer-aided analyses of the behavior of soils and structures under static and dynamic loading conditions.

Q5. What is the purpose of your testimony?

A5. The purpose of my testimony is to respond to allegations raised by the State of Utah in the Unified Contention concerning: (1) the characterization of subsurface soils at the PFSF site through subsurface investigations, sampling and analyses; (2) the stress/strain behavior of the soils under design basis earthquake conditions;

and (3) the use of soil cement and cement-treated soil to enhance the seismic behavior of the soils beneath and adjacent to the foundations of the safety-related structures at the PFSF. Specifically, I will address herein the allegations raised in Section C of the Unified Contention. As indicated earlier, I am also filing separate testimony in which I address the seismic analysis of the cask storage pads, casks, and their foundation soils and the seismic analysis of the Canister Transfer Building and its foundation. That testimony addresses some of the allegations raised by the State in Section D of the Unified Contention.

B. Anwar E. Z. Wissa ("AEZW")

Q6. Please state your full name.

A6. Anwar E. Z. Wissa.

Q7. By whom are you employed and what is your position?

A7. I am President of Ardaman & Associates ("A&A") in Orlando, Florida. A&A is a professional corporation founded in 1959. It provides numerous services, including subsurface investigations, foundation engineering, laboratory testing, construction materials testing and inspection, and contamination remediation. The company employs a staff of over 360 professional engineers, scientists, technicians, drilling personnel, technical assistants and support staff, and maintains a state-of-the-art geotechnical laboratory at its headquarters.

Q8. Please summarize your educational and professional qualifications.

A8. My professional and educational experience is described in the *curriculum vitae* attached to this testimony. Of particular relevance is the fact that I have been a Fellow of the American Society of Civil Engineers since 1983, serving on the

Committee on Placement and Improvement of Soil for nine years. I have also been a member of Committee D-18 on Soil and Rock for the American Society of Testing and Materials ("ASTM") since 1966. I have been extensively involved in projects employing soil cement, including reservoirs and pavements over my professional career, and have authored several publications on the use of soil cement.

Q9. What is the basis of your familiarity with the Private Fuel Storage Facility?

A9. I was retained by PFS to review the program being implemented by PFS to use soil cement to improve subsurface conditions at the PFSF site. In the process of my review, I have examined a number of documents relating to the design of the facility and, specifically, to the proposed use of soil cement at the site.

Q10. What is the purpose of your testimony?

A10. The purpose of my testimony is to respond to allegations raised by the State of Utah in the Unified Contention concerning the use of soil cement and cement-treated soil to enhance the seismic behavior of the soils beneath and adjacent to the foundations of the safety-related structures at the PFSF. Specifically, I will address herein the soil cement-related allegations raised in Section C of the Unified Contention.

II. GEOTECHNICAL INVESTIGATIONS CONDUCTED AT THE PFSF SITE

Q11. Please describe the investigations that PFS has conducted to characterize the soils at the PFSF site.

A11. (PJT) The initial geotechnical investigations were performed in late 1996. The results of those initial investigations were reflected in the initial version (Revision

0) of the Safety Analysis Report ("SAR") for the PFSF, which was filed in June 1997. Later, in 1999, PFS performed considerable additional soil investigations, including borings in the Canister Transfer Building ("CTB") area and a series of cone penetration test soundings to better assess soil strength and compressibility, as well as the faulting study performed by Geomatrix Consultants, Inc. ("Geomatrix"). Specifically, in 1999, 12 additional borings were drilled and sampled, 39 cone penetration tests were performed (16 of which included measurements of pressure and shear wave velocities in addition to the penetration resistance data), and 18 dilatometer soundings were performed. Those investigations were supplemented with further soils investigations performed in January 2001. The January 2001 investigations were conducted in part by Northland Geophysical LLC, which made downhole geophysical measurements in two borings, which corroborated the geophysical measurements that were made in the seismic cone penetration tests. At the same time, S&W performed additional sampling at sixteen test pits excavated at the PFS facility site to obtain bulk samples of the soils for use in the soil cement testing program. As they stand today, the soils investigations performed at the PFSF are sufficient to properly characterize the site from the geotechnical standpoint.

The results of the geotechnical investigations conducted by PFS are presented in Section 2.6 and Appendix 2A of the SAR, as revised through April 2001 (Rev. 22). That section, 219 pages long plus attachments and appendices, presents a comprehensive description of the various investigations that have been conducted, and includes geologic maps, profiles of the site stratigraphy, and discussions of structural geology, geologic history, and engineering geology.

The locations of the borings made to study subsurface conditions at the PFSF site are summarized in three location plans (which are Figures 2.6-2, 2.6-18, and 2.6-19 of the SAR). Boring logs are provided in Attachment 1 to Appendix 2A of the SAR.

Figure 2.6-5 of the SAR includes 14 sheets of "foundation profiles" that depict the composition of the PFSF subsoil layers at various locations in the pad emplacement area and Figures 2.6-20 through 2.6-22 present foundation profiles under the CTB. Seventeen foundation profiles are provided: 2 diagonal, 6 east-west, and 6 north-south in the pad emplacement area and 2 east-west, and 1 north-south in the Canister Transfer Building area. These profiles cover all safety-related structures and encompass all borings made by PSF in the vicinity of those structures.

The initial set of borings was drilled in the pad emplacement area, following a uniform, grid-like pattern, with the borings spaced approximately 600 feet apart. A determination was made after the initial tests that the soil properties at the PFSF site are reasonably uniform in the horizontal direction (that is, across the various site locations). Because of this uniformity, it was unnecessary to establish a denser set of borings than the one initially provided.

Q12. How did you determine that the soils were reasonably uniform in the horizontal direction?

A12. (PJT) The test data, as presented in SAR Figure 2.6-5, Sheets 1 through 14, demonstrate the horizontal consistency of the materials at the site. This consistency was further demonstrated by the cone penetration test data, which show that the upper soil layers have fairly consistent properties across the pad emplacement area and beneath the CTB.

Moreover, data on the properties of the soils in a trench dug by PFS consultant Geomatrix Consultants, Inc. confirmed that the soils in approximately the upper 30 feet of the subsoil are fairly uniform and consistent in the horizontal direction across the site. The site investigations conaucted by Geomatrix for PFS since the SAR was prepared in 1997 are described in the Geomatrix report "Fault Evaluation Study & Seismic Hazard Assessment, February 1999." This report includes two plates, Plates 3 and 4, which present geologic profiles that provide an unambiguous geological characterization of the site and set forth the details of the site's geologic conditions. These geological plates prepared by Geomatrix can be correlated with the data on subsurface conditions presented in the foundation profiles developed under my supervision. Comparison of the Geomatrix plates with the foundation profiles in SAR Fig. 2.6-5 demonstrates that the nature, location, and thickness of the various layers of the profile are identically presented in both documents.

Q13. What methodology was used to characterize the soils at the PFSF site?

A13. (PJT) Soil classification was performed through various methods, including: visual inspection of the samples obtained, in accordance with American Society of Testing and Materials ("ASTM") standards; performance of laboratory tests on soil samples; and interpretation of cone penetration test results. These methods provided a consistent and accurate characterization of the thickness, extent and composition of the subsoil at the site.

Q14. What are the main characteristics of the soils at the PFSF site?

A14. (PJT) Our investigations established that the top 30 feet or so of the subsoil profile are the only ones of interest from the geotechnical standpoint, since below 30 feet, the soils are comprised of very dense sands or silty sands overlying very dense silts, which have great strength, as evidenced by their high standard penetration test blow counts (N > 100 blows/ft).

The investigations also established the thickness and extent of the layers of soil comprised within the top 30 feet of the profile. As shown in the foundation profiles in SAR Fig. 2.6-5, within the first 30 feet of the profile, there are five distinct soil layers. Of these, the topmost "eolian soil" layer is of only limited interest because the design intent is to remove it and mix it with cement to form cement-treated soil. The second layer, which runs generally 3 to ~10 feet beneath the surface (sometimes referred to as "Layer 2") was found through the boring and laboratory testing programs to have the lowest strength and highest compressibility of the soils at the PFS site. Subsequently, cone penetration tests confirmed that the Layer 2 soils are the weakest and most compressible soils. Layer 2 is, therefore, the main layer of concern from the standpoint of soil strength and compressibility. The other three layers in the first 30 feet of subsoil have considerably greater strength and less compressibility than the top two layers.

III. METHODOLOGY AND RESULTS IN THE PFSF LABORATORY TESTING PROGRAM

Q15. Would you please describe the objectives of the laboratory testing program that was conducted with regard to the PFSF soils?

A15. (PJT) The purpose of the tests conducted on the samples of soil collected at the PFSF site was to establish certain properties of the soils that are needed as inputs in the design of the site structures. The design activities supported by the test program include the establishment of geotechnical design criteria, the analyses of settlements and bearing capacity of the foundations, and the seismic stability of the structures.

Q16. How many soil samples were obtained for testing in the laboratory testing program?

A16. (PJT) PFS has conducted a comprehensive laboratory testing program that has included taking 33 undisturbed samples, as shown on Table 1 below. Also, there have been 10 consolidation tests, 19 triaxial shear strength tests, 5 cyclic triaxial tests, 2 resonant column tests (at 3 different confining pressures), and 11 direct shear tests.

TABLE 1: UNDISTURBED SOIL SAMPLES TAKEN AT THE PFSF SITE

Boring ID	Sample	Depth to:		Date Taken
		Top	Bottom	
A-2	U2	5.00	7.00	Oct 1996
B-1	U2	5.00	7.00	Oct 1996
B-2	U1	8.00	10.00	Oct 1996
B-3	U1	5.00	7.00	Oct 1996
B-3	U2	10.00	12.00	Oct 1996
B-4	U3	10.00	12.00	Oct 1996
C-1	U3	10.00	12.00	Oct 1996
C-2	U1	5.00	7.00	Oct 1996
C-2	U2	10.00	12.00	Oct 1996
E-2	U1	5.00	7.00	Dec 1998
CTB-1	U3	7.00	9.00	Jan 1999
CTB-1	U5	11.00	13.00	Jan 1999
CTB-1	U7	20.00	22.00	Jan 1999
CTB-4	U1	6.00	8.00	Dec 1998
CTB-4	U2	8.00	10.00	Dec 1998
CTB-4	U7	12.00	13.50	Dec 1998
CTB-4	U9	16.00	17.50	Dec 1998
CTB-4	U11	20.00	21.50	Dec 1998
CTB-4	U13	24.00	25.50	Dec 1998
CTB-4	U15	28.00	29.50	Dec 1998
CTB-5(OW)	U6	10.00	12.00	Jan 1999
CTB-5(OW)	U8	14.00	16.00	Jan 1999
CTB-5(OW)	U10	18.00	20.00	Jan 1999
CTB-5(OW)	U12	22.00	24.00	Jan 1999
CTB-5(OW)	U14	26.00	28.00	Jan 1999
CTB-6	U3	7.00	8.50	Dec 1998
CTB-7	U3	7.00	9.00	Dec 1998
CTB-N	U1	5.00	7.00	Oct 1998
CTB-N	U2	7.00	9.00	Dec 1998
CTB-N	U3	9.00	11.00	Dec 1998
CTB-S	U1	5.00	7.00	Dec 1998
CTB-S	U2	7.00	9.00	Dec 1998
CTB-S	U3	9.00	11.00	Dec 1998

Q17. How were these samples taken?

A17. (PJT) Samples were taken and tested in accordance with procedures established under the general guidance of ASTM standards. Detailed, quantitative criteria were used to ensure that the drilling and sampling of the PFSF site soils was conducted as recommended by the ASTM standards referenced in those procedures. The procedures required, among other things, that an engineer from S&W confirm that the samples were taken in accordance with ASTM standards and project procedures.

PFS obtained samples of all soil strata, from the ground surface to depths as great as 226.5 feet below the ground surface, beneath the foundations of the Canister Transfer Building ("CTB" in the table) and the pad emplacement areas. As indicated in Table 1 above, a total of 33 undisturbed samples were collected – from eight borings in the pad emplacement area and from seven borings in the CTB area.

As I mentioned earlier, initial tests on samples collected in 1996 determined that Layer 2 soil is the main layer of concern from the standpoint of soil strength and compressibility. This determination was later confirmed through laboratory testing and cone penetration tests. Thus, for purposes of supporting the structural design of the facility, it was appropriate to focus the testing program on the samples of Layer 2 soils. Table 1 shows that two-thirds of the undisturbed samples were collected from Layer 2 (about 3 to 10 feet below the ground surface).

Q18. Why is the number of samples tested sufficient?

A18. (PJT) The number of samples tested is sufficient because the soil properties are reasonably uniform across the various site locations. Moreover, the soil layer of primary interest (Layer 2) exhibits great uniformity across the site, as evidenced by the consistency in standard penetration test blow count values and the cone penetration testing tip resistance values. All *in situ* testing performed at the site, and the laboratory tests performed on samples of the soils obtained from the upper 30 feet of the profile, demonstrated that the soils beneath Layer 2 are stronger and less compressible. Thus, it was conservative to concentrate the sampling and testing program on samples obtained from Layer 2.

Q19. What tests were conducted on the soil samples collected at the PFSF site?

A19. (PJT) The laboratory tests that were conducted on the soil samples identified in Table 1 included dynamic testing of samples in both stress and strain-controlled manner, and they were sufficient to determine the properties of materials at the site and establish the design parameters. Among the parameters investigated in the laboratory tests were those that relate to the static and dynamic properties of the soil including grain size, triaxial shear strength, consolidation characteristics, Atterberg limits, water content, direct shear strength, shear moduli, damping, and strength under cyclic loading. Because the soil tests performed by PFS provide sufficient information on the soils at the site, no other tests would be needed to adequately characterize these soils.

The manner in which the laboratory tests were conducted and the test results are fully documented in the test reports in the attachments to Appendix 2A of the SAR. Soil sample preparation for testing is adequately described in the

Engineering Services Scope of Work documents ("ESSOWs") (with respect to field testing) and in Attachments 2 through 8 of Appendix 2A of the SAR (with respect to laboratory testing).

The results of the laboratory tests conducted on PFSF soils are included in the attachments to Appendix 2A of the SAR. Taken together, the test results are sufficient to ensure that the soil characteristics were conservatively interpreted to develop the design parameters. The tests conducted and their results show that the soil conditions are adequate for the proposed foundation loadings, both static and dynamic; that the static and dynamic properties of the soils, such as their compressibility and shear strength, have been properly defined; and that reasonably conservative values of those properties were used in the design.

IV. RESPONSE TO THE STATE OF UTAH'S CLAIMS IN SECTIONS C.1, C.2 AND C.3.a OF THE UNIFIED CONTENTION UTAH L/QQ

Q20. In Subsection C.1 of the Unified Contention, the State asserts that the Applicant has not performed the recommended spacing of borings for the pad emplacement area as outlined in NRC Reg. Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants," Appendix C. Why is the number of borings taken in the pad emplacement area sufficient?

A20. (PJT) First of all, Reg. Guide 1.132 is only a guidance document, and one that applies to nuclear power plants, which have larger and more heavily loaded foundations than are applicable for this ISFSI. In addition, nuclear power plants have entirely different categories of safety-related systems and components that do not exist at the PFS ISFSI, such as buried piping and electrical power and control systems. These interconnected systems sometimes carry radioactive fluids and high-pressure steam and power and control systems that are required for the safe shutdown of the reactors, and, thus, these systems arguably have much greater sensitivity to movements of the ground and the enclosing structures than the components of an ISFSI, which have no such interconnected systems. The applicable guidance for Part 72 facilities, which is NUREG-1567, does not provide any guidelines on the number or placement of borings for foundation analyses.

At any rate, the PFSF boring program conforms to the general guidance in Reg. Guide 1.132. The Guide states at p. 1.132-3:

> Subsurface conditions may be considered favorable or uniform if the geologic and stratigraphic features to be defined can be correlated from one boring or sounding* location to the next with relatively smooth variations in the thicknesses or properties of the geologic units. An occasional anomaly or a limited number of unexpected lateral variations may occur. Uniform conditions permit the maximum spacing of borings for adequate definition of the subsurface conditions at the site.

We found no evidence of significant horizontal variations in the thickness or properties of the soil layers in the pad emplacement area, so it is appropriate to characterize the PFSF site as "uniform" and thus, as Reg. Guide 1.132 suggests, a maximum spacing of borings is sufficient for the adequate characterization of the subsurface conditions. Indeed, there is no reason to believe that a denser set of borings would have yielded any different results from the ones we obtained. Moreover, for those analyses that required soil properties such as strength and compressibility as inputs, PFS generally used the least favorable value of each of the measured properties (e.g., lowest peak strength and highest compressibility) of the subsoil from the weakest soil layer (Layer 2) to represent the *entire* top thirty feet of soil. (The only exception to this was that a weighted average strength, based on the increase in strength noted in the cone penetration tests that were performed within the CTB area, was used in the bearing capacity analysis of the CTB because of the large size of the foundation mat relative to the thickness of the upper 30 feet of soil.) In addition, even if undetected pockets of subsoil existed in which the soil strength was lower than the value used in the design, the existence of such discrete pockets of weak soils would not adversely impact the validity of the PFS analyses because the foundations for the cask storage pads and the Canister Transfer Building are such wide foundations that the superstructure loads are distributed over a large soil volume. Thus, it is the average soil strength, rather than the strength at discrete points, that determines the foundations' behavior.

Q21. Subsection C.2.a of the Unified Contention asserts that PFS's sampling and analysis are inadequate to characterize the site and do not demonstrate that the soil conditions are adequate to resist the foundation loadings from the design basis earthquake in that the Applicant has not performed continuous sampling of critical soil layers important to foundation stability for each major structure as recommended by Reg. Guide 1.132 Section C6, Sampling. Is this a valid concern?

A21. (PJT) No. Again, the recommendations in Reg. Guide 1.132 are not applicable to Part 72 facilities, and the applicable guidance in NUREG-1567 does not call for any particular method of sampling. Moreover, the State's allegations are in error in several respects. First, in two instances we took a series of samples for testing throughout the first 30 feet of soil, so we did conduct "continuous sampling" of the critical soil layers. As discussed earlier, we needed to go no further down with our sampling because the soils beneath 30 feet or so consist of very dense sands or silty sands overlying very dense silts; these soils have great strength.

Also, PFS obtained, through standard penetration testing, samples of all soil strata, from the ground surface to depths as great as 226.5 feet below the ground surface. (This depth was determined based on recommendations provided in Appendix C of Reg. Guide 1.132). At such depths, the soils are extremely dense. From the standpoint of geotechnical engineering and the design of foundations for the site's structures, proceeding further down with the sampling (arguably to bedrock, which is many hundreds of feet below the surface) is unnecessary. Reg. Guide 1.132 states at p. 1.132-21: "Where soils are very thick, the maximum required depth for engineering purposes, denoted d_{max}, may be taken as the depth at which the change in the vertical stress during or after construction for the combined foundation loading is less than 10% of the in situ effective overburden stress." At the PFSF, the maximum depth d_{max} beyond which no additional sampling is required in accordance with the Reg. Guide's recommendations is 226.5 feet.

Q22. Subsection C.2.b of the Unified Contention faults the laboratory testing program carried out by PFS for being based on an insufficient number of tested samples, and for failing to include strain-controlled cyclic triaxial tests and triaxial extension tests as part of the laboratory shear strength testing program. Do you agree with the State's assertion that the number of tested samples was insufficient?

A22. (PJT) No. All of the data acquired during the various soils investigations conducted at the PFSF consistently indicate that the subsurface profile at the site is fairly uniform and that the area of concern, from a geotechnical perspective, is the Layer 2 soils. Our testing has concentrated, therefore, on determining the strengths and compressibilities of the Layer 2 soils, and our analyses have conservatively used these lower-bound strengths and upper-bound compressibilities in designing and assessing the performance of these foundations.

Q23. Did PFS perform cyclic triaxial tests?

A23. PFS did perform cyclic triaxial tests in the form of stress-controlled cyclic triaxial tests. The purpose of these tests was to determine whether the soils will likely deform under repeated, cyclic earthquake loading. The stress-controlled cyclic triaxial tests that were performed by PFS show very little deformation, indicating no significant reduction in shear strength, even after 500 cycles of loading (versus about 8 to 15 for the PFS design earthquake).

Q24. What other cyclic triaxial tests does the State contend PFS should have performed?

A24. The State contends that PFS should also have conducted strain-controlled cyclic triaxial tests. These tests are intended to measure the dynamic properties of the soils – the shear modulus vs. shear strain (also referred to as the shear modulus degradation curve, because the shear modulus decreases (i.e., "degrades") for higher levels of shear strain) and the damping vs. shear strain – at high shear strain levels.

Q25. Would you please define what you mean by "shear modulus," "damping" and "shear strain"?

A25. For shear forces, that is forces applied on the horizontal plane, the shear modulus is a measure of elasticity, defined as the ratio of the force (stress) applied to the resulting deformation (strain). If the forces are applied vertically, the ratio of applied stress to resulting strain or deformation is known as the Young's modulus.

Damping is a measure of the amount of energy that is dissipated by a body (in this discussion, a soil sample) due to the dynamic excitation applied to it (in this case, during a test.) Shear strain is the straining that occurs as the sample resists application of a shear stress; axial strain is straining that occurs as the sample resists application of an axial stress.

Q26. Is the State's criticism valid?

A26. No. PFS performed resonant column tests, which achieved the same objectives sought by the State. Resonant column tests are a form of strain-controlled, cyclic triaxial testing (although not the same type of strain-controlled cyclic triaxial test referred to by the State). The resonant column tests are in fact the only form of strain-controlled cyclic triaxial testing that is recommended in Appendix B, "Laboratory Test Methods for Soil and Rock," of US NRC Regulatory Guide 1.138, "Laboratory Investigations of Soils for Engineering Analysis and Design of Nuclear Power Plants" ("Reg. Guide 1.138") for use in developing curves of shear moduli and damping versus shear strain.

The resonant column test results can also be easily extrapolated to establish the high-strain behavior of the PFSF site soils. For example, if one compares the resonant column test results (included in Attachment 6 of Appendix 2A of the SAR) for Sample U-3C, obtained from a depth of about 8 feet in Boring CTB-1 and tested to shear strains as high as 0.07%, with those for Sample U-7C, obtained from a depth of about 20 feet in Boring CTB-1, and tested to shear strains as high as 0.15%, it is evident by looking at the plots of G/G_{max} and damping vs. shear strain from the two sets of tests that they are very similar; and therefore, it is reasonable to extrapolate the results from the testing of Sample U-3C along the same curves as those measured in the resonant column testing of Sample U-7C. Moreover, the curves that depict the test results have the expected, characteristic shape of plots of moduli and damping vs. shear strain, providing further evidence that minor extrapolation of the data from testing Sample U-3C is reasonable.

The modulus degradation and damping curves are used as input to the site response analyses, which were performed by Geomatrix in PFS Calculation 05996.02-G(PO18)-2-1. The Geomatrix results indicate that the greatest effective shear strains occur for the Layer 2 soils (depths of 5 to 12 feet). For this layer, the average effective shear strains range between 0.04% and 0.13%. These values are within the range of strains measured in the resonant column tests, which confirms that the results of the resonant column tests adequately encompass the appropriate range of effective strains for these soils for the design earthquake. Therefore, strain-controlled cyclic triaxial tests to measure shear moduli and damping at higher levels of strain than were measured in the resonant column tests are not required.

Q27. What is the State's claim with regard to triaxial extension tests and how do you respond to it?

A27. The State also contends that PFS should have conducted triaxial extension tests for use in assessing the bearing capacity of the Layer 2 soils. In this form of the triaxial test, the specimen is failed in axial tension by decreasing the vertical load on the specimen while maintaining a constant cell pressure so that the specimen ultimately fails in extension. However, such tests typically are not performed to assess the bearing capacity of foundations, nor are they mentioned in Appendix B, "Laboratory Test Methods for Soil and Rock," of Reg. Guide 1.138. Such tests typically are used to assess situations where foundation soils are unloaded, such as at the base of deep excavations. They also are sometimes used to determine the strength applicable for soils at the toe of slopes that might be subject to a deep, circular arc-type failure. These situations are not present at the PFSF site, which is essentially level and will require only very shallow excavations.

Q28. In section C.3.a of the Unified Contention, the State asserts that PFS has not adequately described the stress-strain behavior of the native foundation soils under the range of cyclic strains imposed by the design basis earthquake. Would you please explain the concern expressed by the State in this paragraph and respond to it?

A28. (PJT) This concern is related to the one I just discussed. The State claims that PFS has not performed strain-controlled, cyclic triaxial testing at large strains to show that the shear modulus and damping values used in development the design basis ground motion are appropriate. However, as indicated earlier, the shear strains imposed on the specimens in the resonant column tests that PFS performed were higher than the effective shear strains that the soils will experience during the design basis earthquake. The resonant column test specimens obtained from a depth of 8 feet were not subjected to shear strains quite as high as those expected at that depth in the profile due to the design basis earthquake; however, the shear strains imposed on the specimen of similar soil from a depth of ~20 feet were as high as 0.15%, a value that exceeds the average effective shear strain determined at any depth in the profile in the site response analyses included in Calculation 05996.02-G(PO18)-2, Rev. 1.

Moreover, the modulus-degradation and damping vs. shear strain data from the two sets of resonant column tests are very similar and follow expected trends based on historical data of this type; therefore, it is appropriate to extrapolate these data to encompass the slight increase in the shear strain above the maximum shear strain measured for the specimens obtained at a depth of ~8 feet.

V. USE OF SOIL CEMENT TO IMPROVE SUBSURFACE CONDITIONS

Q29. What is soil-cement?

A29. (AEZW, PJT) Soil cement is a material produced by blending, compacting and curing a mixture of soil, portland cement, other possible admixtures, and water to form a hardened material with specific engineering properties. Soil cement typically has far greater strength than that of the soil that is its main constituent.

Q30. Are all soils suitable for the formulation of soil cement mixtures?

A30. (AEZW, PJT) Almost all types of soils can be used in the formulation of soil cement. The exceptions to this include organic soils and poorly reacting sandy soils, which do not exist at the PFSF site, and highly plastic clayey soils, which will not be used to make soil cement at the PFSF site. There are tests to determine the suitability of soils for the construction of soil cement, including primarily the durability tests, ASTM D559 and 560, the wet/dry and freeze/thaw tests, as well as the compression tests, ASTM D1633. These tests are included in the soil cement testing program that PFS has underway.

Q31. Are the properties of the soil a factor in the manner in which soil cement is prepared?

A31. (AEZW) Yes. Given a desired set of soil cement properties, the mixture of materials that go into constructing the soil cement will differ depending on the soil properties. However, there is usually little difficulty in obtaining a particular set of soil cement properties, and the question is one of varying the proportions of the ingredients. For example, fine-grained soils generally require a higher proportion of cement than other soils in order to achieve a desired strength.

Q32. The term "cement-treated soil" has sometimes been used in this proceeding to denote a different material than soil cement. What is the difference between the two terms?

A32. (AEZW) In general, referring to a particular mixture as a "soil cement" or as a "cement-treated" soil is a function of the durability of the mixture of soil, portland cement, and/or other admixtures that has been formulated. Mixtures with greater degrees of stabilization and/or durability are generally referred to as soil cement, as opposed to cement-treated soil. Soil cement is typically expected to be able to pass durability tests that measure the ability of the stabilized soil to retain its properties after long periods of exposure to the elements. When addressing both soil cement and cement-treated soils, I shall refer to them as cement stabilized soils.

Q33. What are some of the industrial uses of soil cement?

A33. (AEZW) The most frequent use of soil cement has been as a base material underlying bituminous and concrete pavements. Due to its properties, however, soil cement has a wide-range of uses, including slope protection for dams and embankments; liners for channels, reservoirs and lagoons; and, as in the case here, for foundation stabilization.

Q34. What use does PFS intend to make of soil cement at the PFSF site?

A34. (PJT) The topmost layer of soil at the PFSF site is a layer of loose eolian silt. This eolian silt layer would need to be removed and replaced with some other material to provide a suitable foundation subgrade for the pads, as well as for the areas surrounding the pads. Mixing cement with these soils allows them to be utilized as part of the construction of the facility, instead of wasting the soil materials and replacing them with structural fill.

The use of soil cement at the PFSF site serves three specific purposes. In the area directly underneath the concrete pads upon which the storage casks rest, soil cement is to be used as a cohesive material that will be strong enough to resist the sliding forces generated by the design basis earthquake. The soil cement will provide bonding with the bottom of the concrete pad above it and with the clay soils beneath, so as to transfer the horizontal earthquake forces downwards from the pad and into the underlying clay soils.

Soil cement is also to be used in the area around and between the cask storage pads. There, the function of the soil cement is to support the weight of the transporter vehicle that is used to deliver storage casks to the pad area. Again, soil cement was chosen so that the soil materials would not need to be wasted and replaced with structural fill.

Finally, soil cement is to be placed around the Canister Transfer Building foundation mat, extending outward from the mat a distance equal to the associated mat dimension, to provide additional passive resistance against sliding forces in the event of a design basis earthquake. (Passive resistance is a term that refers to the ability of soils to resist horizontal forces, which in this case, are the result of earthquake forces.)

Q35. Is soil cement suitable for each of the functions assigned to it in the PFSF design?

A35. (AEZW) Yes. The PFSF design is relying on the cement stabilized soils to improve the shear and compressive strengths of the surficial native soils at the site. Soil cement has been used to improve these specific soil properties for over half a century.

Q36. Are the engineering functions that the soil cement will serve at the PFSF analogous to the uses soil cement has been given in other projects?

A36. (AEZW) While the specific application of soil cement to an ISFSI is new, the type of foundation stabilization that is proposed is not. Soil cement was used as a massive fill to provide foundation strength and uniform support at Koeberg, South Africa, for example, where an 18 foot thick layer of saturated sand under two 900-MW nuclear power plants was replaced with soil cement. In that particular case, the soils were prone to liquefaction and the soil cement was designed to provide enough shear strength to resist cyclic shear stresses due to an earthquake and, thus, prevent liquefaction. In the PFSF design, the soil cement provides increased shear strength to resist the shear stresses imposed on the cask storage pads by the design earthquake. In both instances, the design relies on the compressive and shear strength of the soil cement to stabilize the foundations.

Q37. What are the design requirements for the soil cement to be placed in each of the areas you mentioned?

A37. (PJT) The soil cement underlying the pads will have a minimum unconfined compressive strength of 40 pounds per square inch (psi). As discussed earlier, given the relatively low strength of this mix, it is referred to as "cement-treated soil" instead of soil cement. This cement-treated soil is required to have a thickness no greater than 2 feet and have a modulus of elasticity or Young's modulus (that is, a vertical stress to strain ratio) less than or equal to 75,000 psi. This modulus value is achievable with cement-treated soils.

The soil cement to be placed around and between the cask storage pads will have a thickness of 28 inches (3 feet height of the pads, minus the top 8 inches, which will be filled with compacted aggregate). This soil cement adjacent to the pads is expected to have a minimum unconfined compressive strength of at least 250 psi, in order to meet the durability requirements (wet/dry and freeze/thaw), since it will be within the frost zone.

The soil cement to be placed around the CTB will have a thickness of 5 feet (plus 8 inches to be filled with aggregate). It also is expected to have a minimum unconfined compressive strength of at least 250 psi, in order to provide the passive resistance to sliding required and to meet the durability requirements (wet/dry and freeze/thaw), since the upper half of it will be within the frost zone.

The aggregate to which I am referring is a coarse aggregate, such as crushed stone, that is to be placed and compacted to be flush with the top of the pads to permit easy access by the cask transporter.

Q38. How will PFS develop an appropriate soil-cement mix for each of the applications you just described?

A38. (PJT) The appropriate soil-cement formulation for each of the applications will be established by means of a program of laboratory tests. A laboratory testing program is being performed in accordance with a document entitled Engineering Services Scope of Work for Laboratory Testing of Soil-Cement Mixes, ESSOW 05996.02-G010 (2001) ("Laboratory Testing ESSOW") (PFS Exh. GGG).

Q39. What are the elements of the soil cement test program being conducted by PFS?

A39. (PJT) The Laboratory Testing ESSOW sets forth a series of tests to be conducted in several phases that will include soil index properties, moisture-density tests, durability tests, and other tests. Additional tests will also be conducted beyond those defined in the Laboratory Testing ESSOW, particularly the direct shear tests that PFS is committed to performing to demonstrate that adequate bond strength exists at the interfaces between the in situ clay and the cement-treated soil and between the cement-treated soil and the bottom of the cask storage pads.

Q40. Would you please describe the index property tests?

A40. (PJT, AEZW) The index property tests determine basic properties of the site soils, such as water content, liquid limit, plastic limit, particle size, etc. Each of these tests is conducted in accordance with well-established industry standards and procedures. The water content of the soils is determined in accordance with ASTM D2216. The Atterberg limits (liquid limits and plastic limits) of the soil are measured according to ASTM D 4318. The sieve analysis test is used to determine the gradation of the particle sizes in the soil samples, in accordance with ASTM D422 and D1140. The hydrometer analyses are conducted in accordance with ASTM D422 to measure the percentages of various clay-size particles in the soils.

These tests provide a basic understanding of the properties of the soil, primarily the moisture contents, the Atterberg limits, and the particle gradation as determined by sieve analysis and hydrometer analysis. Knowing these soil properties for these soils permits comparisons of results of the moisture-density, durability, and strength tests of soil cement specimens from PFSF with empirical data available in the literature that has been developed since the early part of the 1900s.

Q41. What tests are conducted after the index property tests?

A41. (PJT) After the completion of the index property tests, moisture-density tests are conducted in accordance with ASTM D558. This is an appropriate second step in testing. These tests establish, for each soil-cement mixture, the relationship between the moisture content of the mixture and the resulting density when the mixture is compacted. The moisture-density tests establish the optimum moisture content and maximum density for molding laboratory test specimens. This provides data used in formulating a range of soil cement mixtures to be subjected to further testing, to determine which mixes have the optimal combination of properties.

Q42. What tests will be performed on those mixes that have the optimal combination of properties?

A42. (PJT) The next series of tests to be performed are the durability tests. These tests, known as "wet-dry" and "freeze-thaw" tests, determine the durability of soil cement specimens subjected to repeated cycles of exposure to the elements during extreme conditions. For example, the wet-dry tests, which are conducted in accordance with ASTM D559, are used to determine moisture/volume changes and soil cement losses due to repeated exposures to inundation and drying. The freeze-thaw tests, conducted in accordance with ASTM D560, similarly evaluate moisture/volume changes and soil cement losses due to alternate cycles of freezing and thawing.

Successful completion of the durability tests establishes that the soil cement mixture tested is adequate to provide a durable soil cement mix, one that will not lose compressive strength over time due to the effects of weather and normal wear and tear.

The cement-treated soil to be placed under the cask storage pads will not be subjected to durability tests because it is to be located beneath a three-foot thick concrete pad and therefore will not exposed to the elements. The cement-treated soil also will be beneath the depth of frost penetration at the PFSF site and, thus, will be immune from freezing and thawing cycles.

Q43. What additional tests will be performed on the soil cement mixtures that pass the durability tests?

A43. (PJT) For those soil cement mix formulations shown to meet durability tests, compressive strength tests will be performed on cured test specimens to determine whether the formulations meet the design requirements for compressive strength. These tests will be conducted in accordance with ASTM D1633 and D558. If the compressive strength of a soil cement sample is determined to be adequate, the soil cement mixture will be deemed appropriate for use at the PFSF.

The test program may include other tests, such as permeability tests and splitting tensile strength tests. However, the design and performance of the foundations is not dependent on these properties.

The cement-treated soil will also be subject to direct shear tests to confirm that the bond at the interfaces between the concrete bottom of the cask storage pad and the cement-treated soil, the bond at the interfaces between lifts of cement-treated soil, and the bond at the interfaces between cement-treated soil and the in situ clayey soil, exceed the strength of the clay soils at the site. Such confirmation will demonstrate that the cement-treated soil provides sufficient resistance against seismic sliding forces.

Q44. What standards will be used to assure the proper performance of the various tests?

A44. (PJT) The Laboratory Testing ESSOW cites Reg. Guide 1.138 as controlling the performance of the tests, as well as nearly twenty standards issued by the American Society for Testing and Materials and the Portland Cement Association. More generally, the guidance and recommendations in the industry standard publication "State-of-the-Art Report on Soil Cement," American Concrete Institute Report ACI 230.1R-90 (1998) ("State-of-the-Art Report") (PFS Exh. HHH) will be followed with respect to mix proportioning, testing, construction and quality control. Dr. Wissa is one of the developers of the State-of-the-Art Report. State's soil cement expert, Dr. James Mitchell, endorses the use of the procedures contained in the State-of-the-Art Report. Mitchell Dep., PFS Exh. III, at 46-47, 49-50.

Q45. Dr. Wissa, do you have an opinion on the adequacy of the soil cement laboratory testing program developed by PFS?

A45. (AEZW) Yes. Based on my review of the proposed program and the standards and methodology it includes, I am of the opinion that the program, if properly implemented, will lead to the identification of suitable soil cement and cement-treated soil mixes and construction specifications that will meet the specified design requirements and will give adequate performance for the life of the PFSF.

Q46. What is the current status of the soil cement laboratory testing program?

A46. (PJT) PFS has retained a contractor, Applied Geotechnical Engineering Consultants, Inc. ("AGEC"), to conduct the laboratory testing program in accordance with the Laboratory Testing ESSOW. AGEC has provided preliminary test results for the index property tests and the moisture-density tests. AGEC also performed a set of durability tests, but my review determined that these tests failed to demonstrate the durability of the tested samples, likely due to insufficient compaction of the test specimens prior to performance of the tests. The test program is currently on hold, pending determination of the causes for the failure of the durability tests that were performed by AGEC.

Q47. Dr. Wissa, how would you characterize the results of the laboratory testing program conducted so far?

A47. (AEZW) The index property tests completed to date appear to be reliable and adequate to describe the on-site surficial soils that will be stabilized with cement. On the other hand, these and other soil cement test results are preliminary.

I fully expect that when the tests are resumed to completion they will identify several acceptable soil cement mixes, from which one or more can be selected for further testing. Thus, I see nothing so far that would preclude the site soils from being incorporated into a suitable soil cement mixture.

Q48. Do you foresee any difficulty in PFS implementing a successful soil cement construction program?

A48. (PJT, AEZW) No. The soil cement design requirements have been defined by S&W and do not provide any special engineering difficulties. The compressive strengths of the soil cement (250 psi and 40 psi) are not difficult to obtain for soil cement generally. The State's soil cement expert agrees. Mitchell Dep., PFS Exh. III, at 41, 53-54, 90-91, 173-176. The laboratory testing program in place to design a soil cement mix to meet those requirements is set forth in the ESSOW and is in accordance with well-established regulatory guidance and industry standards. That program is in the process of being implemented.

Following completion of the testing phase, procedures for placement and treatment of soil cement will be developed. For example, the two-foot thick layer of cement-treated soil underlying the cask storage pad will be constructed of lifts approximately six-inches thick. This technique will allow adequate compaction of the cement-treated soil layer using low ground pressure equipment. As discussed in the SAR, the time between placing lifts will be minimized to the extent practicable. In any case, PFS will utilize the techniques described in DeGroot, G., 1976, "Bonding Study on Layered Soil Cement," REC-ERC-76-16, U.S. Bureau of Reclamation, Denver, CO, September 1976 (e.g., dry cement or cement slurry between lifts, roughening of surface before placement of soil cement lift) for enhancing the bond between fresh soil cement and soil cement that has already set to ensure sufficient bonding is achieved.

Thus, all the elements of the program exist or can be readily developed in accordance with established industry standards and practices.

Q49. Is the use of soil cement in the manner in which PFS intends a novel technology?

A49. (AEZW) No. The design, placement, testing and performance of soil cement are well-established technologies. There is also precedent in the industry for using soil cement for foundation stabilization in the manner proposed by PFS. The fact that the use of soil cement is an established technology provides reasonable assurance that the program proposed by PFS can be executed successfully.

VI. RESPONSE TO THE STATE OF UTAH'S CLAIMS IN SECTIONS C.3.b, C.3.c AND C.3.d OF UNIFIED CONTENTION UTAH L/QQ

Q50. In Paragraph C.3 of the Unified Contention, the State alleges several concerns about the use of soil cement at the PFSF. Are you familiar with those allegations?

A50. (AEZW, PJT) Yes.

Q51. What is your general response to the State's allegations?

A51. (AEZW, PJT) In general, the concerns raised by the State and its witnesses are well-known potential problems that can be anticipated and dealt with in the testing and construction phases of the program. In fact, the State's soil cement expert, Dr. James Mitchell, agrees that the concerns raised by the State are issues that he would like to see resolved through testing, but are not technically unachievable. Mitchell Dep., PFS Exh. III, at 186.

Q52. In subsection C.3.b of the Unified Contention, the State claims that PFS has not shown by case history precedent or by site-specific testing and dynamic analyses that the cement-treated soil will be able to resist earthquake loadings for the CTB and cask storage pad foundations. How do you respond to the claim that there is no case history precedent for the manner in which PFS proposes to use soil cement?

A52. (AEZW) While the application of soil cement in the design of the PFSF has some particular features that may be uncommon (mainly the need to maintain the cement-treated soil's Young's modulus at or below 75,000 psi), the use of soil cement for foundation stabilization is not. As discussed above, there is ample precedent for the use of soil cement for foundation stability. Some of the instances of the use of soil cement are described on pages R-2 through R-7 of the State-of-the-Art Report. In particular, there is an analogous instance in which soil cement was used to improve the seismic performance of the subsoil at a nuclear power plant site in Koeberg, South Africa, and increase the soil strength against earthquake dynamic loads. While the types of soil were different at both sites, the application is essentially the same for which soil cement is to be used at the PFSF. At the Koeberg, South Africa nuclear power plant, the shear strength of loose sandy soils was increased by the use of soil cement to preclude potential liquefaction due to seismic shear stresses from the design earthquake. At PFS, the shear strength of the eolian silt is being increased by mixing it with cement to provide sufficient shear strength to resist seismic shear stresses due to the design earthquake. The ability of cement stabilized soils to withstand dynamic loads is being demonstrated every day in pavements where they are continuously being subjected to such loads from traffic.

Q53. What is your answer to the assertion that there has been no demonstration by site-specific testing and dynamic analyses that the soil cement to be used at the PFSF will be able to withstand the anticipated earthquake loadings for the CTB and the cask storage pad foundations?

A53. (PJT) With respect to the alleged lack of site-specific testing, I have described above in detail the soil cement testing program being conducted by PFS. The program has been formulated, the design criteria identified, the test standards, methodology and acceptance criteria specified, and some testing has been performed. PFS is committed to performing these tests, as well as tests that demonstrate that the necessary bonding can be achieved and that this bonding is achieved at the various interfaces that are important to providing the resistance to sliding of the cask storage pads. There is nothing else that is required in advance of licensing of the PFSF. These commitments are reflected in Section 2.6.4.11 of the SAR (PFS Exh. JJJ).

The dynamic analyses of the cask storage pads and the CTB are addressed in my testimony (and that of other PFS witnesses) with regard to Section D of the Unified Contention.

Q54. The State has asserted that "proof of design" testing needs to be conducted before the design is finalized and before construction can proceed to final design stage, contrary to PFS's plans. Is that so?

A54. (PJT, AEZW) No. It is unclear what the State means by "proof of design" testing. There is nothing questionable or requiring "proof" about the concept being proposed in the design of the PFSF. The properties of the soil cement are within well-established, attainable parameters, and will be achieved in accordance with standard industry procedures. The construction techniques that may be used to ensure proper placement and curing of the soil cement, and to prevent damage to the underlying soils, have been utilized in numerous construction projects. Likewise, the design functions of the soil cement and the properties relied on to perform those functions are not new. Thus, there is nothing in the design that has not already been proven.

As stated in Section 2.6.4.11 of the SAR, PFS has committed to developing a soil-cement mix design using standard industry practice, and has further committed to performing a soil cement testing program in accordance with specified industry standards. That program follows industry-accepted protocols designed to address environmental factors that may affect long-term soil cement performance including, among others, the methodology set forth in industry codes ASTM D 558 (1996); ASTM D 559 (1996) and ASTM D 560 (1996). Design and implementation of a soil cement and cement-treated soil application that takes into account the results of the referenced soil cement testing program will assure adequate performance of the soil cement and cement-treated soil over the 40-year life of the facility. Thus, PFS has specified the tests it intends to perform and the acceptance criteria for the test results.

Once the test program has demonstrated the achievability of the design criteria, PFS will lay out a program to demonstrate field construction techniques that achieve the required bond strength in the field. As stated in the SAR, PFS also is committed to performing field testing during construction to demonstrate that we have, indeed, achieved in the field the bond strengths that are required.

These commitments are sufficient to provide reasonable assurance that the soil conditions at the PFSF will be adequate for the foundation loading that will be imparted by the design basis earthquake.

Q55. In subsection C.3.c, the State asserts that the Applicant has not considered the impact to the native soil caused by construction and placement of the cement-treated soil. Is PFS addressing this concern?

A55. (PJT, AEZW) Yes. We have always understood that the soil cement construction techniques to be used could potentially impair the surface of the native soils under the soil cement or the cement-treated soil layer ("subgrade") if it is not properly protected. So we intend to demonstrate at the start of construction that the techniques we allow the contractor to use will not have an adverse impact on the strength of the soils.

There are two main mechanisms by which the underlying soils may be disturbed during the placement of soil cement: exposure to the elements and deformation ("remolding") by construction equipment. Neither mechanism provides an insurmountable problem.

Exposure to the elements will be minimized through the use of proper construction procedures and scheduling. Those procedures will require that soil excavation not take place until the first lift of soil cement is ready to be placed. That first lift of soil cement can be pushed out onto the surface of the subgrade with low ground pressure equipment that won't have an adverse impact on the underlying clay. Once in place, the first lift of soil cement will shelter the underlying soil from rain.

If there is a heavy rainfall during construction, one of several available options will be utilized to remove excess moisture from the soil. One option is to let it dry out before placing soil cement over it. It is also possible to accelerate drying by applying quicklime to the exposed surface.

The main area of concern with respect to remolding of the native soils is with respect to the cask storage pads, for which the cohesive strength of the clay under the cement-treated soil is required to provide sliding resistance. However, the pads are only about 30 feet wide. There is construction equipment that can be located on either side of the pads at the placement locations and reach out to make a cut to the final subgrade surface, if necessary. All other construction equipment can be kept off of the exposed subgrade. Through these means, the subgrade can be sufficiently protected during the soil cement installation.

In short, there are a number of construction techniques available to prevent damaging the native soils beneath the cask storage pads, and we intend to use appropriate measures to prevent such damage. We will also test the bond strength achieved at the critical interfaces, which will prove the adequacy of the construction techniques being employed.

Q56. In subsection C.3.c, the State also asserts that the Applicant has not analyzed the impact to settlement, strength and adhesion properties caused by placement of the cement-treated soil. What is your view on these asserted impacts?

A56. (AEZW, PJT) In this issue, the State expresses a concern that the concrete pads and the soil cement to be placed underneath them at the site may serve as an impermeable barrier that will trap moisture in the underlying soils, but it does not appear that such a problem, if existing, will be significant due to the great depth to the groundwater table at the site and because of the semiarid conditions out in Skull Valley.

Q57. State witnesses have asserted that moisture may migrate to the clay soils beneath the cement-treated soil layer and reduce the strength and adhesion properties of those soils. Do you think moisture accumulation in the soils beneath the cement-treated soil layer is likely?

A57. (AEZW, PJT) No. The placement of a cement-treated soil layer and the presence of the cask storage pads may affect the mechanism of moisture migration from the soils adjacent to and underneath the cement-treated soil layer. However, water vapor tends to move from warmer areas to colder areas in response to a drop in air pressure as the moisture condenses. At the PFSF, the storage casks on top of the pads will provide a source of heat that will be conducted down through the concrete pad and underlying cement-treated soil. Therefore, the area beneath the pads on which casks rest will be warmer than surrounding areas. Moisture migration, therefore, will be away from the cement-treated layer beneath the pads to the surrounding areas due to heat gradient effects, as the State's expert Dr. Mitchell recognizes. Mitchell Dep., PFS Exh. III, at 112.

Holtec's "HI-STORM Thermal Analysis Report for PFS," HI-992134, analyzes the thermal characteristics of the casks supported on the pads at the PFSF site. The analyses indicate that the bottom of the storage casks could be as high as 195°F; however, the average temperature for the surface of the pad will be 120°F, which is approximately fifty degrees warmer than the average ambient temperature at PFSF throughout the year. This temperature differential will cause a warming of the cask storage pads, and the transfer of heat through the concrete in the pads towards the underlying soil cement. This heat transfer will in turn cause water to be transported away from the warmer soils underneath the pad to the cooler soils adjacent and beneath them. Thus, there will not be an increase, but a reduction in the water content of the soils underlying the cask storage pads once the casks are placed on the pads, which if anything, is expected to increase the strength of the clayey soils underlying the cement-treated soils.

Q58. In section C.3.d of the Unified Contention, the State argues that PFS has not adequately addressed several possible mechanisms that may crack or degrade the function of the soil cement or cement-treated soil over the life of the facility. The first such alleged mechanism, set forth in subsection C.3.d(i), is shrinkage and cracking that normally occurs from drying, curing and moisture content changes. How serious a problem is shrinkage and cracking of soil cement and cement-treated soil?

A58. (AEZW, PJT) Shrinkage cracking is a normal phenomenon in soil cement and cement-treated soil. Shrinkage cracking has been extensively investigated over the years and shown to not generally affect the performance of cement stabilized soils. Steps can be taken during the curing and placement process to minimize the amount of shrinkage and the potential for crack formation. For example, there are shrink resistant types of cement – known as Type K cements – which can inhibit the formation of shrinkage cracks. Also, during curing, a sealing coat (such as a geomembrane) can be put on the soil cement, to minimize the formation of cracks.

In our professional opinion, the existence of cracks will not adversely affect the ability of the soil cement and cement-treated soil to perform their design functions. The design does not rely on the cement-stabilized soil layers to transmit tension, but on lateral compression and shear. The ability to transmit compression and shear is not affected by shrinkage cracks, which develop in a vertical direction. If required, the amount of lateral movements needed to close the cracks in order for the soil cement to resist compressive forces can be substantially reduced by filling the cracks with grout after they have developed.

Q59. Why do you believe that the existence of cracks will not adversely affect the performance of the soil cement and the cement-treated soil?

A59. (AEZW, PJT) The cracks that form in soil cement and cement-treated soil due to shrinkage and curing are very narrow (fractions of an inch wide), occur at random locations, and are vertically propagating. Such cracking does not impair the compressive strength of the soil cement or the cement-treated soil.

With respect to the passive resistance of soil cement, which is relied upon for providing resistance to sliding of the CTB, such resistance is not diminished by the presence of vertical cracks. All of these cracks would have to be lined up parallel to the edge of the foundation to have the greatest impact on the passive resistance; however, such a lining up is highly unlikely because of the random orientation of the cracks. The presence of these cracks will not affect the magnitude of the horizontal resistance that the soil cement is capable of providing. The aggregate width of the cracks is small (on the order of few inches), and the potential effect of such cracks relates to the amount of horizontal displacement required to reach full passive resistance; thus, the cracks have no effect on the amount of sliding resistance available from the soil cement. In addition, PFS has the opportunity to seal these cracks in the soil cement surrounding the CTB, where the soil cement is relied upon to provide passive resistance, prior to placement of the layer of compacted aggregate in the area.

A slight horizontal movement may be required to close such vertical cracks if they are aligned nearly parallel to edge of the foundation before the compressive strength of the soil cement can once again provide the full resistance. Such a horizontal movement of the CTB is of no consequence because there are no safety-related connections between the CTB and the surrounding yard area.

Q60. The State witnesses assert that tensile loads may tend to impart bending stresses on the soil cement and the cement-treated soil, and that the presence of cracks will further reduce whatever little resistance the soil cement and the cement-treated soil may have to tensile loads. Is this a valid concern?

A60. (AEZW, PJT) No. The cement-treated soil layer under the cask storage pads will be subjected to very limited bending stresses because the heavily reinforced concrete pads will carry most of those stresses. In addition, the design function of the cement-treated soil is to transmit shear stresses to underlying strata and not for resistance to bending.

For the soil cement surrounding the CTB, any bending of the soil cement cap is only going to change the shape of the gaps of existing shrinkage cracks. Under bending loads, the width of the gap across the crack at one of its ends will increase, while at the opposite end it will decrease. Thus, there will be no permanent effect on the soil cement cap or its ability to provide passive resistance against sliding of the CTB. As noted earlier, if a crack exists and the building exhibits forces that would cause it to tend to slide, then the soil cement will move to close the crack, after which the soil cement will still be able to provide the resistance that it needs to keep the building in place.

Q61. Another mechanism posited by the State in subsection C.3.d(ii) of the Unified Contention for the potential degradation in performance of the soil cement at the PFSF is potential cracking due to vehicle loads. Are vehicle loads potentially capable of causing cracks in the soil cement and the cement-treated soil at the PFSF?

A61. (PJT) No. The vehicles in question are the cask transporters that will move the storage casks from the CTB to their locations in the pad emplacement area. With respect to the soil cement layer around and between the cask storage pads and surrounding the CTB, PFS Calculation 05996.02-G(B)-18-1 demonstrated that a 2-feet thick layer of compacted structural fill would be sufficient for distributing the transporter loads down to the underlying clayey soils. That structural fill layer has now been replaced by approximately 5 feet of soil cement, which has an unconfined compressive strength that will exceed 250 psi, or 36 ksf. Such soil cement is several times stronger than the structural fill that it replaces.

The loading at the bottom of the transporter crawler tracks is less than 10 ksf. Thus, the soil cement (with a compressive strength of 36 ksf) provides a firm foundation for the transporter to travel, and it will not be subject to cracking due to the loads imparted by those vehicles.

Q62. Another mechanism posited by the State in subsection C.3.d(iii) of the Unified Contention for the potential degradation in performance of the soil cement at the PFSF is potential cracking resulting from a significant number of freeze-thaw cycles at the Applicant's site. Is this a valid concern?

A62. (PJT) No. As I explained earlier, the soil cement mixture to be used at the PFSF will have been subjected to durability tests that demonstrated the mixture's ability to withstand freeze-thaw and wet-dry cycles without degradation in performance. For many years, soil cement has been used for erosion protection of reservoir slopes and has proven to able to perform satisfactorily under far more severe environmental conditions than those applicable for the PFSF. With respect to the cement-treated soil under the cask storage pads, the top of the layer of cement-treated soil will be six inches below the frost level for the site; thus, it will not be exposed to freeze-thaw cycles. In addition, when storage casks are present, the cement-treated soil will be warmed by the heat released from the storage casks.

Q63. Another mechanism posited by the State in subsection C.3.d(iv) of the Unified Contention for the potential degradation in performance of the soil cement at the PFSF is interference with cement hydration resulting from the presence of salts and sulfates in the native soils. How can the presence of sulfates potentially affect the performance of soil cement or cement-treated soils?

A63. (AEZW) The presence of sulfates can have two potential deleterious effects on soil cement. First, sulfates may affect the properties of the soil cement itself. Second, sulfates can potentially affect soil cement by attacking the soil cement after placement. This may occur through soluble forms of sulfates in underlying soils being carried upwards to the soil cement layer by moisture migration.

Q64. Do you have any information on the presence of sulfate in the soils at the PFSF site?

A64. (PJT) Preliminary testing of the site soils for the presence of sulfates indicates that very low levels of sulfates are present in the eolian layer of soil that will be used to fabricate the soil cement or cement-treated soil. The preliminary testing for sulfates of soil samples from the PFSF site yielded the following results:

Summary of Sulfate Test Results

PFSF Soil Cement Testing Program

Test Pit No.	Sample No.	Depth (Feet)	Bucket	Water Soluble Sulfate (ppm)
1	1	0 – 2	1 of 4	65
4	1	0 – 2	4 of 4	
3	1	0 – 2	3 of 4	100
3	1	0 – 2	4 of 4	
2	1	0 – 2	3 of 4	530
13	1	0 – 2	n/a	560
14	1	0 – 2	n/a	
15	1	0 – 2	n/a	120
16	1	0 – 2	n/a	
5	1	0 – 2	n/a	110
6	1	0 – 2	n/a	140
7	1	0 – 2	n/a	375
8	1	0 – 2	n/a	< 10
9	1	0 – 2	n/a	210
10	1	0 – 2	n/a	250
11	1	0 – 2	n/a	430
12	1	0 – 2	n/a	110

I should note that the above table excludes the tests on two samples, drawn from depths of 2 to 4 feet, which showed higher levels of sulfates. These were likely

Layer 2, Upper Bonneville clays, which PFS does not intend to use for making soil cement or cement-treated soil.

Q65. What conclusions do you draw from those preliminary sulfate test results?

A65. (AEZW) The test results indicate that, for all the samples of the eolian soil material, the sulfate content is less than 600 parts per million. There should be no problem in constructing soil cement or cement-treated soil out of such material.

Although additional tests are necessary, it would appear that the potential presence of sulfates will not pose an obstacle to the hydration of the soil cement and the cement-treated soil. In any event, should sulfates be present in the soil in such high concentrations as might interfere with the hydration process, the problem would be evidenced by the failure of the soil cement test samples to pass the durability tests discussed above. For example, the presence of sulfate in the form of ettringite (calcium aluminum sulfate) can result in expansion of the ettringite over time in the soil cement mixture. This effect can be readily discernible in the testing program by monitoring strength gain as a function of curing time.

Should the presence of sulfates be determined to be a concern, there are a number of alternatives that can be implemented to address the problem, including: using a sulfate resistant cement, increasing the treatment levels, or conducting chemical treatment on the soil. For example, barium compounds can be added to the mix to immobilize the sulfates, or lime or lime ash can be added, since they will react with the sulfates before the sulfates can attack the cement. An increase in the cement content of the mixture, say from five percent to seven percent cement content, will also increase resistance to sulfate attacks. A certain amount of sulfate can only react with a certain amount of cement, so even if there is some cement loss due to sulfate attack, there would still be adequate cement to maintain the compressive strength required.

Additionally, because water will migrate away from the cask storage pads and the cement-treated soil layer for the reasons discussed earlier, soluble sulfates in the underlying soils would be precluded from reaching the cement-treated soil.

Q66. The last mechanism posited by the State in subsection C.3.d(v) of the Unified Contention for the potential degradation in performance of the soil cement at the PFSF is potential cracking and separation of the cement-treated soil from the foundations resulting from differential immediate and long-term settlement. Would you please address this concern?

A66. (AEZW, PJT) Our earlier general discussion of cracks and their limited impact on the performance of soil cement and cement-treated soil also applies to settlement cracks. We would add that settlement cracks occur when the foundation mat of a building or structure is loaded. As this happens, the soils adjacent to the foundation also experience increases in stresses, as the loading is distributed over a widening area as one moves deeper into the soil profile. Through this mechanism, the settlement that occurs in the soils adjacent to the foundations will tend to approximate the settlement level at the edge of the foundation, so that there will be no abrupt differential settlement at the joint between the edge of the foundation and the soil cement. Soil settlement will gradually diminish with increased distance from the edge of the foundations.

The resulting settlement profile will be dish-shaped, extending some distance away from the edge of the mat. Therefore, the differential settlement between the edge of the foundation and the surrounding soil will be minimal, and crack formation due to differential settlement will be inconsequential.

Q67. Does that conclude your testimony?

A67. (AEZW, PJT) Yes, it does.

ANWAR E. Z. WISSA, Sc.D., P.E.

President/Senior Consultant
Ardaman & Associates, Inc.

EDUCATION:

Bachelor of Arts, Engineering Science, Oxford University, Oxford, England, 1957.

Master of Science, Civil Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1961.

Master of Arts, Oxford University, Oxford, England, 1962.

Doctor of Science, Geotechnical Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1965.

PROFESSIONAL HISTORY:

1975 to Present	President and Chairman of the Board of Directors Ardaman & Associates, Inc., Orlando, Florida
	Responsible for the overall engineering and business activities of twelve offices in Florida and the Middle East with a staff of over four hundred. International consultant on earthen dams, industrial and mining waste disposal facilities, pavements, soil stabilization, geosynthetics, and construction materials. Guest lecturer at leading universities
1977 to Present	Director and Senior Consultant Ardaman-ACE, S.A.E., Cairo, Egypt
1961 to Present	Principal and Chairman of the Board of Directors Geotechniques International, Inc., Middleton, Massachusetts
	Responsible for the design and development of geotechnical field instrumentation and specialized soil testing equipment.
1978 to 1983	Director and Senior Consultant, Saudi Geotechnical Services, Ltd., Jubail, Saudi Arabia
1973 to 1975	Senior Vice President and Chief Engineer Ardaman & Associates, Inc., Orlando, Florida
1965 to 1973	Principal Wissa Associates, Marblehead, Massachusetts
	Independent consultant on foundations, pavements, earthen dams, soil stabilization, and construction materials.

1969 to 1972 — Associate Professor of Civil Engineering, Dept. of Civil Engrng.
Massachusetts Institute of Technology, Cambridge, Massachusetts

Taught graduate and undergraduate courses and conducted seminars in soil mechanics, soil behavior, pavements, soil stabilization, experimental soil mechanics, and instrumentation. Director of soils research laboratory. Supervised doctoral and master student theses and several $100,000.00 of sponsored research per year on soil behavior, soil stabilization and frost action. Developed and holds a patent on laboratory and field instrumentation.

1965 to 1969 — Assistant Professor of Civil Engineering, Dept. of Civil Engring.
Massachusetts Institute of Technology, Cambridge, Massachusetts

Taught graduate and undergraduate courses in soil stabilization, instrumentation, civil engineering materials, asphalt and Portland cement concrete, soil and materials testing. Director of soil stabilization laboratory. Supervised graduate thesis students and sponsored research in soil stabilization, asphaltic concrete, pavements and experimental soil mechanics.

1962 to 1965 — Instructor of Civil Engineering, Department of Civil Engineering
Massachusetts Institute of Technology, Cambridge, Massachusetts

Taught undergraduate and graduate course in experimental soil mechanics. Supervised research in soil stabilization.

1959 to 1962 — Research Assistant in Soil Engineering, Dept. of Civil Engineering
Massachusetts Institute of Technology, Cambridge, Massachusetts

Conducted research in soil stabilization, soil technology, and soil behavior.

1957 to 1958 — Junior Civil Engineer
Richard Costain, Ltd., London, England

Designed prestress concrete bridge deck, supervised subsurface investigations and worked in soil testing laboratory.

PROFESSIONAL REGISTRATION:

Reg. Professional Engineer, Massachusetts No. 22816.
Reg. Professional Engineer, Florida No. 52326

ANWAR E. Z. WISSA, Sc.D., P.E. (continued)

PROFESSIONAL AFFILIATIONS:

Fellow, American Society of Civil Engineers	Present
Member, Committee on Placement and Improvement of Soil	1969-1978
American Society of Testing and Materials	1966 - present
Member, Committee D-18 on Soil and Rock	
Association of Soil and Foundation Engineers	1978 - present
Boston Society of Civil Engineering	1968 - 1972
Member, Executive Committee, Geotechnical Section	
International Society of Soil Mechanics and Foundation Engineering, Member	1966 - present
Transportation Research Board, Member	1965 - 1994
Member, Committee on Soil-Bituminous Stabilization	1965 - 1978
Chairman, Committee on Soil-Bituminous Stabilization	1966 - 1975
Member, Committee on Soil-Cement Stabilization	1965 - 1975
Member, Committee on Flexible Pavement Design	1970 - 1973
Member, Committee on Soil and Rock Instrumentation	1976 - 1991
Member, Committee on Physicochemical Phenomena in Soils	1982 - 1994
Florida Engineering Society	1974 - Present
National Society of Professional Engineers	1974 - Present
Society of Mining Engineers of AIME	1975 - Present
American Concrete Institute	1985 - 2000
Member, Committee 230, Soil-Cement Stabilization	
Florida Institute of Phosphate Research	1985 - Present
Member, Technical Advisory Committee on Beneficiation	1985 - 1989
Chi Espilon	1965 - Present
Sigma Xi	1965 - Present

American Society of Civil Engineers	1985 - Present
National Task Committee on Response to Disaster Situations	1985-1987
International Geosynthetics Society	Present

FOREIGN LANGUAGES:

Arabic and French

PROFESSIONAL PUBLICATIONS:

Author or co-author of over 50 professional papers and publications.

Publications

ANWAR E. Z. WISSA, Sc.D., P.E.

Wissa, A. E. Z. (1963). "Triaxial Equipment and Computer Program for Measuring the Strength Behavior of Stabilized Soils".

Wissa, A. E. Z. and Ladd, C. C. (1964). "Effective Stress-Strength Behavior of Compacted Stabilized Soil".

Wissa, A. E. Z. and Halaby, R. (1964). "Chemical Stabilization of Selected Tropical Soils from Puerto Rico and Panama".

Wissa, A. E. Z. and Ladd, C. C. (1965). "Shear Strength Generation in Stabilized Soils".

Wissa, A. E. Z. (1965). "Preliminary Investigation of the Mechanical Behavior of Idealized Aggregate-Asphalt Composites".

Wissa, A. E. Z., Lambe, T. W., and Ladd, C. C. (1965). "Effective Stress Strength Parameters of Stabilized Soil", 6th International Conference on Soil Mechanics and Foundation Engineering, Montreal.

Wissa, A. E. Z., Moavensadeh, F., and Williamson, R. B. (1966). "Rock Fracture Research".

Wissa, A. E. Z. and Blouin, S. E. (1967). "Report on the Influence of Asphalt Properties on the Behavior of Bituminous Concrete".

Wissa, A. E. Z. ,and Ho, K. N. (1967). "Up-grading of Marginal Granular Materials for Highway Construction".

Wissa, A. E. Z. and Martin, R. T. (1968). "Development of Rapid Frost Susceptibility Tests".

Wissa, A. E. Z. and Monti, R. P. (1968). "Compressibility-Permeability Behavior of Untreated and Cement Stabilized Clayey Silt".

Wissa, A. E. Z., Blouin, S. E. (1968). "Strength Behavior of Selected Asphalt Aggregate Systems in Triaxial Compression", presented at the 47th Annual Meeting, Highway Research Board, Washington, D.C., Highway Research Record No. 256.

Wissa, A. E. Z. (1969). "Pore Pressure Measurement in Stiff Soils", American Society of Civil Engineers, Journal of Soil Mechanics and Foundations Division, Vol. 95, SM4.

Wissa, A. E. Z. and Helberg, S. (1969). "A One-Dimensional Consolidation Test".

Wissa, A. E. Z. and Paniagua, J. G. (1969). "A Durability Test for Stabilized Soils".

Wissa, A. E. Z., Feferbaum-Zyto, S., and Paniagua, J. G. (1969). "Effect of Molding Conditions on the Effective Stress-Strength Behavior of a Stabilized Clayey Silt".

Wissa, A. E. Z. (1969). "Discussion on Roads and Pavements", presented at Specialty Session 18, Proceedings of 7th International Conference on Soil Mechanics and Foundation Engineering, Vol. 3, pp. 550, Mexico City.

Wissa, A. E. Z. (1969). "A New One-Dimensional Consolidation Test", presented at Specialty Session 16, Proceedings of 7th International Conference on Soil Mechanics and Foundation Engineering, Vol. 3, pp. 524, Mexico City.

Wissa, A. E. Z. (1969). "Discussion on Pore Pressure Response", presented at Specialty Session 4, Proceedings of 7th International Conference on Soil Mechanics and Foundation Engineering, Vol. 3, pp 438-439, Mexico City.

Wissa, A. E. Z. (1969). "Discussion on Pore Pressure Measurements in the Laboratory", written discussion, Specialty Session 4, Proceedings of 7th International Conference on Soil Mechanics and Foundation Engineering, Vol. 3, pp. 440-441, Mexico City.

Wissa, A. E. Z. and Ladd, C. C. (1970). "Geology and Engineering Properties of Connecticut Valley Varved Clays with Special Reference to Embankment Construction".

Wissa, A. E. Z., Christian, J. T., Davis, E. H., and Heiberg, S. (1971). "Consolidation at Constant Rate of Strain", Journal of Soil Mechanics and Foundation Division, ASCE, Vol. 97, No. SM10, pp. 1393-1413.

Wissa, A. E. Z., McGillivray, R. T., and Paniaqua, J. G. (1971). "The Effect of Mixing Conditions, Method of Compaction and Curing Conditions on the Effective Stress-Strength Behavior of a Stabilized Soil".

Wissa, A. E. Z. and Garcia, L. O. (1972). "Marshall Tests of Bituminous Concrete Mixes".

Wissa, A. E. Z. and Martin, R. T. (1972). "Operation Manual for Permeability Systems".

Wissa, A. E. Z. and Paniagua, J. G. (1972). "Equipment for Studying the Effect of Repeated Loading on the Stress-Strength Behavior of Stabilized Soils".

Wissa, A. E. Z., Martin, R. T., and Koutsoftas, D. (1972). "Equipment for Measuring the Water Permeability as a Function of Degree of Saturation for Frost Susceptible Soils".

Wissa, A. E. Z. and Martin,R. T. (1973). "Frost Susceptibility of Massachusetts Soils-Evaluation of Rapid Frost Susceptibility Tests".

Wissa, A. E. Z and Garcia, L. O. (1973). "Statistical Evaluation of the Marshall Test for Bituminous Concrete".

Wissa, A. E. Z., Krizek, R. J., Farzin, N. H. and Martin, R. T. (1974). "Evaluation of Stress Cell Performance", Journal of Geotechnical Engineering Division, ASCE, Vol. 100, No. GT12, pp. 1275-1295.

ANWAR E. Z. WISSA, SC.D., P.E.

Wissa, A. E. Z., Olsen, J. M., and Martin, R. T. (1974). "Use of the Freezing Soil Heave Stress to Evaluate Frost Susceptibility of Soils".

Wissa, A. E. Z., Suh, N. P., Martin, R. T., and Fuleihan, N. F. (1974). "New Concepts in Soil Stabilization Mixing", TR-74-114, AD-A007-887, U.S. Air Force, Kirtland Base, New Mexico.

Wissa, A. E. Z. (1974). "Gypsum Stacks", Canadian Phosphate Producers, Montreal, Canada.

Wissa, A. E. Z., Martin, R. T., and Garlanger, J. E., (1975). "The Piezometer Probe", Proceedings of the Conference on In-situ Measurement of Soil Properties, Specialty Conference of the Geotechnical Engineenng Division, ASCE, North Carolina State University, pp. 536-545.

Wissa, A. E. Z. (1975). "Design of Secondary Pavement Systems", Engineenng Laboratories Forum, Florida Engineering Society, Orlando.

Wissa, A. E. Z., Martin, R T.; Garlanger, J. E. (1975). "The Piezometer Probe," Proceedings of the Conference on In-Situ Measurement of Soil Properties, ASCE, Volume I, pp. 536-545.

Wissa, A. E. Z. (1976). "Industrial and Chemical Wastes", University of California, Berkeley, California.

Wissa, A. E. Z. (1977). "Gypsum Stacking Technology", Clearwater, Florida, American Institute of Chemical Engineers, 1977 Annual Technical Meeting.

Wissa, A. E. Z. (1978). "Environmental Engineering of Gypsum Stacking", 85th National Meeting, American Institute of Chemical Engineers, Pennsylvania.

Wissa, A. E. Z. and Palm, Gordon F. (1978). "Environmental Aspects of Waste Disposal in the Phosphate Industry", Proceedings 1978 Environmental Symposium, New Orleans, Louisiana, The Fertilizer Institute.

Wissa, A. E. Z. and Fuleihan, N. F. (1980). "Critique of Proposed Phosphate Industry Waste Storage Regulations", Proceedings 1980 Environmental Symposium, New Orleans, Louisiana, sponsored by The Fertilizer Institute, Washington, D.C.

Wissa, A. E. Z. and Fuleihan, N. F. (1980). "Control of Groundwater Contamination from Phosphogypsum Disposal Sites", 1980 International Symposium on Phosphogypsum, Lake Buena Vista, Florida, sponsored by the Florida Institute of Phosphate Research, Bartow, Florida.

Wissa, A. E. Z. and Fuleihan, N. F. (1981) "Control of Groundwater Pollution from Phosphoric Acid Waste Gypsum Stacks", Proceedings 1981 Annual Meeting, American Institute of Chemical Engineers, Presented at Session on Phosphoric and Sulfuric Acid Pollution Abatement, New Orleans, Louisiana.

Fuleihan, N. F. and Wissa, A. E. Z. (1983). "Piezocone Testing, Research, Theory and Applications", Presented at New Methods in In-Situ Testing Workshop/Seminar, University of Florida, Gainesville, Florida.

Wissa, A. E. Z., Fuleihan, N. F and Ingra, T. S. (1983). "Evaluation of Phosphatic Clay Disposal and Reclamation Methods", Florida Institue of Phosphate Research, Research Project 80-02-002.

Wissa, A. E. Z. and Garlanger, J. E. (1984). "Impact of Dam Failures on Safety Regulations", 1984 ASCE Convention, Atlanta, Georgia.

Wissa, A. E. Z. (1985). Recent Developments in Measurement and Modeling of Clay Behavior for Foundation Design, M.I.T. Conference, Chairman of Panel on Geotechnical Instrumentation and Testing

Wissa, A. E. Z., Garlanger, J. E. and Ingra, T. (1985) "Engineering Properties of of Phosphogypsum as they relate to Design, Operation & Reclamation of Gypsum Stacks", 3rd Seminar on Phosphogypsum, Fla. Inst. of Phosphate Research)

Wissa, A. E. Z., Fuleihan, Nadim F., (1986) "Impacts of Phosphogypsum Stack Management on Process Water Balance", 1986 Spring National Meeting and Petrochemical and Refining Exposition - American Institute of Chemical Engineers

Wissa, A. E. Z., Fuleihan, Nadim F., Ingra, Thomas S., (1986) "Implications of Phosphogypsum Engineering Properties on Gypsum Stack Management and Reclamation", Second International Symposium on Phosphogypsum - University of Miami, Phosphate Research Institute.

Wissa, A. E. Z., (1989). "Synthetic Liners; An Engineers Perspective", Presented at University of Florida Short Course titled " Design Construction and Performance of Liner Systems for Environmental Protection", TREEO Center, Gainesville, Florida.

Wissa, A. E. Z., (1989). "Liner Case Histories", Presented at University of Florida Short Course titled "Design Construction and Performance of Liner Systems for Environmental Protection", TREEO Center, Gainesville, Florida.

Fuleihan, N. F. and Wissa, A.E.Z. (1992). "Design and Reclamation of Phosphogypsum Disposal Sites", Presented at the 1992 AIChE Spring National Meeting, Symposium on Advances in Phosphate Fertilizer Technology, Environmental Session, New Orleans, Louisiana

Wissa, A. E. Z., (1993). "Closure and Long Term Care Overview of Florida Rules (Effective January 6, 1993)", Presented at University of Florida TREEO Center Landfill Series titled "Landfill Design: Closure and Long Term Care", Orlando, Florida

ANWAR E. Z. WISSA, SC.D., P.E.

Wissa, A E. Z., (1993). "Synthetic Liners - Construction and QA/QC", Presented at University of Florida TREEO Center Landfill Series titled "Landfill Design: Closure and Long Term Care", Orlando, Florida

Wissa, A. E. Z., (1993). "Selection and Design of Landfill Closure Covers", Presented at University of Florida TREEO Center Landfill Series titled "Landfill Design: Closure and Long Term Care", Orlando, Florida

Wissa, A. E. Z., (1994). "Synthetic Liners - Construction and QA/QC", Presented at University of Florida TREEO Center Landfill Series titled "Landfill Design: Closure and Long Term Care", Orlando, Florida

Wissa, A. E. Z., (1994). "Selection and Design of Landfill Closure Covers", Presented at University of Florida TREEO Center Landfill Series titled "Landfill Design: Closure and Long Term Care", Orlando, Florida

Wissa, A. E. Z., (1994). "Landfill Liners - Facts and Fallacies", Presented at "The Robert V. Whitman Symposium: The Earth, Engineers and Education", Massachusetts Institute of Technology, Cambridge, Massachusetts

Wissa, A. E. Z., (1999). "Phosphogypsum Disposal and the Environment", Presented at "International Environmental Workshop", Prague, Czech Republic. International Fertilizer Development Center, Muscle Shoals, Alabama.

Wissa, A. E. Z. and Fuleihan, N. F. (1999). "Phosphogypsum Stacks and Groundwater Protection", Proceedings of 12th International Technical Conference. Sponsored by the Arab Fertilizer Association, October 5-8, 1999, Casablanca, Morocco.

Wissa, A. E. Z. and Fuleihan, N.F. (2000). "Protection of Water Resources Using Natural and Synthetic Liners", Presented at Fourth International Geotechnical Engineering Conference, Cairo University, January 26, 2000, Cairo, Egypt.

Wissa, A.E.Z, Fuleihan, N.F., and Leto, T.J. (2000). "Inspection and Maintenance of Earthen Dikes and Phosphogypsum Stacks", Presented at Fourth Annual Florida Phosphate Council Training Course February 23, 2000, Lakeland, Florida.

Book Reviews

The Penetrometer and Soil Exploration by G. Sanglerat, Elsevier, Amsterdam, 1972, Geoderma, 1975.

CHAIRMAN FARRAR: And, Mr. Travieso-Diaz, they are available for cross examination?

MR. TRAVIESO-DIAZ: Well, there are some exhibits, also, that go with the testimony.

CHAIRMAN FARRAR: Go ahead.

MR. TRAVIESO-DIAZ: Accompanying the testimony of these witnesses there are four exhibits, exhibit GGG, entitled: Engineering Services Scope of Work for Laboratory Testing of soil cement mixes.

(Whereupon, the above-referenced to document was marked as Applicant Exhibit GGG for identification.)

MR. TRAVIESO-DIAZ: And I would like to note that the copy that we handed out this morning to the Court Reporter, and to the parties, differs from the prefiled copy, in that the proprietary markings have been removed, consistent with the discussions that we had at the Hearings previously.

So it is the same document, but it is now free of all proprietary markings.

The next exhibit is exhibit HHH, it is ACI report 230.1R-90, entitled: State of the Art Report on Soil Cement.

(Whereupon, the above-referenced to document was marked as Applicant Exhibit HHH for identification.)

MR. TRAVIESO-DIAZ: The next exhibit is exhibit III, it consists of excerpts from the deposition of James K. Mitchell that took place on Friday, March 15th, 2002.

(Whereupon, the above-referenced to document was marked as Applicant Exhibit III for identification.)

MR. TRAVIESO-DIAZ: And the fourth and last exhibit JJJ, is Section 2.6.4.11 of the PFS Safety Analysis Report, entitled: Techniques to Improve Subsurface conditions.

(Whereupon, the above-referenced to document was marked as Applicant Exhibit JJJ for identification.)

MR. TRAVIESO-DIAZ: And I would move that these four exhibits be admitted into evidence.

CHAIRMAN FARRAR: Any objection?

MS. CHANCELLOR: No objection, Your Honor.

CHAIRMAN FARRAR: Staff?

MR. O'NEILL: No objection, Your Honor.

CHAIRMAN FARRAR: All right. Then those four exhibits, III through JJJ will be admitted into evidence.

(The documents referred to, having been previously marked for identification as Applicant Exhibits III through JJJ were received in evidence.)

MR. TRAVIESO-DIAZ: The witnesses are now available for cross examination.

CHAIRMAN FARRAR: Let's go off the record for just a moment.

(Whereupon, the above-entitled matter went off the record at 10:00 a.m. and went back on the record at 10:01 a.m.)

CHAIRMAN FARRAR: Is the Staff prepared for cross examination?

MR. O'NEILL: Yes, Your Honor.

CHAIRMAN FARRAR: Go ahead, Mr. O'Neill.

CROSS EXAMINATION

MR. O'NEILL: Good morning, Mr. Trudeau, Dr. Wissa. I'm Martin O'Neill, Co-Counsel for the NRC Staff.

I have a short series of questions pertaining to soil cement issues aimed at obtaining some clarification, or some additional explanation of terms or concepts.

My first question is for Mr. Trudeau. I would direct your attention to answer 34, page 23 of your prefiled testimony.

In that response you discuss the proposed purposes of the soil cement, cement treated soil. Among those is the proposed use of the cement treated soil to resist sliding forces, correct?

MR. TRUDEAU: Correct.

MR. O'NEILL: Is it correct that PFS, however, is not taking credit for the resistance to sliding that might be provided of soil cement, or cement treated soil under and around the pads, with respect to its design calculations, specifically the computation of factor against safety, factor of sliding against safety?

MR. TRUDEAU: Our base case for the sliding stability of a pad includes the shear strength of the cement treated soil beneath the pads, but it does not include the passive resistance, or the buttressing capability of the soil cement adjacent to the pads.

And for those conservative assumptions our factor of safety is at least 1.27 for the pads out on that site.

MR. O'NEILL: Without taking into account the passive resistance, correct?

MR. TRUDEAU: That is correct.

MR. O'NEILL: Mr. Trudeau, you note that one advantage of mixing cement with soils at the site is to avoid the wasting of soil materials, and replacing them with structural fill.

Could you tell me whether the cement treated soil is intended to provide a function that is comparable to that typically associated with structural fill, or are there additional functions to be served as well?

MR. TRUDEAU: The cement treated soil is better for this application than structural fill would be, because structural fill would typically be a well-graded granular material, which has, or derives its strength from its frictional characteristics.

At this site we have a high earthquake load, and when the uplift forces, due to the earthquake, when the forces due to the earthquake act in the upward direction, the normal force is reduced.

And the frictional resistance is a function of the tangent of the phi angle of the soils times this normal force. So when the normal force is reduced by having the earthquake forces acting upward, then the resistance to sliding for a structural fill type material is reduced significantly for such a large earthquake.

The cement treated soils, on the other hand, derive most of their strength from their cohesion. And the cohesion is not affected by the loss or decrease of normal forces, as is the frictional resistance portion of the strength.

So the cement treated soils are better for this application than a structural fill material would be under the pads.

MR. O'NEILL: Thank you. Could you please turn your attention to answer 43 on page 29?

I believe at some point you state that the test program may include other tests, such as permeability tests, and splitting tensile strength test, even though the design and performance of the foundations are not dependent on these properties.

Could you explain, to me, in greater detail how the design and performance of the foundations are not dependent on these particular properties?

MR. TRUDEAU: Well, the permeability tests that are referenced here are really, in this response, primarily based on potential use of soil cement in the detention pond area.

This is not a safety related issue, it is just my understanding that PFS has agreed, as part of the settlement for Utah O hydrology, that we may end up with a soil cement layer under the detention pond area to help prevent seepage of any storm water that runs into the detention pond from seeping down into the underlying soil.

Now, I don't know that soil cement will be used there, at this point. But this was a for-instance. We might end up doing some permeability test to address that kind of an issue.

The splitting tensile strength tests are tests that we have talked about since the original depositions, and they are not that hard to do. So we may, indeed, do some of them to demonstrate what the tensile strength of the soil cement is.

But our position is that our design does not rely on the tensile strength of the soil cement.

MR. O'NEILL: Well, is it true that your focus is more on the ability of the cement treated soil to transmit stresses, and to resist lateral compression?

MR. TRUDEAU: Yes, we are relying on the

compressive strength of the soil cement to provide passive resistance to sliding of the canister transfer building.

And we are relying on the shear strength of the cement treated soils underneath the pads to essentially bond the pads to the underlying stiff clays.

MR. O'NEILL: Thank you. I have a question for you, Dr. Wissa, finally.

Throughout the testimony you used the term foundation stabilization. Could you provide me with a definition of that term, specifically what it encompasses, with a focus on how it relates to your soil properties, how soil properties might be improved, and what specific properties are improved.

DR. WISSA: By foundation in general, are you --

MR. O'NEILL: Foundation stabilization. I mean, I know this is a term that is used in the ACI 230 report. It is a term that you used as well, in your testimony.

And I just wondered if you could explain specifically what you mean by that term.

DR. WISSA: Stabilization, let's start by stabilization. It is making something more stable, that could be, depending on what you are trying to stabilize, you could do it to stabilize it as far as compression, to make it more rigid, and less flexible.

You could do it to stabilize it against movements where you would want strength, compressible shear strength. And in this case we are speaking about improving the properties of the foundation, whether it is of a building, or a pad, or whatever.

So I think that is basically what we are talking about, is improving the properties, or making them more stable. I don't know if I've answered the question.

MR. O'NEILL: Well, would this include improvement of cohesion soil, cohesion as well?

DR. WISSA: Well, cohesion is a form of stabilization. It is a strength. The difference between cohesion and friction, cohesion is independent of the load you place on it. Friction is a function directly of the load.

For example, if you take a block and slide it on the surface, depending on the weight of the block, the force required to make it move will increase the heavier the block is.

On the other hand, if you take the same block and add an epoxy, and glue it to that surface, now the force required to move that block would be dependent on the bond which is, if you want to think of, the cohesion versus the normal load, which would be applied on the weight of a block.

So cohesion is a form of strength which is independent of the load you are applying. And this is what Mr. Trudeau was explaining, as far as using structural fill versus soil cement.

In one case it is the ability to move, is a function of the normal load of the load you apply. In the other case it is independent of the load applied.

MR. O'NEILL: So would the addition of cementitious materials would increase the cohesion of a given soil, correct? I mean, is that the gluing effect you referred to?

DR. WISSA: That is the main function, by definition, cementitious materials meet, it cements together, or adheres.

MR. O'NEILL: The ACI 230 report, it refers to foundation stabilization as one example of an application of soil cement. Would you agree with me that foundation stabilization is an application that might actually include multiple sub-applications, correct?

I mean, you may be using soil cement in a number of different applications, but maybe the ultimate goal or function of that soil cement is the same, correct?

DR. WISSA: Well, you stabilize it, and it depends for what reason. So you may do it to reduce compressibility, make the movements less. You may do it to improve the ability to spread the loads, which would be as to shear strength.

So the applications of using it for stabilization may vary.

MR. O'NEILL: So foundation stabilization would encompass all of these in your view, correct?

DR. WISSA: Depending on the situation that is correct. It is a wide range of abilities to stabilize, including the possibility of using it as a buttress, or to prevent sliding.

MR. O'NEILL: Do you have anything to add, Mr. Trudeau?

MR. TRUDEAU: I could add the following. Some of the eolian silts at the site are non-plastic soils. In this condition they behave more like a frictional material.

So when we mix those soils with cement, we will be imparting a cohesion to these soils, which improves their characteristics for resisting these horizontal loads due to the earthquake.

So in that regard we are stabilizing the non-plastic eolian silts by the introduction of cement and moisture in the proper proportions, and sufficient compaction, to get a stabilized soil cement product.

MR. O'NEILL: Thank you. Dr. Wissa, in response to question 49 on page 32 of your prefiled testimony, you state that there is also direct precedent in the industry for using soil cement for foundation stabilizaTion, in the manner proposed by PFS.

Specifically what precedent are you referring to? Are there any other cases, in addition to those that were cited in the PFS SAR, or safety analysis report in ACI 230?

DR. WISSA: Yes, there has been a more recent situation where, as a matter of fact, it has been used for a very similar application. In this case it was in situ mixing, rather than mixing in a plant.

But it has to do with the situation in the Boston area, the Big Dig, where they used in situ mixing of soil and cement. I shouldn't say in situ, deep mixing soil cement to achieve, to be able to transmit shear stresses down to the foundation, which is exactly the same situation as we are talking about here.

MR. O'NEILL: Mr. Trudeau, in answer 34, with respect to the canister transfer building, you discuss a proposed use of soil cement to provide additional passive resistance against sliding forces in the event of a design basis earthquake.

You define passive resistance as the ability of soils to resist horizontal forces, noting that in this particular case these forces would be the result of earthquake forces.

Is that a correct characterization?

MR. TRUDEAU: That is correct.

MR. O'NEILL: Does this imply that there might be other sources of horizontal forces, not necessarily at the PFS site, but in other applications that utilize soil cement?

MR. TRUDEAU: Well, the typical horizontal force that a foundation like a retaining wall is required to resist, are just based on the active pressures of the soils behind the wall.

And in those applications there is passive resistances at the toe of the wall that help to provide stability of the wall against sliding.

MR. O'NEILL: So on balance soil loads would be another example?

MR. TRUDEAU: That is correct.

MR. O'NEILL: Of horizontal forces that might be acting --

MR. TRUDEAU: Or hydrostatic pressures behind a wall. Those cases don't apply here. Our horizontal forces that are driving the canister transfer building are derived from the earthquake at the site.

MR. O'NEILL: I understand that, but in your view the soil cement is used to provide additional passive resistance. Wouldn't the ultimate purpose or function be the same regardless of the precise origin of these horizontal forces?

I mean, you could draw an analogy, correct?

MR. TRUDEAU: Correct. And if we didn't have the soil cement there we would have a structural fill type material there that would also provide passive resistance.

But making the soil cement enhances the ability of that material to provide passive resistance. So that is why the cement is added to the soil, rather than using a structural fill. It provides an increased passive resistance.

MR. O'NEILL: Thank you. Mr. Trudeau, in answer 53, page 34, you indicate PFS' commitment to perform tests that will demonstrate the necessary bonding of soil cement, I mean, that it can be achieved and this bonding will be achieved at various interfaces that are important providing resistance to sliding in the cask storage pads, correct?

MR. TRUDEAU: That is correct.

MR. O'NEILL: Now, to your knowledge, the NRC did acknowledge this commitment in its safety evaluation report, correct?

MR. TRUDEAU: That is correct.

MR. O'NEILL: However, is it your understanding that the Staff's approval of your analysis of the pad stability against sliding does not rely on this commitment per se? I mean, the Staff doesn't view sliding as a safety hazard, correct?

MR. TRUDEAU: I understand that, and the basis for that is that there are no safety related connections to either the pads or the canister transfer building.

So that whether they slide or not the safety function is not going to be compromised.

MR. O'NEILL: Now this question, I guess, would be directed to both of you, gentlemen.

In answer 59 on page 40, discussing possible cracking of the soil cement around the CTB, in response to claims raised by the State, you mentioned the presence of vertical cracks.

I think you suggested that if any cracks were to form they would be primarily vertical, or near vertical. But then you subsequently referred to the random orientation of the cracks.

Did you mean to refer to the random location of the cracks? I think you made this statement in the context of the need for the cracks to be aligned parallel to the edge of the foundation to maximize --

MR. TRUDEAU: That is correct. By random orientation there I meant if you were looking down at these cracks from the top you would see some that would be lined up parallel to the foundation, perhaps. Some that would be perpendicular to the foundation, some that would be at some angle in between.

So the orientation of these vertical cracks with respect to the important direction, which is lined up parallel to the foundation is random. So they aren't all lined up in a row, row after row, after row, parallel to the foundation, where they would have the maximum effect sliding resistance.

MR. O'NEILL: So you were referring to the relative locATion, as opposed to their orientation, whether it be vertical, or --

MR. TRUDEAU: Yes.

MR. O'NEILL: Okay, thank you.

Mr. Trudeau, in answer 40 in page 27 you talk about comparisons of the result of moisture density, durability, and strength, test of soil cement specimens from the proposed facility, with empirical data available in the literature that has been developed since the early part of the 1900s.

What is this particular empirical data, and what is the purpose of this comparison?

MR. TRUDEAU: The data that I'm referring to is the results of compressive strength test, primarily, that show the benefit of adding cement to soils, in various soil types.

Some silts, like eolian silts, some clays, and sands, and a wide variety of soils have been used, historically, to make soil cement. And when these soils are used, index property tests are generally performed on these samples, as well as the important compressive strength test.

Because those typically provide the

feature, the design feature that is looked for in a soil cement application, the compressive strength of the soil. Soil cement mix, I mean.

MR. O'NEILL: I think that is all I have for now, thank you.

CHAIRMAN FARRAR: Thank you, Mr. O'Neill. Go ahead, Ms. Chancellor. Do you need a minute, or?

MS. CHANCELLOR: No, I'm fine, thank you, Your Honor.

CROSS EXAMINATION

MS. CHANCELLOR: Good morning, Mr. Trudeau, good morning, Dr. Wissa. My name is Denise Chancellor, representing the State of Utah.

Mr. Trudeau, part of the testimony that you are responsible for includes soils, and I will not be cross examining you on this today. My cross examination will be limited to the soil cement portion of the testimony.

MR. TRUDEAU: That is my understanding.

MS. CHANCELLOR: Good, that is something we agree on.

Mr. Trudeau, have you -- do you know of the geological province, the basin and range?

MR. TRUDEAU: Yes.

MS. CHANCELLOR: Have you done any

geotechnical work in the basin and range before?

MR. TRUDEAU: Not prior to this project.

MS. CHANCELLOR: Dr. Wissa, other than the PFS site, have you been involved in a seismic design of NRC regulated facilities in areas of high to moderate seismicity, such as the western U.S.?

DR. WISSA: No, I have not.

MS. CHANCELLOR: Have you been involved in any site where peak ground accelerations are approximately 0.7G?

DR. WISSA: No.

MS. CHANCELLOR: Have you performed any dynamic analysis of foundations?

DR. WISSA: No.

MS. CHANCELLOR: Have you any experience with soil structure and direction?

DR. WISSA: Other than in college I took courses in it, but I'm not an expert in that area.

MS. CHANCELLOR: What other projects have you been involved, have you been involved in any other projects where soil cement, or cement treated soil has been used to provide resistance to sliding of shoddily embedded foundation?

DR. WISSA: No other one.

MS. CHANCELLOR: Are you aware of any

direct examples of the application of soil cement, or cement treated soil, to provide resistance to sliding to shoddily embedded foundation?

DR. WISSA: Yes, the example I just gave, which was the case of a soil cement buttress in the Four Point Channel in the Boston area.

MS. CHANCELLOR: During your deposition, Dr. Wissa, my understanding was that you had not, at that time, been retained by PFS to assist them, formally retained, to assist them with their soil cement program. Has that changed since that day?

DR. WISSA: Yes, to some extent. I've had conversations with them about future work and what type of program would be undertaken.

MS. CHANCELLOR: And is there any formal arrangement, as yet, as to any future work?

DR. WISSA: No, not at this time.

MS. CHANCELLOR: What is the scope of any future work that you may be involved with, with PFS?

DR. WISSA: We've discussed what would be needed as a testing program, how it would be implemented.

MS. CHANCELLOR: Would you be doing any of the work that is currently being -- that is anticipated to be done by AGEC, the engineering company, Geotechnical Engineering Company in Salt Lake City, that is now performing -- that has performed some of the tests?

DR. WISSA: Well, I can't exactly answer that question. To my knowledge I gave the owner an outline of work I think would be needed. And, obviously, some of that work overlaps what has already been undertaken.

So there would be duplication or there would be overlap.

MS. CHANCELLOR: Your Honor, we haven't seen a copy of any of the scope of work that, the planned scope of work that Dr. Wissa would be involved with, and we would request a copy of that outline, or whatever it is, that he has provided to --

Did you give that to Mr. Parken? You stated you gave it to the owner of PFS?

DR. WISSA: I gave an outline of my work to Mr. Donnell, I believe.

MS. CHANCELLOR: Mr. Donnell?

DR. WISSA: Donnell.

MR. TRAVIESO-DIAZ: Can we go off the record for a second?

CHAIRMAN FARRAR: Yes.

(Whereupon, the above-entitled matter

went off the record at 10:29 a.m. and
went back on the record at 10:34 a.m.)

CHAIRMAN FARRAR: Let's go back on the record. We've had off the record a discussion of the availability of documents the State asked for. Ms. Chancellor, is there something you're asking for that might have been created before the discussions we had in Salt Lake City, because we see a difference between anything created before then, and anything created after that.

MS. CHANCELLOR: I don't know, Your Honor, because we've never received any documentation that describes the extent or scope, or any information about Dr. Wissa's work with PFS, other than a discovery response saying that PFS expects to retain Dr. Wissa to assist it in its soil testing program, and that's the extent of our knowledge, other than at Dr. Wissa's deposition in March, in the middle of March. And at that time, Dr. Wissa had not -- had just been in preliminary discussions with PFS. It sounds like these discussions have advanced and that maybe Dr. Wissa has proposed a scope of work.

It will be rather laborious. I can go through and try and establish through cross examination the scope of his proposed involvement.

CHAIRMAN FARRAR: Mr. Travieso-Diaz, do you know what documents exist, given where we'd like to head? What can you propose that would solve this?

MR. TRAVIESO-DIAZ: Well, first let me state for the record, and Dr. Wissa will confirm, that the document that Ms. Chancellor is interested in was generated after our -- the beginning of the record conversation in Salt Lake City. It was prompted by those conversations. Now again --

CHAIRMAN FARRAR: Is there something similar that exists, that was created before that time?

MR. TRAVIESO-DIAZ: Not to my knowledge. Dr. Wissa, again, can confirm. There is no piece of paper, aside from the one that we are referring to, in which Dr. Wissa has committed to paper what a program that he will be involved with will consist of. It's true that document he created in a different context at a future time, that during the course of this ongoing proceeding, that will fall under the scope of documents requested by the State, but such a document doesn't exist to date.

CHAIRMAN FARRAR: And the Staff has not insisted on such a document being created at this point in connection with its Safety Review.

MR. O'NEILL: No, not to my knowledge, Your Honor.

MR. TRAVIESO-DIAZ: I want the record to be clear, Dr. Wissa is not now, and has never been under contract to PFS. He has had discussions for some time with PFS representatives, but he is not under contract to do any work at this point, except the work that he's doing in support of the litigation.

MS. CHANCELLOR: But we do have a discovery response, and in that discovery response, it was actually stated that he had been retained -- that he would -- had been retained by PFS to assist them in the Soil Cement Program, and during the deposition it was established that no, he had a contract with Shaw Pittman for the expert portion, but the State's a little surprised that PFS states that it's going to use Dr. Wissa for its -- to assist in its Soil Cement Testing Program, and that given that there's no contract, we're wondering if PFS is even going to use Dr. Wissa's proposal, so it's a little late in the day to be trying to figure out where we are on this one.

MR. TRAVIESO-DIAZ: I don't understand what the problem is. The situation is very clear. It hasn't changed since his deposition either.

Dr. Wissa has been (a) retained to provide litigation assistance in this case. He has concurrently been talking to PFS about potentially being retained to actually do the work at the point at which that work is done. And there is no contract or no agreement between the parties, they just have been talking about it. And I think that that is the beginning and the end of it, and I don't see what problem the State has with it.

MR. O'NEILL: Your Honor, I mean, I think a point to keep in mind is, I think what's at issue is the adequacy of the Soil Cement Testing Program as, you know, described in the SAR. I mean, to the extent that this document might have been developed in accordance, or pursuant to the settlement discussions, I'm not sure I see why it would be subject to discovery.

CHAIRMAN FARRAR: Ms. Chancellor, at this point, we don't see that there's anything to be produced, or anything permissible to be produced, so there's no --

MS. CHANCELLOR: I'll proceed through cross examination, Your Honor.

CHAIRMAN FARRAR: Go ahead.

MS. CHANCELLOR: Dr. Wissa, are you familiar with PFS Exhibit GGG, which is the

Engineering Services Scope of Work for laboratory testing of soil cement mixes between Private Fuel Storage and Applied Geotechnical Engineering Consultants, AGEC, dated January 31, 2001? It's attached to your testimony.

DR. WISSA: Yes.

MS. CHANCELLOR: Do you anticipate that you will -- is it correct that there are certain tests described in this ESSOW that AGEC will perform, such as Section 3.2, Test Procedures?

DR. WISSA: Can you clarify that? Whether they will continue doing the testing, is that what you're asking?

MS. CHANCELLOR: Well, that's what I'm going to get at. But first of all, do you recognize that in this document it describes certain test procedures that will be conducted for the PFS Soil Cement Testing Program?

DR. WISSA: Right.

MS. CHANCELLOR: And my understanding is that the first tests were Index Property Testing. Is that correct?

DR. WISSA: Yes.

MS. CHANCELLOR: Have you -- do you know when AGEC has completed those tests?

DR. WISSA: No, I'm not familiar with -- I've seen work they've produced. Whether that's completed, or whether there's additional work, I do not know.

MS. CHANCELLOR: Do you anticipate that you'll be involved in Index Property Testing at the PFS site?

DR. WISSA: If I do any work, the first thing you do in any testing program is to classify the soils involved, and Index Testing would be the first step in the process.

MS. CHANCELLOR: Would you be willing if you were hired by PFS to step into the Testing Program partway through and accept any of the work that AGEC has already completed?

DR. WISSA: Yes and no. Sorry, answering that way. Obviously, any information they have supplied would be beneficial. However, when you go through a program, you want to get the same soils throughout the program, and the probability of getting samples from them, or sufficient material from them to be able to continue a program, or to compliment the program would be difficult, so I would look at their data and take advantage of it. On the other hand, I think I would be inclined to -- well, I would probably want to sample the soils to know what soils you're looking at, get big enough samples to be able to complete the entire program without getting -- going back to the site more than once. So the answer is, I would use their data, however, I would be inclined to repeat some of their testing too.

MS. CHANCELLOR: I understand that AGEC used 16 test pits. Is that -- do you know whether that's true?

DR. WISSA: I can't remember what it was, but I know they used test pits.

MS. CHANCELLOR: Would you use the same test pits?

DR. WISSA: Not necessarily. I haven't studied it sufficiently to be able to tell you yes or no. I'd have to look to see that it is representative, and if it is, I'd probably use the test pits. But again, I don't know if they -- they probably have been filled back in, which would make it more difficult to get virgin material, because you wouldn't leave them open for safety reasons.

MS. CHANCELLOR: So if you were hired by PFS, you would start by collecting soil samples. Is that correct?

DR. WISSA: Of sufficient quantity to

complete the program, yes.

MS. CHANCELLOR: And then what would be the next step in your program?

DR. WISSA: Well, I think my program very much follows what the SAR says. I think maybe in essence it would be implementing that program, maybe in a little more detail, and with more -- looking at more variables.

MS. CHANCELLOR: The problem I have with the SAR, it is very short on detail. Would you first do Index Property Testing?

DR. WISSA: Yes, I would obviously do Index Property Testing.

MS. CHANCELLOR: And then what would be the next areas of -- I'd like to take us through step by step, the entire suite of tests that you would conduct at the PFS site, starting with collection of soil samples. What would be the next step?

DR. WISSA: The first step, as you said, would be Index Testing. What that does, allows you to determine the variability of the soils that are going to be stabilized over the entire site, or where we're going to be using Soil Cement or Cement-treated Soil. Once you have that, then you would want to determine how many different type materials need to be investigated based on variability, and that's where the classification or index tests come in useful.

Once you have that, you start designing your Soil Cement Mix, and that involves adding different amounts of cement to the range of soils, so you may have three, four, five different soils which will be used, and you'd want to determine how the soils respond to cement stabilization. And from that, once you get a mixed design, if you want, for each soil, then you'd go through varying the cement content and determining how they perform as far as durability, as far as strength and modulus.

MS. CHANCELLOR: Now with respect to collecting samples in the Index Test, how long do you anticipate that would take?

DR. WISSA: Well, collecting samples, I would say a week in the field should be enough to collect all the samples, provided you have a back-hoe or something to be able to help you collect samples. Then the Index Tests don't take very long. You're speaking by the time you ship the sample and so on, maybe a couple of weeks.

MS. CHANCELLOR: And then designing the Soil Cement Mix, getting the correct proportion of cement?

DR. WISSA: Well, maybe I can simplify things for you. Making it down date by day is difficult. My estimate would be six months, to eight or nine months to complete the whole testing program.

MS. CHANCELLOR: So after you design the Soil Cement Mix, and you get three to five soils, you do durability tests, moisture density tests?

DR. WISSA: Well, you start by doing moisture density. You also have to look at, in this case, modular, the modulus, because that's a criteria for the case of the Cement-treated Soil. There's no point testing a soil as a Cement-treated Soil if it's too strong. In those cases, for example, you're more interested in modulus and strength versus durability because they're not going to be subjected to climatic conditions, since they are much deeper down, and they're protected by the layers above them, so they're not going to be subjected to environmental conditions that the Soil Cement will be.

So each case is slightly different as far as, you have two things you're looking at. You have the Soil Cement, and you have the Cement-treated Soils, and each one has its own program.

MS. CHANCELLOR: And would they overlap at times? Is durability testing the only difference between the tests for the Soil Cement and the Cement-treated Soil?

DR. WISSA: They overlap in as much as the same properties you'd be looking at, with the one exception, which is the durability aspect of it.

MS. CHANCELLOR: And how long do you anticipate that the Bond Testing Program would take?

DR. WISSA: The which?

MS. CHANCELLOR: The Bonding, the DeGrobb Bonding Type Test?

DR. WISSA: Well, that would have to come after you've got a mixed design or designs, because it may be more than one soil involved, and therefore, there may be more than one cement content, and moisture conditions, and compaction conditions. But once -- you'd have to have those established before you go into the Bond Testing Program.

MS. CHANCELLOR: And how long do you anticipate the Bond Testing Program would take?

DR. WISSA: Well, probably a couple -- two to three months because you have to cure your samples beforehand, and then run the test.

MS. CHANCELLOR: So with respect to AGEC, you'd only use the data as background information and you would not rely on any of the work they had done to date?

DR. WISSA: I don't know if it's background. It's a piece of data which would be considered in guiding me. The work done to date -- any data is helpful about the site. So, for example all index tests would help me determine the variability of soils and be able to help me select soils to do, what I consider, the more extensive program. When I say index tests, I mean classifications tests.

MS. CHANCELLOR: I'd like to talk for a moment -- turn for a moment to specifics of the PFS site, and just what's involved with Soil Cement.

I'd like to have marked as State's Exhibit 212, this is an enlargement of PFS SAR Figure 4.2-7. I believe the entire exhibit is already in the record, but this may help us through our discussion.

(State's Exhibit 212 marked for identification.)

MR. TRAVIESO-DIAZ: What State exhibit number is this?

MS. CHANCELLOR: 212.

MR. TRAVIESO-DIAZ: Ms. Chancellor, so the record is clear, this exhibit is a portion of the figure?

MS. CHANCELLOR: Yes, it is. It's a

portion of Figure 4.2-7, and it has been enlarged about 120 percent, I think. It's a portion of the figure, and it show -- Mr. Trudeau and Dr. Wissa, are either of you familiar with this figure?

MR. TRUDEAU: Yes, I am.

MS. CHANCELLOR: And does this show a three foot thick concrete storage pad?

MR. TRUDEAU: I'm sorry. I didn't understand the first part of that question.

MS. CHANCELLOR: Does the top rectangular box, if you will, or top rectangle on the -- the rectangle on the top of the exhibit, does this -- does a certain portion of that show a three foot thick concrete pad?

MR. TRUDEAU: Yes, that's correct.

MS. CHANCELLOR: And then under that, is there two feet of Cement-treated -- a maximum of two feet of Cement-treated Soil?

MR. TRUDEAU: That is correct.

MS. CHANCELLOR: : And so there's a total depth of approximately five feet?

MR. TRUDEAU: That is correct.

MS. CHANCELLOR: And then around the pads, starting at the top where you've got the little circles, is that aggregate, compacted aggregate?

MR. TRUDEAU: That is correct.

MS. CHANCELLOR: And then below is the four foot -- two foot eight layer of Soil Cement?

MR. TRUDEAU: Two foot four inch.

MS. CHANCELLOR: Isn't there four inches of gravel, and then two foot eight inches of --

MR. TRUDEAU: No, it's eight inches of gravel, and --

MS. CHANCELLOR: Oh, eight inches. Oh, you're right, and two foot four. And then below that, is there two feet of Cement-treated Soil?

MR. TRUDEAU: That is correct.

MS. CHANCELLOR: So the Cement-treated -- is it correct that the Cement-treated Soil extends both under the pads and under the Soil Cement?

MR. TRUDEAU: That's the intent, yes. It'll be easier to construct it that way.

MS. CHANCELLOR: So at the sides, you've also got a total depth of five feet.

MR. TRUDEAU: That is correct. The key, however, is that the Cement-treated Soil under the pads is the key to this design.

MS. CHANCELLOR: And what are the restrictions, if any, that Holtec in its Cast Tip-over Analysis have placed on the pads and the soil treatment with cement?

MR. TRUDEAU: The Cast Tip -- because of the Cast Tip-over Analysis, the Cement-treated soil under the pads needs to be -- needs to provide a modulus of elasticity that is less than 75,000 PSI. And to provide sufficient shear resistance to sliding forces, to obtain our factor of safety for sliding greater than 1.1, that material needs to provide an unconfined compressor strength of at least 40 PSI.

MS. CHANCELLOR: And has Holtec --

CHAIRMAN FARRAR: Now, Ms. Chancellor, let me have that read back, please, that answer.

(Answer read back.)

CHAIRMAN FARRAR: Okay.

JUDGE LAM: Mr. Trudeau, assuming you believe in some of the testimony offered before this licensing board which were, one, sliding may actually be beneficial in terms of earthquake hazard. Two, that the factor of safety of 1.1 may not be binding on the applicant. Assuming you believe that, then you would need the Cement-treated Soil underneath the pad. Is that correct?

MR. TRUDEAU: That is correct.

JUDGE LAM: Okay. Thank you.

CHAIRMAN FARRAR: Go ahead, Ms.

Chancellor.

MS. CHANCELLOR: Mr. Trudeau, will there be any surfacing over the eight inches of compacted aggregate?

MR. TRUDEAU: You mean like an asphalt surface?

MS. CHANCELLOR: Right.

MR. TRUDEAU: That's not intended.

MS. CHANCELLOR: Okay. Modulus of elasticity, is that also sometimes refer -- is that the same thing as Young's modulus?

MR. TRUDEAU: That is correct.

CHAIRMAN FARRAR: Ms. Chancellor, if you're going to shift to a new subject, this might be a good point for a mid-morning break.

MS. CHANCELLOR: Always ready for a break, Your Honor.

CHAIRMAN FARRAR: It's just about 11, just before 11. Let's come back at 11:15.

(Off the record 10:58 - 11:18 a.m.)

CHAIRMAN FARRAR: All right. We're back on the record for the State to continue its cross examination. Oh, by the way, if we cannot secure a video conference, would the -- and assuming the State loses its argument that we should not have Dr. Singh, is teleconference all right?

MS. CHANCELLOR: Yes, that's fine, Your Honor, provided that Dr. Singh has a copy of the document with him.

CHAIRMAN FARRAR: All right.

MR. TRAVIESO-DIAZ: I'll make the point that Ms. Chancellor hasn't raised the argument yet. She's thinking on it.

MS. CHANCELLOR: Yes, I'm mulling it over, Your Honor.

CHAIRMAN FARRAR: All right.

MS. CHANCELLOR: So there may be nothing to lose.

CHAIRMAN FARRAR: Okay.

MS. CHANCELLOR: Are we ready, Your Honor?

CHAIRMAN FARRAR: Yes. And in terms of privacy of conversations, we have a mute button up here for our microphones, but these are sound activated. As I understand it, you cannot turn your's off, so you have to push them away from you if you don't want to be heard.

Go ahead, Ms. Chancellor.

MS. CHANCELLOR: Mr. Trudeau, is it correct that PFS will not be -- that the top layer of soil at the PFS site would either have to be used in some way, or carted off-site?

MR. TRUDEAU: I don't think that that's correct. It would need to be replaced, so whether it was carted off-site, it's more logical and likely that it would be used for landscaping on site, create berms or something like that, rather than hauled off some place.

MS. CHANCELLOR: But PFS needs to do something with that surficial layer of material. Is that right?

MR. TRUDEAU: That's correct.

MS. CHANCELLOR: And how thick is that surficial layer?

MR. TRUDEAU: How?

MS. CHANCELLOR: How thick?

MR. TRUDEAU: Thick?

MS. CHANCELLOR: Thick.

MR. TRUDEAU: On the order of three feet, plus or minus.

MS. CHANCELLOR: And is it correct that you have described this layer as an Eolian Silt?

MR. TRUDEAU: That's correct.

MS. CHANCELLOR: Could you describe how Eolian Silts are deposited, and their general geologic characteristics?

MR. TRUDEAU: Eolian Silts are deposited as windblown deposits, and they're typically non-plastic silts, but they can vary in grain size characteristics. Typically, they're uniform sized particles.

At the site here, these soils are slightly plastic, likely due to chemical decomposition through the years, in my estimation. Some of them are, indeed, non-plastic, as have shown up in the Index Property Test, and some of them have slight plasticity.

MR. TRAVIESO-DIAZ: Ms. Chancellor, if you don't mind, could I ask the witness to clarify what he means by plastic?

MS. CHANCELLOR: Certainly.

MR. TRUDEAU: Clay soils have different degrees of plasticity. It's the stickiness of the clay soils, I guess, and non-plastic soils lack this cohesion that's caused by the clay sized particles.

MS. CHANCELLOR: And is it true that the Eolian Silts at the PSF site are not -- there's not -- is there one predominant grain size in those Eolian Silts?

MR. TRUDEAU: I don't know if that's correct.

MS. CHANCELLOR: Do you know whether the Eolian Silts contain a large amount of clay?

MR. TRUDEAU: As I just said, I -- some of them do contain some clay. That's what the plasticity is derived from.

MS. CHANCELLOR: And how does -- how would -- if you have some areas of highly plastic soil, what does that do with respect to the Soil Cement Mixtures?

MR. TRUDEAU: Well, that goes to the number of tests that Dr. Wissa was referring to earlier, the variability of the soils. And, hence, is the need for doing these Classification Tests. One of those Classification Tests is the Attenberg Limits Test that measures the amount of plasticity, and the higher the degree of plasticity, typically the more cement you would need to achieve a certain compressive strength.

Our goal would be to use the less plastic, the more non-plastic soils where we need a durable Soil Cement Mixture, because that'll give us a better quality product.

MS. CHANCELLOR: Will you be able to distinguish plastic from non-plastic soils when you're excavating the site?

MR. TRUDEAU: This can be determined by a visual classification technique, yes. So the soils can be stockpiled according to them.

MS. CHANCELLOR: And if you did get some plastic soils within the Eolian Silts, isn't it true that you would then have problems meeting Young's Modulus, and as well as obtaining the 40 PSI compressive strength?

MR. TRUDEAU: That particular material is going to be required only directly under the pads. It will be used elsewhere, but its 40 PSI limit, and its 75,000 PSI limit is really only of significance and concern directly under each of the pads, so there's a relatively small volume of, let's call it preferred silt-like, you know, Eolian Silt material that we need to have available directly under the pads.

MS. CHANCELLOR: And there are 500 pads. Correct?

MR. TRUDEAU: That's correct.

MS. CHANCELLOR: So is it correct to say that you really can't at this stage say that the Eolian Silts blanket in a horizontal plain the entire 99 acre pattern placement area?

MR. TRUDEAU: I'm not sure that's fair, because we've seen it in all the borings, and we can see similar soil behavior-types in the Cone

Penetration Tests that were done across the site. The thickness near surface varies depending on where it may have been eroded by wind, or perhaps surface water in the past, but typically, it's found in all of the investigations.

MS. CHANCELLOR: Typically what is found?

MR. TRUDEAU: The Eolian Silt layer at the surface.

MS. CHANCELLOR: I'd like to have handed out and mark as State's Exhibit 213. This exhibit consists of a cover letter from AGEC dated March 27, 2001, two-page letter, and four pages of test results. Table One, Summary of Laboratory Testing.

CHAIRMAN FARRAR: All right. The court reporter will mark that as State 213 for identification.

(State's Exhibit 213 marked for identification.)

MS. CHANCELLOR: Mr. Trudeau, are you familiar with this Summary of Laboratory Testing, Table One on State's Exhibit 213?

MR. TRUDEAU: Yes.

MS. CHANCELLOR: If you look at the far right hand column called "Soil Classification" -- first of all, are these -- is the Summary of Laboratory Testing in State's Exhibit 1, is this a summary of testing done by AGEC at the PFS site?

MR. TRUDEAU: Yes, it is.

MS. CHANCELLOR: So these are site specific PFS soils. Is that correct?

MR. TRUDEAU: That's correct.

MS. CHANCELLOR: And in the soil -- and at what depth are these soils taken?

MR. TRUDEAU: They're taken at various depths, as indicated in the depth column on the left hand side.

MS. CHANCELLOR: So they range from zero to six feet?

MR. TRUDEAU: That's correct.

MS. CHANCELLOR: And the second entry at two to four feet, it's got Elastic Silt MH. Is this a plastic soil?

MR. TRUDEAU: Yes.

MS. CHANCELLOR: One, two, three, the fourth entry at zero to two feet, fat clay with sand CH. Is this also considered a plastic soil?

MR. TRUDEAU: Yes.

MS. CHANCELLOR: If you go down to one, two, three, four, five, six, seven, the eighth entry taken at two to four feet, elastic silt MH. Is this a plastic soil?

MR. TRUDEAU: Yes.

MS. CHANCELLOR: And third from the bottom, taken at two to four feet, fat clay CH. Is this also plastic?

MR. TRUDEAU: Yes.

MS. CHANCELLOR: So would anything with an MH or CH be a plastic soil?

MR. TRUDEAU: Yes.

MS. CHANCELLOR: If you look on the second page of the four entries there that are either CH or MH, the first --

MR. TRUDEAU: Yes. Three of them two to four foot deep samples. The other one is at zero to two foot deep sample.

MS. CHANCELLOR: And on page five of State's -- page five of Table One, are there five entries there with an MH or CH classification?

MR. TRUDEAU: I see one from a depth of four to six feet, two from a depth of four to six feet, one from a depth of zero to two feet, and another one from a depth of four to six feet, and another one from a depth of four to six feet. Clearly, in my estimation, the four to six foot deep samples are the upper Bonneville Clay, and the shallower ones would be more representative of the

Eolian Silt.

Now even for those in the zero to two foot range, those samples were obtained in the lower quadrant, the TP-1 through 4, in six inch increments going down, so even if it showed up there as zero to two feet, it could have been at the lower part of that depth range, and still it could have ended up being the upper Bonneville Clay deposit, rather than the Eolian Silt.

MS. CHANCELLOR: If you look on page six of Table One, in TP-14, at zero to two feet, we've got another plastic clay showing up there. Is that correct? Plastic soil showing up there, is that correct?

MR. TRUDEAU: That's correct.

MS. CHANCELLOR: And at zero to two feet, third from the bottom, is another plastic clay, plastic soil?

MR. TRUDEAU: That's correct.

MS. CHANCELLOR: And second to the end, two to four feet, another plastic soil. Right?

MR. TRUDEAU: That's correct.

MS. CHANCELLOR: So it's fair to say that the Eolian Silts are not uniform.

MR. TRUDEAU: Some of them may have some

plasticity, yes. Some of these samples may not be representative of the Eolian Silt.

MS. CHANCELLOR: Well, now when -- if and when Dr. Wissa comes on board, is that right?

MR. TRUDEAU: Well, that's why we do these tests, to find out how to categorize the soils, and to see which ones to put different percentages of cement into.

MS. CHANCELLOR: Do you know whether sulfates are present in any appreciable quantities in the Eolian Silts at the PSF site?

MR. TRUDEAU: We have measured sulfates in some of the sample. And typically, the results for the zero to two foot depth samples show minimal sulfates. We did have two specimens that I believe were in the Bonneville Clay layer at two to four foot depth, that had higher amounts of sulfates, in the order of 13,000 parts per million, I believe.

MS. CHANCELLOR: Thirteen eight, does that sound right? Thirteen thousand eight hundred PPM?

MR. TRUDEAU: That's around 13,000. Yes.

MS. CHANCELLOR: Dr. Wissa, any --

CHAIRMAN FARRAR: Ms. Chancellor, before you leave that, just so the record is clear, what do these various abbreviations stand for?

MR. TRUDEAU: The MH is high plasticity silt. ML is a low plasticity --

CHAIRMAN FARRAR: MH means?

MR. TRUDEAU: Silt. It's not an acronym.

MR. SILBERG: It's phonics.

CHAIRMAN FARRAR: It's phonics, so I shouldn't try to figure out what MH stands for.

MR. TRUDEAU: I don't know what the M stands for. The H is high, and the L is low.

CHAIRMAN FARRAR: Okay. At some point, someone can put this on the record for us, but the H and the L are high and low?

MR. TRUDEAU: For plasticity, yes.

CHAIRMAN FARRAR: Okay. The Cs do mean clays.

MS. CHANCELLOR: Your Honor, Dr. Mitchell has the answer is you want to do it now, or I can ask him on redirect.

CHAIRMAN FARRAR: Ask him on redirect.

MS. CHANCELLOR: Okay. Dr. Wissa, would any program that you anticipate developing for the PFS site, will that include Sulfate Testing?

DR. WISSA: Yes.

MS. CHANCELLOR: And how will you test for sulfates?

DR. WISSA: I'm not sure of the actual procedure off-hand. I think it's a Titration Test, a color change test, to determine sulfates, but I couldn't swear to that. Wait a minute. There may be a -- I believe there may be a specific electrode you can use too for it. I'm not a chemist, so I don't know the exact procedure, but you would -- you're looking at the soil for sulfates, and it's not a very complicated test. I know that.

MS. CHANCELLOR: Dr. Wissa, how in the field would you anticipate excluding either Bonneville Clays, Sulfate material, or plastic soils, how would you exclude those from the mix that goes into the Cement-treated Soil that will be beneath the pads?

DR. WISSA: The -- first of all, to differentiate between a highly plastic soil, and a low plasticity or non-plastic soil, there's a standard visual procedure which by feel, so anyone with experience can classify highly plastic materials from low plasticity materials, or granule materials. That's a fairly simple thing that anyone who has done any geotechnical engineering, even our undergraduates, are given that test to classify soils visually.

MS. CHANCELLOR: Would a contractor be able to classify such material over a 99 acre site?

DR. WISSA: The contractor usually has engineers on site, and in addition, I would assume that the owner would have representatives for quality control and quality assurance who would be there to supervise the work. You don't leave a contractor on-site on his own without supervision and monitoring. My company does a lot of this type of work, and we have people who essentially are there during construction to make sure the right materials are excavated, stockpiled and placed, so in a job like this I would see a lot of people on site.

In addition, you would have an on-site laboratory to do testing, so if there's any debate or question, you would probably have it sent to the laboratory. But generally, I'd say it's a fairly simple way to identify highly plastic CH Clays, let's say, from silt. It doesn't take an expert to do that.

MS. CHANCELLOR: But getting back to how many people you have on-site, and whether you have an on-site lab, a lot of that gets down to dollars, the cost. Isn't that true?

DR. WISSA: No, it isn't true. I think it comes down to what you expect as quality of work finally, and it's inherent in the cost of any project. I mean, I don't think any reputable engineer would sign-off on a project without having representation on-site during construction.

MS. CHANCELLOR: What about an on-site lab?

DR. WISSA: Depending on the size of the project, it's more efficient usually having a -- for this size project, I'd say it's taken -- and usually the contractor may supply the facilities that an engineer can use, or the engineer may put it on, so this is not an out-of-the-ordinary situation.

MS. CHANCELLOR: But that assumption is based on the assumption that there would be quality assurance people on-site, that there'd be sufficient lab testing. That's based on your -- on the quality of work that you would expect from yourself. Right? If some other contractor -- if some other person did this, such as AGEC, you don't know what they would require.

DR. WISSA: They're not the design engineers. They're a testing lab, so that isn't it up to them to make a decision on this.

MS. CHANCELLOR: You're correct.

DR. WISSA: The person who makes the decision is the owner. And usually, I don't know about with NRC, but in other fields where we have to get permitting, it becomes a requirement of the permit condition, is to have this quality assurance program, and quality control program as part of the conditions of a permit, so I would assume that in this case you would have conditions requiring these -- this type of testing program.

MS. CHANCELLOR: You've used the term "owner". Who are you referring to?

DR. WISSA: Well, the owner, I suppose, is the applicant in this case.

MS. CHANCELLOR: Private Fuel Storage.

DR. WISSA: Right.

MS. CHANCELLOR: And are you aware of any NRC requirements with respect to PFS' proposed Soil Cement Program, not just testing, testing through construction. Are you aware of any NRC requirements?

DR. WISSA: I'm not familiar with any of the requirements of NRC.

MS. CHANCELLOR: Now in terms of how you would actually prepare the site, would the first thing you'd do would be to excavate the surficial layer. Is that correct?

But that assumption is based on the assumption that there would be quality assurance people on site, that there would be sufficient lab testing that's based on the quality of work that you would expect from yourself. Right? If some other person did this such as AGEC, you don't what they would require.

DR. WISSA: They are not the design engineers. They are testing that so that isn't up to them to make a decision on this. The person who makes the decision is the owner. Usually I don't know about with the NRC but in other fields where we have to get firmity it becomes a requirement of the firmite condition to have this quality assurance program and quality control program as part of the conditions of a permit. So I would assume in this case you would have conditions requiring this type of testing program.

MS. CHANCELLOR: You have used the term "owner." Who are you referring to?

DR. WISSA: The owner I suppose is the Applicant in this case.

MS. CHANCELLOR: Private fuel storage.

DR. WISSA: Right.

MS. CHANCELLOR: Are you aware of any NRC requirements with respect to PFS's proposed soil-cement program? Not just testing but testing through construction, are you aware of any NRC requirements?

DR. WISSA: I'm not familiar with any of the requirements of NRC.

MS. CHANCELLOR: Now in terms of how you would actually prepare the site, the first thing you would do would be to excavate the surficial layer. Is that correct?

DR. WISSA: No.

MS. CHANCELLOR: Okay.

DR. WISSA: There are a lot of steps involved. A lot of this is left to the discretion of the contractor how he proceeds. The only area where if I were an advisor or consultant on the program would do is prevent a contractor from doing certain things which may impair or promote performance at the site.

The first thing you would do is remove any vegetation at the surface. You would not expose the whole site. You would do it in very small steps because we're concerned about disturbing underlying foundation soil. I think it can be left up to the contractor to some extent but there would be a lot of restrictions on what he could or could not do. I would assume in the bidding process of selecting a contractor the owner would give some of these constraints on what he can and cannot do in general terms. But if it would be up to the discretion of the contractor on how he implements it.

MS. CHANCELLOR: What type of experience would a contractor need to insure that the specifications or performance that you would require could be brought to fruition?

DR. WISSA: I think that any contractor who has a lot of experience in earth moving, highway contractors, would be able to implement a program like this.

MS. CHANCELLOR: So what size area would you begin excavating?

DR. WISSA: I cannot answer that question because it's a function of all phases. It depends on what is the production of soil-cement today would be. I can't answer that question until I know how big I assume it's going to be a central plant mixing what is its capacity in producing soil-cement.

You wouldn't want to expose a lot of area where you wouldn't be able to place a soil-cement down in a reasonable amount of time. You wouldn't want to leave several months open while you are producing the soil-cement modified soil. It would be done in stages. The bottleneck or the critical part I think will depend on what equipment and what facilities the contractor has.

MS. CHANCELLOR: Why do you assume that there would be a centralized plant?

DR. WISSA: I would think that it's the most practical way to do it. It also helps with the quality control because you would stock pile your material. A lot of your concerns about variability and so on, it gives you more lead time to be able to stock pile suitable materials.

MS. CHANCELLOR: What do you mean by a centralized plant?

DR. WISSA: You have two or three ways you can produce soil-cement. One is what they call on-site where you would take the soil, windrow it possible, mix it with cement and then take that windrow mixed with cement and put it back wherever you want to stabilize it.

The other one is take material and take it to a central plant, one area where you have a plant which has control. The cement is in silos in the plant. The feeding system is mechanical. It feeds the amount of cement in and moisture count is controlled.

So it's more automated. It's something like a concrete plant where you produce concrete.