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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of:	Docket No. 72-22-ISFSI ASLBP No. 97-732-02-ISFSI
PRIVATE FUEL STORAGE, LLC	Deposition of:
(Independent Spent Fuel Storage Installation)	**DR. STEVEN F. BARTLETT** and **DR. FARHANG OSTADAN**
	Vol. II

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Salt Lake City, Utah

Reporter: Vicky McDaniel, RMR
Notary Public in and for the State of Utah

NUCLEAR REGULATORY COMMISSION

Docket No. 72-22 Official Exh. No. 236

In the matter of PFS

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DATE 6/20/02

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Q. And he has now left the deposition and you're testifying by yourself; is that correct?
A. Yes, that's correct.
Q. Again, when we broke for the night last night, you were in the middle or started to disclose what has been identified as Exhibit 59; is that correct?
A. Correct.
Q. Now, I know we went through this to some degree last night, but just to provide continuity, will you briefly describe for the record again how Exhibit 59 was prepared and what the purpose of the exhibit is?
A. I'll explain the preparation first and then what I was trying to accomplish through the preparation.
The applicant has done a grid of cone penetrometer testing throughout the pad emplacement area, and also not a grid but, however, some cone penetrometer testing in the area of the canister transfer building.
One of the issues that we're trying to -- let me stop before I get into -- one of the issues that we're trying to understand is what is the potential for variation of undrained shear strength across this site to see if the applicants used reasonable and representative values for that -- for the analysis that pertains to dynamic sliding and dynamic bearing

capacity.

The cone penetrometer I think when we looked at that data did reveal to us a layering system that was slightly more -- well, more complex than we saw from the first phases of investigation, and revealed that the shallow surface soils have an Eolian silt approximately three feet thick underlain by approximately seven feet of upper Bonneville predominantly clays that are probably best characterized as silty clays/clayey silts with low to some high plasticity to them. We understand that the applicant plans to treat the Eolian silts, and so we also then wanted to look to see what would be the resistance that the underlying clayey silts/silty clays could provide to these dynamic analyses.

The laboratory data really did not help us greatly in understanding the variability, because based on our understanding of the way the data were used for the dynamic -- the dynamic sliding and bearing capacity analyses, that they were based on laboratory testing, and the number of data for the laboratory testing are probably not large enough to really make a statistical sampling of the area.

For example, it's our understanding that the canister transfer building relied for the dynamic bearing capacity analyses on UU testing. I believe the value that was used in the design is approximately 2.2 kips per square foot. And as I recall, those were coming from I believe Borehole C-2 and No. 4, but I could be wrong. And we had concerns about the proximity of some of those boreholes to the canister transfer building.

Also, for dynamic sliding, my recollection is that the results were coming from the direct shear test. For the pad emplacement area, I believe the borehole was C-2. The design value was approximately 2.1 kips per square foot. And for the canister transfer building, I can't exactly recall where the direct shear test came from, probably a couple borings within that area. And the design value, best I can recall for the loads due to the mat foundation was about 1.75, 1.8 ksf.

So we wanted to know whether those values represented low-bound values, mean values, upper-bound strengths for the design; and I believe in our discussions Wednesday when we discussed these, they were characterized as mean, though we may be using "mean" maybe not in a statistical sense. I'm not sure what the mean meant in that context.

We realize then because of that sparse sampling that it may not give us an idea of variation across the site. However, the cone penetrometer data were pushed in I would say a nonbiased fashion. It was pushed as a grid, so it did not appear to be any bias in where those cone penetrometer data were pushed. Also, because the cone penetrometer gives you a continuous vertical profile, it allows you to understand the variation in the vertical direction quite well so one can see subtle but insignificant changes in the tip resistance.

Likewise, if one would compare cone to cone to cone laterally across the site, one could begin to understand if there were significant variations in the strength of the soils by just doing comparisons from one cone to another for the particular layer of interest. And again, most of our interest has been focused really on layer -- what we've been terming layer 2.

When I went to try to do that analysis, I couldn't really find any composite plots to try to understand that. I was in haste to prepare for this deposition, did not have the digital data available to me to plot it up. So I got some overhead transparencies and began with my pen to just trace down the traces of the tip resistances from the cone penetrometer. In preparing to do that I enlarged them on the photocopy machine and then traced them in different colors according to groups of five. I did not really bias the way I was grouping them. I just went through them numerically 1 through 5 and then 6 through 10. I didn't want to get too many traces on one plot, or I couldn't really make any sense of it.

Also, if you notice on the sheets that have been provided in Exhibit 59, there's the -- one of the heads, for example, the first one says CPT 1 through 5, and the dash by it which is brown just means that I used brown for that. And as I went through the zone of interest, which would be layer 2, I tried to make a mental note when I went through a group of five which one out of the group of five potentially had the lowest tip resistances in layer 2. So that's what it means by "(CPT lowest)" underneath it.

The reason for doing this is, I think that I had in my mind that undrained shear strength is correlated with tip resistance. We discussed it being linearly correlated. There are published correlations that establish that there's a linear correlation between tip resistance and undrained shear strength.

So maybe we cannot really use these in quantitative manner to do design, and the I think applicant has also said they have not used the cone penetrometer in a quantitative way to do design; however, they have used it in a qualitative way to adjust their undrained shear strengths according to corresponding and relative changes in the tip stress.

So I was hoping to just discover by the variation in tip stress the potential range of undrained shear strength. For example, a variation in tip stress by a factor of 2 would suggest that the undrained shear strength in this layer could also vary by approximately a factor of 2.

And I think we were starting to look at the variation on some of these. I believe we started on the first plot, CPT 1 through 5, and saw something. We were discussing values and ranges as we last left. And I don't know if you want to continue doing that, or --

Q. Well, I do, but before we look at results, let me try to get some better understanding of the record as to what the parameters of interest are here. I take it that you are using the cone tip resistance as a proxy to try to estimate the changes in the parameter that you really care about, which is undrained shear strengths.

A. That's correct. They are correlated.

Q. And your belief is that there's a correlation that's linear, so it's that. If for a given value of cone penetration resistance there is a corresponding value of unstrained shear strength --

A. Correct.

Q. -- and if we move, say, horizontally, laterally across a layer of soil --

A. Right.

Q. -- that parameter that relates to the two of them remains a constant.

A. If the soil was homogeneous.

Q. Exactly. Well, try this again. In order to determine, assuming that in fact that correlation factor is a constant, if you move from point A to point B horizontally --

A. Correct.

Q. -- you get the same tip resistance or a small variation in it --

A. Correct.

Q. -- you are entitled to assume that the corresponding undrained shear strength is essentially the same according to points. Is that the reasoning?

A. Correct.

Q. In order to do that, it requires for you that the correlation be indeed linear, that the constant be -- that the number that relates to two, whatever that may be, be a constant.

A. Be nonchanging, yes. And the assumption then would be, the soils are relatively homogeneous.

Q. Now, with that background, let's go back to your previous, the calculation that you gave me, the Exhibit 49. Remember it was --

A. Oh, yes, I remember that.

Q. I believe that one identified the parameters.

A. It does. It's one of the correlations, yes.

Q. That's what I'm trying to use. Identified the parameters of interest.

A. It's entitled N sub K.

Q. Now -- I'm looking now at Exhibit 49, and I'm looking at the -- there are a number of equations on the exhibit, but the one that I'll ask you to look at is the last one that reads as follows. And I don't know if this may be captured by our able reporter, but I'll try. $S_u = (Q_c - \text{sigma}_v)/N_k$. Did I read that right?

A. Uh-huh.

Q. Now, please identify for the record what each of these four parameters are.

A. Okay. S_u is the undrained shear strength. Let's see if it mentions what units it's in. I think for this example we haven't probably plugged any values of N_k in, but it looks like it would give you values in ksf.

Q. And that would be?

A. Kips per square foot.

Q. Thousand pounds per square foot?

A. Thousand pounds per square foot. Q_c would be the tip resistance or tip stress that would have to be in the same units which the undrained shear strength was in.

Minus sigma-V would be the overburden stress. It doesn't say whether it's effective or total. However, that would be fairly minor for this -- differences would be fairly minor for this case.

And then divided by a coefficient that relates the two determined by regression analysis or some other method is called N_k.

Q. All right. So that again the record is very clear: in this equation what we want to do is get a better understanding of S_u, and the variable, if you will, that we're using to understand S_u is Q_c?

A. Q_c.

Q. Now, tell me a little bit more about sigma-V, since that's another factor that is involved.

A. Sigma-V is essentially the weight of the materials overlying where the particular reading was taken. The readings are taken somewhat continuously as you push down through the profile, so as you get deeper and deeper in the subsurface, sigma-V is changing. It's a function of the unit weight of the soil above and the thickness of the material above.

Q. Right. Now, based on the results of the tests the applicant has conducted and samples taken from the site, is the unit weight for a given layer of soil a constant, or does it exhibit variability?

A. The unit weight for a given layer?

Q. Yes.

A. I'm not sure I've seen a breakdown according to layer by layer in the system. That was one of things that --

Q. Let me show you, and we can make this an exhibit --

A. Sure.

Q. But the SAR has a Figure 2.6-31, which I will turn into an exhibit, which I'd like to show you. Do you have a copy of the SAR?

A. I do.

Q. Can you take a second and find your copy, and we can look at it at the same time?

A. Sure. The figure was --

Q. I'm sorry. Figure 2.6-31. It's entitled "Dry Densities of Subsurface Soils at the Site."

MR. TRAVIESO-DIAZ: We have -- we can turn this into an exhibit now because we have a sufficient number of copies, I believe. This will be Exhibit 71, and I will provide more copies tomorrow, but we have at least one for the court reporter. And the witness has his own copy.

A. I do. I do remember seeing this.

Q. This plot appears to be one of dry unit weight in pounds per square foot versus depth for locations both of the pad emplacement area --

A. Yes.

Q. -- and the canister transfer building.

A. Yes, it does.

Q. And they're identified differently. The ones in the pad emplacement area are circles, and the ones in the canister transfer building are little diamonds; is that correct?

A. That's correct.

Q. Now, will you take a look across -- let's take a look at the layers that we're interested in that we believe is from three to ten feet. Take a look for me at the data points that are shown in this figure for the pad emplacement area, which I believe are the circles.

A. Yes.

Q. Go across for me -- the values are recorded, and if I read this graph properly, you are recording dry weights anywhere between 40 and 70?

A. Correct. But I would wonder if the two data points between 60 and 70 may be of a higher unit there. They're quite a bit out of range from the other data. So I think one would have to verify that those are actually part of the data set.

Q. All right. Well, how about in that same layer, the value for the canister transfer building? I see that those vary in terms of unit weights anywhere between like 45 and as high as almost 80.

A. Yes, but I see again two points that are quite out of the data set. There may be something abnormal about those two data points. They may be in the right zone. Maybe there's something different about them.

Q. But would you agree with me that aside from the potential fact that some of this may be outliers, that you believe the data as plotted could be almost a factor of 2 variation in the unit weights?

A. That I can't testify to.

Q. Well, okay. What it would be -- take just the values across on the -- for the pad emplacement area going --

A. Sure.

Q. Do they go anywhere from 40 to 70, assuming that you give credit to all the data points?

A. For the pad emplacement area?

Q. Yes. The circles, don't they go from 40 to 68 or something?

A. They do, but the depth to the Eolian silt which may be denser is not always exact, and I still don't know if 60 and 70 are in or out of that data set. But for the moment for the argument, let's go ahead and discuss what they are.

Q. But as an engineer, would you tend to at least have a question in your mind as to whether you can assume -- based on the data as presented in this exhibit, that it is correct to assume that the sigma sub V, the dry unit weight, is uniform across the layer?

A. I'm sorry. I missed question.

Q. I don't know if I said this right. Let me try again. Without trying to reach a conclusion, as an engineer wouldn't at least you have a question raised in your mind by looking at this plot --

A. Correct.

Q. -- as to whether it is a correct assumption to assume that the dry unit weights are uniform across a layer of soil?

A. What I would do as an engineer with this data set is I would come in and say I have potentially two ranges now, particularly where I see a couple data points that are somewhat out of the rest of the data range, and first try to verify where those particular samples were stratigraphically. Then if I can determine that, then I would feel more comfortable where I place them. So I guess I could be looking now with potential two ranges, something between 40 and roughly 55, or something between 40 and possibly as high as 70.

Q. All right. But let me put the question this other way. Without further investigation, would you feel that it would be prudent to assume looking just at this data as you have it and looking further into it that the dry unit weights are constant across a layer horizontally?

A. Well, "constant" defines one point or line. There's variability to any data.

Q. Right. Would it have low variability across a given layer of soil without reaching conclusions without -- I'm sorry. Strike that question.

My question is, can you assume based on this data as reported without looking more into it that in fact sigma sub V --

A. Correct.

Q. -- is a constant across a given layer?

A. We talked about differences in approach and philosophies of how investigations are done, and if I were going to use data that have been attained to determine unit weights -- that's why I preferred when we talked about these to have paired CPT and boring data together. Then there would be no question to where potential outliers fall. I would be hesitant to assign a range -- I think the data tend to support more between the 40 and 60 range than the 40 to 70 range.

I would also then get all the unit weights of the overlying Eolian soil, which are not plotted here, and see where they lie in relation to the data that I'm looking at. I'm only looking at the -- from five feet down. And I assume this was done on five-foot sampling, so it's kind of a hit-and-miss proposition what layer we're in.

Q. Dr. Bartlett, I guess it should be no secret to you where I'm going with this question.

A. I know where you're going.

Q. And my question is only -- and I'm going to ask you the question just based only for the moment on this particular parameter, sigma sub V. I understand what you have done with Exhibit 59 --

A. Correct.

Q. -- and I understand that you're trying to derive some feel for whether you have variation or not.

A. Right.

Q. But before you could print an opinion or have a conclusion based on Exhibit 59, wouldn't you with respect to unit weights have to look more into it?

A. Well, I think before we worry about whether we have a unit weight that could be somewhat variable, I guess the next approach would be is to go back in and look at the effect of sigma-V on the parameter that we're trying to calculate. Even if we looked at variations between 40 and 70, if the component of sigma-V which is contributing to the shear strength is not large, then this may be somewhat of a trivial thing we're doing here.

Q. Are you saying that perhaps if Q_c is so much larger, that --

A. Yes, that it may override the variation that we see in sigma-V.

Q. Okay. That's a fair consideration. But then you'd have to do that analysis?

A. I would just have to plug in the values. It's not a very difficult thing to do if we know the weights of the materials.

Q. Before we do that, let's talk now on N_k. I take it that you are assuming, as you said, N_k is a constant?

A. Well, N_k would vary according to different types of soils. That's reasonably known. In fact, it's unfortunately a very variable parameter, and that's what makes this correlation hard to apply to soils without some prior experience of calculating it. What I'm saying is N_k should be locally correlated and used not trying to apply an N_k for soils here versus soils somewhat quite a distance away.

Q. Let me ask the question this other way. In order for the relationship between the cone penetration tip resistance --

A. Correct.

Q. -- and the undrained shear strength to be able to draw up the conclusions, you testified earlier that you would need to have N_k be a constant across a layer?

A. It would have to be assumed if you're going to use it to predict a certain layer that it is constant, yes.

Q. All right. And what is your basis for assuming that N_k is constant across a layer of soil?

A. Just from the cone penetrometer data, it seems to be that the upper Bonneville clay seems to be relatively homogeneous, at least in the interval from about somewhere around five feet. It's hard, you know, that five-foot boundary gets a little blurred. Sometimes it's as high as three feet. Down to about eight to ten feet we seem to get a monotonous, if you will, tip stress signature, and my prior experience with the upper Bonneville clay is it's somewhat of a monotonous clay. It can vary from a silty clay to clayey silt.

Q. Even within a monotonous layer, as you describe it, would N_k be a function of factors such as plasticity?

A. It could, yes.

Q. Let me show you -- let's mark this as an exhibit. Let's call that Exhibit 72.

(Exhibit-72 marked.)

Q. (By Mr. Travieso-Diaz) Now, what I have provided you as Exhibit 72 I believe is a portion of a treatise called -- or it's not a treatise, at least -- a monograph perhaps is the word, called "Cone Penetration Testing in Geotechnical Practice" by Tom Lunne, L-u-n-n-e, Peter Robertson, and John Powell.

A. Yes, I see.

Q. Are you familiar with this treatise or this monograph?

A. I haven't seen it in this form, but I may have seen parts of the equation. So it's -- there's been several people investigating N_k.

Q. I know. Let's look at page 64, the bottom of the page in an equation that is identified as 5.16. Is that equation the same as the one that you have at the bottom of the front page of Exhibit 49?

A. Yes.

Q. So the parameters are the same?

A. Yes.

Q. Let's turn, then, to the next page, which is page 65. And I'm not going to, but I invite you if you wish to, review the discussion on that page, which I believe talks about how you go about predicting or estimating N_k.

MS. CHANCELLOR: Do we know the date of this document? Do you know if it's recent or if it's --

MR. TRUDEAU: It's in the SAR reference list. I can find that for you.

MR. TRAVIESO-DIAZ: I can tell you there is a list -- more -- no older than 1985, because if you look at the last page, 106, it references a 1985 study by Greig, and he says "recent data." So without attempting to testify, I will guess that this document is of approximately 1985 vintage.

THE WITNESS: In fact, I could probably find it. If I may pull out the EPRI manual, it may be referenced in here. The EPRI manual does reference these authors. We could get the exact date.

MS. CHANCELLOR: I was just trying to establish whether this was recent.

THE WITNESS: It may not be. Well, it has a 1986 reference, so it's -- wait. Excuse me. There is a 1996 here, so it's within the last four years.

Q. (By Mr. Travieso-Diaz) Well, I am shown a page 2.8-6 of the SAR that has a list of references.

A. Okay.

Q. And it lists this work as being a 1997 date.

A. Okay, fair enough. That's fine. So it's relatively recent.

Q. Again, I'm not requiring or asking you to read it in detail, but I'm inviting you to look at how they go about estimating N_k. And what I want to draw your attention is to two figures. First figure is on top of the page on the left, in which there is a plot of N_k versus something known as the rigidity index, and it is described in -- within a rectangle by what appears to be a logarithmic relationship.

A. That's correct.

Q. And I'm not technically competent to render a judgment, but that would tend to indicate to me --

A. Tremendous scattering.

Q. -- that this is a logarithmic scale that is not a straight line.

A. No. And there could be potential large scattering of these data, too.

Q. And now I invite your attention to look at two plots of N_k again versus plasticity index.

A. I see it.

Q. And they are in fact I believe identified for particular types of soil. They have a series of plots for onshore Norwegian clays and a series of plots for North Sea clays.

A. Yes, I see that.

Q. Without attempting to imply that these are the same soils as at the PFS site --

A. I understand that.

Q. -- the published data appears to indicate that there is a wide range of values for N_k depending on what plasticity index you have.

A. I disagree.

Q. Oh. Well, help me here. Maybe I'm misreading it.

A. The lines that are plotted on this figure, you can see they plotted an upper and lower bound based on it looks like ranges of data that they plotted to either horizontal or vertical bars with the two lines on the end.

Q. Right.

A. And the authors here have chosen to draw a relationship based on no statistical analysis. When you do statistical analysis, you should show all data points and fit with regression line. And you'll notice there on the plasticity index between about 5 and 10 several significant points of their data above their upper bound line. I might argue that if one would use the correlation of the whole data, there might be essentially a flat line across there.

Q. If you circumscribe yourself just to looking at what you describe as being the extreme bounds of the set of data points.

A. Sure.

Q. For example, in the first of the two figures, I see that for a variational plasticity index going from, say, what is shown here as 5 percent to maybe 45 percent, you have values of N_k that go anywhere between 15 and -- I don't know. Can you read the graph?

A. I can't.

Q. Well, let me just ask you a question. Again, presented with data of this sort, and without asking you to draw any conclusions, would it be prudent to look more into the extent to which it is fair to assume that N_k is a variable or is a constant?

A. That's a fair question because, you know, when we look at the borehole data we do see CLML materials in this range, and we also see indications of some CH and MH materials. And given all things constant, I still think there is a relationship between plasticity index and N_k. I'm not sure if this document doesn't slightly overstate it in its presentation.

So yes, the assumption that N_k is constant through this layer may not be valid because we do see indications from for the borehole data that the plasticity is changing, and my experience with the Bonneville clays elsewhere have suggested there's some high plastic zones in it. For whatever reason, they show up.

Now, I think again all I was doing, this was in a relative sense, trying to understand, and yes, the assumption was that N_k in this monotonous zone was somewhat constant.

Q. I'm not trying to denigrate what you did, I'm just trying to explore the bounds of what you can --

A. Explored the assumptions that we're going through, yes.

Q. And would it be fair to say that, while useful to try to figure out the extent to which you may have a variation on undrained shear strength across a layer using cone penetration tip resistance, you couldn't just do a single plot by this and draw a definitive conclusion. Is that correct?

A. No, I think it's just a possible approach. And that's all it was for me was a possible approach to try to understand potential variability. Because we have discussed differences in plasticity, void ratio, water content, and potential -- now slight cementation in this zone, it is reasonable to assume that the undrained shear strengths in this layer is variable.

Q. On the other hand, you could also assume that the undrained shear strength is fairly constant and the other things have changed. Is that right?

A. I have a hard time assuming that.

Q. Well, you cannot rule it out. You cannot rule it out because you --

A. Well, I can say definitively if the void ratios are changing, if the moisture contents are changing, and if the plasticity is changing, the undrained shear strength is changing. And I'll say that definitively.

Q. All right.

A. If those are true.

Q. Right. And you can do that even without referring to --

A. I can pull you a standard textbook and show you those statements.

Q. And you can do that even without doing --

A. I do not have to do analyses to make those assumptions.

Q. One more question that I have on this Exhibit 59. And just keep looking just between five and ten feet, if you will, which is I think the layer that you are interested in.

A. Yeah.

Q. Even though they are in your plots, and assuming for purposes of this discussion that in fact there's a linear relationship in these two parameters, that there is some variability. To my very untrained eye, they appear fairly homogeneous throughout all layers in terms of you're going to assume that there is a band, the band as such is pretty uniform throughout.

A. Out of all that we see in this system, it is the most monotonous, yes.

Q. In fact, the layer that relates most uniformly as compared to --

A. Is layer 2. That's fine. That's why we can pinpoint it so well from these data.

Q. All right. Do you think there's anything else that we can draw from this Exhibit 59?

A. No, other than it's just a potential approach to look at the variability. Do with it what you may. It was just something I was trying to understand.

MR. TRAVIESO-DIAZ: All right. Off the record for a second.

(Discussion off the record.)

MR. TRAVIESO-DIAZ: Let's go back on the record.

Q. (By Mr. Travieso-Diaz) And before we talked about Exhibit 59, we were beginning to go over Basis 3b as it is described on Exhibit 3, page 85.

A. Exhibit 3?

Q. Exhibit 3 is the statement of the contention.

A. Got it.

Q. If I recall, yesterday we did go through Basis 3.

A. Yes. This is the copy I had yesterday, because I recall my markings on it.

Q. Right. And we were on b on page 85.

A. Okay.

Q. And I am embarrassed to tell you that I don't recall exactly where on page 85 we were, but at