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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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REGULATORY POLICIES & PRACTICES SUBCOMMITTEE

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TUESDAY

SEPTEMBER 30, 2014

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ROCKVILLE, MARYLAND

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The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B1, 11545 Rockville Pike, at 8:30 a.m., Dana Powers, Chairman, presiding.

COMMITTEE MEMBERS:

DANA A. POWERS, Chairman

DENNIS C. BLEY, Member-at-Large

STEPHEN P. SCHULTZ, Member

GORDON R. SKILLMAN, Member

DESIGNATED FEDERAL OFFICIAL:

QUYNH NGUYEN

NRC STAFF:

ANN BRADFORD, NRO

LUISETTE CANDELARIO, NRO

PROSANTA CHOWDHURY, NRO

STEPHANIE DEVLIN, NRO

VLADIMIR GRAIZER, NRO

ANN HOVE, OGC

REBECCA KARAS, NRO

DYLAN SEBER, NRO

GERRY STIREWALT, NRO

FRANKIE VEGA, NRO

ALSO PRESENT:

OSMAN EL MENCHAWI, PSEG

JAMIE MALLON, PSEG

AL TICE, PSEG

T-A-B-L-E O-F C-O-N-T-E-N-T-S

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

(8:29 a.m.)

CHAIRMAN POWERS: Let's come back in session. This is a continuation of the Regulatory Policies and Practices Subcommittee meeting looking at the PSEG Early Site Permit application. You may wonder why it's done under Regulatory Policies and Practices.

We used to have an early site permit subcommittee. There's a lot of pressure on us to keep our number of subcommittees small, so we let it atrophy. And when your application came in, we didn't have a place to put it, so we put it under regulatory policies.

Everything I said yesterday about the meeting is still roughly applicable. I think I forgot to introduce Quynh Nguyen as our designated federal official for the meeting. I left you out. Did I?

MR. NGUYEN: I think so.

CHAIRMAN POWERS: Yes. See, I ignored you. I tried to --

MR. NGUYEN: I work behind the scenes.

CHAIRMAN POWERS: You work behind the scenes. He's pulling my strings, actually.

Apparently, we were not intense enough yesterday because we didn't scare Anna off. She came back. Entirely welcome.

Today we're going to work largely on Section 2.5 I think. Okay. Prosanta, do you want to begin this process?

MR. CHOWDHURY: Yes. Good morning, everybody. We started this meeting yesterday at 1 o'clock, and we covered Chapter 2 Sections 2.1, 2.2 combined, and then 2.3. This is related to PSEG early site permit review.

And one comment I would like to make about the staff's process of review is that in doing the review, the staff does site audits, staff does site visits, tours, et cetera. In addition, we have issued a number of REIs, questions that the staff had in their mind and necessary for completing their review.

And that was a lot of work in going back and forth with the Applicant to get satisfactory response to those inquiries. So I just wanted to emphasize the fact that not only what you saw yesterday has been done, but behind that, there's a lot of work that the Staff did.

CHAIRMAN POWERS: My understanding is

we're working that in a much more informal process so that we can get resolution to these REIs. Is that working?

MR. MALLON: It is. We seem to draft REI because so often you misunderstand the question. So seeing the draft REI and making sure you understand what the question is helps us to make sure we answer it.

CHAIRMAN POWERS: Well, it seems to be how it's being generally done even on DCDs and COLAs. And it's my impression that that's working a lot better than what we did in the past where it was kind of at an arms length, relatively formal process with limited amounts of communication on that.

MR. MALLON: I also think the audits are helpful because then you can get right into page turns on calculations and go out and see hopefully what it is.

CHAIRMAN POWERS: Okay, okay. We want to flag that, that you're seeing the audits as being helpful.

MR. MALLON: Yes.

CHAIRMAN POWERS: Okay.

MEMBER SKILLMAN: I would communicate

though, you presented that the conditions that you identified yesterday in the two chapters reflected the sensitivity and the focus to ensure that the questions you had were answered, and that the commitments from the Applicant were appropriate for the item that you were concerned about.

So it's clear in your track record that you are using that degree of thoroughness and sensitivity to make sure that this is done properly. So I give you a compliment on that.

MR. CHOWDHURY: Thank you so much. And talking about the communication between us and the Applicant, we do have sort of informal when communications when we exchange draft REI just for the purpose of clarification.

I want to be clear on the record that during that clarification process, we do not discuss any technical matters that go behind the scene of the public transparency. So we are greatly transparent in that process except where proprietary or sensitive information is discussed.

So we have been very careful and meticulous about it, and a lot of work went into that permit condition, Dr. Skillman, you just mentioned is that we actually had to have a public meeting with PSEG to clarify and then to explain in detail regulatory basis and our expectation that led to the permit condition the way it is today in the SE.

And then the Applicant submitted a revised portion of the site specific analysis report in that regard, and that satisfied us with the permit condition as it is in the SE.

MEMBER SKILLMAN: Thank you.

MR. CHOWDHURY: So we will, today our primary focus is to present Chapter 2 Section 2.5 which is geology, seismology, and geotechnical engineering. Before we go into that, I believe there was a question from the Members on the Coast Guard to PSEG regarding Coast Guard.

MEMBER SKILLMAN: Yes, my question. Yes.

MR. CHOWDHURY: So Jamie Mallon is going to address that.

MR. MALLON: So what we did last night was we checked with our site about how do we do it for Salem and Hope Creek. And Salem and Hope Creek have the same issue where a portion of the ten mile, or excuse me, the EAB, a portion of the EAB is in the Delaware River.

The answer is in the National Response Framework which is in place very high overarching document that links federal agencies to the State Government. So what we would do is ask the State of New Jersey to have the Delaware River evacuated.

They would then contact the Coast Guard in accordance with the National Response Framework, and there's an annex for radiological incidents response. And that gives them the ability and really the authority to ask the Coast Guard to evacuate that area. So the new plant would invoke a similar regulatory framework to make that happen.

MEMBER SKILLMAN: Salem and Hope Creek. Jamie, thank you.

MR. MALLON: Sure.

MEMBER SKILLMAN: That's a thorough answer, I appreciate that. Thank you.

MR. CHOWDHURY: Okay, so if there are no questions to the Staff at this point, then I'll turn over to PSEG to begin their presentation on Section 2.5.

MR. MALLON: Okay, so for our presentation on 2.5, I'm initially going to hand it off to Al Tice. And Al, can you provide a short summary of your experience?

MR. TICE: Good morning. My name is Al Tice, I'm a principal geotechnical engineer with AMEC in environment and infrastructure. And AMEC is a short term that I may use during the presentation.

My background is a Bachelor of Science in civil engineering from Virginia Tech followed by a Master of Science in civil engineering with a specialization in soil mechanics as geotechnical engineering was called at that time from MIT.

I've been working with AMEC over 45 years. And as predecessor names as Law Engineering, Law Environmental, MAC Tech and so on and so forth. So it's hard to keep straight what hat I put on each morning.

I have worked on various nuclear projects in site permitting starting with North Anna's early site permit back in 2002 in which we did the data collection and geotechnical data reports. We also worked on the follow up work with North Anna in 2006 with the same areas.

Worked on Bellafonte, both episodes of Bellafonte when there were units three and four, and then for reestablishing unit one. Worked on Grand

Gulf in Mississippi, worked on Clinch River which is TVA small modular reactor demonstration project that's currently under licensing reviews.

My role in this project was as a technical lead for Section 2.5. And under that umbrella, we retained the services of Fugrow, earlier some William Lettis Associates who was then purchased by Fugrow. So another changing of hats. They provided geologic and seismologic portions for 2.5.1, 2.5.2, and 2.5.3. AMEC provided the 2.5.4 and 2.5.5 sections.

Today I'm going to review first the 2.5.1, and I would like to continue with 2.5.3, as they are closely related. And then we'll follow that with a presentation by Osman El Menchawi of Fugrow on 2.5.2, and then later I'll come back to talk about 2.5.4.

Okay, can we see the next slide, please? Thank you. All right, well the areas for overall coverage in 2.5, the areas covered in the early site permit process are the same areas that are covered in the COLA. However, the scope of coverage in the ESP is not as thorough or in depth as it would be for a COLA.

Standard 002 gives an NRC review approach, and we considered that as we planned the expiration in the studies. Regulatory Guidance, as you can see on the screen, from several of the Reg Guides, and NUREG 2115 was then implemented later in the process for the seismology work.

We used existing and published data. We tried to supplement that data with new site data, but it's a limited number of tests and we recognize in a COLA, of course, you will be doing more expiration points, more underground studies, more laboratory studies to flush out what you've learned in the ESP.

10 CFR 50 Appendix B, QA Requirements apply, and AMEC has a 10 CFR 50 Appendix program that was accepted and has been used on the project. Next slide?

MEMBER BLEY: I may not have a clear picture of the ESP versus the COLA in this area. I thought only the seismology stuff was covered at the time of the site approval, but if I understood you right, there are things that are delayed until the COLA, and is that, I'm not quite sure how that's clear.

MR. TICE: Speaking generally for all of 2.5.

MEMBER BLEY: Okay.

MR. TICE: The geology and seismologies are, for the most part, completed at the ESP, and it is expected that there would not be major changes in those for the COLA. There might be some supplemental things based on new information --

MEMBER BLEY: Okay. But just --

MR. TICE: -- and new regulatory requirements.

MEMBER BLEY: Okay. That's --

MR. TICE: It's not necessarily --

MEMBER BLEY: That's my understanding.

MR. TICE: Yes, right.

MEMBER BLEY: I misunderstood what you were saying.

MR. TICE: The geotechnical portion, which involves drilling borings and taking laboratory tests, is much less at the ESP stage than it is at the COLA stage. That's where the additional information is collected.

MEMBER BLEY: Okay.

MR. TICE: And in the case of an ESP, the technology that's planned for the site is, I believe was explained yesterday, is not identified, and a plant parameter envelope process is used.

And so much of the geotechnical portions and slope stability portions relate to what technology is applied and showing that technology then works for that particular set of site conditions, whereas in the ESP, we don't have a specific technology and we have to work with the plant parameters.

MEMBER BLEY: That's clear, yes.

MEMBER SKILLMAN: Al, may I please ask this question? Regarding your Appendix B program, when you communicate that, my first challenge is tell us about how you develop and use your models, how they're verified or validated so that we know that the product that you're using for guidance to the owner is accurate. It's about models, their verification, validation.

MR. TICE: All right. The 10 CFR 50 Appendix B as we implement it has application --

MEMBER SKILLMAN: We're just turning up the light here.

MR. TICE: I understand.

MEMBER SKILLMAN: Just kidding, Al, just kidding.

MR. TICE: Well, we'll light all this up.

MEMBER SKILLMAN: That's right, that's

right.

MR. TICE: We have a process for any computer software that is used to make calculations. We use of course now a commercial grade dedication process. We establish a plan for what are the critical characteristics of the software, how could it fail, and how would you know that it would fail. So there's a three step process for identifying the characteristics and setting out tests that you would use to test the software before you run it.

Fugrow has their own program, but in this particular project, they worked under our program. And I know that their software processes are very similar to the ones that we use. But we required Fugrow, who was doing most of the analytical modeling and seismology was being done by Fugrow where probably 90 percent of the computer programs were involved, and the models.

But we had to accept, through our program we reviewed their commercial grade dedication, and they had to complete our forms, run the test cases, and show us that the software produced outputs that it was expected to produce.

And that process is documented and

reviewed by not only the technical side, but our quality assurance personnel to then say yes, we've been through this process, we've seen the test cases, the test cases show the software produces a result it's intended to produce, and then we accept it for use on the project.

MEMBER SKILLMAN: Thank you.

MR. TICE: All right. So we're going to talk first about the geological studies, next slide, please. Geological studies are intended to characterize site conditions within a regional context. Basically, we're looking with an increasing level of focus down to the site area.

The primary focus areas in the geology or the stratigraphy. We want to understand the layers as they correlate to engineering, site engineering stratigraphy, site geology stratigraphy. We want to look at geologic structures, and we want to look at engineering geology as well to see if there are indications of potential points or zones of weakness such as a Karst topography situation with sinkholes and fissures. Next slide, please.

The scales of investigation for ESP are the same as a COLA. We start with a 200 mile radius for regional studies. We really scour the literature, we spent a lot of time talking with the local geological surveys in Delaware and New Jersey. A lot of good information from those people who have done a lot of intensive study in the coastal plain areas in which the site sits.

Also then look at regional gravity of magnetic data for indication of the structural deep crustal structures that might indicate concerns about tectonic activities.

Then we narrow the focus down to a site vicinity of 25 miles, a site area of five mile radius, and then the site itself, which is 0.6 mile radius. And then in those, as well as in the region, we do field reconnaissance and mapping. We also do aerial photography, flying over the site to look for features I'll speak to later, and imagery analysis was available to remote sensing imagery.

Data gathered during the expiration for the ESP is collected, analyzed, and turned to these geological comparisons. And we also expand to use any data that's available from the Hope Creek and Salem FSARs that might provide more information about the geological context. Next, please. Next, thank you.

This is a general view of just the regional physiography. We put the site in it in its physiographic setting. Site is the little red spot in the middle of the blue circle. It sits on the eastern edge side of the Delaware River. It's in the Atlantic Coastal Plain physiographic Provence.

The Atlantic Coastal Plain is a low lying, generally flat topography. The ground surface elevations in the area of the plant have been modified by construction of existing plants in the ground surfaces at approximate elevation plus ten.

Areas around the plant further away are closer to sea level, and the plant has mostly marshy deposits outside of the areas that have been prepared for the plant islands.

CHAIRMAN POWERS: I suppose the fact that you have marshy deposits raises the issue of this being a relatively wet site? Is my characterization correct there?

MR. TICE: The site area is relatively wet. We do have the marshy deposits, we have a shallow ground water table, and the --

CHAIRMAN POWERS: Well, it raises the question of carbonaceous material.

MR. TICE: I'm sorry?

CHAIRMAN POWERS: That raises the question about carbonaceous material in the bedrock.

MR. TICE: What type of material?

CHAIRMAN POWERS: Carbonates.

MR. TICE: Carbonates?

CHAIRMAN POWERS: Yes.

MR. TICE: Limestones? Well, sir, marshy deposits don't necessarily indicate the presence of limestone. They indicate the presence of volatile gases.

CHAIRMAN POWERS: No, it raises the question of. Okay, do you have --

MR. TICE: Okay, let me address that with the observation, and we'll mention it later, the only limestone features in the area are mapped to the extreme northwest of the site vicinity, approximately 20 miles from the site up in Pennsylvania called the Cockeysville Marble Formation, which is known to have some sinkhole activity related to it.

Review of the geologic information and the publications about that show that it does not extend past the Piedmont. It's in the Piedmont Provence that we haven't spoken of yet. It doesn't extent past it, doesn't come under the site.

There are within some of the coastal plain deposits under the site some carbonaceous submitted materials and some calcareous submitted materials. Those being marine deposits, you have some shale layers. And a few, in some of the layers you will get a small amount, if you put some acid on it, hydrochloric acid, you will get a little bit of fizz indicating that presence.

This is not the same as a limestone unit that's subject to disillusion. And there's no indication in any of the borings, both from Hope Creek Salem and from what we have done, that there are any voids or subsurface karstic type conditions in these types of materials. Does that help you?

CHAIRMAN POWERS: You went after what I was looking for here.

MR. TICE: Okay.

CHAIRMAN POWERS: I mean, we've become sensitized over the issue of sinkholes in some of our site reviews lately. And so I can look at your site and say well, it's not obvious that there are any sinkholes. But the trouble is you've got these marshy areas and you're standing on the surface, you don't know why it's marshy there.

It could be because there was a sinkhole there, got filled up with a bunch of material and it soaked up water.

MR. TICE: Good point. Okay, I have become sensitized due to work on Bellefonte and on the fringes of the Turkey Point Projects.

CHAIRMAN POWERS: Yes. Well, someday look at Levy.

MR. TICE: That's true.

CHAIRMAN POWERS: Get sensitized.

MR. TICE: All right. So the coastal plain physiographic Provence we say is kind of low lying and flat. These coastal plain deposits for course start as recent and current deposits that are still happening.

And most of the coastal plain materials is drawn from the adjacent Piedmont Provence, the green area to the left of the yellow area on the slide. Can you back up one, please? Thank you. The green area to the left of the yellow area.

Erosion and land raising in the Piedmont, materials are brought down and deposited either as river deposits, as underwater deposits in a marine environment. And the coastal plain has been subject to rise and fall of sea levels.

There are some documented evidence that this area of the sea level may have been as low as -300 elevation and might have been as high as +150 in the past. So all these ups and downs, sometimes a site is covered with marine, therefore you get your shales and your calcareous submits and sands.

Other times you get runoff and more clastic clay sediments from the uplands on the Piedmont. The coastal plain deposits continue down at the site to approximately 1,800 feet below ground surface.

And when we look at, let's just jump to the next section. I think we'll want to go ahead with that. This section is a regional geologic section drawn from the publication by Benson at the Delaware Geologic Survey.

I don't ask you to absorb the names and numbers and figures. I want you to see that the little circle shows you the orientation of the section. It begins up to the northwest of the site, proceeds generally southeasterly, and actually has a boring on the site at the red star, which is the 1,800 foot depth boring that was advanced for the Salem project very well.

And that boring did encounter material that was described as Piedmont material that underlies the coastal plain. The section then turns and proceeds a little bit more southerly.

The basic point of the section here is to show you that on these borings, there's not any significant off set seen in the layers. The layers are consistently kind of parallel, the boundaries are parallel to each other.

The general depth of the layers is towards the southeast. Of course, the layers do vary in thickness depending on their aperture. I'll point out that the orangish color there, I'll point to it on the screen here, this orangish layer right up there we will be talking about more.

And that's a general overall perspective. That is a formation called the Vincentown Formation. The Vincentown is a bearing layer upon which the Hope Creek and Salem safety related structures are supported. And it is the indicative bearing layers we'll discuss later for the planned future structures at the PSEG site.

I mentioned that the well is 1,800 feet at the site. There have been some other deep wells drilled in the coastal plain area in New Jersey. They indicate depths that allow us to project a depth to the site because none of those holes are right on the site.

The projected depth from the available data is about 1,750 feet below ground surface, which matches pretty closely to the well. And we believe based on the data that's available, there's probably about a 200 foot, plus or minus, variation in what could be the bedrock surface at the site. And that was taken into account when we do our seismic analysis.

MEMBER SKILLMAN: Al, curiosity question. How does a layer get its name? Vincentown layer, where does that come from?

MR. TICE: Well, most of the naming of the layers is from some surface geologic feature where you go to the point and there is the material. And the person, the geologist looks at that and says this has these characteristics. It's a different formation than what I saw over here a mile away.

So okay, I'm near the town of Vincentown, and this is the type section. I'm going to say this is what the Vincentown Formation looks like if you want to really see it, you go here and you look at it. Now obviously that's an outcrop.

Other formations all get their name typically from some geographic feature, whether it's a town, it may be a river. You've got the Cape Fear Formation in North Carolina named for the Cape Fear River. It may be other features, but typically geographic features are the source for the geologic names.

MEMBER SKILLMAN: And that is the location where it's characteristics are most visible?

MR. TICE: They are either most visible or considered the most typical of what that formation represents.

MEMBER SKILLMAN: Representative.

MR. TICE: Yes, representative. So you look at that, and then you drill your hole two miles away and you say oh, I'm getting this dark green material that has some calcareous submitted sand, and that's the same as it was over here. It must be the Vincentown.

MEMBER SKILLMAN: Yes, sir. Okay, thank you. Thank you very much.

MR. TICE: Sure. Okay. So I think we've caught the information I wanted to capture on that slide. So let's move to the next slide.

What I've done here is bring us into the site. We saw the regional section there. And this is a site geologic column of the formations as developed from our borings and site investigations.

Just point out here that this section covers from +10 elevation, essentially ground surface, and I put on -450 elevation, which is the top of a formation called the Potomac Formation. Now the Potomac Formation is a thick formation deposited in the early Cretaceous time period from roughly 100 million years ago to 145 million years ago.

And then the other formations that are younger were deposited on top of that. Again here, the Vincentown Formation you can see a little better how it is positioned. The layers above the Vincentown here at the site, you have some alluvial deposits from stream inflows Delaware River.

And actually on top of those you have some hydraulic fill that was placed by the Army Corps of Engineers as they dredged material from the Delaware River beginning around 1890 and continued on to near present day, creating made ground out here. And you see that as artificial and hydraulic fill on the section.

Underlying the alluvial, there's a time in which the ground was exposed and other materials were not deposited, and then the Kirkwood Formation is found. Kirkwood formation is predominantly sandy material, but it's pretty loose, and it has some not desirable characteristics. It has some plastic clay seams in it. That material is, we later will say, is not suitable for the foundations.

And then you see the word unconformity below that. And again, that means --

MEMBER BLEY: For me, I'm looking at your other picture, too.

MR. TICE: I'm sorry? Okay.

MEMBER BLEY: And I'm trying, I can't read the scale stuff under it.

MR. TICE: I don't want you to read the scale on that.

MEMBER BLEY: So how far down are we when we're getting to these things?

MR. TICE: Okay. I'll get some more details in 2.5.4. But for talking purposes today --

MEMBER BLEY: Oh, okay. You're going to get to that?

MR. TICE: Yes, sir, in 2.5.4.

MEMBER BLEY: That's fine.

MR. TICE: This is more a --

MEMBER BLEY: Happy to wait.

MR. TICE: -- tie to site geological, regional geology.

MEMBER BLEY: I'll keep quiet.

MR. TICE: And to make the point that the Vincentown Formation was exposed surface of the Vincentown exposed for a long time. It had some erosion. And then below that, it's pretty continuous sequence of deposition. So any other points I wanted to mention here?

All right, let's go to the next slide, if we may. I mentioned that we used aerial reconnaissance. We also used remote sensing data. We used both gravity and magnetic data. Gravity data was obtained from the decade of North American Geology project. And that was a national geophysical data center that supplied that data. And it's pretty widely recognized as good data.

The magnetic data that we're looking at here came from the 2002 magnetic map of North America. This was published by the North American Magnetic Anomaly Group. And again, this data was collected on about a six kilometer ridge spacing, later re-gridded to a smaller size. But because of the large grid spacings, it's difficult to interpretate its small distances in between those grids.

Purpose of magnetics is to look below the surficial materials that are non-magnetic. And most of the coastal plain deposits are non-magnetic, so you're seeing the crustal materials of the earth underneath.

And what we're trying to see with that are there features, lineaments in there that may reflect some deeper crustal features that would be of interest as to how it might relate to tectonics in the site.

Just to point out a couple of things on this feature to the white dash line to the upper left of the figure is the New York-Alabama Lineament. That's a pretty well known lineament that represents boundaries between deep crustal blocks.

Other features on the map are, you go to the farthest right corner, the East Coast Magnetic Anomaly, and that's one that's fairly visible in the curved red arc there. Again, that is considered to represent a boundary between continental crust and oceanic crust materials.

The point of looking at this here is again, our site that you can see is the red star, there's really nothing that goes right under the site in terms of big anomalies. You get a little closer view on the next slide, please.

The same information, but blown up a little bit so that we're within the 25 mile site vicinity radius. And you can see again the star where the site is. You see that there are very few items in here. The Sussex-Leonardtown Anomaly is one that shows up both on gravity and magnetics.

It's not particularly clear what that's associated with, but again it is not under the site. And so we don't see crustal features or concerns for under the site here.

The areas with the black dash lines are thought to be buried Mesozoic Age basins, 150, 160 million years old. These are showing up as magnetic lows because the materials deposited in the basins are sedimentary materials, and have essentially no magnetic characteristics. So very little magnetic field there.

These basins, again, are not under the site is the main point to draw from our magnetic and the gravity studies.

MEMBER BLEY: Can you, I don't know if it's possible to give a capture tutorial here for me. A nanotesla is pretty small.

MR. TICE: Yes, sir.

MEMBER BLEY: Magnetic field. And I'm a little interested when we could measure things like that. But then we look at, what are we actually looking at on this plot when we see these magnetic fields? Are they just an indication of iron deposits or what do they mean to us?

MR. TICE: Igneous and metamorphic rocks are formed, and at the time they're formed, the particles are oriented and a magnetic field of those particles is developed. And that's locked into the rock.

And in fact, they can do various age dating by just looking at the directions of magnetic fields and see if they've been flipped or turned in layers below --

MEMBER BLEY: So we're assuming, I mean, the stronger fields would me more --

MR. TICE: They dig more iron related types of mineralogy in the rock.

MEMBER BLEY: Okay.

MR. TICE: The lower magnetic fields would be less of those minerals or less magnetic types of materials.

MEMBER BLEY: For the seismics that we're interested in, does that translate into the hard rock sort of idea, or what is it?

MR. TICE: Well, it's not so much a density as it is what you're looking for here are the anomalies or the differences. So you're looking for areas that would have relative to areas around a lower magnetic field which might suggest that that area, the original magnetic rocks that were there were gone somehow, maybe the land subsided and it was replaced by sediment deposits which have essentially no magnetic field.

And so now all of a sudden you're seeing a low like the blue areas here --

MEMBER BLEY: So that's an indication of possible past activity?

MR. TICE: Past activity, right. Nothing, this does not ill tell us much about anything happening today.

MEMBER BLEY: Okay.

MR. TICE: What it does again is look through the surficial materials of the coastal plain which are not magnetic and look underneath at the basic original deep crustal structures to see well is there an indication?

There's a line, say this New York-Alabama Lineament line is one that's from New York to Alabama. It really represents ancient, as you may know, the continents have collided and split apart and come back together again. And these collisions, and this has formed one of those boundaries of those ancient, ancient collisions.

But those features may form, it's possible, some type of source for a tectonic feature. So it's useful to know where those are so later in looking at earthquakes, if there are a lot of earthquakes happen to be right above one of those anomalies, then you maybe have some issues or concerns.

And what we were trying to see is is there anything like that just under the site? And we do not see any such features under the site.

MEMBER BLEY: Thanks.

MR. TICE: Yes, sir. So to the next picture then. And this is a site vicinity surficial geologic map. And its only significance really is that there's not much on it in terms of features or subsurface features or tectonic features or fault lines running through this whole area.

Only significant structural features are to the extreme northwest side of, I'll call your attention to the Rosemont Shear zone. The Rosemont Shear zone is a known structure feature, but it's over 250 million years old out in the Piedmont areas. It does not come underneath the site or under the coastal plain even.

And so the point of this slide is to show you that our various surficial units mapped in the surface geology in the coastal plain. I mentioned a few names, and I'll point out in this particular case to the far left you see a few green blobs with a KP on them. That's the Potomac Formation which is the deeper formation in the coastal plain that is encountered under our site.

And so we have outcrops over to the far west where the coastal plain begins that it was initially deposited. And then it slopes down and comes under the site. We encountered it at approximately 400 or 500 feet below the top of ground. And it extends on down to that depth of 1,800 feet or so.

The other formations in our profile, the only one that is visible, and as we call it in outcrop, that is you can see it on the surface, is the Kirkwood Formation which is the tan zone. That shows up pretty well over here.

And that is at the top of the basic profile in the site. And so it does slope up and crop out over there. Again, the key to this is in looking at surface features, subsurface features, tectonic information, just nothing there under this in this region.

So we'll move onto the next slide. So I would like to summarize the geologic findings in the regional and the site stratigraphy correlate well. They correlate well with previous studies that were done at, of course in the coastal plain by other geologic surveys.

And they correlate well with existing data at the site and with the ESP data in terms of the types of formations and the thicknesses of formations.

The field and aerial reconnaissance that we conducted didn't show evidence of surface faulting or surface expression of weak zones such as we talked about the karst type topography in the site region, site vicinities.

I mentioned the only evidence was outside really our site vicinity, outside a 25 mile radius of the karst, the Cockeysville Marble. And there's no evidence of geologic hazards within the site area, no evidence of Karst topography, no evidence of surface depression areas and that sort of thing.

So that completes what I wanted to present for the site geology portion.

MEMBER SCHULTZ: Could we go back to, I didn't get a clear picture on Slide 10, the larger view. And you mentioned briefly the East Coast Magnetic Anomaly. Could you describe what that is and what it might portend. From some perspective it seems ominous to have that feature off coast.

MR. TICE: Well, it really is an indication that deep in the crust is a boundary between the continental type crust material formed by one process many millions of years ago and what's been considered the ocean crust.

When the Atlantic Ocean was formed, it had more of a crustal plate. Now I don't want to say that's a crustal plate boundary like subduction zones or that sort of thing.

MEMBER SCHULTZ: Okay.

MR. TICE: But it is a magnetic feature. And you can see it's identified by the higher magnetic content of the red dots there. And it is a feature that's recognized as, well this is kind of where old coast, old continental deposits might have stopped and more ocean deposits may have been. And these would be, again, very old.

MEMBER SCHULTZ: And how does that description differ from the lineament that you described?

MR. TICE: The New York-Alabama Lineament?

MEMBER SCHULTZ: Yes.

MR. TICE: A different sequence of continental collisions and different blocks that run together at different times in the millions of years that this process has been going on.

MEMBER SCHULTZ: So there is a similarity?

MR. TICE: Yes, there would be a similarity in those. As far as portending anything for the site, essentially it portends really nothing because it is not under the site or not even really close to the site.

MEMBER SCHULTZ: And not a subduction zone?

MR. TICE: No, sir. Not that I'm aware of.

MEMBER SCHULTZ: Thank you.

MR. TICE: Any other questions before we move on to 2.5.3? Okay. So in Section 2.5.3, you can go to the next slide, please. In Section 2.5.3 we're taking information on the geology and then we're looking for the potential for surface faulting in the site area. Of course, that would be a significant concern.

So there are a number of focus areas that are listed on the screen there. And really, we're looking for evidence of some tectonic surface deformation in the site area, something that's recent.

We want to look at earthquake histories and try to correlate that with any known capable faults, see if we can determine ages of recent deformations, if there's a relationship of structures in the site area to, you know, regional structures characterizing the sources, looking for evidence of recent quaternary deformation, and look at the potential for surface deformation at the site.

And to do that, the next slide, please. The approach is similar to other geology. We've got an extensive literature search, and much of the literature reviewed in the geology, regional geology was pertinent to the work of surface faulting.

Same with the expert interviews with the geologic surveys in the area. Looking at existing data, this would include existing data on known earthquakes in the area from earthquake catalogues.

We did field and area reconnaissance coupled with the geology where both of these were done at the same time, looking for evidences of surface features that might represent deformation or offsets or that sort of thing that could indicate a possible fault.

We of course looked at the site investigation data. And we also took aerial photography, basically black and white photography and some color aerial photography from high levels looking for changes in vegetation tones, stream lineaments and other features that might be items to look at and see if on the ground those represent some area of concern for the surface faults.

So this slide is the surface site vicinity, a 25 mile radius. And in the site vicinity, we're showing all of the features that we've identified as possible tectonic features. And there are a variety of lines on there. I'll point out a couple of features on this.

The blue lines with the circled B on them, these are what are considered to be possible basin bounding faults by Benson. And if you remember on the magnetic, we talked about some basin structures that are out there. These happen to be the fault areas that would be at the borders of those basins.

They are older than the Cretaceous. There's no surface expression of these, no offsets in the surface. The other features on here in the blue dashed lines and in the green line are hypothesized possible faults. And various researchers have studied geologic conditions and said well, we could explain that feature if there was a fault down in the ground.

Maybe there's not a surface expression here, but in the instance of Pazzaglia, who has a feature that is indicated on the map with, over at the 9 o'clock position, the light green line. This was postulated as a fault going under the Chesapeake Bay.

But all the evidence presented for it was at the formations on one side of the bay seem to be at an elevation offset from the formations on the other side of the bay.

A number of people looked at this. Pazzaglia has gone back and reevaluated, concluded this is more likely just a topographic change because of erosion or other topographic type features, not a structural feature such as a fault.

We went to the field, looked at some exposures that could be seen at the Turkey Point Lighthouse exposure, very nice exposures there. No offsets of the surface beds. So we don't believe that that hypothesized fault is really a fault.

Similarly, another trend, the river bend trend of marple, Stafford falls of marple expressions. These are again hypothesized based on looking at trends of river shapes and offsets. And there's no surface evidence that anything has come to the surface that would represent a fault. These are older than the Cenozoic Age, and would not be considered of concern because there's no indication of any activity on any of these features.

And so the other thing on this thing that's important is I believe you can see are the little circles in yellow with some numbers beside them. Those represent all of the earthquakes that have been recorded within the site vicinity. There's not very many, and they're very low magnitude.

But basically, none of these are on top of these potentially buried features that people have hypothesized to be faults. So the earthquakes are not having any spatial relationship to what might be present under the surface as a fault. Next slide, please.

CHAIRMAN POWERS: Can you go back?

MR. TICE: Yes, sir.

CHAIRMAN POWERS: I'm sitting here saying okay, why is the Delaware River there?

MR. TICE: Why is the Delaware River there?

CHAIRMAN POWERS: Yes.

MR. TICE: Well. The Delaware River and Susquehanna River start as streams that erode into Piedmont and work their way down. And as a stream does, it follows variations in rock hardness, and so it may bend and move.

But it finds a softer spot and erodes deeper and forms a channel that carries more water, more velocity of water, more erosive sediments that come in, then the erosion gets deeper.

And so this is followed some original points in there. It does make a kind of 90 degree bend as you see, a 90 degree bend is not associated, anyone has been able to find with any fault or tectonic activity.

CHAIRMAN POWERS: I mean, why is it there? I mean, what you described is an accurate description of why rivers go the way they do. And for the life of me, it seems to me that there's nothing there to cause the river to go where it goes.

MR. TICE: Well, I can't really answer that question.

CHAIRMAN POWERS: I can't either.

MR. TICE: I would be happy to send that to a couple of the other geologists and see if they have a specific answer. But basically, rivers follow the softer rock features and find their way to make a channel. And as the land rises, the river resizes.

CHAIRMAN POWERS: I mean, what you have described is something that slopes kind of in the direction of the, after it makes the hooking bend, okay. And there's something softer there that obviously is more erodible.

But there's nothing that causes it to make, for instance, that bend that I can see in anything you've described. So I'm sitting here saying why is the Delaware River there.

MR. TICE: Let me see if we can answer your question.

MR. MALLON: Isn't that why someone drew this fault line?

MR. TICE: Partly. The river bend trend you see on that figure was derived, if you back out in further aerials you can find somewhat similar places down toward the southwest where rivers do seem to make a little bit of a bend.

So it's called the river bend trend for that reason. But no one's been able to identify any structural feature associated with it.

CHAIRMAN POWERS: It's just interesting.

MR. TICE: And even if it's there, it's buried. It's a deep system that would not be a concern for the surface activities.

CHAIRMAN POWERS: This is not one of those rivers that meanders a lot.

MR. TICE: The Delaware?

CHAIRMAN POWERS: Yes.

MR. TICE: I don't think there's a lot of meandering. But I suppose it does make some turns.

CHAIRMAN POWERS: Well, I'm thinking of in the Midwest, our rivers wander a lot.

MR. TICE: Yes. Yes, sir.

CHAIRMAN POWERS: On decadal scales, and the geologic time scales. This one doesn't. Okay.

MEMBER SCHULTZ: While we're on this slide, the offset feature that maybe about 20 miles northwest up above, can you describe that? The triangle is what I'm looking at.

MR. TICE: Oh, the offset of Benson?

MEMBER SCHULTZ: Yes.

MR. TICE: Okay.

MEMBER SCHULTZ: What's the characteristics of that?

MR. TICE: Well, it was thought to be interpreted as a deep subsurface offset in some formations. And other than that interpretation, there's no other hard data to indicate that it's a fault that's present at that --

MEMBER SCHULTZ: It's not a surface offset?

MR. TICE: No, it's not a surface offset.

MEMBER SCHULTZ: Thank you.

MR. TICE: Yes, sir. All right, if there's no other questions, go back to the reconnaissance picture. On this photograph, we're showing several things.

In addition to our reconnaissance, you may see the red, the blue, and the yellow lines that all are interpretations from our reviews of aerial photography as to features that might represent a line in the ground.

And then when you look at aerial photography, you can see differences in the color or tone of the vegetation, that you can infer that there might be a feature. Nature doesn't typically do straight lines. So when you see a straight line feature, you mark it and say why is it there, just as the question was asked about the Delaware River.

The way to see those is typically not on the ground, but to get up in an airplane and fly over them. And then you mark them and go on the ground, drive around and drive over them to see if, well is there an offset at this point and do we see it again at another point along these lineaments?

So we did two ground reconnaissance which are tracked by the black series of lines on here, driving as best we could to get to these lineaments and see if there were features that represented a concern because they might represent something deeper in the ground than just surface.

Then we flew over the area with the blue tracks in a flight that went over areas spread over a couple of days, again trying to fly over these features also flying over some of the features that were on the previous slide and looking for surface evidence that you could see of offsets.

And nothing is seen. These lineaments did not show existence of offsets or indications of any subsurface anomalies.

Okay, so summarizing the 2.5.3, while there are several structures that are mapped in the site vicinity, these are structures that do not show any evidence of surface deformation.

There's no correlation of earthquakes that are known in the site with any of these site vicinity structures. Conclusion is from the surface faulting is that there is not surface faulting present in the vicinity of the site. That concludes what I wanted to present on 2.5.3.

MEMBER SKILLMAN: Now let me ask this. If there had been faulting, for instance at a different site, would that faulting be obvious from aerial?

MR. TICE: That's kind of a relative question. Sometimes yes, sometimes no. It depends on the ground vegetation cover and that sort of thing. But if it's a significant offset tens of feet, then yes, you should be able to see something from the air.

In the east, we do not have the luxury, in the west you can see lots of subdued faults because there's not much ground cover or grass cover or vegetation. But in the east, we have all the vegetation that obscures some of that view. So it would take a pretty good offset to be able to see something.

Now, one of the features that was noted on the earlier slide are some faults that were near New Castle, Delaware that were suspected. And in that case, there was no real surface evidence. The geologic survey of Delaware went out and conducted a test trenching program across to try to see if there were some offsets.

And they weren't able to identify any offsets. But there's no surface offsetting that we've been able to identify in the site here.

MEMBER SKILLMAN: Thank you.

MR. TICE: All right, well thank you for your time.

CHAIRMAN POWERS: We're going to go on to their discussion, continue their discussion?

MR. MALLON: Okay. So now we'll turn it over to Osman El Menchawi who will talk about vibratory ground motion.

MR. EL MENCHAWI: Okay. So my name is Osman Menchawi. I'm the principal geotechnical engineer and Vice President for Nuclear Services at Fugrow Consultants.

Subject matter expert on this project for 2.5.2, and I've worked on several nuclear power plants, not as much as Al. But worked on the Bloue Castle project, which is currently still in the ESP stage, on the Comanche Peak Units Suite N4, this project, and several DOE sites like Savannah River and LNL Lab.

I got my Bachelor's of Science in construction engineering and my Master's and PhD in, it's called structural engineering from UC San Diego, but it was really seismic geotechnical engineering. But the degree says structural on the wall, but I'm not a structural engineer. I'm not a structural engineer.

All right, and with that let's, okay, so the objectives for 2.5.2 are basically characterizing the earthquake hazard in the site region, seismic hazard at the site, and finally computing the ground motion response vector, the GMRS.

And because this is an ESP and the technology still hasn't been selected, so we still didn't get to the stage of developing foundation, interface response vector.

The next two slides 22 and 23 are a list of acronyms that are either in the slides or I may mention because this industry prides itself in the use of acronyms as much as we can, and even sometimes using the same acronym for different things like ultimate heat sink would also be the --

CHAIRMAN POWERS: You guys are toe line inchers compared to the military.

MR. EL MENCHAWI: We try our best.

CHAIRMAN POWERS: You got a long ways to go.

MR. EL MENCHAWI: So moving on to Slide 24. So the methodology followed in 2.5.2 pretty much follows Reg Guide 1208. And the basis for everything that was done in 2.5.2 now is the center and eastern U.S. seismic source characterization model that came out out of a SSHAC level 3 program adopted by the U.S. NRC.

And so we take that as our basis and we put the SSHAC guidelines per the reports. So we need to go back and look as we need to to define enhanced update NUREG 2115.

So first thing we look at is the earthquake catalogue is complete up to December 31st, 2008 in the catalogue. So we need to look in updated catalogue. Are there new events that happened since then that may impact seismicity.

So we look at that, we particular emphasis is placed, of course, on the site region, the 200 mile radius. But actually, we looked at the updated catalogue for the whole CEUS SSC because events further away could impact the earthquake rates or the maximum magnitude distributions.

We used CEUS SSC in its entirety, including all background sources on RLMEs. Central eastern U.S., New Madrid could be 1,100 miles away, and yet it's a large contributor at the low frequency, just because of the low seismicity and the attenuation characteristics in CEUS.

There was a small zone that was in our 200 mile radius that fell outside the CEUS study region which I'll talk about later, and we called that AHEX-E, Atlantic Highly Extended Crust East, just to incorporate that zone. It's a very low seismicity, there was only one event back in 1990. But for completeness, we added that zone.

And finally, using all that data in the updated catalogue, we evaluated the need to refine NUREG 2115 or can we use it as is?

Earthquake occurrence rates for two of the RLMEs had to be updated. Those were the New Madrid Fault System, the in-cluster branch of the model, and the Charleston Area source. And the reason we have to do that is that the earthquake occurrence rates that were in the model, those are based on a certain plant start date and the plant exposure time of 60 years.

If your plant start, because it's a Brownian Passage of Time Renewal model, if your plant start date change and you still use, you know, same exposure time or different, your equivalent Poissonian rate would have to be updated because it's a function of when do you start, and you're taking the probability of it happening in those 60 years from that start date.

So we had to update that. Calculated the mean, median, and fractal hazards using Fugrow's FRISK88 software suite. And we used at that time the EPRI 2004, 2006 ground motion prediction equations.

MEMBER BLEY: I should probably ask the staff, and I will. But when it says NRC audited FRISK88 suite, was there an SER on that? Is that something they've approved? Or did they --

MR. EL MENCHAWI: There was a report that came out --

MEMBER BLEY: I'll ask them, I'll ask them. Okay.

MR. EL MENCHAWI: Yes.

CHAIRMAN POWERS: I want to point out that we have asked one of our consultants, Bill Hinze, to look at this material. And he's posed a variety of questions. We've passed them on to the Staff to ask them to provide responses to them. You may get some fall out from that.

MR. EL MENCHAWI: That's fine.

MS. KARAS: This is Becky Karas. I'm chief of the geosciences and geotechnical engineering area. We did perform audits of the different codes that were out there in industry. And so they looked at each different vendor.

Those are described in audit reports for those audits, and then they're also described within the SERs for the different applications that utilized that software.

And I think the Staff's going to talk a little bit about the fact that we did those audits when we give our presentation.

CHAIRMAN POWERS: Very good.

MEMBER SCHULTZ: Okay, okay, good. Also, and I took from what you described about the importance of picking a starting date is just that it's you have to pick something in order to make a calculation that we can all look at and examine.

Because I don't, you know, I don't believe we have an understanding enough to pick a start date and believe that there's a difference between a start date in 2020 or 2025.

MR. EL MENCHAWI: Yes. The impacts for --

MEMBER SCHULTZ: The purpose is really so that so that discussion is focused on a particular calculation with a defined start date that corresponds to an expected time of operation.

MR. EL MENCHAWI: Exactly. Something closer to reality as opposed to NUREG-2115, I believe it was 2012.

MEMBER SCHULTZ: Okay.

MR. EL MENCHAWI: So we know we're not, we didn't build the plant yet, so we know we're not there.

MEMBER SCHULTZ: In terms of prediction of the hazard we're not implying that we have enough understanding to differentiate between one 60-year period and another.

MR. EL MENCHAWI: Exactly.

MEMBER SCHULTZ: For the record, if you will.

MR. EL MENCHAWI: Yes, thanks. Exactly.

MEMBER SCHULTZ: Thank you.

MR. EL MENCHAWI: Next slide, please. So we followed the guidance in Reg Guide 1.208 to develop the GMRS and that includes in co-creating, like I said, NUREG-2115, incorporated the information that Al will be discussing in 2.5.4 relative to the geophysics and the various site layering.

And we performed a site response analysis to generate the site-specific amplification factors and we used the Approach 3 in NUREG-6728 where we would perform what we call the soil PSHA, which is essentially the PSHA at the GMRS horizon incorporating the site-specific amplification factors and their uncertainties.

That's essentially what Approach 3 is. We're bringing the site amplification and its uncertainty into that hazard integral and from that we developed our horizontal and vertical GMRS.

So moving on to the next slide, this is the updated CEUS catalog. This incorporates the CEUS- SSC catalog and it includes the events that were post-CEUS catalog, so events from January 1, 1999, I'm sorry, 2009, until December 31, 2011.

If you move on to the next slide, please. So this actually shows that new events post that CEUS catalog and like I said we've updated the catalog for the entire CEUS-SSC study region while only really performing the de-clustering within that 200-mile region.

So really the key event there that happened within that 200-mile radius was the Mineral earthquake, which is that red one over there just inside the circle, the Mineral, Virginia earthquake. The other events were all less than magnitude four.

So, next slide. So by looking at the updated catalog for the entire CEUS study region there are two things we wanted to look at.

First off was do we need to update the, well first off are there any tectonic, any earthquake events which may indicate some, that a different zonation may be required or adding a fault or anything like that, but decreasing, we was also looking at do we need to update the maximum magnitude distributions for the various background seismic source zones?

And by looking at that, we found that all of the maximum magnitude values were either equal to or lower than the lowest moment magnitude in all of the NUREG-2115 Mmax distributions.

So based on that we concluded that we don't need to refine NUREG-2115 relative to the Mmax distribution. We can use it as is. The other thing we wanted to look at was do we need to update the regional earthquake recurrence rates?

The earthquake recurrence rates were developed using special smoothing techniques, which was based on the earthquake catalog that was developed at the time, so a new earthquake catalog may indicate that we need to update the earthquake recurrence rates, so what we did was we looked at the predicted earthquake counts for the region up to December 31, 2011, which was the date for our updated catalog.

And we looked at what the observed earthquake counts are in the regional catalog, and based on that and based on the uncertainties, this is essentially, the red line is what we're getting from the CEUS-SSC model and the black line, the black points are what was observed.

Based on that we concluded that we don't really need to refine CEUS-SSC. We can use the earthquake recurrence rates as is. Next slide, please.

MEMBER SCHULTZ: How are you deriving the error bars on the data?

MR. EL MENCHAWI: The error bars of the data are based on published uncertainties by, how do you pronounce his last name? Weichert? I'm not sure I got his name correctly, but he came up with the questions for uncertainties based on the various magnitudes and the number of observed, a number of earthquakes in the band, other the earthquakes in the band and so on.

So based on that, we came up with those error distributions. This point there is primarily because of the Mineral, Virginia earthquake which had just occurred.

MEMBER SCHULTZ: Thank you.

MEMBER SKILLMAN: Let me ask you to please go back to slides 27 and 28, particularly slide 28. If I look at the several dots on 28, and I'm just going to refer to the Northwest corner of Wyoming and the South, excuse me, the Northeast corner of Wyoming and the Southeast corner of Montana, that green dot.

That green dot shows up on both slides, 27 and 28, so my question is, is slide 28 new data from your update or does slide 27 incorporate all of the data that is on slide 28?

MR. EL MENCHAWI: Twenty-seven is all of the data.

MEMBER SKILLMAN: Through when?

MR. EL MENCHAWI: Through December 31st.

MEMBER SKILLMAN: Of?

MR. EL MENCHAWI: 2011.

MEMBER SKILLMAN: Done. Okay, thank you. Now I understand.

MR. EL MENCHAWI: Yes.

MEMBER SKILLMAN: Thank you. Now I understand the rest of your slides.

MR. EL MENCHAWI: Okay.

MEMBER SKILLMAN: Thanks.

MR. EL MENCHAWI: You're welcome. So slide 31, please. Okay, so this is now looking at the region, the 200-mile radius and we developed this prox when we were looking at the regional seismicity for updating the catalog.

And when we looked at that, the purple line is the boundary of the CEUS-SSC study region, but the 200-mile radius actually falls outside of that region.

So there's really no seismicity there, but, you know, we looked at the box and, well, lucky or unlucky, we came up, there was one event in 1990 which fell right inside that box there.

So we decided that just for completeness and to make sure that we're capturing seismicity that we actually created this zone which we call the Atlantic Highly Extended Crust East.

We created that source zone there and we made estimates on basically using, you know, uniform distribution, seismic distribution, it's only a single event there, and we compared that seismicity with seismicity at the boundaries of the AHEX zone itself in the CEUS-SSC model and we kind of used a conservative approach to come up with estimates on the earthquake occurrence rate.

And you're going to see later on that its impact, it was insignificant. It has almost no impact on the hazard at the site. This single zone was that single event there.

MEMBER BLEY: I think Dana had mentioned that our consultant had posed some questions and we'd pass them on to the staff, but one of them I guess I'd like to read to you know and he talked about the zone you picked to fill in the rectangle, essentially, and it's a very low seismic region.

He says "On the other hand you could've filled it in using the CEUS-SSC narrow seismic zone A-H-E-X," which I don't know if you know that off the top, "whose location is largely specified by the location of the East Coast magnetic anominally," which we talked about earlier.

And we kind of wonder, you know, why you didn't do that instead or if there's anything hiding in there that could be important to us?

MR. EL MENCHAWI: I mean like I said it was, if you look at the logic tree later on AHEX-E pretty much has the same, we used all of the features in AHEX in that Atlantic Highly Extended Crust Zone in the logic tree.

The only thing we didn't use was that there's spatial smoothing done there in AHEX. So to incorporate that area we would've had to rerun the spatial smoothing for that whole AHEX zone.

So we wanted to minimize adjustments to NUREG-2115 so it was cleaner to just consider this a separate zone and to come up with a uniform distribution there to be used.

Now like I said the uniform distribution that was done there was compared to what was there in AHEX.

MEMBER BLEY: Okay. And they're reasonably consistent?

MR. EL MENCHAWI: Yes, they are.

MEMBER BLEY: Okay.

MR. EL MENCHAWI: They are, and like I said the contribution from it later on when we look at the hazard curves was insignificant. All right, next slides.

Okay, and that's the logic tree. So if you look at the logic tree the crustal thickness we used it based on AHEX values in NUREG-2115. The rupture geometry, again, based on AHEX.

The only difference, the seismicity approach, we used the uniform distribution but then we came to, uniform rate, sorry, and then you came to the maximum magnitude and, again, it was based on AHEX.

So we did, yes. We were informed it was AHEX. We used AHEX for everything except when it came to just selecting that number of the rate and we used what we consider the conservative approach.

MEMBER BLEY: Okay, thanks.

MR. EL MENCHAWI: You're welcome. Okay, so taking the seismic source model like I said for CEUS-SSC in its entirety, so every single background source zone, every single RLME that's in there.

We performed a PSHA at the bedrock level basically crystalline bedrock with a share load velocity of 9200 feet per second or higher and we came up with the three UHRS, the mean and the medians as shown there are the ten to the minus four, ten to the minus five, and ten to the minus six annual frequency of exceedance.

Hold on. Then we performed our deaggregation to -- deaggregation to look at the primary contributors to the hazard and to develop our controlling earthquakes.

So at the frequency average of the five hertz and the ten hertz and this is pretty much the same at ten to the minus four, ten to the minus five, ten to the -- It's the same story more or less.

We have moderate magnitude events controlling the hazards as a mean of earthquake magnitude 5.9 at a distance of around 27 kilometers and as we can see there everything is, here you've got the distance, percent contribution to the hazard, and here you have the magnitude.

This is magnitude nine, over there is magnitude five behind those bars, nine through five. So a primary contribution is all from these moderate magnitude events around 27 kilometers.

Moving on to the next slide, and then when we looked at the low frequency contribution, so again we have three significant contribution again from those moderate earthquake events, but now we start to see New Madrid come in, so this bump there is New Madrid.

So New Madrid's contribution to the, so it pretty much really invents greater than 100 kilometers contribution to the hazard. It was about 36 percent contribution at this ten to the minus four.

MEMBER BLEY: And that's down at one hertz. You have two of these in your package here. Did you do a similar kind of look up at 20, 30 hertz, for instance?

MR. EL MENCHAWI: No. But at 20 hertz, 20 hertz would be a high frequency, so it would be those moderate events.

MEMBER BLEY: It would look pretty much like that?

MR. EL MENCHAWI: It would be like the five and ten hertz, yes.

MEMBER BLEY: That's kind of what I expected to that.

MR. EL MENCHAWI: Yes, it would be like the five or ten. Yes, so low frequency we start to get New Madrid's contribution to the hazard.

MEMBER BLEY: Interesting, yes. It's a nice slide.

MR. EL MENCHAWI: So using that information we developed the controlling earthquakes and we developed the smooth horizontal rock spectra on the PSEG side for the high frequency and the low frequency at the various annual frequencies of exceedance and we used that as our input into the site response analysis to develop our site amplification factors and their corresponding uncertainties.

So to perform our site response we need the --

MEMBER BLEY: I'm going to ask you the same kind of vague question I asked Al earlier. Can you briefly tell us a bit about what FRISK88 is doing in this deaggregation process to get us to the variant point of the little pictures here?

MR. EL MENCHAWI: Sure. So basically what it does is that the way the PHSAs run is that you have a hazard integral, so you're looking at the probability of exceedance for a certain amplitude.

So you put in a list of amplitudes and what the program is doing is that it's going through all these various scenarios of magnitude, so it's an integral where you're looking at magnitude, you're looking at distance, you're looking at the ground motion prediction equations, you are looking at epsilons, standard, basically, yes, the number of standard deviations, and MR epsilon.

You got the various GMPEs and then we have, so the magnitude you have magnitude distributions and these magnitude distributions you have, it depends on which one we're looking at, but you have like a maximum magnitude distributions, you have magnitude of occurrence.

You have magnitudes of occurrence and put all of that into your hazard integral and you come up with the probability of exceedance for each one of these scenarios that we're looking at.

So you're looking at a thousand and some scenarios and then we're going this logic tree and, this monster of a logic tree that came out of NUREG-2115 and, you know, going through all of those branches.

So in the end what you see when you look at the mean and the medians and so on that's basically the mean of all of that together. But then you want to look at the deaggregation, so what you're doing is that it's a binning process.

So you're looking at, okay, at ten to the minus four for 100 hertz or five hertz or ten hertz, what was contributing to my hazard? I had magnitude bin five to 5.5 --

MEMBER BLEY: And if all those little bitty pieces --

MR. EL MENCHAWI: Exactly. So it's basically adding that all up.

MEMBER BLEY: This is a massive model and you've got a result that you understand, but understanding where it's coming from takes a lot of digging, okay.

MR. EL MENCHAWI: Yes.

MEMBER BLEY: That's enough for me, thank you. That's helpful.

MR. EL MENCHAWI: So slide 37. Okay, so to perform our site response we need to come up with our site profile and the site profile inputs came in from 2.5.4, which Al will be talking about and based on that we had the dynamic properties, shear wave velocity model, shear modulus reduction, and damping curves.

And what we did is we performed a randomization for the uncertainties, because, okay, we have a mean shear wave velocity but we know that there's an uncertainty associated with it and the same thing with our shear modulus reduction, same thing with our damping curve, so we perform a randomization process where we develop 60 randomized profiles that essentially just randomizes the profiles on the site and that takes into account the uncertainty on shear wave velocity, shear modulus reduction, and the damping curve.

But what we have here at this block is the red line, the solid red line, that's the input, log- mean, so that's the idealized, single idealized mean profile, log-mean profile, and these red lines are the mean plus and minus sigma, one sigma, and our randomization is the black line and the light black line what we're getting for our log plus or minus a sigma.

And no profiles are eliminated from this. Only the profiles that go outside of the plus or minus two sigmas are taken out. Everything that was in plus or minus two sigmas is maintained.

So taking those controlling earthquakes at the high frequency and low frequence and the randomized profiles we perform our site response analysis using the random vibration theory, RVT methodology, and we come up with these are the median amplification factors.

This case, for example, is at the high frequency using the high frequency controlling earthquakes and this is the standard deviation of the log of the amplification factor, so these are sigma lns.

So these amplification factors along with the sigma lns are then used as, and put back into FRISK88. So we ran FRISK88 initially for the bedrock case then we rerun it at the GMRS horizon, but we add these site amplification factors and these uncertainties.

So these are then brought into the integral, that hazard integral I was talking about, these are brought in there, because the site response has its own level of uncertainty, which is represented here.

MEMBER BLEY: When you're representing the uncertainty by a standard deviation is there an, well there is, what assumption is there on what the form of the uncertainty curve is? Is it assumed normal, some other --

MR. EL MENCHAWI: It's log normal.

MEMBER BLEY: It's just in log normal.

MR. EL MENCHAWI: Yes.

MEMBER BLEY: Okay. Sigma is hard to envision for a log normal, but that's okay as long as that's what it so I understand. Go ahead.

MR. EL MENCHAWI: Next slide. So that last slide was high frequency, this is the low frequency, so it's relatively the same but just using the low frequency controlling earthquakes.

And then we have all the inputs we need to perform what we are calling the Soil PSHA, which is just a PSHA at the GMRS horizon. So, again, we're repeating that PSHA we did before, now with the site amplifications, so we come up with our mean, median, and fractile hazard curves.

Now we're integrating the site amplification factors and sigmas. We didn't choose a CAV filter, instead we used a minimum magnitude of 5.0.

MEMBER BLEY: What's the impact of doing that? I mean the CAV filters kind of, as I understand it, it's kind of covering the effect of the energy content, the duration, all of that, and you're just lopping off a 5.0, those are really different approaches and --

MR. EL MENCHAWI: Yes. The NRC when they came up with the recommendation 2.1 guidelines it was either a CAV filter would be applied, but we can only limit the use of the CAV filter up to a magnitude 5.5, so the CAV filter now is kind of used with a dash.

MEMBER BLEY: Hmm. I didn't know that, okay.

MR. EL MENCHAWI: Yes. It was an, or they said you can use a minimum magnitude of 5.0.

MEMBER BLEY: So this come straight from staff and guidance?

MR. EL MENCHAWI: Yes.

MEMBER BLEY: Okay. And that's in the Reg Guide?

MR. EL MENCHAWI: That's in Rec 2.1, Recommendation 2.1.

MEMBER BLEY: Okay. Recommendation 2.1, okay. Thank you.

MR. EL MENCHAWI: So like I said, same thing, NUREG-2115 adopted in its entirety for the full CEUS and it included that small box, AHEX-E. Then we computed the horizontal GMRS based on the guidelines in Reg Guide 1.208 and we, that's just going to show what those reg guides are, scaling the median high frequency and low frequency at the seven spectral frequencies and then finally we tabulated the soil spectral frequencies, so just following Reg Guide 1.208 pretty much verbatim.

Next slide.

Then we had computed the vertical GMRS and since there aren't any V/H scaling relations for Central and Eastern U.S., and I see Ballinger there smiling because this keeps on coming up over and over and over and over again.

There isn't anything out there, V/H scaling relations for anything outside of rock, you know, kind of a CEUS rock. So the approach that we used was that we used the Western U.S. V/H relations but we did a frequency scaling to bring it in line with Central and Eastern U.S.

And we did that choosing the two GMPEs that were out there at the time and actually the only two in Western U.S. that are still recommended at this stage.

Gulerce and Abrahamson, 2011, and Campbell and Bozorgnia, 2003, and using that we came up and we just developed a recommended V/H by binding everything we had.

So we used that to come up with a V/H scaling relation and then finally we came up, and that's the final result, our horizontal and vertical GMRSs.

CHAIRMAN POWERS: Have you taken the next step and looked at those and how they compare to what various candidate technologies will tolerate?

MR. EL MENCHAWI: We compared these to the design --

MR. TICE: I'm sorry, I didn't understand your question?

CHAIRMAN POWERS: Have you looked at what various of your candidate technologies for the nuclear power plant will tolerate?

MALE PARTICIPANT: For this GMRS?

MR. EL MENCHAWI: Yes. Have we looked at the --

MALE PARTICIPANT: Well those are --

MR. TICE: This ground motion response spectrum could be used later when a technology is selected and the technology base may be up here, so we're going to have to take that ground motion response spectrum and create a foundation interface response spectra that will then be used to analyze the plant --

CHAIRMAN POWERS: Yes, I just wondered if you looked at --

MR. TICE: We have not --

MR. MALLON: The engineered fill in there, whether it's lean concrete or some --

CHAIRMAN POWERS: I understand.

MEMBER BLEY: That's going to be at the COLA time?

MR. MALLON: Yes.

CHAIRMAN POWERS: Yes.

MR. MALLON: I'd be curious if I were you.

CHAIRMAN POWERS: It must have, well never mind.

MEMBER SCHULTZ: Yes, the question is your process may have created a very challenging expectation for the designs.

CHAIRMAN POWERS: Yes.

MEMBER SCHULTZ: And as you say you've taken an approach that is bounding of the data that you have for the vertical accelerators.

CHAIRMAN POWERS: Yes.

MR. EL MENCHAWI: Well I mean, so at this stage those were Gulerce and Abrahamson and Campbell and Bozorgnia were the only ones. The future, they're supposed to be out of the NGA-West 2 Program.

There are vertical GMPEs that came out in draft form, but nobody's, the authors themselves have said they only released those to meet schedules.

MEMBER BLEY: So they don't even stand behind it?

MR. EL MENCHAWI: They don't stand by it yet. No, they don't stand by it yet, but they're final report should be coming out in the next, hopefully, year.

CHAIRMAN POWERS: I did not follow one step in your process a little bit. When you go through and you're doing kind of a Monte Carlo on certain analysis on your spectrum up through the rock and you said "I truncate out anything beyond three sigma."

MR. EL MENCHAWI: That's for the shear wave velocity profile randomization.

CHAIRMAN POWERS: Right.

MR. EL MENCHAWI: Not in the PSHA itself.

CHAIRMAN POWERS: I wondered why you truncated out beyond the two sigma line?

MR. EL MENCHAWI: Well the reason we do that is because of the way the stochastic analysis works you end up getting these values that are unrealistic.

I mean we're doing the randomization to get realistic site profiles. Once you start getting into the three sigmas what ends up happening is that you end up getting stuff that's either way too, you know, it's essentially a different layer.

If you do a layering process and you're looking at this stratigraphy you're looking at either something that's way too stiff that --

MALE PARTICIPANT: Doesn't exist.

MR. EL MENCHAWI: -- doesn't make sense, doesn't exist, or that's way too soft that, again, doesn't exist. So the idea is to keep the randomization so that in the end you're looking at something that's realistic.

Because, unfortunately, mathematically just the way the hertz --

MEMBER BLEY: You're kind of saying you don't believe the log normal distributions you're using?

MR. EL MENCHAWI: You are using, yes.

MEMBER BLEY: You're trying to truncate it.

MR. EL MENCHAWI: You're using log normal, but you're trying to stick to reality.

CHAIRMAN POWERS: So why don't you just go ahead and truncate the log normal?

MEMBER BLEY: They are.

CHAIRMAN POWERS: But then the problem is the densities aren't right there.

MEMBER BLEY: Now they're up some, yes, and they might not be normalized very well.

CHAIRMAN POWERS: I mean they're just not normalized anymore. That's the --

MEMBER BLEY: Well they're not, but how much and that depends on how broad that distribution was.

CHAIRMAN POWERS: Well, no, I mean since he's truncating at sigma it doesn't --

MR. EL MENCHAWI: Two sigma.

MALE PARTICIPANT: Two sigma.

CHAIRMAN POWERS: But based on sigmas the formative distribution is fixed now so he's losing, what is that, it's unnormalized by roughly 10 percent.

MEMBER BLEY: Well given it's the log normal it can be really wacky.

CHAIRMAN POWERS: Yes, I mean I understand what the problem is.

The problem is that the log normal is unbounded.

MEMBER BLEY: Yes, and that's --

CHAIRMAN POWERS: Okay, and what you're arguing is is you really have some sort of a beta distribution that is finite out here, okay, but you're using log normal because that's what the code expects to get, okay.

And so now you're trying to take care of that, but you end up with an unnormalized distribution going that route.

MEMBER BLEY: But does it renormalize?

CHAIRMAN POWERS: Maybe it renormalizes.

MR. EL MENCHAWI: Weakly.

MEMBER BLEY: I don't know what the hell happened.

MR. EL MENCHAWI: So basically if you look here for example when we were looking at the log-mean plus sigma here, or minus sigma --

CHAIRMAN POWERS: Right.

MR. EL MENCHAWI: -- this is after taking out the events that were, so that's you find, you know, at the shallow depths, for example, you still have the same sigma, but it's like that's why, you know, for example, you were like slightly lower, you were underestimating it slightly at the deeper depth just because you took out those plus or minus two sigma.

CHAIRMAN POWERS: Yes, it does require some thought. I understand what you're doing, it is that the, I mean the trouble is the data around the high density part of a distribution looks like a log normal but the log normal is unbounded.

So based on that you would predict that there's one person in the world that's ten feet tall.

MR. EL MENCHAWI: Right, right.

CHAIRMAN POWERS: Because that, too, would fall in the log normal distribution.

MR. EL MENCHAWI: Yes.

CHAIRMAN POWERS: And you're saying well there just aren't ten feet tall person so I'm going to truncate it down, but you're not renormalizing the distribution.

MR. EL MENCHAWI: Yes.

CHAIRMAN POWERS: But, yes, all right, you're losing 10 percent of the density, okay, 0.91, I mean this all done in log space because --

MR. EL MENCHAWI: Exactly.

CHAIRMAN POWERS: -- our uncertainty is pretty fair here. So, thank you, I understand what you did, that's not irrational.

Okay. I think it's appropriate to go ahead and take a break and then we'll come back and listen to the staff on this same subject or --

MR. EL MENCHAWI: Go through 2.5.4 and --

MR. MALLON: We have about 12 more slides.

CHAIRMAN POWERS: Well, we can go ahead -- What?

MR. MALLON: I think about 12 more slides to finish up 2.5.

CHAIRMAN POWERS: Does the committee want to take the break here. The subcommittee wants to take a break, so we're going to take a break.

(Laughter)

(Simultaneous speaking)

CHAIRMAN POWERS: We'll come back at twenty after the hour.

MALE PARTICIPANT: Okay.

MALE PARTICIPANT: Okay, thank you.

(Whereupon, the above-entitled matter went off the record at 10:03 a.m. and resumed at 10:21 a.m.)

CHAIRMAN POWERS: We're here and we can resume.

MR. TICE: All right, okay. Again, I'm Al Tice and I want to talk about Section 2.5.4, but before I jump right into that I'd like to go back to your question about why is the Delaware River there.

CHAIRMAN POWERS: Yes.

MR. TICE: I think if I had a little bit more information that we wrote about in the SAR section, so, essentially, and on the figure we had up there you saw one bend in the Delaware River.

If you had expanded that figure out you would see another --

CHAIRMAN POWERS: Right.

MR. TICE: -- a more abrupt bend, and what's happening is the, you know, where it's coming off the Piedmont harder rocks where it's found a home, it gets to the Coastal Plain which is softer rock so now it can turn and follow more of a meandering pattern as you described and that continues down and eventually it's influenced by where the sediment is going to go.

Off the coast in the continental crust there are deep canyons, the Baltimore Canyon being one where the Delaware aims toward, that receives the sediment and so that tends to pull the river towards it as its sediment receptor.

So it's geomorphological sort of a reason as opposed to a structural geology --

CHAIRMAN POWERS: Do we have an understanding on the meandering of the Delaware River and this softer rock over the eons?

MR. TICE: I do not. Others may, there may be others, which is not something I'm familiar --

CHAIRMAN POWERS: Yes, I mean it's not one of those river alignment, most of these coast rivers don't show evidence of past meandering the way that you can for the

Mississippi or any of the Midwest rivers.

I mean there you'd fly over them you can see that it's meandered, you know, by miles and miles in historical times, I mean just from the ground.

MR. TICE: I know, but these rivers don't tend to do that.

CHAIRMAN POWERS: Well I imagine they meandered hundred million years ago.

MR. TICE: Yes, over a million year time range I imagine they meander pretty well, but not in historical times.

CHAIRMAN POWERS: Okay.

MR. TICE: Okay, we'll move onto Section 2.5.4 which is the stability of subsurface materials and foundations and here we focus on the site geology and the site geotechnical characteristics.

We look at the stratification of the layers and how that varies, engineering properties, foundation support, and we also come up with dynamic properties that would be used in Section 2.5.2 as Osman was mentioning.

This next picture shows you a perspective of a site and I wanted to point out that we explored for the ESP work two different areas. The original start of the exploration focused on both an East area and a North area.

During the course of our initial work PSEG as part of their site selection process narrowed the site down to select the North site, or the PSEG site, that we continued and collected most of the data we needed to collect on the East so we actually have more sets of data to use and, you know, obviously being consistent we can apply information, use that information.

The next slide, please. No, move forward. There we go. The exploration approach was we collected the data in these two areas that I just showed you, the North and East areas.

Now we did eight borings in each area, that's a total of 16 borings, and at those locations there might have been multiple borings at any one spot, but eight spots at each location.

Boring depths ranged from 150 to 600 feet. The 600-foot depth was at one boring on each of the two areas. We did the standard penetration test and an undisturbed sampling as best we could.

Four of those borings were drilled and used geophysical logging and what's called PS suspension logging, it's a shear wave velocity technique done down the hole.

We also installed two cross hole clusters on the North site area to look at shear wave velocity in a little bit different method. We installed 32 water level observation wells, 16 on both of the areas.

These we used to look at water tables and the hydrology folks then used those for water table fluctuations and considerations in dealing with their modeling in Section 2.4.

Evaluate for geotechnical characteristics, and we used data from all of the borings, the North and the East areas. A couple we found very consistent geologic formations, the formations that we saw at Hope Creek, the formations we see at Salem, the formations here, essentially identical in appearance and seeming in characteristics.

Next slide, please. Just to illustrate some of that consistency here's a comparison of the PSEG site stratigraphy on the left and the Hope Creek site stratigraphy on the right.

The basic coloration is a guide to see the similarities here of the different layers. Again, I'll point out that Vincentown is the kind of burnt orange formation that shows up and is going to be at an area that we talk a good bit about.

And you can see the layers are of consistent depths. A variation is from the, the slopes of the lines represent the high/low points, so there's very little variation in the tops and bottoms of these formations for the most part if we go across.

And looking at that we concluded that some of the Hope Creek geotechnical data, shear strength results and things of that nature, would be useful as a guide in some of the work we were doing now because the geologic conditions are similar.

Next slide, please. This illustrates where the borings were in the spatial distribution. The darker borings with the little filled in symbols are borings that we have drilled, you can see those.

The other borings are borings that were drilled in those areas, mostly the North area, when Hope Creek was done there were some borings up in that vicinity, as well as a couple of borings from the earlier Salem site exploration, and so we were able to look at that information again and seeing the similarity and consistency.

Next slide is going to be a cross section of A-A, which is down the geologic dip direction, which is to the Southeast, and we created that for both the North and East for visibility, I've truncated this to the Northern portion of the site which is our area of the PSEG site interest.

And several things to point out on here, first of all the gray upper layers are the artificial fill, the hydraulic fill that was placed with the Corps of Engineers, it was 50 to 60 feet thick, underlaid by the yellow layers of alluvial sands, or the original river bottom materials.

The pink layer is the Kirkwood formation, which predominately is a sandy material that does contain some clay layers.

MEMBER BLEY: Are you going to do anything with that fill that the --

MR. TICE: I am just getting ready to tell you.

MEMBER BLEY: Okay.

MR. TICE: Anticipated that one.

MEMBER BLEY: You're welcome.

MR. TICE: The gray, yellow, and pink layers all essentially are very soft or loose materials.

MEMBER BLEY: Yes.

MR. TICE: Particularly the hydraulic fill material, it's a dredge spoil. When we would put the sampler in the holes to try to take a sampler sometimes it would just fall with its own weight.

So clearly they are not suitable to support nuclear power plant structures. As in Hope Creek and Salem these materials are removed and one of the goals for removing materials is you get to something that is stable that you can work with.

Now that something that is stable could be below the level of your foundation, in which case you have to bring in some material to replace it and we'll just talk on that in just a second.

But I do want to talk about the Vincentown for a moment while we're on this slide. The burnt orange with a little bit of a brown cap on it there is the Vincentown formation.

Now Vincentown is predominately a silty sand, a dirty sand if you will. It contains some zones in which we have like cementation, that is they're very hard and dense layers.

These layers are anywhere from an inch to 12 inches in thickness. They were sporadic. In some places you would see a number of them in a boring, other borings you would not see very many, and they varied up and down throughout the formation.

Now these cemented zones act as a little bit of, almost like a little reinforcing condition, but it's not a consistent thing that we could model and put into any sort of a model, so essentially we kind of ignored the fact that there were there recognizing that in that ignorance we were taking some conservative approaches.

Now the upper part of the Vincentown, before the Kirkwood and things were deposited, the Vincentown was exposed for several millions of years and in that exposure timeframe it got eroded and so you see at the top the Vincentown surface is more irregular than the layers below the Vincentown, and that's the erosion.

And the upper portions that were exposed for long periods of time underwent some weathering from exposure, and so they have the, the darker brown is what we call the weathered Vincentown, or oxidized Vincentown is another term that is often used for it.

It's not necessarily good or bad. In some cases the weathered or oxidized Vincentown was dense, other cases it was relatively looser than the other Vincentown materials.

So as we look at this we want to determine how we want to think about our foundation, so if we look at the next slide we kind of went about it this way.

We said well, you know, we just said the soft fill, the loose sands are unsuitable and are going to have to be taken out. We need to identify a competent later for support, and the term "competent layer" kind of came out of Reg Guide 1.208, in which you are going to establish a ground motion response spectra GMRS at the top of the competent layer.

And this doesn't necessarily mean that it's the whole layer itself, it's the top of that layer, so we called it the competent layers as a term.

And we're going to excavate to this competent layer and replace the material. And we may replace it, I say we, PSEG may replace it with lean concrete, they may replace it with rolled or compacted concrete, they may replace it with a suitable structural compacted field, which is some of what was used for some of the other units there.

And they'll bring that up to wherever the bearing surface needs to be for the technology that is chosen. But our focus on testing and analysis was on materials below the competent layer because these ones above will be taken away.

We did laboratory testing, classification testing, a limited amount of strength testing, now a good bit of difficulty trying to recover testable samples from the very dense sands and the cemented sand zones.

We pushed a tube into it and come back and the end is crumpled up so we don't have our useable sample. We did take a fair number of the tubes and then tested some that were suitable for testing.

During the COLA phase it would be more laboratory testing and more boring supports done related specifically to the technology selected in its location.

We used the geophysical test results, I'm not only just looking at the shear wave velocity, but then we could take the shear wave velocity and use it to estimate the shear modulus of low strains and then we could use that shear modulus to estimate an elastic modulus for later work in our calculations.

Next slide, please. So the competent layer, what we looked at to select a spot for the competent layer --

MEMBER BLEY: Let me --

MR. TICE: Yes, sir.

MEMBER BLEY: -- extend you a question to the PSEG at this point.

MR. TICE: Okay.

MEMBER BLEY: Many sites prefer to actually have their license, get a work permit to authorize some parts of construction. I'm guessing you have to finish that part of this work, which is going to be borings and all that sort of thing to confirm you've got the right base structure before you could start any kind of construction, even service water kind of stuff, is that right?

MR. MALLON: And we would actually, outside of NRC regulated construction our critical path is construction of an access road, because we looked at our existing, we are, and I know you've been to this site, we're one of the few sites in the U.S. that has one access road in.

MEMBER BLEY: Yes.

MR. MALLON: And so when we looked at this to have, you know, 1600 employees, plus another 1000 during an outage, plus another 3000 to 4000 for construction, our access road cannot support that and the time to permit and build that access road becomes critical path for us.

So the decision to go with the COLA comes with it, start work on the road and that's actually what we would have to proceed with first.

CHAIRMAN POWERS: I came away from our first meeting with the perception that the local authorities would welcome this road.

MR. MALLON: I think they would. The Town of Elsinboro where it would land is a sleepy little town. There isn't even a shop to get milk and eggs, so there will be a little bit of the --

CHAIRMAN POWERS: Resistance.

MR. MALLON: That town might be a little uncomfortable with the traffic but I think the overall benefit to the community, they will be out tomorrow night at our draft EIS public meeting speaking on our behalf.

CHAIRMAN POWERS: Okay, good. Well that's, yes, I mean that is just the impression I came away with.

MR. MALLON: Yes. Thank you.

MR. TICE: Okay. We were talking about selecting the competent layer location and we did this based looking on all of the borings that were done. I've shown only one boring on this slide.

We looked at the pattern of our standard penetration resistance, the N-Value column that you see there, and, again, here you can see the soft materials up high, the weight of hammer material.

And then you see some localized venture area, softer materials with erratic values, and then it seems to seems to stabilize at a fairly regular trend below that green line.

We also looked at shear wave velocities. The shear wave velocities increased to on the order of 2000 feet per second as you got into the Vincentown, in this case the NB-1, it started a little higher than the green line, other borings it was a little lower.

So based on the compilation of that we selected minus 67 elevation as our competent layer, and I realize the green line is not precisely on that elevation but PowerPoint was being cranky and didn't want to move it around to the right spot.

So minus 67, we think there's probably a plus or minus four foot variation in that and this would be the key thing during any excavation activities for this, we're going down to that level, and then we inspect and we determine if there is an additional excavation or treatment needed for materials below that level.

Similar situations happened in Hope Creek where a level was selected, it was inspected, and one corner of the site had some additional excavation necessary because of a deeper zone, in this case the weathered Vincentown, so we settled on this minus 67 as our competent layer.

The next slide, please. And I want to talk now a little bit about the foundation aspect. This illustrates the concept of excavation and replacement.

It also shows the range of levels that might be for the technologies under consideration by PSEG. The shallowest technology would have a mat bearing an elevation minus 2.1, the deepest technology would bear an elevation of minus 47, and our competent layer is at roughly minus 67.

So you can see there is a fair amount of replacement material that will be put in place and the design and selection of that is going to be a part of the COLA process as to what that material would be.

All right, the next slide, please. So using that we looked at the range of the technologies for bearing capacity and calculated an ultimate bearing capacity based on the levels that they would bear.

We could assume for purposes of our analysis a granular backfill as opposed to a stiff concrete backfill just to give us more conservatism in our analysis, still place the mat foundations at either the minus 47 or the minus 2.1 and looked at the rest and distributed down into the competent layer.

So our calculated ultimate bearing capacities range as you can see, 420,000, 678,000 pounds per square foot in the static mode. The technologies under consideration only require 15,000 to 35,000, so there's a large margin of safety, if you will, against failure by bearing capacity.

For settlement, which typically for a mat foundation settlement will be the governing performance indicator. We used an elastic methodology because the soils in the competent layer below are predominately sandy.

It's not a consolidation issue with clays, it would take settlements out over a long period of time. Now we used the largest and the heaviest technology that was planned, so we had the most stress on the foundation.

And from our elastic techniques we calculated approximately 2.6 inches at the center and 1.5 inches at the edge. In comparison, Hope Creek had measurements of settlement that were made as they loaded up their mat foundation.

Their mat foundation is slightly smaller in size and considerably about half of the applied pressure that would be for these new technologies and they had settlements of about one to 1-1/2 inches, which is I think consistent with the fact we have heavier loads when we have slightly more settlement.

Now the settlements we looked at are in the acceptable range for the technologies and Hope Creek did confirm that the settlement behaved as an elastic response to settlement. There was a not a long term settlement component.

All right, next slide, please. And we also looked the potential for liquefaction to occur at the site. Liquefaction phenomena occur when an earthquake creates shear stresses in the soil to the extent that the soil particles begin to float apart, the soil particle is not supporting the shear stress, as you can see. We followed the Reg Guide 1.198 methodology. We considered the conditions below the top of the competent layer.

We evaluate first on the composition of the competent layers and because we have sands below the water table, even though there are some dense sands and cemented sands, they still fall under the possibility of liquefaction.

We looked at geologic age. Geologic age is a factor that is somewhat qualitative, but geologic age, old formations such as the Vincentown, which is, you know, in the Pleistocene and about 60 million years old or so, are not known to liquefy except in rare instances if they happen to have dune sands buried in them or salt, marshy deposits, or things of that nature, which aren't present here.

But we also then did a quantitative evaluation with the --

MEMBER BLEY: Is there enough of that kind of structure in places that have had significant earthquakes to be confident about?

MR. TICE: Yes, I believe there is. They have not reported liquefaction of these pre-Pleistocene formations.

MEMBER BLEY: I just don't know where they are that's why I'm asking that question.

(Simultaneous speaking)

MEMBER BLEY: If they had them around, we'll just call them earthquake, then maybe we don't have evidence of them not being suspect.

MR. TICE: That's a good question. It's a good question, but I don't know the nationwide of the distribution of those formations.

MEMBER BLEY: Okay. Go ahead.

MR. TICE: The reference that's in the reference documents that were put out, a paper by Youd and many other people that summarize the current state of practice for earthquakes and liquefaction evaluation has to, pulls that together from their panel of experts.

So the SPT assessment of using N-Values isn't the most quantitative-based assessment it's still an estimate in a screening concept approach and we used the simplified procedure that is a recommended procedure in 1.198.

We did initially look at liquefaction in recent conclusions and then CEUS, NUREG-2115 came along and updated the earthquake criteria, so of the new earthquakes that Osman ran through and produced a new GMRS which gives us the acceleration to use in our liquefaction estimates.

The new acceleration was slightly higher than the one that we had before. I think it went from 0.18 to 0.22. So we had to reevaluate the potential for liquefaction using the newer earthquake guidance.

And we did that. There are, actually in the subsurface there are two clay formations and clays are not susceptible to liquefaction, but everything else are generally a sandy material.

And so we looked at all of the samples we took, 257 samples in these materials, of those 32 had factors of safety that were less than 1.4, which is kind of considered, anything less than 1.4 is considered possibility that you could have potential liquefaction.

We used a lower bound magnitude scaling factors and other conservative --

MEMBER BLEY: When you look at those samples how do you come up with the factor of safety on liquefaction?

MR. TICE: You don't just look at the sample, you take the, the N-Value is a number that you calculate and you make, that number gets corrected for factors such as what is the overburden pressure at the level where you took the sample, what is the energy that was used by the drill rig to drive that sample, which we measured that in our job site.

What were the size of rods that were used, there's about ten different correction factors that you put in, and I call them corrections, but they're adjustments for differences in equipment, differences in energy, depths, and that sort of thing.

MEMBER BLEY: Okay.

MR. TICE: And so then you have an N-Value that's corrected for all of these features and then you make a calculation based on that N-Value to come up with an expected resistance to an earthquake motion.

And from the earthquake acceleration then you could calculate the expected earthquake motion and that's adjusted based on the magnitude of earthquake because the standard correlations are based on a magnitude seven.

And so we have a lower magnitude earthquake at the site, I think we use a 6.1 as the maximum magnitude.

MEMBER BLEY: How can we, if just, not having studied this, but thinking about structures and earthquakes it would seem like the duration of an earthquake of a particular size would be pretty significant to this sort of thing, is that true or not?

MR. TICE: It can be, but at this screening level stage that's not taken into account. Again, this was a simplified procedure that's intended to be a screening and say if you pass the screening you don't have to do --

MEMBER BLEY: Anything, it would be okay. Okay.

MR. TICE: If you've identified the liquefiable layer on your site then you may have to do additional lab testing where you actually can account then to input to earthquake and the history time of history and frequencies and see what the response of the sample would be.

MEMBER BLEY: Okay.

MR. EL MENCHAWI: And the duration implicitly is in there because of the magnitude of correction that Al was talking about. So what part of the reason these are the magnitudes --

MR. TICE: Implicitly, but in a soft kind of way.

MR. EL MENCHAWI: -- just to take into account. So a magnitude 7.5, which is considered the benchmark in liquefaction assessment, that's equivalent, a considered equivalent to 15 cycles. So for each one of these different magnitudes, there's an equivalent number of cycles. And that's where that MSF comes in. So it said implicitly. It's not explicit, but it's implicitly in the --

MEMBEER BLEY: But I like the fact that if it's close, then you've got to do some more tests.

MR. EL MENCHAWI: Exactly.

MEMBEER BLEY: -- to see what real time histories do instead of equivalent ones. But it might not be equivalent.

MR. TICE: Oh, yes. And so we came up with the fact that out of these 257 samples we did have 32 that had the factor-safe list of 1.4.

MEMBEER BLEY: Significantly less or just barely?

MR. TICE: Ranging anywhere from 1.1 to 1.4. I think there might have been one value that was 1.05 or something. But nothing was less than one as I recall. And it turns out that many of those values were in the Vincentown formation up near the top of the Vincentown formation.

And we did eight borings. And then these eight borings, some borings had no values that were less than 1.4. Others had some scattered values, maybe two or three back to back, others had distribution.

We're 800 to 1,000 feet apart. And these locations, nothing really matched up to say we've got a layer in here that is all, consistently always having these low values. So our conclusion here is that, yes, we had some borings that indicate potential liquefaction in the Vincentown formation.

I'm sorry, next slide please. We do have some samples in the, that indicate a potential for liquefaction, but go back to the fact that it's pre-Pleistocene in age, liquefaction is not normally expected for that.

We also found, as we looked at old borings from Hope Creek and Salem, that those borings, although we didn't look at liquefaction in those borings, those borings also illustrated a variability and a sporadic occurrence of low-end values and higher-values. And those were closer in space.

Our conclusion was that we don't have a layer out here in the Vincentown that's as susceptible to liquefaction in and of itself. And we recognize that we're going to do more closely spaced borings at the COLA and that the COLA studies are going to further evaluate liquefaction potential.

MEMBEER BLEY: Okay, that's good. The one and two seem, they're not independent sort of things.

MR. TICE: Right. And the conservative approach to the analysis by not modeling any of the cemented zones or that sort of thing, which you can't really figure out how to model with this analysis, leads us to conclude this is not an overall liquefaction situation.

It's a condition that will require further stage during the COLA. We certainly acknowledge that. And the inspection of the foundations would allow us to identify some looser areas if they exist up below the top of the competent layer, to remediate or remove those as --

MEMBEER BLEY: Say that last one again. I think that's important.

MR. TICE: The foundation excavations, as we said earlier, when we get to that level we don't shut our eyes and walk away. We go in and inspect that level. It's a required geologic mapping technique to be done of that level.

And we will identify, and we've described some techniques that can be used for that in the SAR to see if there are local weak zones, areas that need to remediated or excavated into place. So that's all part of the normal process.

MEMBEER BLEY: Okay. And we've seen some cases where there've been extensive --

MR. TICE: In some cases, yes.

MEMBEER BLEY: -- work done and be set up.

MR. TICE: And those, Items 5 and 6, are addressed, will be addressed in the COLA. I'll also, as an aside, say that in the Hope Creek records there was an extensive study of liquefaction performed using samples and laboratory tests to reach the conclusion that in the actual testing in the laboratory it did not show the potential for liquefaction.

I did not bring that information into the ESP project, simply because of its age and uncertainty about various pedigrees of data and that sort of thing. So next slide.

MEMBEER BLEY: Just a last question on that to help educate me. The cores are how big around?

MR. TICE: The standard penetration test sample is about an inch and a half in diameter --

MEMBEER BLEY: Okay.

MR. TICE: -- and about that tall as the sample. We drive the sample 18 inches and recover typically.

MEMBEER BLEY: So with an inch and a half sample, I'm wondering if the physics of liquefaction are such that testing that sample gives you solid information or the things that go on from one area to another that encourage that sort of problem.

MR. TICE: The physics of liquefaction is such that it deals at the granular level with the material. Our grain sizes here are sand sizes. And we would not be testing an inch and half sample if we went to the laboratory. There you take what's called an undisturbed or intact sample that's about three inches in diameter.

MEMBEER BLEY: Okay.

MR. TICE: And so you take that in the laboratory and run tests on that. And --

MEMBEER BLEY: And you haven't, none of that's been done?

MR. TICE: None of that's been done. That would be a COLA level study, depending on further borings and determining more screening of these --

MEMBEER BLEY: That helps me. Thank you.

MR. TICE: All right. Pardon me while I get a drink of water here.

(Pause)

MR. TICE: The last major thing that we did in the 2.5.4 was to look at the soil dynamic profile. You heard Osman mention earlier that he took information that we developed in 2.5.4.7 and used that to help inform his shear wave velocity profiles that he used for his GMRS.

So that was developed below the competent layer. We had shear wave velocities from the geophysical logging, and we used those velocities to help define layers with similar shear wave velocities and divided the site up into layers with similar shear wave velocities.

It turned out, in looking at all four of our bore holes that were geophysically logged using the PS shear wave velocity logging, really very uniform across the site. And that's not a proper term to say very uniform. They were uniform across the site with very little variation in the shear wave velocity measure.

We put together all of those, got the averages and means, standard deviations to the supply from Osman, for the shear wave velocity profile. Then we needed shear modulus degradation properties and damping variation with shear strain.

Because the shear strain changes, the shear modulus will change, and what we measure in the field with the logging techniques is called a low strain shear wave velocity. And that low strain shear wave velocity then gives you a low strain shear modulus which is the highest shear modulus you would have.

But as you strain this oil through some kind of shaking or some kind of forces from foundations, you induce shear straining in the soil. And the modulus will degrade and get lower.

And there are techniques to determine that. One technique is a resonant column/torsional shear test performed in the laboratory where we take one of these intact samples into the laboratory, combine it with various levels of confining pressure and then essentially shake it with a variable frequency technique and look at the way the shear modulus degrades the more shear strain happens.

And you come up with charts that show the degradation of shear modulus with strain, similar changes with damping. Damping actually increases with shear strain increase.

Well, we took the samples to the lab and first of all had difficulty getting samples because of the denser layers and the cemented layers in the Vincentown. And in the lab, when we ran the test, we got test results that were all over the place. They did not fit normal expected patterns, they were inconsistent.

And we concluded they were not really representative of the material out there, partly because the only sample you could test in the lab is the material between the cemented layers. And we don't know what the effect of the cemented layers would be.

So an alternate approach was taken to determine the properties of degradation and damping. We applied the computational methods that were developed by a Dr. Darendeli at the University of Texas.

And these were vetted, if you will, by extensive studies at Savannah River site under the direction of Dr. Ken Stokoe and reviewed by a peer review panel and concluded that these computational techniques were appropriate means to estimate these properties.

One other approach you could be taking was to apply curves supplied by the Electric Power Research Institute, or EPRI, to publish what they call generic degradation and damping curves that you could adopt if you had no other input.

We looked at the data from the lab, we looked at the computational techniques. And in general, they're similar shapes to the EPRI curves. But we felt that they were more appropriate to use our calculated curves at the site than the generic EPRI curves which cover a wide range of possible overburdened pressure.

But they're very similar in shape. So we created the dynamic profile for the soil and supplied that for this use. And before we move on, is there any questions about 2.5.4?

MEMBER SCHULTZ: I had one question relating to the comparison that you made in settlement. You'd made a comparison to the Hope Creek experience.

MR. TICE: Yes, sir.

MEMBER SCHULTZ: My question was, in terms of the excavation that was done for Hope Creek and the backfill that was utilized there, is that similar, sufficiently similar so that we can draw some confidence in the settlement figures that have been shown for Hope Creek as applied to this site?

MR. TICE: Yes, sir.

MEMBER SCHULTZ: This section of the site, if you will.

MR. TICE: Yes, sir. The Hope Creek excavation was approximately 55 feet below, 55 to 60 feet. It did vary a little bit.

MEMBER SCHULTZ: Which matches up with --

MR. TICE: Which is a little shallower, probably about ten feet shallower than we will be.

MEMBER SCHULTZ: But it matches to the profiles.

MR. TICE: Matches to the profile because of the procedures --

MEMBER SCHULTZ: -- of a similar structure.

MR. TICE: That's correct.

MEMBER SCHULTZ: -- that you showed.

MR. TICE: Yes, sir. It matches to the profiles, same material was exposed at the base. And the backfill was, I believe, I believe it was lean concrete was used for part of it. And there was some granular backfill used.

MEMBER SCHULTZ: So at this point you'd say that the actual was similar to what would be planned for use in this site?

MR. TICE: The actual excavation approach?

MEMBER SCHULTZ: No, the backfill I'm thinking of.

MR. TICE: The backfill.

MEMBER SCHULTZ: You described it as --

MR. TICE: Don't really know and --

MEMBER SCHULTZ: -- likely to be that, but it would be a choice of technology related.

MR. TICE: The backfill material for purposes of our settlement calculation, we actually assumed the bearing pressure from the mat will be applied directly to the top of the competent layer.

We didn't take any account of stress distribution through the backfill to reduce the amount of stress on the competent layer. So we were actually kind of conservative in doing it that way.

MEMBER SCHULTZ: Good. Thank you.

MR. TICE: All right, gentlemen. One more slide, it's Section 2.5.5 on stability of slopes. The one slide shows you that we are not calculating stability of slopes at the ESP stage.

The grading pattern for the site is not yet developed. The final grade is currently at 36.9 plus 36.9, possible it may change up or down a little bit. We don't know at this point.

The fill slopes are going to be at least three horizontal to one vertical, which is a pretty standard fill slope for the types of materials that would be expected to be used for backfill in the field.

The purpose of this slide really is to illustrate to you that, in terms of impacts on the Delaware River, the site area off to the extreme right side of the slide is far removed from the Delaware River by approximately 800 feet.

And so placing the field in the slopes here in the places that we'll be doing it for the site is too far removed from the Delaware River to create a slope stability issue on the existing Delaware River slopes. And that concludes my presentation on 2.5.5.

CHAIRMAN POWERS: Any additional questions?

(No audible response)

MR. TICE: Thank you for your time.

CHAIRMAN POWERS: Your staff is ready to --

MR. CHOWDHURY: Yes.

CHAIRMAN POWERS: -- go forward?

MR. CHOWDHURY: Yes. Yes, Dr. Powers. The staff is ready to start with 2.5.1 and 2.5.3. But before we go into that, we had a little discussion yesterday based on Dr. Schultz's inquiry about any regulatory, you know, hooks, so to speak, regarding possible new constructions or major constructions after a license is issued, essentially.

And we didn't forget that. We did a little research. And our good friends the Office of General Counsel also looked into the regulations. And Ms. Ann Hove's there, and she's going to shed some light today and hope that will help further clarify the question.

MS. HOVE: Hello. Again, my name is Ann Hove, the Office of General Counsel. So while --

CHAIRMAN POWERS: Oh, you don't get away that easy. Ground rules here are very explicit. You've got to tell us something about your background.

MS. HOVE: My background? I went to law school at the University of Florida and undergrad at the New College of Florida. And my undergraduate degree is in environmental sciences.

So while there's no generic requirement in our regulations for periodic updates or review that would, you know, I think the question had to do with whether or not something like that would capture changed conditions or hazards relating to the site.

And an ESP holder is required at the COL stage to provide any new information relating to emergency preparedness. And those requirements are found in Sections 52.79(b)(4) and 52.39(a) and (b).

Once an ESP holder applies for a COL and becomes a COL licensee, the NRC has authority to ask questions and impose or issue orders that follow-up on reasonable assurance. And that requirement is found at 50.54.

Our Appendix E in Part 50 covers any changes in population within the EPZ. And that requirement to review those changes is within a year of fuel load -- and I think also Sections 52, sorry, excuse me, Sections 50.72 and 50.73 regarding notification or reporting is also required to a COL licensee.

But for an ESP holder, there is no generic periodic updating or review requirement that would otherwise apply. Does that answer your question?

MEMBER SCHULTZ: Well, our question was really not associated with the licensing process but in the next 60 or 80 years beyond that, if there were a facility that was proposed. What regulations or what interactions would cause reviews to be reopened, if you will?

MEMBEER BLEY: Once a plant has an operating license and is operating.

MEMBER SCHULTZ: During the operational phase of the facility.

MS. HOVE: Okay. So that would be where we're dealing with a COL licensee?

MEMBER SCHULTZ: Yes.

MS. HOVE: So those sections, we've got 50.54 and 50.72, 73, and then Appendix E of Part 50 that should cover, in the context of emergency preparedness, that would cover any of those changed conditions that would affect it. Anything like that would be like --

MEMBER SCHULTZ: Is there a periodic review that we could point to that would suggest during the operational phase, during 60 years, is there, there's reviews that are done periodically that would examine hazards that have come into being?

MS. HOVE: I believe it's in the context of emergency preparedness. So with the Census I believe it's every ten years that review takes place. And that's --

MEMBER SCHULTZ: For the population?

MS. HOVE: For population. And that's in Appendix E of Part 50. Otherwise, there's no generic periodic review requirement that would otherwise apply in addition to that.

And like I said, our authority under 50.54 applies to ask questions and issue orders. One example was in response to Fukushima, we issued those orders relating to reasonable assurance. And so in that sense it would apply. But there's no other section that you can point to that mandates a, you know, every five years or something like that.

MEMBER SCHULTZ: Thank you.

MS. HOVE: Thank you.

MR. CHOWDHURY: Okay, Gerry? Thank you, Ann. So we are the starting the staff's evaluation of Chapter 2, Section 2.5. And specifically now, 2.5.1 and 2.5.3. Dr. Gerry Stirewalt will begin the presentation.

MR. STIREWALT: I have my, rest of my colleagues up here, no?

MR. CHOWDHURY: Yes.

MR. STIREWALT: Okay.

(Off microphone discussion)

MR. STIREWALT: Okay. Thank you, Prosanta.

MR. CHOWDHURY: You're welcome.

(Off microphone discussion)

MR. STIREWALT: We commonly have us all up here together. It feels really good to have them all up here.

(Laughter)

MALE PARTICIPANT: We fully understand.

(Simultaneous speaking)

MR. STIREWALT: So I would make that request if no one protests. I mean, you know, this is the team. Have them up here.

FEMALE PARTICIPANT: Part of the team, but yes, the team.

MR. STIREWALT: Thank you for that indulgence.

MR. CHOWDHURY: Okay. So we do have the entire 2.5 team here. And Gerry will start.

MR. STIREWALT: Yes, I will. Again, I'm Gerry Stirewalt, senior geologist in NRO. And I understand you'd like a little bit of background of why we believe we know what we're doing.

I have a PhD in structural geology, and I didn't really feel very bright after that, so I did two post-docs. I did one at Lamont-Doherty Observatory, it was Lamont-Doherty at that stage at Columbia, couple of years I also did another post-doc because I loved being in academia, admittedly, at the University of British Columbia. Both of those involved research and teaching.

I'm a registered professional geologist in North Carolina and Oregon, certified engineering geologist, CEG, in Oregon.

Things like pertinent training, well, we're all actually qualified as official reviewers.

We go through, I almost said a painful process, I should not have said that, but I did already, but really a lengthy process to make sure we're qualified to be able to properly technically review the various sections that we work on. So we all have that.

But other training, I have, you know, multiple short courses in everything from field geophysics to 3D geospacial modeling. And in fact, 3D geospacial modeling was a specialty that I really worked on when I was primarily working on the NMSS high-level waste site here really doing 3D modeling of structures, and water table and morthologies at Yucca Mountain, a place you might have heard of, as well as doing some contaminate transport for low-level waste sites, defining ground water flow pathways.

And, well, really in the field training for a geologist never stops. So basically the more rock we see, the better we understand. So that's sort of ongoing.

Again, technical specialties, as I alluded to, structural geology, engineering geology, focus on geologic site characterization in both national and international locations, nuclear studies, fossil fuel plants in the eastern and western U.S. and the central U.S., work in the Philippines doing some siting work there which is, by the way, an active island arc setting just like Japan. So I've had some experience in working in areas where there's recent faulting, active faulting and volcanics.

Let's see, I worked in the high-level waste disposal program in the U.S., in Canada and Sweden. And actually, in concert with a couple of USGS geologists, I wrote the screening criteria for what was a second repository east of the Mississippi. I've done, that really involved field investigations, and tuffaceous rock, Yucca Mountain, salt, Texas and Utah, and basalt in Washington. Years of experience with all that that I just went through. Gosh, I realize there's about 45 years which is, well, a short amount of time geologically, of course.

But anyway, if you sort of roll the university teaching efforts with various architectural engineering firms, independent consulting, work at the NRC, then that's where all those years come in.

I was the lead geologic reviewer on, let's see, Vogtle, Summer, Levy, Lee and PSEG, multiple other efforts where I've worked with some other fine folks on, I guess the most recent was Fermi, providing some input for that, but Bellefonte, South Texas, Blue Castle, Northanna, Shearon Harris, et cetera.

I'm also in several professional societies, and I regularly make technical presentations at their conferences just to sort of talk about what the NRC does and let them know we don't just sit here and just read papers. We actually get out in the field and do stuff. Publications include peer reviewed papers, and abstracts and company reports.

I would also like to acknowledge my, the person that I have worked with, as is shown on the first slide, Ms. Meralis Plaza-Toledo. Meralis has a bachelors and MS from, in geology of course, from University of Puerto Rico.

She's been at the NRC since 2006. And in fact, as soon as she arrived she became involved in the nuclear safety professional development program which is really, again, a rigorous training session that she went through to get where she is today. She finished that in 2008.

Prior to that, she was actually working on the student career experience program with the USGS, geological survey, in Reston, Virginia. She did that for about three years. When she was at the USGS in that particular program, she worked on EPA superfine mine sites in various parts of the U.S., did lab work related to water and sediment quality.

And she has worked on really quite a number of applications doing, I mean, excellent supportive work, let's see, Vogtle, Summer -- I've got to read these, because there's a whole litany -- Vogtle, Summer, Levy, Lee, Fermi, PSEG and Turkey Point.

And I have to mention that her exemplary work on the Turkey Point site, pardon me, where she actually was in the process of digging out additional data, and she received the NRO employee of the month for that extra effort. Really good work.

She's also been involved doing some independent studies on geoarchaelogy in Israel, and she has a publication at GSA, an abstract. She did a presentation there.

And so, the thing is that we, again, geologists don't just sit around and read papers. We go in the field and do stuff. Okay. Let me get into the more fun stuff if I may. And were you going present that slide?

MR. CHOWDHURY: No, no. This is, yes, well, I can present this slide. Thank you, Gerry.

MR. STIREWALT: Please.

MR. CHOWDHURY: This is, the staff did an extensive work in reviewing this section of the site safety analysis report. But in addition, the staff did, as I mentioned yesterday, there was this pre-applicant site visit in 2008.

And then as listed here, September 2011, there was a site audit. And then September 2013 there's seismic software audit. So these audits and site visits were done in conjunction with the review of this application and in particular Section 2.5.

MR. STIREWALT: Okay. One other point, actually, I'd like to make regarding teamwork, I mean, it isn't just sort of all the geologists get together and talk by themselves. It really is a team effort. And everybody involved, there's really cross discipline work when we do it. I mean, it really is a team effort. And I guess I just think that's worth mentioning. It's an integrated, cross discipline team effort.

Okay, well let's pounce on 2.5.1 and 2.5.3, so I can exercise my specialties and have a little fun talking with you. As the applicant has very clearly defined, we've got two sections involved, 2.5.1 is basic geologic and seismic information. 2.5.1.1. is the regional geology.

The applicant defined that by regional we mean 200 miles around the site location. And basically, we're looking at regional relationships in physiography, and geomorphology, and geologic history, and stratigraphy, and tectonic setting, and gravity, and magnetics and seismic zones that are defined by patterns of regional seismicity.

The other part of 2.5.1 is for site geology, 2.5.1.2. And basically we're looking at a finer scale. And again, the applicant defined what those were. Site vicinity is 25 miles down to site area and site location.

So we're sort of focusing down, finer scale on physiography, geomorphology, site stratigraphy, lithology, geologic history, structural geology and site engineering geology.

And then 2.5.3 certainly presents data that's related to the potential for tectonic or non-tectonic surface deformation at the site, two rather important aspects.

Well okay, let me zero you in to the site location physiographically. You saw the applicant present a more regional physiographic map. And you realize if you looked at that closely that there's actually seven different physiographic provinces within the site region.

You've got the continental rise, the coastal plain where the site's located, the Piedmont, a part of New England, a part of the Blue Ridge, a part of the Valley and Ridge and the Appalachian plateau.

But what I want to do in this slide is actually focus on the site location itself. And then consider this outline, 25 miles, is the site vicinity. And the site itself is located in the outer coastal plain sub-province of the coastal plain physiographic province, east side of the Delaware River. And you're sort of aware of that already.

But again, and you saw a more regional look that the applicant presented to you. Well, you might suspect that kind of setting that you don't have a great number of mountains at this location. This is the actual site location, the physiography of the site, relatively flat by most standards.

And what I'd like to do is to just step quickly to a stratigraphic column of the site area and site location just to sort of reiterate again part of what the applicant mentioned.

And I'll take the next slide. Let's look at this quickly. As the applicant explained, that basically Quaternary materials cap the entire site area. You saw that on the map that they presented.

Those materials, they're certainly fill and artificial fill. But the units themselves are, it's estuerine terrain. You've got marsh deposits, fluevial units, so you're looking at stuff like muck, and peat, and silt, and clay, and sand that were deposited along the margins of tidal creeks. This is the geologic setting of that physiographic province, if you wish.

I'd like to point out that we're looking at a package of rocks. Again, as the applicant mentioned, this is coastal plain stratigraphy, upper Mesozoaic, and Tertiary and Quaternary, that's about, oh, 1,800 or so feet thick in total.

And the Vincentown unit, the foundation unit which is marked here, lower Tertiary in age, that's sort of an age range of from about 20 or 30 to about 65 million. So these are old rocks and obviously buried by overburden. So they're rather consolidated, again, as the applicant indicated.

There is some range in thickness of the Vincentown. And if you'll just sort of do a quick glance at what the material type is, it's basically a silty sand, so again, sort of a dirty sand and again, you know, quite compacted.

It does range in thickness. And the upper part is weathered. And I frankly will show another section later that we showed a variation in thickness. You note there that the range in thickness is 52 plus 26. Well, in fact, at the site location it's about 90 feet thick. So it's rather thick at the site. But it's not exposed at the site. It's only in the subsurface. Okay.

MEMBEER BLEY: Before you go on --

MR. STIREWALT: Yes?

MEMBEER BLEY: Back on Slide 39, you don't have to get it, but it was a surface map that showed the Piedmont. Yes, that's it.

MR. STIREWALT: Yes.

MEMBEER BLEY: Why do we always show the water there. I mean, it's white. I mean, you know what the surface is under the water, right?

MR. STIREWALT: Well, we have --

MEMBEER BLEY: But, I mean, it's the same as on both sides here. Is that correct?

MR. STIREWALT: Well, because these units, sort of like, again, in that regional section that they showed you, this is sort of like layer-cake geology. These units are continuous. So in fact, in the subsurface that stratigraphy is continuous, absolutely, absolutely.

MEMBEER BLEY: Okay.

MR. STIREWALT: That's a good question though. It's a good point. Yes?

MEMBEER BLEY: It just seems funny that you'd paint it white. They do it too. Everybody seems to do it.

MR. STIREWALT: Well, and I want to make -- I'm sorry, did that --

MEMBEER BLEY: That's good enough.

MR. STIREWALT: -- satisfy you? Okay. What I would like to do is just mention that direct field observation is really a critical part of what the NRC does and when you're thinking about the geology part.

Well, I'm not sure you can't satisfy a field geologist with just reading somebody else's report. So I've got to get out there and get my hands on it along with Meralis and the rest of the team too. But the point is, at the September 2011 site audit that Prosanta mentioned, we were on the site examining samples from the location itself. And you can see everybody is congregated looking at these samples.

And that gave us a chance, in fact, to take an actual look at the Vincentown which again is buried. So you can't walk up to it and poke on it. But we could certainly see this is from a depth, and NB-1, that hole was actually shown by the applicant also, this is from a depth of about 92 feet. So it's a pretty darn good sand.

And it's, again, fine to medium grain silty sand. So this is really what the unit looked like at the that depth. So it's valuable for us to get a handle on it from the geologic point of view, from the geotechnical point of view and from the seismic point of view. Because this is the foundation unit that we have to deal with in all of those facets.

Okay. Let me sort of outline what the upper level conclusions were.

MEMBEER BLEY: Just to understand that structure --

MR. STIREWALT: Yes?

MEMBEER BLEY: -- if you rub your hand across that thing, does the sand come off, or is it kind of solid?

MR. STIREWALT: It is. The word we use is friable. It is not indurated hard rock. It is sandy. So, you know, you can sort of rub, and you can sort of see on this end just for the core and process itself sort of scooped out a little bit. But it's still, it's consolidated, and compacted and quite dense which is a very important point. But it's not, the word we use is indurated. It's not solid rock. But it's still good --

MEMBEER BLEY: Bound together in some way.

MR. STIREWALT: -- dense and compact material. Thank you again for that question. What I'd like to do is just outline the upper level conclusions that we sort of derived. And then I want to talk about the basis for those conclusions.

For 2.5.1, conclusions that we were able to make after reviewing the information in the SSAR and certainly again after the field visits, there's no tectonic or non-tectonic features at the site location, region, vicinity or area that have the potential for adversely affecting suitability and safety of the site. Well, that's pretty important.

And for 2.5.3, we sort of stepped down closer and get the concern about actual surface deformation. And again, in this case at this scale, no tectonic or non-tectonic surface deformation features in the site vicinity, site area or at the actual site location that could affect the suitability of the PSEG site.

Well, with that as my introduction, I'd like to do a little bit of talking about, well okay, those are nice conclusions. How did you make them?

And so what I'll do is outline just a couple of key topics of interest for 2.5.1. Then I'll step to 2.5.3. And these were facets that we probed in our RAIs. And the applicant provided good responses. And so we were able to take that, in addition to what they'd already talked about, and sort of draw our conclusions.

But what we focused on primarily for 2.5.1 were that we wanted to look at the youngest regional faults that, in fact, were hypothesized to extend into the site vicinity.

Now, our primary focus is on Quaternary which is 2.6 million years to present. And the focus is done on Quaternary because, if you have features of that age, there's a higher likelihood that they might have something that's sort of detrimental to the site.

If you think about a fault that's Paleozoic, greater than 500 million years, that's probably okay, gang. But on the younger side of things, there's just a higher level of awareness that these could possibly produce something relative to the site that might not be satisfactory.

So let me talk about two things in particular. The Fault of Pazzaglia, again, that the applicant mentioned, he hypothesized that in 1993, and he initially postulated that it was conceivably Cenozoic in age if it existed. And I'll remind you that Cenozoic is from 65.5 million to the present. So it includes that Quaternary time frame.

Well, sort of a quick summary, but again, I'm going to go over the logic. But there's no geologic or geomorphic evidence for Quarternary deformation. And there's also no spatially associated seismicity with those features. Those are important facets.

The other feature, and I'm going to locate these on a map, again, a map you've already seen, but I'm going to show you anyway. The River Bend Trend and Stafford fault of Marple, again, he initially postulated this to be Tertiary. Well, okay, now we're older than Quaternary. So I'm not going to concentrate on that as much.

And again, the point is, if it exists. There's no geologic or geomorphic evidence in the site vicinity that suggests Quaternary displacement, Quaternary deformation along this feature. And there's also, again, no seismic or associated seismicity.

This was actually proposed by Marple, because if you go further southwest along that trend where the Stafford fault actually occurs in Piedmont rock, there really is a definitive structure quite some distance away for the Stafford fault. So he just sort of projected that trend into the river bends.

Well, okay, let's take a look at the map and remind you where those things are. Geologists can't sit still for too long. You've got to pardon me. But Pazzaglia's feature is here. River Bend Trend is here.

You can certainly see where the seismicity is and I think certainly reinforces the thought that you don't really have definitive seismic events that sit along these things that locate them like you might anticipate if they're active.

Now, there's other information on this image as well that I'm going to talk about specifically for 2.5.3. These other proposed tectonic features that you have, again, that I'll discuss in more detail, you've got lineaments, you've got the Mesozoic boundary fault that the applicant mentioned. You've got some subsurface features that are on there.

Basically, there's no evidence that those, again, if they exist, are Quarternary in age. And the lineaments themselves, in fact, are most likely even non-tectonic in origin. But I'll get back to those when I talk more about 2.5.3.

Let's pounce on Pazzaglia's work just a wee bit. Okay, why did he propose this fault when there's no geomorphic evidence of it? Well again, the applicant nailed it rather well.

What he noted on opposite sides of the Chesapeake Bay, which is a distance of about nine or so miles of not exactly juxtaposed, but he was looking at the top of a particular stratigraphic unit that's within the coastal plain, the Turkey Point beds, so Pleistocene in age. And that's 2.6 to 0.01 million which means they're Quaternary.

So in fact, if they really were displaced, then we're seeing some Quaternary deformation. Anyhow, he saw an elevation difference in the top of that stratigraphic unit on opposite sides of the bay. Well, okay. That might be one way of indicating a potential structure. And he postulated the fault strictly on the basis of that elevation difference.

Well, the applicant, as they indicated, interviewed a whole litany of technical folks. And when they spoke with Pazzaglia specifically, he indicated, I almost said he did it, indicated that, well, you know, original depositional relief when you think about the sedimentary environment and the erosion that the actual relief on top of that particular unit could also be the cause of the elevation difference.

And there's no field evidence for a fault. Well, that's kind of an important point. And we wanted to investigate that in the field. And I'm going to walk you into the field in a minute and let you help me do that.

The field reconnaissance and the inspection of aerial imagery that the applicant did also revealed no indicators of faulting along this hypothesized structure. Well, okay.

Now, during that September 11, 2011 audit that the staff conducted, we were able actually to examine units along the side of the Chesapeake Bay to actually look at the unit, the top of the unit that he said was deformed, and determine whether or not there was any field evidence for faulting by actually looking at things in the field.

So let me walk you to that exposure. This, again, is west of the PSEG site location. And it's along the eastern side of the Chesapeake Bay. And if you take a look at this, and I'm going to help you, but the Turkey Point beds, and again, these are the units that he speculated, well, you know, you've got some variation in the top of this, so maybe it's faulted.

Well, if you look at the base of this, pretty continuous, sitting right atop the Pensauken which is a little bit older. And, in fact, if you think about the depositional environment of this for just a moment to show that there is some variation in relief just because of the depositional history, if you look at this coarse sand and gravel in the Pensuaken, that indicates sort of a higher velocity, a higher energy environmental deposition location.

And you note that that's actually eroded into the finer grain cross-bedded unit even though it's the same unit. So you have strong evidence that there is erosion and variation in the depositional surface itself. Even at this scale you can see that. But again, looking at this exposure, there's surely no off -- and if it offset the Turkey Point beds, then of course it would also be offsetting everything below it.

You do not see that in this exposure. So we felt that was good evidence that there's no field evidence for faulting. And this is sort of how you do it in geology. Any questions on 2.5.1 that I could happily enlarge on? No, I guess not. Okay.

All right. Let's look then at the key topics for 2.5.3. And again, these were things that we concentrated using RAIs to sort of consider them. And again, I'm going to show you that same map I've already showed you and talk about specific features.

But basically, we've got interpreted buried faults, interpreted from bore holes, from geophysical data, but again, buried, not exposed, no surface exposure.

And also one other thing, there were some areas that could have been indicative possibly of earthquake induced paleoliquefaction. Let me talk more about that and why we made those analogies.

Well, okay, the faults that are buried beneath the coastal plain include the Mesozoic basin-bounding faults of Benson. The applicant showed you where those were. This is sort of early to middle Mesozoic. So these things are more than 200 million years old.

There's also a basement offset of Benson, again, strictly from subsurface data, no surface expression, and again, I'm going to locate these on a map, and also a batch of faults that Spoljaric labeled the New Castle County fault that comprises lineaments and some inferred but pre-Cretaceous basement fault.

And again, I'm going to locate those for you on the map and talk a bit more about them, and then the possible earthquake induced paleoliquefaction features that occurred in and around the site.

Well, they are light-colored sandy looking patches with eliptical surrounded shapes that are northeast of the ESP site. And if you think about how a sand blow might actually form because of seismic shaking, you produce that kind of pattern. So we thought, well okay, we want to make sure we get our hands around this and actually question the applicant on that.

Okay, let's step back to that map one more time. And the basement and Mesozoic basin-bounding faults, these in fact are very old. They actually developed when North America and Africa were parting to open the present day Atlantic.

And these are normal faults, movement is like this, down in this direction because of extension. So you were pulling this area apart as the continents moved. So these are old. Again, this is early to middle Mesozoic. They're old things.

The basement offset of Benson is this location. And the New Castle, pardon me, the New Castle County faults comprise the lineaments that are shown in the heavy lines and also some interpreted subsurface structures in the finer dashes there.

And again, let me just point out one more time that there's no definitive spatially associated seismicity with these features. And again, that's a pretty important point.

Well, okay. Let's talk a little bit more and give you, again, more of the logic about why we think none of those features actually are going to be an issue for surface deformation.

Okay, again, the Mesozoic faults, as I mentioned, they're basin-bounding faults, none underlie the site location, again, a point that the applicant clearly made. And they're Mesozoic, early to mid. They're really old. They're more than 200 million years old.

Okay. The offset basement rock of Benson, that was that little colored triangle, they do affect rocks of Cretaceous age, but that's pre-Quaternary. So there's no indication from the geophysical world data that Quaternary deposits overlying Cretaceous materials are offset. So again, they're not an issue relative to our concern.

And the New Castle County faults of Spoljaric, again, comprising the lineaments and is inferred subsurface pre-Cretaceous, again, pre-Cretaceous, so older than Quaternary, again, there's no geologic evidence or geomorphic evidence that they represent Quaternary features.

And there's no field evidence that they're associated with surface deformation. Okay. So again, good field data to support that, even though some of it's in the subsurface.

Well, what about those little light colored patches that might well represent paleoliquefaction due to earthquake shaking in the past? Well, it turns out paleoliquefaction data have become even more important in light of the Reg Guide 2115 where you think about, perhaps you've perused some part of that report, but for Charleston in particular a whole new bit of information on Paleoseismology helped them really nail down recurrence intervals for Charleston.

So we're really tuned to concerns about anything that might represent paleoliquefaction data that, in fact, we would need to use or the applicant would need to use for qualifying and quantifying seismic events.

Well, okay, if you look at where those features are, there're multiple features. I have those same characteristics, again, sort of the light sandy looking patches. They occur in the site vicinity, and the site area and along Delaware Bay.

Well, okay. What I'm saying is that they occur over a rather a broad area including the Delmarva Peninsula that includes part of Delaware, Maryland and Virginia and in the coastal plain of New Jersey. So they're pretty broad, pretty broadly distributed which isn't commonly the case when you have things that develop due to an event along a particular structure.

And the applicant did some field reconnaissance of one of those patches and, again, found no definitive evidence that they should have been caused by earthquake induced liquefaction, that's to say a tectonic origin which would be important.

But one of the most important parts of this is that, based on the broad distribution of those features, multiple authors -- and we're in an area that was affected by glaciation, by the way, to remind you in case you've forgotten -- but multiple authors interpret those features as resulting from processes that occurred at the immediate margins of ice sheets or glaciers.

So, I mean, because they're so widely distributed and there's that coloration which we can see in the modern day, so it looks as if those features, in fact, are not, are not earthquake induced paleliquefaction features. And everybody breathes a sigh of relief there. Okay. Are there any questions on 2.5.3? Okay, well let me --

CHAIRMAN POWERS: If the --

MR. STIREWALT: Yes, sir?

CHAIRMAN POWERS: If the area has been subject to glaciation, then non-tectonic earthquakes need to be considered, don't they?

MR. STIREWALT: Well, when you get earthquakes relative to rebound, and that has happened, those are pretty small and really, I mean, they are totally overshadowed by the stuff that's tectonic, relative to magnitude.

CHAIRMAN POWERS: Well, I'm thinking like New Madrid.

MR. STIREWALT: Uh-huh.

CHAIRMAN POWERS: Tectonic?

MR. STIREWALT: New Madrid is certainly tectonic. I don't want to step on the toes on my seismologist, but yes. I mean, that's a very well defined, probably an old pre-Cambrian weakness in the crust and related to different theories. But that most certainly is tectonic.

CHAIRMAN POWERS: How about Carbondale?

MR. STIREWALT: I'm sorry?

CHAIRMAN POWERS: Carbondale?

MR. STIREWALT: That's probably tectonic as I'm recalling that location, yes.

CHAIRMAN POWERS: Do you think that's, do you think that's tectonic? It's out in the middle of nowhere?

MR. STIREWALT: Well, I'm kind of guessing. I mean, it's certainly up in the region where there's more uplift from glaciation, because it's closer to that. But I'm recalling that there are some tectonic structures up in that direction.

And my recall is that they thought they might have been related to some of the tectonic features. I would have to double check that to make sure. But that's my recall at the moment.

I could check. Yes, I mean that's, we're certainly getting up into the more stable regions seismically. But you do get those events hither and yon, well, Oklahoma for example, which is ideally in a relatively stable crust. Okay.

All right. Let me mention one more thing in regard to the permit condition. Next slide please, sir. Thank you. What the NRC has done is based on an acknowledged need in the SSAR and

Section 2.5.4 where the applicant said, hey, you know, we really know we need to do detailed geologic mapping to document the presence or absence of faults and shear zones in the actual excavation for safety related structures in those particular materials.

Well, to address that need we identified Permit Condition 1 that's identified in Section 2.5.3.5, because it really relates to surface deformation point of fact. And I know you can read as well as I, but let me go over what the wording is there.

And that permit condition says specifically that for COL or CP that references this particular ESP, that geologic mapping of excavations for safety related structures shall be performed. The geologic features discovered in those excavations shall be examined and evaluated.

And the director of the Office of New Reactors where I work, well, where we all work, or the director's designee will notify the NRC once they're ready for examination by NRC staff.

And that gives us one good final look at the actual foundation grade level material so we can make that assessment regarding, hey, looks good. There are no features in here that are tectonic or non-tectonic in nature that might produce something unsuitable about the site location. So that's our kind of our final grab at that geology. Do you have any questions on anything I've spoken about?

CHAIRMAN POWERS: What do you expect them to deliver?

MR. STIREWALT: I'm sorry?

CHAIRMAN POWERS: What do you expect them to deliver?

MR. STIREWALT: Oh, what they will deliver is they will produce the geologic maps and accompanying report that talks about the map data, talks about the units, talks about what they found or didn't find. So they will actually produce final geologic maps and a report that documents the results.

What we would do, we'd actually compare right on top of the material itself. Look at the map that they produced, oh yes, you have that accurately located. So that's what they would do. They'd produce that kind of relative pertinent information about the foundation.

CHAIRMAN POWERS: Would you expect them to drill a bunch of holes?

MR. STIREWALT: Well, they certainly will drill additional holes for the COL, yes. But remember, the bore holes aren't very big. And it really doesn't replace the concept of actually mapping that surface in detail geologically. That's where you really see stuff.

But you incorporate that thought with the subsurface information, maybe some geophysics, certainly new bore holes, so that you have an idea of from the top down, basically, of what is or is not there relative to geologic features.

CHAIRMAN POWERS: But in the end, they will drill a bunch of holes. And then they draw straight lines between them.

MR. STIREWALT: Umm --

CHAIRMAN POWERS: I mean, that's all they can do.

MS. DEVLIN: No, but they excavate down. And the surface of the bottom, like the excavation is what they'll map.

CHAIRMAN POWERS: They'll get down to the top of this Youngstown --

MR. STIREWALT: Well, they go down to top it. They go down to the top of the foundation unit. But, I mean, you're still using bore hole data for some parts of it. That's a very important thing within geology, geotech and seismology, yes. Yes?

CHAIRMAN POWERS: So in place of one very deep hole that they have here, they'll have what, a dozen?

MR. STIREWALT: I'm sorry, say again?

CHAIRMAN POWERS: How many holes do they need to drill to meet this requirement, off the top of your head?

MR. STIREWALT: Wow, Frankie? How many geotech bore holes do we need? Do you remember? I mean, there's guidance. It's some density --

MR. VEGA: But the way I see it, it's, I guess, definitely mentioned. We're talking about the excavation itself. We're mapping the excavations. The bore hole data will be used surrounding that excavation which is going to be mapped based on that permit condition.

MR. STIREWALT: Yeah, there's a certain spacing that's sort of designated in 1.208. And off the top of my head, I don't remember what it is. But there is a reasoned density. And there will be additional bore holes in the safety related excavation.

MS. KARAS: This Becky Karas. If I can just jump in, so there're two different things. This permit condition is dealing with when you excavate, because under the regulations you can excavate without that being considered construction. And you don't have to have a license.

So we place a permit condition so that we're sure that we're informed when they would excavate so that staff could come out and observe as part of inspection process.

Part of that, those mapping activities, separately from that though under the guidance when you apply for a combined license, you do have to drill additional bore holes.

And there are guidance documents that specify, based on the exact footprint of the design that you select, the spacing for those bore holes. So they're kind of two separate things. And this is the mechanism that we make sure that we're notified when they actually do that excavation, can look at those maps.

MR. STIREWALT: Are there other questions on 2.5.1, 2.5.3 or the permit condition?

(No audible response)

MR. STIREWALT: I suppose not. And I'll pass the baton to Dr. Devlin.

MS. DEVLIN: Thank you, Gerry. Committee members, I am Stephanie Devlin. I am one of two technical reviewers on the Section 2.5.2, vibratory ground motion. Dr. Dylan Seber is over on the sidelines. He and I are both the technical reviewers on this section. We're both present here today to field the questions.

Dr. Seber and I both have PhDs in geophysics from Cornell University. Dr. Seber also has 13 years of experience in academia between being a senior research associate at Cornell and also as a researcher and director at a geoinformatics lab at University of California, San Diego.

Dr. Seber has worked at the NRC as a senior geophysicist for six and a half years. And I have worked at the agency for five years. Our collective work at the agency has been to review numerous COLA and ESP applications, some of which are the Levy application, the Calvert Cliffs application, William States Lee, Comanche Peak, Turkey Point and, of course, the PSEG application.

Additionally, Dr. Seber and I have also worked on numerous existing reactor hazard reevaluations associated with the Near-Term Task Force Recommendation 2.1 Seismic. And those evaluations are ongoing at the agency.

So going to Section 2.5.2, the sections that we review are seismicity or the earthquake catalogue. Following that is the geologic and tectonic characterization of the site and region. And we look at the correlation of the earthquake activity and the seismic sources.

Following that, we have the probabilistic seismic hazard analysis, the PSHA, and controlling earthquake calculations. Next section is the seismic wave transmission or the site response section and then lastly the ground motion response factor or the GMRF section.

The key review areas for the PSEG, Section 2.5.2, originally when the application was submitted in 2010, the applicant used the EPRI SOG seismic source model which was a generally used model at the time.

In January 2012, the NUREG-2115 was published, so the CEUS SSC model came out. Following the Fukushima disaster in Japan and the Near-Term Task Force recommendations, RAIs were sent to all COLA and ESP applicants. And so an RAI was similarly sent to PSEG.

This RAI prompted significant changes in Section 2.5.2 as the applicant changed its seismic source models from the EPRI-SOG model to the newly published CEUS SSC model.

This resulted in complete reanalysis of the ESP Section 2.5.2. So many of the original RAIs that we asked became irrelevant, because they were related to the EPRI-SOG model. We additionally asked two RAIs on the implementation of the CEUS SSC model. And those RAIs are now resolved by staff.

Next slide, please. In terms of the seismicity or earthquake catalogue, the NUREG-2115 earthquake catalogue is complete through the year 2008. The applicant provided quantitative analysis of earthquakes within the 200 mile radius for the site from 2009 through 2011.

Additionally, the staff performed confirmatory analysis for the earthquake catalogue beyond that time frame. And I'll show that in the next slide.

The most recent earthquakes were located within identified active CEUS seismic regions and did not add any new information to the catalogues used by the applicant.

And then one point of note, the Mineral, Virginia, earthquake in 2011 is the most important earthquake in the updated earthquake catalogue. And that was included in the applicant's catalogue.

Next slide, please. This map just shows the staff's updated earthquake catalogue with the addition of putting also the Mineral, Virginia earthquake on the map.

So the staff's confirmatory catalogue covers the time frame from 2012 through October 15th, 2013. And all of these earthquakes are associated with known seismic sources and do not change any of our interpretations of the CEUS SSC model.

Next slide, please. As the applicant stated, they made one update to NUREG-2115 model. They added an additional seismic source. They added this model due to the fact that the boundary of the PSEG site region did not cover the 200 mile radius. Well, the model did not cover that radius.

The applicant added this new seismic source AHEX-E. The staff evaluated this source and found that the seismicity is very limited in this region, and therefore there is no significant impact on the total seismic hazard calculations due to this additional source. The staff concluded, so the PSHA inputs were consistent with Reg Guide 1.208.

One of the RAIs that were asked by the staff was based on the 2011 Mineral, Virginia, earthquake and its effect on the PSEG seismic hazard. The Mineral, Virginia, earthquake is not included in the NUREG-2115 seismic source model, and the applicant did not update the model according this event. The staff asked the applicant to address this earthquake's impact on the seismic hazard at the PSEG site.

In response and in resolution to the staff's question, the applicant conducted a sensitivity study. The applicant's sensitivity study indicated that the earthquake had little impact on the total seismic hazard at the PSEG site.

Continuing on this RAI, thank you, the applicant sensitivity study showed that the earthquake modestly increased the recurrence rates in the vicinity of the epicenter of the earthquake. The rates increased translated to 1.4 and 0.9 percent increase in the background and the total seismic hazard at the site respectively.

The NRC concluded that the effect of the Mineral, Virginia, earthquake on the total site hazard at the PSEG site is negligible and that the applicant's use of the original CEUS SSC model recurrence parameters is acceptable.

Next slide, please. The next -- yes?

CHAIRMAN POWERS: When they developed that catalogue, they assumed earthquakes are independent of each other?

MS. DEVLIN: Largely, yes. Any event, the CEUS SSC catalogue did decluster their seismic catalogue. So dependent events are removed from the catalogue, yes.

The second RAI that the staff asked of PSEG is with reference to the modification of the NUREG-2115 seismic source model. NUREG-2115 describes that any simplification of the model needs to be justified for application to any specific site.

And so the staff asked, in accordance with NUREG-2115, if the applicant did simplify the model in any way and if they could justify that.

In resolution and in response to the staff's REI, the applicant performed sensitivity calculations and compared the hazard from using a simplified point source model which the applicant chose to use for background sources in the PSHA analysis to the hazard from using a finite rupture model as described in the NUREG-2115 model. The applicant showed that the impact of this simplification is minimal on the site.

Continuing on this, the applicant's sensitivity study showed that, for select individual seismic sources, the hazard curves at ten to the minus four and ten to the minus five annual frequencies of exceedance increase by up to 15 percent due to the use of a full source rupture model.

The staff concluded that even though the individual seismic source hazard contribution may be higher by up to 15 percent, the overall percentage increases to the total seismic hazard at the site will be significantly lower.

The staff considers the differences calculated in the sensitivity study to be within the uncertainty in the overall PSHA calculation.

Next slide, please. The staff also performed independent confirmatory calculations on the applicant's PSHA calculations. So this is a modified figure from the SER. So this is modified from SER figure 2.5.2-7. What's modified on this slide is the red line that's shown here. That's the additional line here that's new.

The staff's calculations that were done when we wrote the SER as well as when it was published, we only had access to PSHA code that calculated background or distributed site sources.

We now have access to code that calculates distributed seismic sources as well as RLME sources. So we now have code that calculates all of the model from NUREG-2115.

So the red lines are not in the SER, but they're here for everyone to see. We compared our calculation of the total site hazard for PSEG compared to the applicant's total site hazard.

These independent calculations show that the seismic hazard curves are in good agreement for the annual frequencies of exceedance that are of interest which is ten to the minus four, ten to minus five and ten to the minus six. The next slide shows --

CHAIRMAN POWERS: I don't know if they're in agreement. There're factors of two difference.

MS. DEVLIN: I'm not quite, where do you see the factors of two difference?

CHAIRMAN POWERS: Well, take just an easy one, one Hertz --

MS. DEVLIN: Uh-huh.

CHAIRMAN POWERS: -- 0.001, just reading on the access there.

MS. DEVLIN: Uh-huh.

CHAIRMAN POWERS: Your curve and their curve, roughly a factor of two difference there.

MS. DEVLIN: This is for -- there are some differences. At one Hertz, we saw in the applicant's deaggregation curves that they are getting a contribution from the New Madrid source. We do not have the New Madrid source in our calculations.

We capped our calculations for the distributive seismicity sources at 500 kilometers and then the RLME sources for 1,000 kilometers. So we don't get the contribution from New

Madrid in there.

Also, the difference here we're seeing at 0.0 or 0.01G. That's up at annual frequencies of exceedance that are not of interest specifically to the PSEG site. So it's ten to the minus three.

CHAIRMAN POWERS: Well, I know --

MS. DEVLIN: So the larger differences are happening at annual frequencies of exceedance that are not specifically of interest at this site.

CHAIRMAN POWERS: Well, I guess the point is when you say good agreement, that's a fairly subjective statement. And I'm trying to understand what good agreement is. Because they're obviously not coincident which I think we would all --

MS. DEVLIN: For ten Hertz and 100 Hertz they're nearly identical at the annual frequencies of exceedance of interest. In addition, for one Hertz the applicant's curves are slightly higher than our curves. So they are slightly more conservative than our confirmatory analysis.

CHAIRMAN POWERS: That's because they used, I mean, particular --

MS. DEVLIN: It's possible that --

(Simultaneous speaking)

MS. DEVLIN: -- because they used a larger distance range, yes?

CHAIRMAN POWERS: Yeah. I mean, it's --

MS. DEVLIN: But it'd also be the implementation, how our code is developed, how our code is written, so that there are some implementation details that can differ from code to code.

CHAIRMAN POWERS: So we have a strong user's effect on these code calculations?

MS. DEVLIN: I wouldn't say a strong user's effect, no. There can be effects due to how the code is written and how it is implemented, yes. I don't think that, at this site with the two codes that we're using, it's particularly strong.

CHAIRMAN POWERS: Well, it does seem to be more pronounced at the lower frequencies which you would expect the New Madrid, I mean, the different --

MS. DEVLIN: That's where the applicant is seeing their contribution.

CHAIRMAN POWERS: The more different the source, it's going to affect the lower frequencies more.

MS. DEVLIN: Correct.

MEMBER SCHULTZ: When the seismic software audit was performed --

MS. DEVLIN: Yes?

MEMBER SCHULTZ: -- how was that done? You're now talking about, well, there are two codes. There's your code and there's the code that the applicant has used. Are these results what you're describing as part of the audit? Or did the audit identify specific differences or similarities between the two codes?

MS. DEVLIN: These are different results from the audit, the software audit. But my colleague, Dylan Seber, was the staff member that performed the software audit. So he can speak to exactly what was reviewed at the audit.

CHAIRMAN POWERS: Are we going to get to that later, or --

MS. DEVLIN: It was before we reviewed these calculations.

MR. SEBER: But just to say we've increased things, at the time we did the audits, we did not have our code. It was just implying that we would have it at some point.

But the audits basically focused on primarily the implementation of the NUREG-2115. There was a brand new model. And we did not know how it was going to be incorporated. And we wanted to be in a sense ahead of the curve.

And an audit, not really for primary consultants who work on that area, and we audited everyone of them individually, separately. And the audit topics went into checking the numbers, all the numbers, the new model numbers, implemented correctly to very simple things. How do you conduct distance calculations.

We know that actually almost everybody has it differently, I mean, just two points in a sphere or in other words. And we know, so NUREG-2115 had seven test sites and sample outputs. And we wanted to make sure everybody could reproduce those using their own implementation of the models and the audit reports written based that, on some of these comparisons.

MEMBER SCHULTZ: And so the speculation here for the lower frequency is that it could be attributed to the inclusion of the New Madrid --

MS. DEVLIN: It could be.

MEMBER SCHULTZ: -- and data. But you don't know? I mean, it --

MR. SEBER: I actually would say strongly that, yes, it was the only difference. I mean, like Stephanie said, there will always be mismatches. And this is the nature of this game. Everybody has, excuse me, different implementations of, like I mentioned just before, how the distances are calculated, I think. And ultimately you never expect identical results. But you want it to be within the ballpark. And these curves we believe that are within the ballpark.

MEMBER SCHULTZ: Is it difficult to include that in your calculation --

MR. SEBER: No, we could have done that.

MEMBER SCHULTZ: To see if --

MR. SEBER: It is not --

MEMBER SCHULTZ: -- for the difference?

MR. SEBER: It is just one parameter change in the code. We could do that. It is not a traditional thing that we do usually. We stopped at 1,000 to give the credit to PSEG.

MEMBER SCHULTZ: At that distance?

MR. SEBER: I think that it could have been further conservative and they would have the farther distances.

MEMBER SCHULTZ: Okay, thank you.

MS. DEVLIN: Next the staff performed confirmatory analysis on the applicant's site response amplification function. The staff also has independent computer software to calculate the site response functions. The staff conducted the confirmatory analysis using the same input parameters as the applicant but also conducted alternative calculations to investigate potential impact of parameter uncertainty in the calculations. And again, you can see that the PSEG and the NRC confirmatory calculations are generally in good agreement.

CHAIRMAN POWERS: Why does the staff not do like a Monte Carlo uncertainty analysis on its parameters? It would be good to see the distributions and the uncertainty brought on by the parameters.

MS. DEVLIN: Well, we tested some of the parameter uncertainty by just kind of changing some of the parameters. We don't do a statistical --

CHAIRMAN POWERS: Yeah, I'm asking you why you don't.

MS. DEVLIN: -- parameter uncertainty. The staff's calculations are not the final calculations. So we're just really confirming that the applicants have developed good analyses. And so we're confirming their analyses. So any uncertainty changes in parameters that we make, if anything significant, it would have to then be cascaded into the applicant's calculation.

CHAIRMAN POWERS: I think the applicant's calculations are specified by regulations and Reg Guides. But I'm asking if any staff, I mean, obviously you were concerned about your parameters, because you varied them. And that's fine. Why not vary them in a statistically justifiable fashion and display the range of outputs that you get as distributions that we can interrogate.

MS. DEVLIN: I guess that's a possibility of the way we could implement this. We could implement our confirmatory analysis in a different way.

CHAIRMAN POWERS: I mean, certainly in the phenomenological analysis of reactor accidents, it's very rare now to get a point calculation that in general we get uncertainty distributions for those now. And they tend to be very useful.

MS. DEVLIN: There are uncertainties taken into account in what the applicant has done as well as what we have done in the PSHA as well as in the site response. We're not showing those now. But there are uncertainties inherent in the calculations, yes.

MR. SEBER: This slide does not show it, but actually we do have the Sigma calculations just like Osman showed earlier. And since they already actually chose to use Approach 3 in site response calculation GMRS, those segments are used as an input parameter to GMRS.

But what we're showing here is what our regulatory guide requires, the mean site amplification. And that is what the mean site amplification, the mean site amplification comparison just to feel confident that applicant did not miss something or did not do some gross error in the calculations.

The little differences in things, we don't worry too much about it, because ultimately this is part of the system. We always have sigmas.

And that sigma, like I said earlier, we have the records of it. Perhaps we should have put it in and it's like we didn't, but they're incorporated in the final GMRS calculation in this Approach 3. But it is one of the approved approaches by NRC.

They have chosen to do Approach 2, so called 2A, 2B, doesn't matter. And they do not directly incorporate it. And the mean is what is required in that case. So we do it on a case-by-case.

MS. DEVLIN: In conclusion, for the Section 2.5.2, the applicant provided a thorough characterization of the seismic sources surrounding the site as required by 10 CFR 100.23.

The applicant adequately addressed the uncertainties inherent in the characterization of the seismic sources through the PSHA and as PSHA follows the guidance required in

Reg Guide 1.208.

The applicant's GMRS adequately represents the regional and local seismic hazards and accurately includes the effects of the local site subsurface properties. Are there any further questions on Section 2.5.2?

MEMBER SCHULTZ: Yeah. I just want to, I would just like to go back one step. And that was, again, because you stated that the applicant, in comparing your results with the applicant's results, again at low frequency, just so I clearly understand, that you mentioned that the applicant had included the New Madrid information. And that was a conservative assumption. Is that not an expectation in the analysis that that be included in their evaluation of the hazard?

MS. DEVLIN: It's not an expectation that every site in the central and eastern U.S. included New Madrid. It's an expectation that every site that we review in the CEUS include every seismic source within the 200 mile radius and then also those outside that affect the seismic hazard significantly.

So typically for our calculations, we consider 1,000 kilometers to be almost beyond what most sources would contribute to any given site. So for this particular site with the low ground motion that they had at the site, New Madrid was found to contribute a small part at low frequencies.

MEMBER SCHULTZ: Uh-huh.

MS. DEVLIN: So it's based on a site-by-site basis.

MEMBER SCHULTZ: I'm just remembering back 20 years ago. And the information that all the sites on the East Coast had was specifically and dominantly the New Madrid hazard. And that was applied to all sites. So this appears to be a change in --

MS. DEVLIN: Well, generally it depends on where it's located. The closer that a site would be to, say Charleston, the less that New Madrid would matter in the site hazard, as well as the further north that you go.

You would get larger contributions from, say, Charlevoix and other seismic sources. And so you don't, not every site will have New Madrid that actually contributes significantly to the seismic hazard.

MR. GRAIZER: Ah. And this is more just also working for the same group, but not for this application. And I would like to kind of try of --

MR. CHOWDHURY: Please introduce yourself. Please introduce yourself.

MR. GRAIZER: Oh, Vladimir Graizer, seismologist, NRO. Okay. The question that you asked about 1,000 kilometers and New Madrid, the problem is that basically, if you take all this software, it is not applicable beyond 1,000 kilometers.

You can do it, but all our own software, all our technique is developed up to probably 750 kilometers. And we extrapolated up to 1,000. This is why extrapolated beyond 1,000 kilometers, kind of how to say, doesn't make much sense from a technical point of view. You can do this, but it doesn't make much sense scientifically.

Because all the attenuation curves which have embedded in this software, they are developed after 500 of 750 kilometers. You extrapolate them up to 1,000.

If you go beyond, you know, that it's kind of, you also get all these errors which exist in these calculations also contribute to the results. This is why when you go beyond 1,000 kilometers, you don't necessarily see the effect of New Madrid in this case. You may see the effect of accumulation of errors due to something else. This is why kind of there is a reason to never go beyond 1,000 kilometers. That's kind of --

MEMBER SCHULTZ: I appreciate the clarification. Thank you.

CHAIRMAN POWERS: Okay, Frankie.

MR. VEGA: Okay. Good afternoon. My name is Frankie Vega. And I was one of the technical reviewers for Section 2.4 and 2.5. My colleague sitting in the back, Luisette Candelario, was also involved in the technical review of these sections.

I've been working at the NRC for the past eight years, six of those have been a technical reviewer working in the Division of Site and Environmental Analysis.

I possess a bachelors degree in civil engineering from the University of Puerto Rico and a masters in geotechnical engineering from the University of Mehran. I'm also a registered professional engineer in Puerto Rico.

During my years here in the NRC, I've supported five COL reviews in the areas of geotechnical engineering and presented STPs, SERs, Sections 2.4 and 2.5 to the ACRS earlier this year.

Luisette Candelario has been a technical reviewer working in the DSEA, Division of Site and Environmental Analysis, for the past five years. She has also worked as an engineer in the Office of Nuclear Regulatory Research.

She possesses a bachelors degree in civil engineering from the University of Puerto Rico and a masters degree in geotechnical engineering from the University of Merhan. She has supported five COL reviews in the areas of geotechnical engineering.

And the next slide. These slides present a summary of PSEG SSAR as well as the key technical areas reviewed by the staff. SSAR Section 2.4 presents the stability of subsurface materials and foundations related to the PSEG site.

The staff reviews included the engineering properties of subsurface materials. We reviewed the field and laboratory data, the assumption, the calculations that led to these properties.

We reviewed the foundation interfaces, geophysical service performed on site, the proposed excavation and backfill, ground water conditions, response to soil and rock dynamic loading, liquefaction potential for the site and the static stability which includes settlement and bearing capacity.

And the staff performed confirmatory analysis in the areas of liquefaction and bearing capacity basically to address the accuracy of the applicant's results.

Our staff evaluation, Section 2.4 again, includes 19 COL action items. These will be addressed by the COL applicant in that specific stage. It also includes one confirmatory item which basically deals with a discrepancy identified by the staff in the way the applicant defined the backfill item. This will be revised in the next SSAR revision.

And one permit condition dealing with liquefaction basically addresses the need for the soils above the Vincentown formation to be removed and replaced by competent backfill. Thanks.

All right. I will be going over these next two slides rather quickly since they've been discussed by the applicant already. This slide presents a plan view of the site exploration, includes the 16 bore holes that the applicant talked about.

Most part we could see the proposed new power block area. In addition to what we see here, a downward physical testing were performed at the site, plus the seismic velocities, PS suspension logging was also performed.

And the 32 of storm water observation wells were also performed to assess the ground water elevations at the site. And they're not pictured here in the specific figure.

Next slide, please. This slide presents stratigraphic cross-section for the site showing borings from the northwest to the southeast. Again, this slide has been discussed already.

But most importantly, we could see the Vincentown formation. This is the foundation-bearing layer. It was defined as the competent layer. It has an average thickness of around 52 feet. And I have geoweight velocities in excess of 1,000 feet per second.

And we can see it's around, it's encounter around elevation minus 67. Everything above the Vincentown formation including those end-oxidized layers, lenses will be also removed.

The staff identified COL action item 2.5.1 which addresses the need for the applicant to perform additional subsurface investigations to better characterize these islands and the actual Vincentown formation.

Next slide, yeah. The PSEG applicant decided to follow the PPE approach. Details regarding the PPE were discussed in yesterday's presentation.

In order to provide sufficient geotechnical information at the site without having a specific design, the applicant provided a surrogate design in its application. The surrogate plant approach covers a set of bounding parameters, the plant parameter envelope.

Under the PPE approach, ESP applicants do not reference any specific reactor technology. And the resultant ESP is applicable for a range of reactor designs. For this specific case, before reactor technologies that were considered include the ABWR, the AP 1000, USEPR and US-APWR.

COL action items, basically COL action items identified certain matters that shall be addressed in the FSAR by an applicant who submits a COL application that reference the ESP.

The staff identifies COL action items in order to ensure that particular items are tracked and considered during the review of a later application referencing the early site permit. Support information of most of these COL action items are consistent with commitments that were provided by the applicant in the SSAR.

The staff identified 19 COL action items that, again, will need to be addressed at the COL stage once the reactor technology is selected. These items are related to the following site characteristics, static and dynamic properties, backfill criteria, ground water, liquefaction, static stability and the design criteria.

MEMBER SCHULTZ: Frankie, you mentioned that most of them were identified in the SSAR?

MR. VEGA: Most of them were identified in the SSAR.

MEMBER SCHULTZ: Were there any particular areas that you would point to and indicate that further discussion had to be had with the applicant in order to identify something new that they had missed that needed to be examined in the COL?

MR. VEGA: If I recall correctly, some were identified as part of RAI responses.

MEMBER SCHULTZ: So you asked questions --

MR. VEGA: We asked questions, they provided the --

(Simultaneous speaking)

MEMBER SCHULTZ: And the applicant indicated that they weren't going to consider that information until the COL time when they had selected their design?

MR. VEGA: Yes.

MEMBER SCHULTZ: And so that added to the list, that was the type of thing that added to the list?

MR. VEGA: Yes, responses to the questions we asked.

MEMBER SCHULTZ: All right. Thank you.

MR. CHOWDHURY: I can also add to that, that we had internal discussions many times. When we went to the safety evaluation editing within the agency, technical editing and technical discussions between the licensing office and the technical office, we had many sessions discussing what is missing, what cannot be provided this time at the ESP which may be acceptable for the ESP stage but needed later.

We not only relied on what the applicant provided in the SAR, we actually identified several areas. And then we added those to the safety evaluation and identified those also as COL action items. Often we furnish them as needed.

MEMBER SCHULTZ: This is good, because this process we're going through here is a learning process in this particular type of application where the design has not been selected. So it's good to understand what was originally proposed as items by the applicant in the SSAR and then what you found with the RAI process and --

MR. CHOWDHURY: Yes.

MEMBER SCHULTZ: -- as items that need to be examined also in the SAR, at the COL time frame.

MR. CHOWDHURY: Yes. That's correct.

MR. VEGA: The permit condition, this is actually Permit Condition Number 2, Gerry, this was Permit Condition Number 1, which dealt with the excavation mapping.

Given that the soils above the Vincentown formation, it seemed unsuitable as a very low strength, the staff identified this permit condition, again, for the applicant to remove the soils above the Vincentown formation and replace them with competent backfill.

It's important to mention also that COL Action Items 8 and 9 addresses the need for the applicant to characterize this backfill that will be used underneath the reactor buildings, seismic Cat 1 structures.

Next slide. The ITAAC, ITAAC stands for, I'm sure you all know, but inspection test analysis and acceptance criteria. Basically, it verifies that the plant has been constructed as the sign of license.

The staff identified this specific ITAAC given that the considered reactor technologies require a minimum geoweight velocity of 1,000 feet per second for soils underneath the reactor foundation in order to ensure that the backfill complies or has a minimum shear weight velocity of 1,000 feet per second. The staff identified the need for an ITAAC in COL Action Item 2.5-8.

Next slide. Our conclusion in Section 2.5.4, the applicant adequately determined the site-specific engineering properties of the soil underlying the ESP site following state of the art methodology for field and laboratory methods in accordance with Reg Guide 1.132. That's related to site investigation for foundations and nuclear power plants.

The specific guidance that Dr. Powers was asking for regarding the specific borings, it's included in that Reg Guide. I cannot remember from the actual spacing from my top of the head, but that's something I'll follow-up with you on that.

CHAIRMAN POWERS: Okay. Luisette?

MS. CANDELARIO: My name is Luisette Candelario, and I was one of the additional geotechnical reviewers of this section. Actually, Reactor Reg Guide 1.13, Appendix D, is the one that deals with the spacing and borings to be done on the power block area.

MR. VEGA: In addition to Reg Guide 1.132, 1.138 and 1.98, subject to Permit Condition 2, the staff concludes that the applicant meets the requirements of 10 CFR, Part 52, so Part A, applicable to stability of surface materials and foundations for an early site permit.

Next slide, Section 2.5 is stability of slopes. There's not much to say about this section since the reactor is totally dependent on the reactor technology. However, we reviewed what was provided in 2.5 which provides a general description of the applicant's plan for a future slope stability analysis in the COL stage. We identified COL Action Item 520 which addresses the need for a future slope stability analysis once the reactor technology has been defined.

Next slide, our conclusions to Section 2.5, the staff evaluation of slope stability will be performed as part of its review of COL for construction permit application. Questions?

CHAIRMAN POWERS: Any questions on this material? I should say there's not a lot to say here on stability analysis. The rest of it was excellent I think. I think at this point we're going, should we break for lunch now?

MR. CHOWDHURY: I have a few concluding slides.

(Off microphone discussion)

MR. CHOWDHURY: Yeah, I'm going to recap yesterday's and today's in couple of slides. And then we can break for lunch. But I leave it up to you to decide.

CHAIRMAN POWERS: If you're just going to recap, then just go ahead and do that.

MR. CHOWDHURY: Okay.

CHAIRMAN POWERS: I will interject, by the way, that this was an outstanding presentation by the staff. And you made it very clear the amount of work that's involved in doing these things and the quality and depth to which you pursued some of this material to do confirmatory investigations.

And I myself think that that is just excellent, to show the committee what you've done very explicitly and make clear that this is not just, what'd you call it, reading papers at the desk, but getting out and getting your hands dirty, if not in the field then running the code calculations and things like that. So I really appreciate that.

MR. CHOWDHURY: Thank you.

MEMBER SCHULTZ: Exactly. I would --

MALE PARTICIPANT: Very much, yes.

MEMBER SCHULTZ: -- I would second that and say that the hands-on approach that has been exhibited by the staff in terms of the review is admirable both in terms of, as you said, the field activities not only geologically but also analytically, and the seismic analysis work.

CHAIRMAN POWERS: And so often, so often the staff's work gets hidden in, oh, we accepted this. You know, a statement on a viewgraph says we accepted this. Yeah? Or we put this condition on it.

Showing us exactly how you came about this, these conclusions, showing us the comparison between your codes, showing us comparison between maps and analysis just really helps us understand the depth to which you're going to.

And it also makes it clear on the public record that this is not any kind of a rubber stamp sort of approach. And so I very much appreciated these sets of presentations, Prosanta. I know you're responsible for --

MR. CHOWDHURY: Thank you.

CHAIRMAN POWERS: -- for this. And I give you all the credit in the world for putting together an excellent team --

MR. CHOWDHURY: Thank you.

CHAIRMAN POWERS: -- and making these presentations on this.

MR. CHOWDHURY: But I must say that it was not easy for the staff to, while dealing with me on this project --

(Laughter)

MR. CHOWDHURY: -- but clearly --

MALE PARTICIPANT: No comment.

MR. CHOWDHURY: -- I learned a lot as we moved along from 2010 through 2014. It has been a learning experience for me.

And then one of the comments I learned to make is that just because this is an early site permit application, it did not take away our attention from the details just because we know that there will be a civil application, no. It has been paid as much attention. I think sometimes more than we did. We didn't leave any stone unturned in this review.

So what I wanted to do is to, for the public record and for those who were not here yesterday, that in two days we presented Chapter 2, Sections 2.1 and 2.2 combined, then Section 2.3. And then today you presented Section 2.5, and Section 2.5 had five sections in that.

And I just want to summarize the conclusions at the end of this presentation that I promised yesterday that I would do. Is that on this slide, Number 81, some conclusions from individual sections were presented.

And we referred to Permit Conditions 1 and 2 in Section 2.1 and 2.2 combined, as we discussed yesterday. Those permit conditions are in here, part of the staff's recommendation to the

Commission to be included in the permit.

Our permit permissions are 2.3.1, 2.3.2 and 2.3.2, there are several comments here or conclusions that essentially what the applicant presented to us, and I want to emphasize also that what the staff asked the applicant to provide additional information on, including any site visits, any audits, have been, at the end of day, acceptable and met the requirements for the ESP application.

CHAIRMAN POWERS: We've had an indication from the applicant that he found the audits to be useful, because it allowed him to go into greater detail.

And I think that was an interesting observation, than rather being a pain in the ass that this is the chance that you get to show details that ordinarily wouldn't be revealed in an ordinary presentation unless somebody really ploughed into it. I found that a very significant observation but also suggests that the staff is a good visitor and didn't piss him off.

(Laughter)

MR. MALLON: I think it's also more efficient than multiple rounds of RAIs.

CHAIRMAN POWERS: Absolutely. I can --

MR. MALLON: You get through issues more quickly.

CHAIRMAN POWERS: Yeah, I think that's both the two take home lessons from this meeting in that regard is the efficiency of audits and the communication at the draft RAI stage to make sure everybody agrees on what the question is that's being posed. And those are good take home lessons.

MEMBER SCHULTZ: Prosanta, before you go off to further conclusions, I did want to remark on your first indication about how seriously the staff has taken the review of the ESP process through this effort.

And I do want to emphasize that what I've taken from this meeting, and I think what we are all taking, is that the seriousness with which the process has been taken is exemplary.

That's the only way this process will work is if both the applicant and the staff work diligently to assure, to every extent possible, that the site permit evaluation is taken very seriously and the full evaluation, to every extent possible, is done. And that's what we're seeing. That's what we're seeing.

MR. CHOWDHURY: Thank you.

MEMBER SCHULTZ: That the staff's review has been very thorough. It's caused the applicant to look further and even to try to get more done before the COL phase than perhaps you're even willing to accept.

And that's the process and attention that we would like to see in this process to make sure that it, in fact, is accomplished to its fullest. So it's good to see that it is being taken seriously and things are not being deferred to the COL phase unless it makes complete sense to do so.

MR. CHOWDHURY: Thank you. And this was in, with the atmosphere that, or the conditions, challenges that we have gone through during, you know, the Federal budget sequestration, what not, continued revelation, and also the Fukushima events that took away, rightfully, so much of our effort and attention.

MEMBER SCHULTZ: Yeah. And we were talking about that before the meeting began this morning, that that was the additional challenge, the Fukushima results that affect much of the work that we're discussing over the last day and half.

And so that's important, that's important that we have taken the experiences from that event and, in this process, applied it fully. And it almost provides an additional example of the value that one can take in this application.

MR. CHOWDHURY: And likewise this Slide 82 also shows the conclusion. You have seen and heard about these conclusions yesterday. I just wanted to capture, in a few slides for the record. And today you heard Gerry's, and Stephanie's and Frankie's conclusions on Chapter 2.5. In addition, Becky and Dylan provided, and Luisette also provided additional clarifying information to your satisfaction.

So essentially, we have only Chapter 2, Section 2.4 which is hydrology to be done. And the next interaction, I think we are closing with Quynh and do everything we can to see what's the most appropriate timing in terms of our processing and then providing the ESP to, a good ESP to ACRS which you have been able to do in the past. So with that, there are questions I can answer? No?

(No audible response)

CHAIRMAN POWERS: I don't see any here. I will ask if there's anybody on the phone line that has comments that they want to make?

(Off microphone discussion)

CHAIRMAN POWERS: Well, I hear none. Let me say universally excellent, I am quite impressed with the diligence with which this is being done. And this is a difficult and very important aspect of the early site permit.

And I'm coming away with a great deal of respect for all the people that are involved in this. And I appreciate the quality of presentations you put together for us in this area very much. I regret only that the full committee couldn't see all of this work that was done.

MR. CHOWDHURY: Thank you.

CHAIRMAN POWERS: And if none of the members have any additional comments, I'll bring this subcommittee meeting to a conclusion then. We're done, right? We've covered it.

MR. LEWIS: Can you hear me?

CHAIRMAN POWERS: Ah, we have a comment. We do hear you. Please state your name.

MR. LEWIS: My name is Marvin Lewis. I am a member of the public. I wish to point out that considering that there's a new plant requesting early site review right here in Delaware where I live, in fact, I'm within walking distance of it in Delaware right now, I find it very disappointing that

I did not see any notice in the local papers.

I did not hear any notice on the radio, TV. I did not see any notice on the various non-governmental organization sites about this early site application going through.

I don't, I'm not pointing fingers at anybody. I'm pointing fingers at everybody. Nobody got the word out to the public. I happened to be on this site for other reasons and I simply stumbled upon it.

Secondly, this presentation was very good. And it showed me that a great deal of the earthquake danger is a matter of opinion between experts. And I think I don't have to go into the details on that. I think you probably know that better than I.

Finally, there was talking about putting another nuclear power plant up. And I actually have not heard any word from the northeast regional electric group, or whatever they call themselves, that covers this area that they are in need of another base plant. I think that's enough for my comments. Thank you.

CHAIRMAN POWERS: Thank you, Mr. Lewis. Any other comments?

(No audible response)

CHAIRMAN POWERS: Hearing none, I'm going to adjourn the session. We are adjourned.

(Whereupon, the above-entitled matter went off the record at 12:46 p.m.)

PSEG Early Site Permit
Advisory Committee on Reactor Safeguards
Subcommittee Meeting
SSAR Section 2.5

September 30, 2014

PSEG
Power LLC

Chapter 2 – Section 2.5
Geology, Seismology and Geotechnical Information

PSEG Power LLC

Areas covered in ESP same as for COLA

- RS-002 outlines NRC review approach
- Regulatory Guidance
  - RG-1.132
  - RG 1.138
  - RG 1.198
  - RG 1.206
  - RG 1.208
- NUREG-2115
- Level of site exploration not as detailed in ESP vs. COLA
  - Use existing/published data
  - Supplement with new site data (limited number of tests)
- QA requirements apply – 10CFR50 Appendix B

Chapter 2 – Section 2.5.1
Basic Geologic and Seismologic Information

PSEG Power LLC

Geological Studies

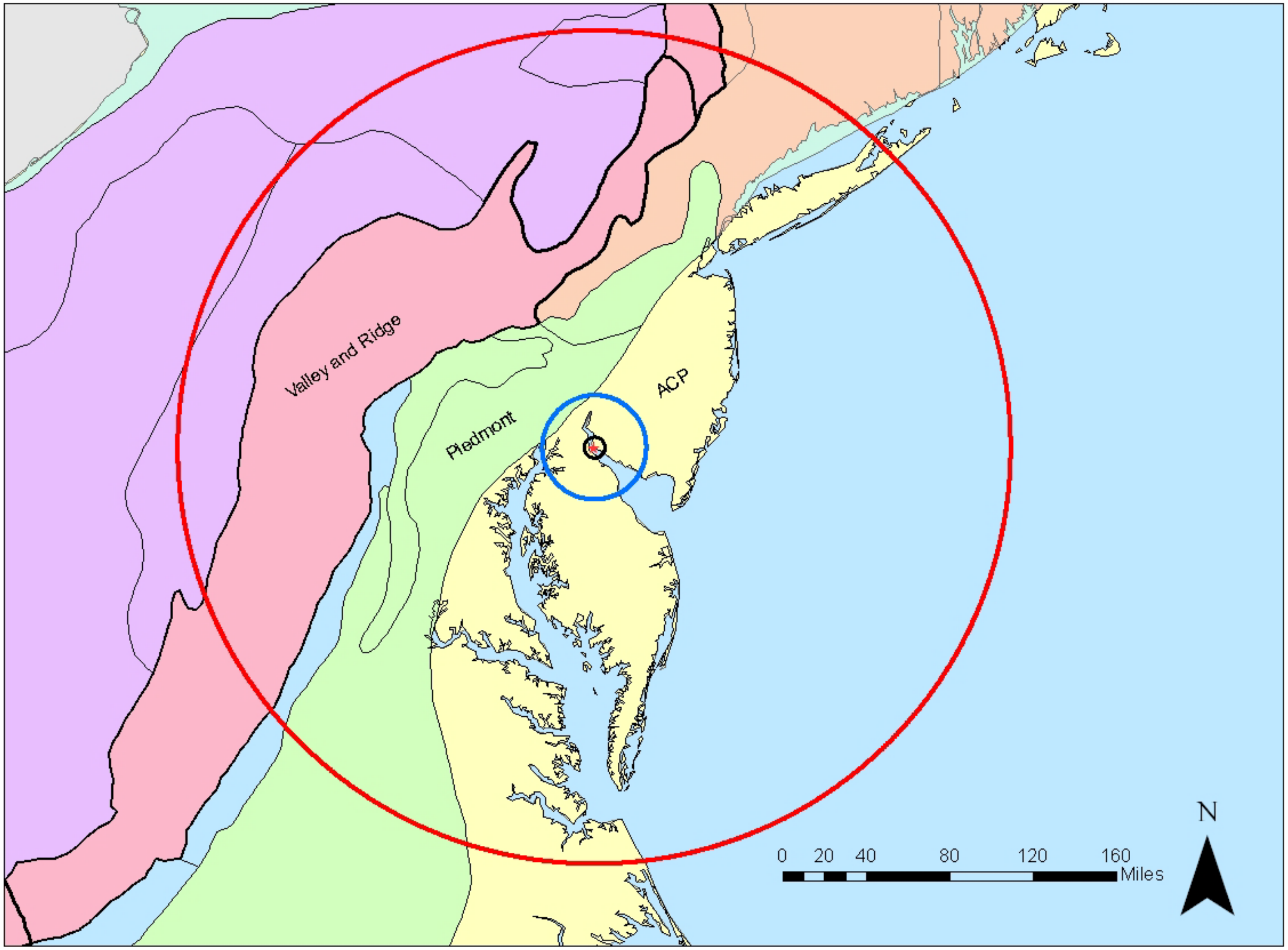
- Characterize site conditions within regional context
- Study geologic conditions with increasing focus on site area
  - Focus areas:
    - Stratigraphy (correlated to site engineering stratigraphy)
    - Structure
    - Engineering Geology (potential zones of weakness, etc)

Scales of Investigation

- Regional studies (200 mile radius)
  - Extensive literature search and review
  - Expert interviews
  - Analysis of regional gravity and magnetic data

- Site studies (25, 5, 0.6 mile radius)
  - Field reconnaissance and mapping
  - Aerial photography and imagery analysis
  - Analysis of ESP exploration data

Regional Physiography



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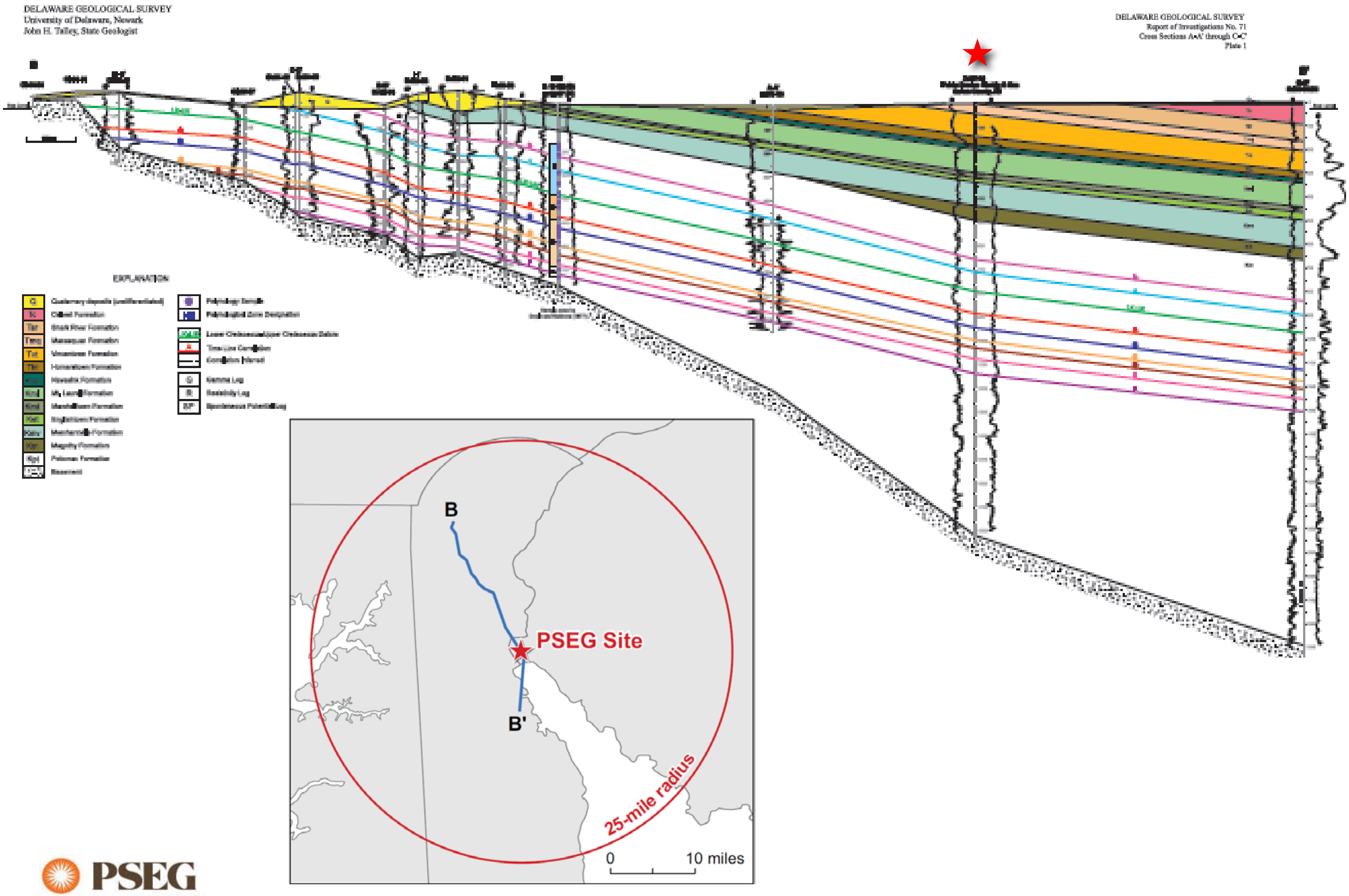
2.5.1 Basic Geologic and Seismologic Information



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2.5.1 Basic Geologic and Seismologic Information

Site Geologic Column

- Relative thicknesses of formations shown.
- Same basic strata at adjacent Hope Creek and Salem sites.

Approx. Elev. Ft. NAVD

+10

ERA	PERIOD	EPOCH	SITE STRATIGRAPHIC UNIT
CENOZOIC	QUATERNARY	HOLOCENE (RECENT)	ARTIFICIAL & HYDRAULIC FILL
		UNCONFORMITY	
		PLEISTOCENE	ALLUVIUM
		UNCONFORMITY	
	NEOGENE (UPPER TERTIARY)	MIOCENE	KIRKWOOD FORMATION
		UNCONFORMITY	
	PALEOGENE (LOWER TERTIARY)	PALEOCENE	VINCENTOWN FORMATION
			HORNERSTOWN FORMATION
MESOZOIC	CRETACEOUS	UPPER CRETACEOUS	NAVESINK FORMATION
			MOUNT LAUREL FORMATION
			WENONAH FORMATION
			MARSHALLTOWN FORMATION
			ENGLISHTOWN FORMATION
			WOODBURY FORMATION
			MERCHANTVILLE FORMATION
			MAGOTHY FORMATION
		UNCONFORMITY	
		LOWER CRETACEOUS	POTOMAC FORMATION

-450±

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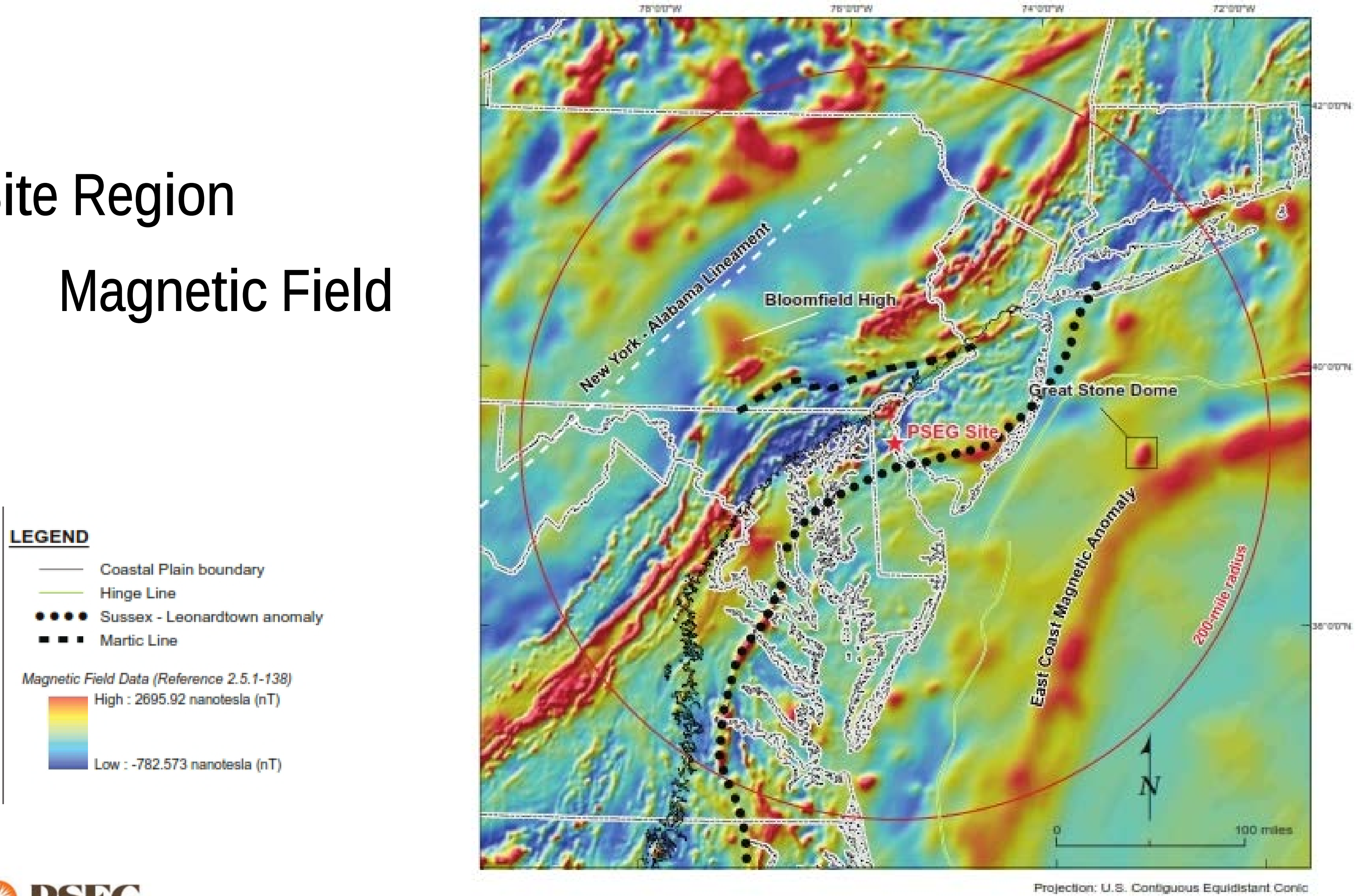
Site Region

- Magnetic Field



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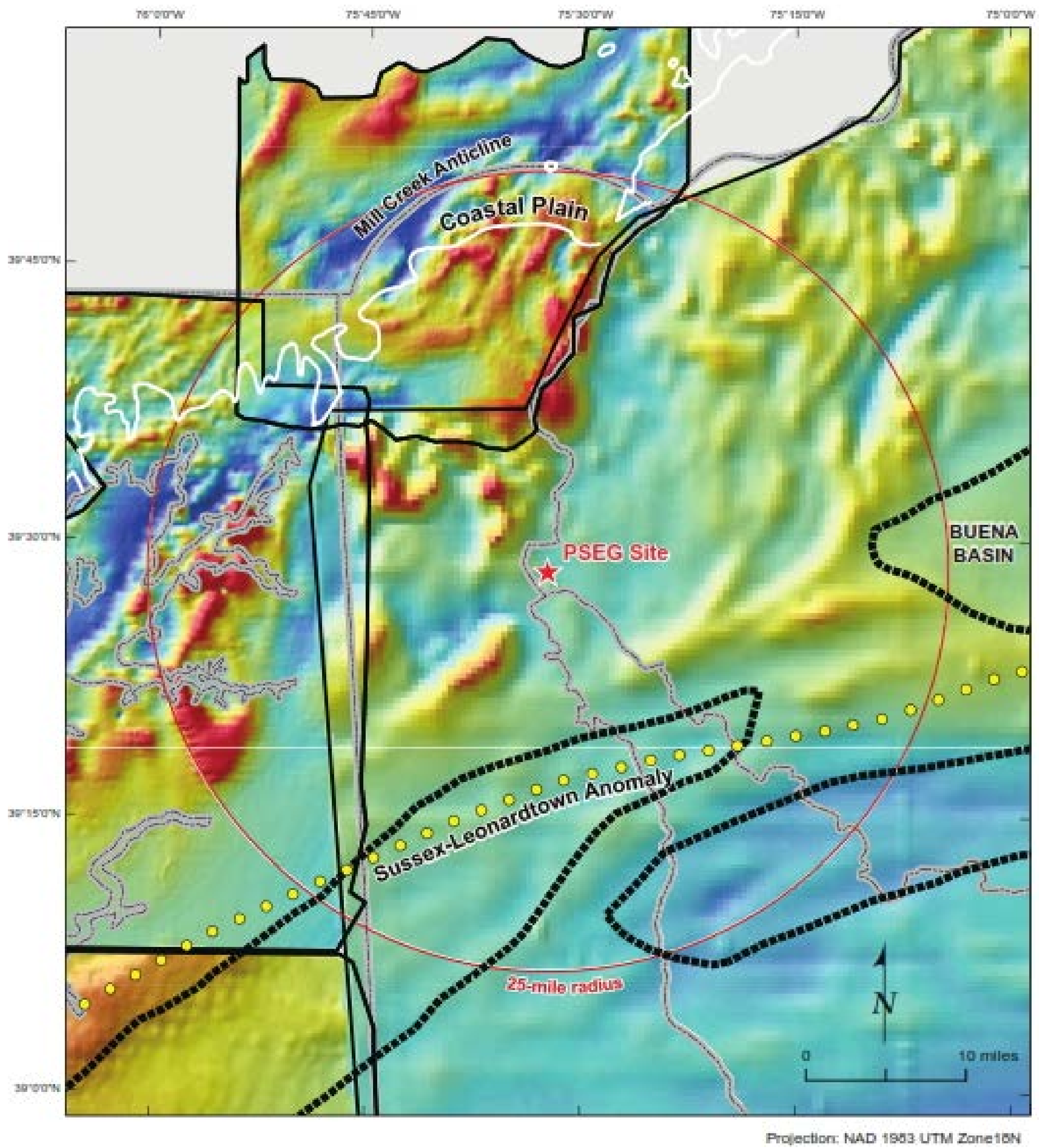
2.5.1 Basic Geologic and Seismologic Information

Site Vicinity

- Magnetic Anomaly Map Features



LEGEND

Mesozoic basins (Reference 2.5.1-15)

Exposed

Buried

For explanation of magnetic data see Figure 2.5.1-24b

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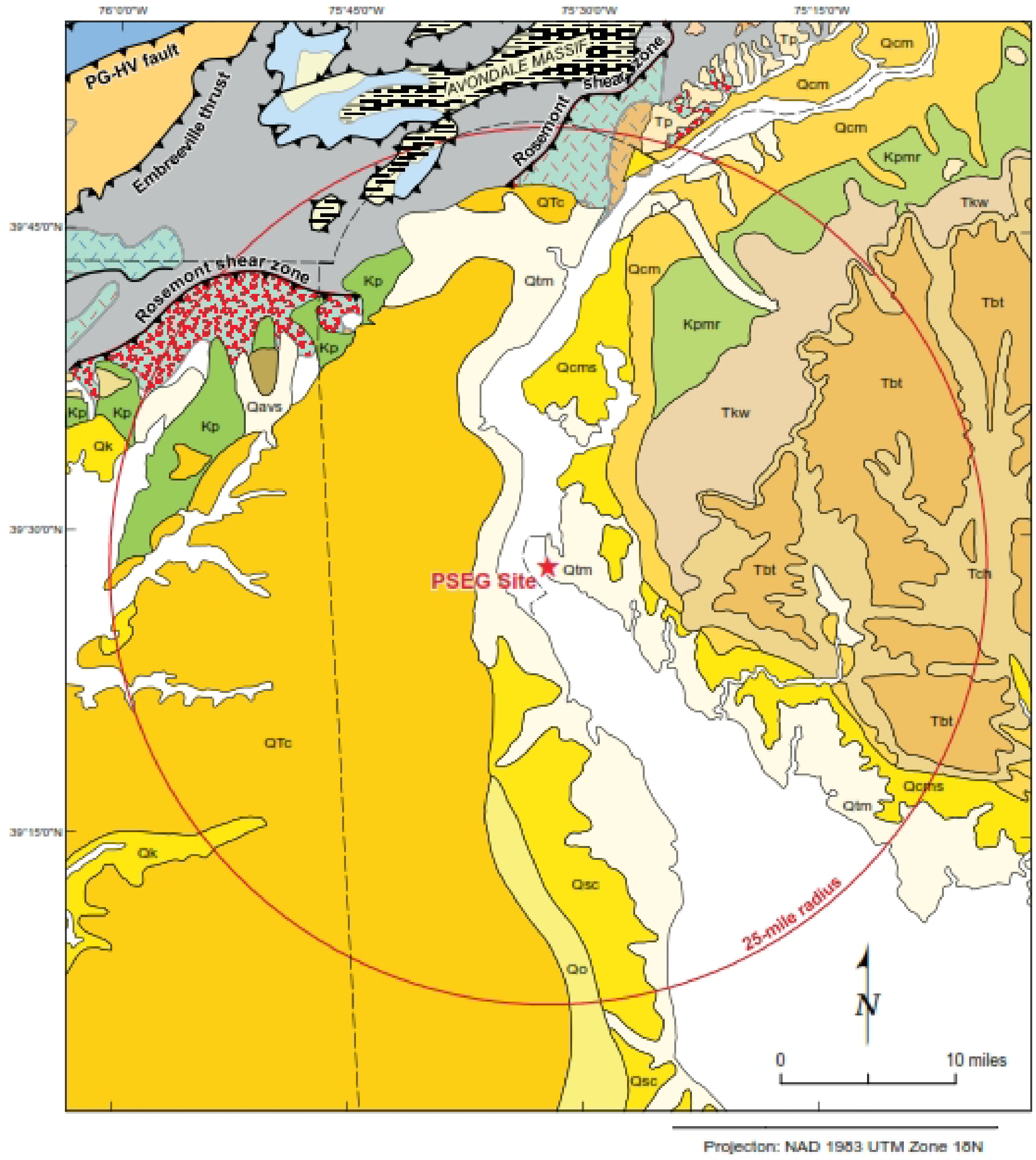
Site Vicinity Surficial Geologic Map

(SSAR Figure 2.5.1-12)



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Summary of Findings

- Regional and site stratigraphy correlates well with previous studies and ESP data
- Field and aerial reconnaissance indicate no evidence of surface faulting or surface expression of subsurface weak zones
- No evidence of geologic hazards within the site area

Chapter 2 – Section 2.5.3
Surface Faulting

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Evaluate the Potential for Surface Faulting in the Site Area

- Focus areas:
  - Evidence for tectonic surface deformation in site vicinity
  - Correlation of earthquakes with known capable faults
  - Ages of most recent deformations
  - Relationship of structures in site area to regional structures
  - Characterization of capable tectonic sources
  - Characterization of quaternary deformation at the site
  - Potential for surface deformation at the site

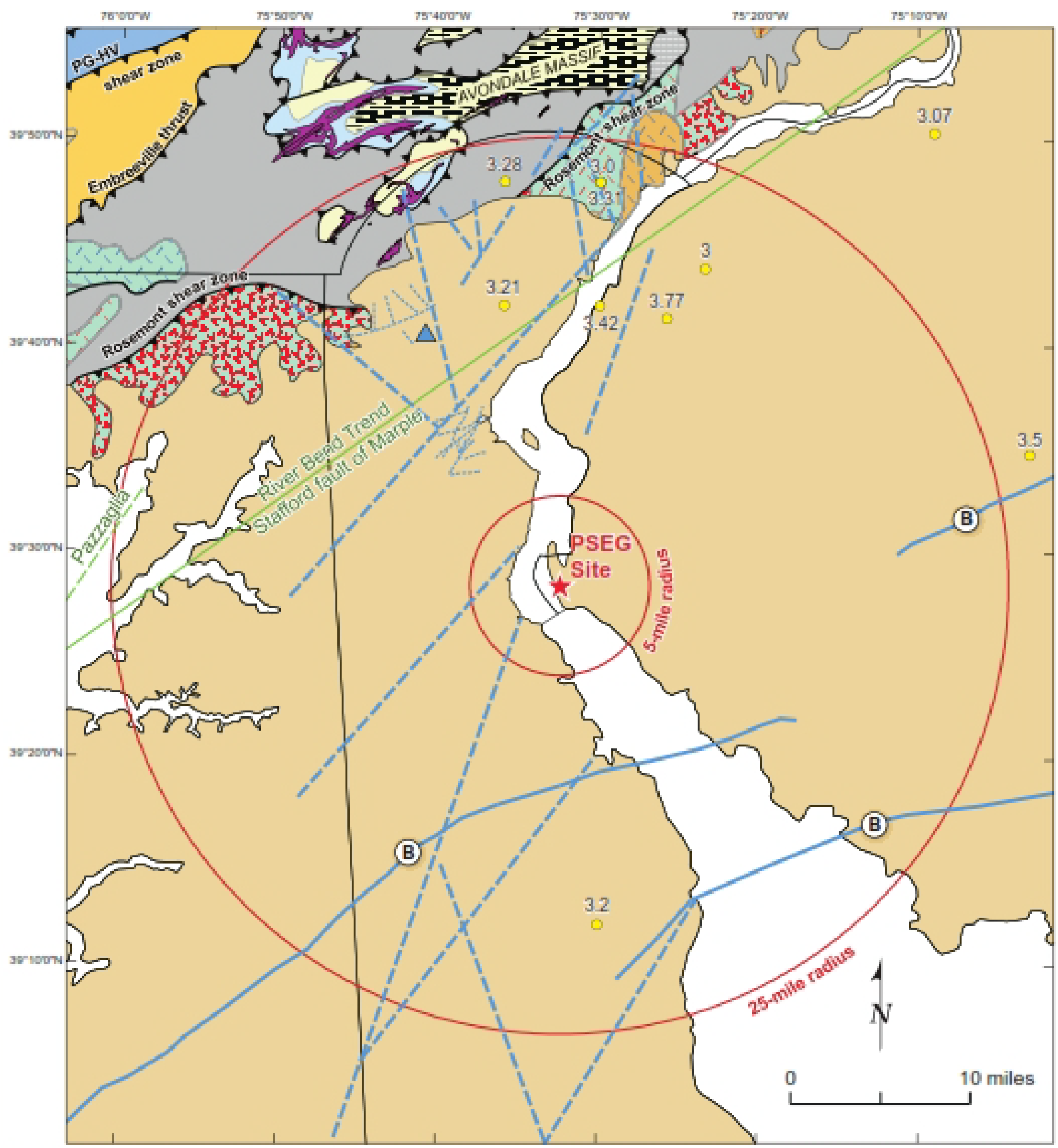
Approach for Structural Studies

- Extensive literature search
- Regional expert interviews
- Evaluation of existing data
- Field and aerial reconnaissance
- Analysis of site investigation data
- Analysis of aerial photography

2.5.3 Surface Faulting

Site Vicinity

- Structures and Earthquakes



LEGEND

Paleozoic Piedmont fault

Faults buried by coastal plain sediments

Offset, from Benson (Reference 2.5.3-2)

Basin-bounding fault of Benson (Reference 2.5.3-3)

Basement fault of Spoljaric (Reference 2.5.3-24, Reference 2.5.3-26)

Lineament of Spoljaric (Reference 2.5.3-27, Reference 2.5.3-25)

Hypothesized features

River bend trend Stafford fault extension of Marple (Reference 2.5.3-12)

Fault from Pazzaglia (Reference 2.5.3-16)

PSEG Regional Seismic Catalog, updated from CEUS SSC seismicity catalog (Reference 2.5.3-42)

3.0 - 3.9 magnitude E[**M**]

Cretaceous–Quaternary coastal plain units

Cockeysville Marble, Karst Unit (Reference 2.5.1-22, Reference 2.5.1-199)

For explanation of geologic units, see Figure 2.5.1-12a and 12b.

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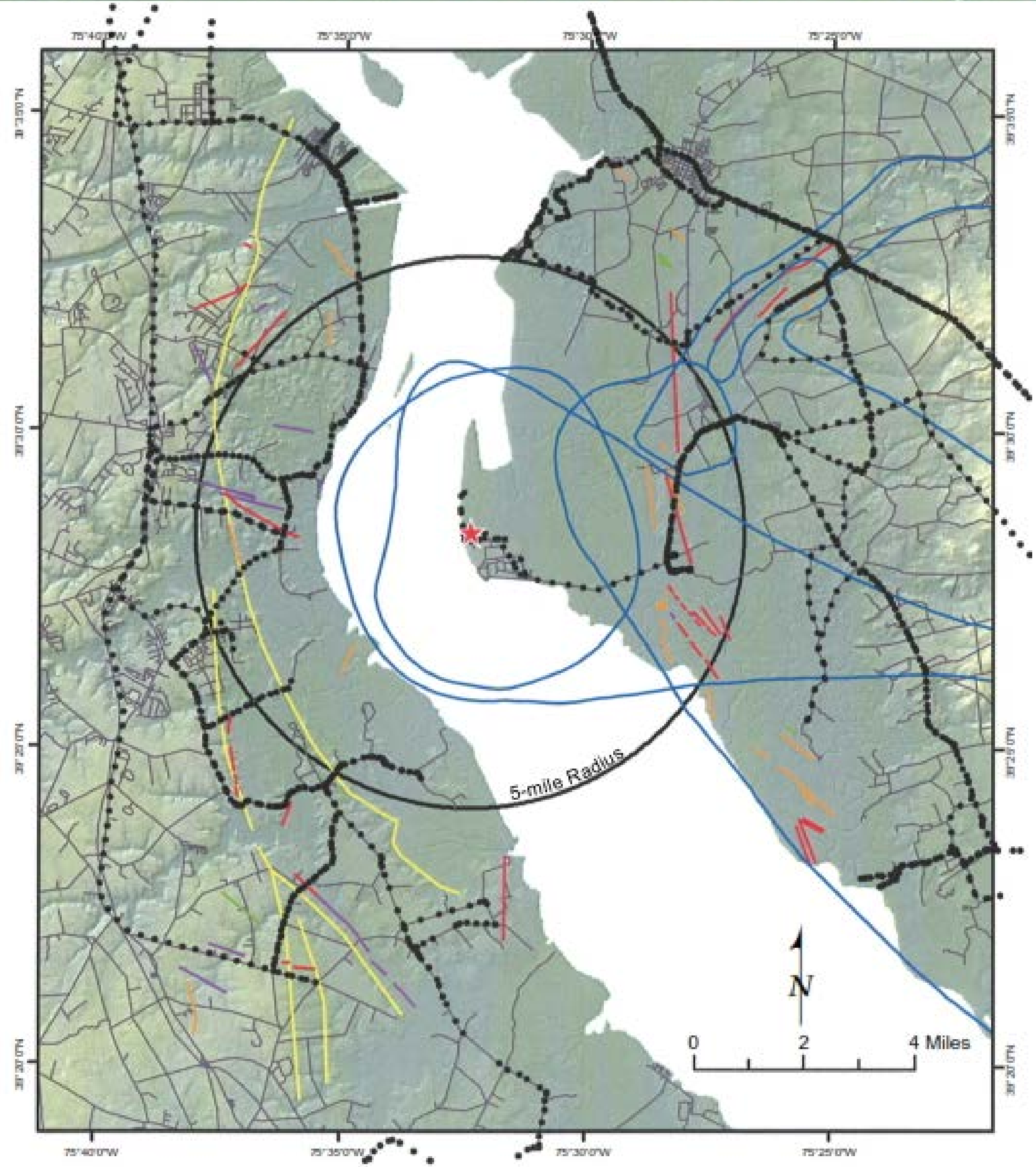
Site Geologic Reconnaissance



Explanation

★ PSEG Site

GPS Tracks

Flight

• • • Ground

Lineament Analysis

Potential Shoreline

Stream Lineament

Tonal Change

Tonal Lineament

Vegetation Lineament

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Summary of Findings

- Several Structures Mapped in the Site Vicinity
- No Evidence for Surface Deformation at the Site
- No Correlation of Earthquakes and Site Vicinity Structures

Chapter 2 – Section 2.5.2
Vibratory Ground Motion

2.5.2 Vibratory Ground Motion

Objectives

- Characterize potential earthquake hazard in the site region (200 mi radius)
- Characterize seismic hazard at the site
- Characterize the seismic response of the site to develop the Ground Motion Response Spectrum (GMRS)

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2.5.2 Vibratory Ground Motion

Abbreviations

- AFE – Annual frequency of exceedance
- AHEX-E – Atlantic highly extended crust - east
- BPT – Brownian passage time
- CAV – Cumulative absolute velocity
- CEUS SSC – Central and Eastern United States Seismic Source Characterization
- EPRI – Electric Power Research Institute
- ERM-N – Reelfoot Rift – Eastern rift margin north
- ERM-S - Reelfoot Rift – Eastern rift margin south
- G, Gmax – Shear modulus, low-strain shear modulus
- GMPE – Ground motion prediction equations
- GMRS – Ground motion response spectrum
- HF – High frequency in Hertz (Hz)
- LF – Low frequency in Hertz (Hz)
- NAVD – North American vertical datum

Abbreviations (Cont.)

- NMFS – New Madrid fault system
- OCR – Over-consolidation ratio
- PGA – Peak ground acceleration, taken at 100 Hz
- PSHA – Probabilistic seismic hazard analysis
- RLME – Repeated large-magnitude earthquakes
- RVT – Random vibration theory
- SPT – Standard penetration test
- SSAR – Site safety analysis report
- T – Fundamental period of a structure
- T_L – Long-period transition period
- UHRS – Uniform hazard response spectra
- WUS – Western United States

2.5.2 Vibratory Ground Motion

Methodology

- Updated earthquake catalog (1/1/2009 to 12/31/2011) to characterize potential earthquake hazard in the site region (200 mi radius)
- Used CEUS SSC as defined in NUREG-2115 in its entirety including all background sources and RLMEs
- Incorporated new information into NUREG-2115 (AHEX-E)
- Evaluated the need to refine NUREG-2115

2.5.2 Vibratory Ground Motion

Methodology (Cont.)

- EQ recurrence rates for two RLMEs updated:
  - New Madrid Fault System (in-cluster branch)
  - Charleston (narrow source geometry branch)
  - Update based on site-specific inputs to the BPT renewal model
  - Equivalent Poissonian rates calculated based on June 1, 2021 plant start date with plant exposure time of 60 years
- Mean, median, and fractile hazards computed
  - Used NRC-audited FRISK88 suite
- Used EPRI (2004, 2006) Ground Motion Prediction Equations

2.5.2 Vibratory Ground Motion

Methodology (Cont.)

- Followed guidance in RG 1.208 to develop the GMRS:
  - Performed PSHA at bedrock
  - Mean, median, and fractile hazards computed
  - Performed deaggregation of the hazard
  - Developed HF and LF controlling EQs
  - Performed randomization of dynamic site profiles
  - Performed site response analysis to generate site-specific amplification factors including their uncertainties
  - Using Approach 3 of NUREG/CR-6728, performed soil PSHA integrating the site amplification into the hazard
  - Developed horizontal and vertical GMRS

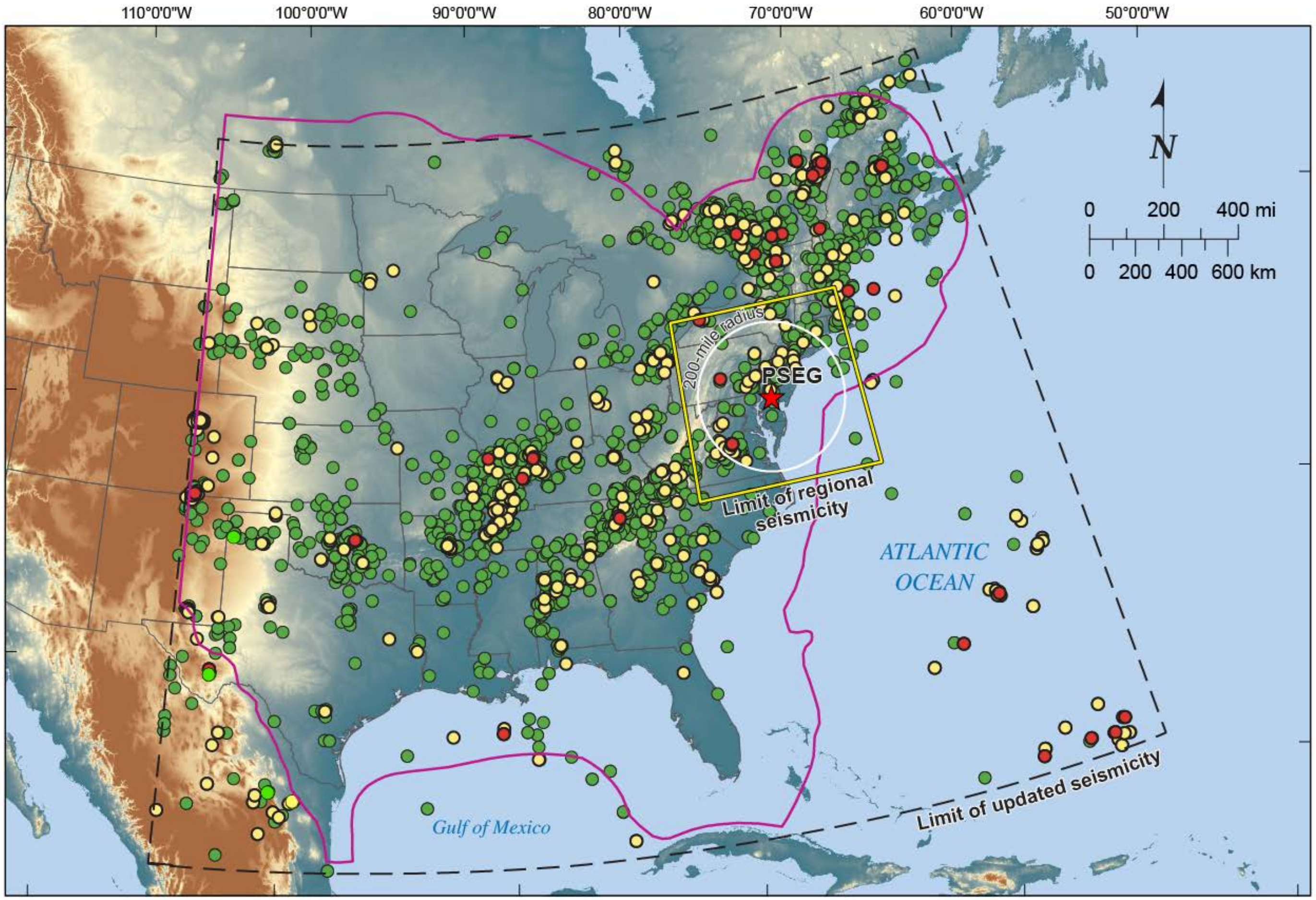
Updated Seismicity Catalog - 1

- Compiled for CEUS Region and Regional updated boundary

CEUS SSC Study Region

Earthquake Epicenters
(by estimated moment magnitude E[**M**])
Updated CEUS SSC Seismicity Catalog

- 2.90 - 3.99
- 4.00 - 4.99
- 5.00 - 5.80



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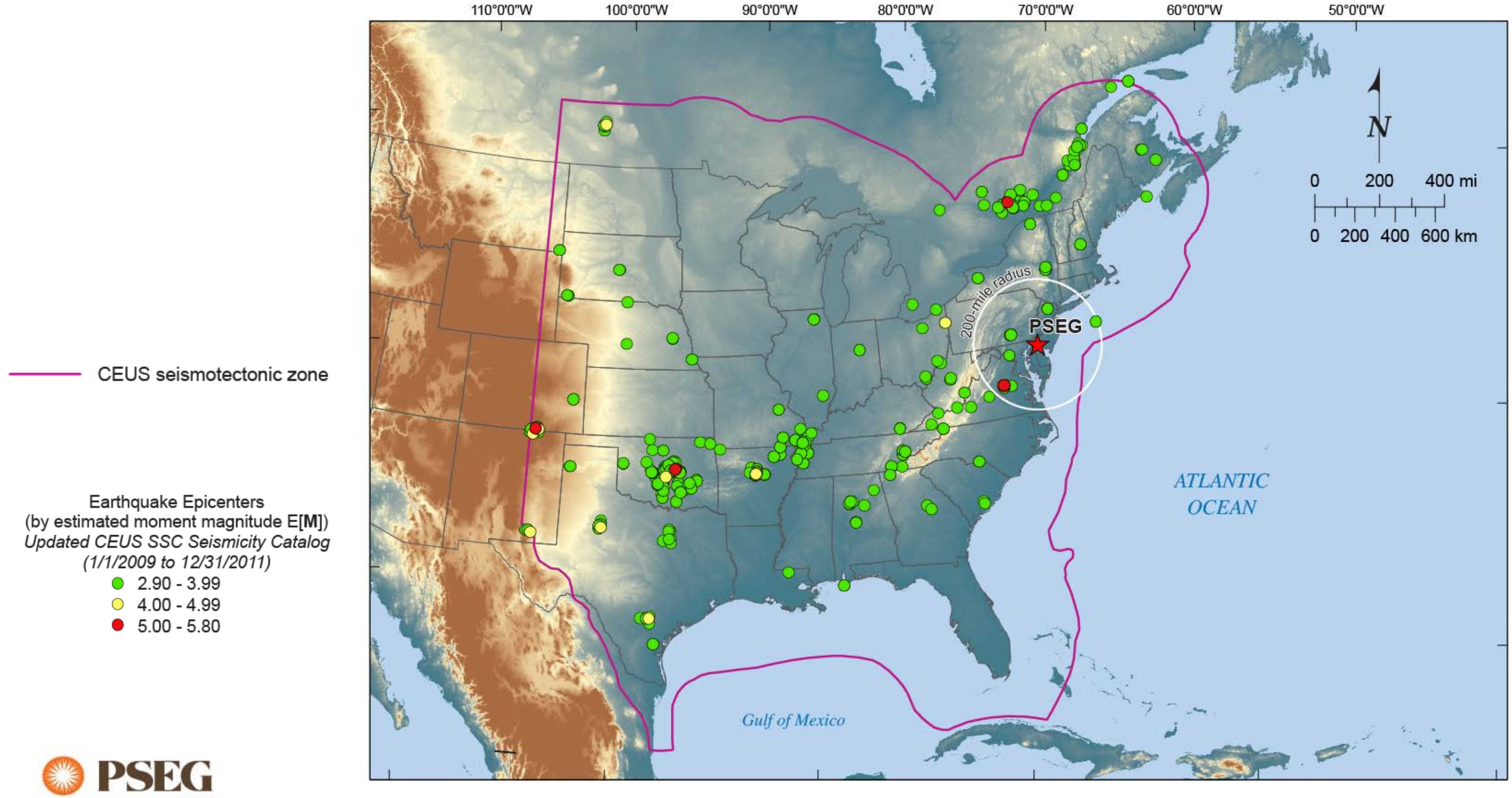
Updated Seismicity Catalog - 2

- Updated CEUS SSC Catalog for 1/1/2009 – 12/31/2011



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2.5.2 Vibratory Ground Motion

Magnitude Distribution

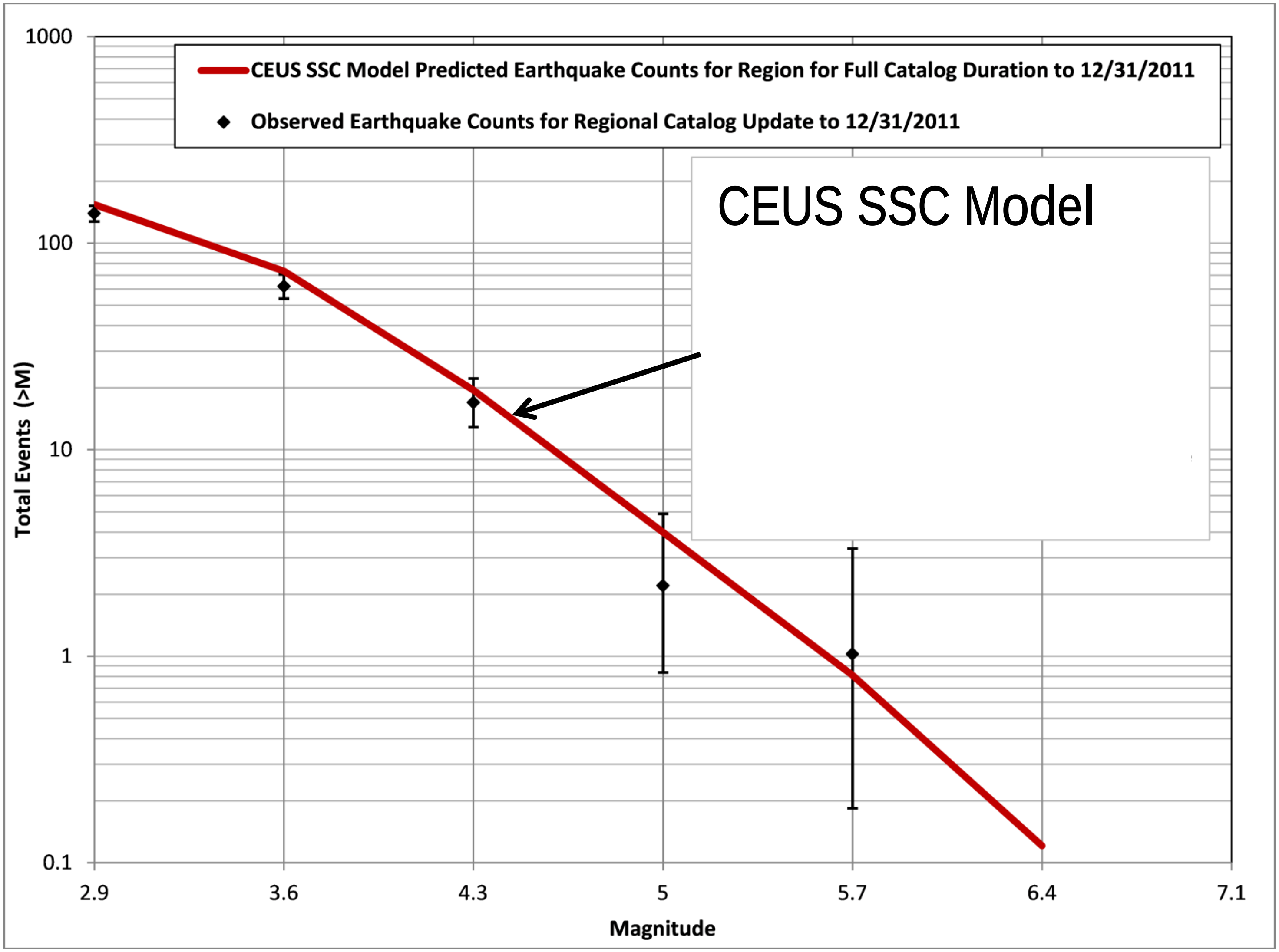
- All M_w values in updated catalog events equal to or less than lowest M_w in NUREG-2115 M_{max} distributions

Conclusion

- No updates in M_{max} distributions needed
- Can use NUREG-2115 M_{max} distributions

2.5.2 Vibratory Ground Motion

Regional Earthquake Recurrence Rates



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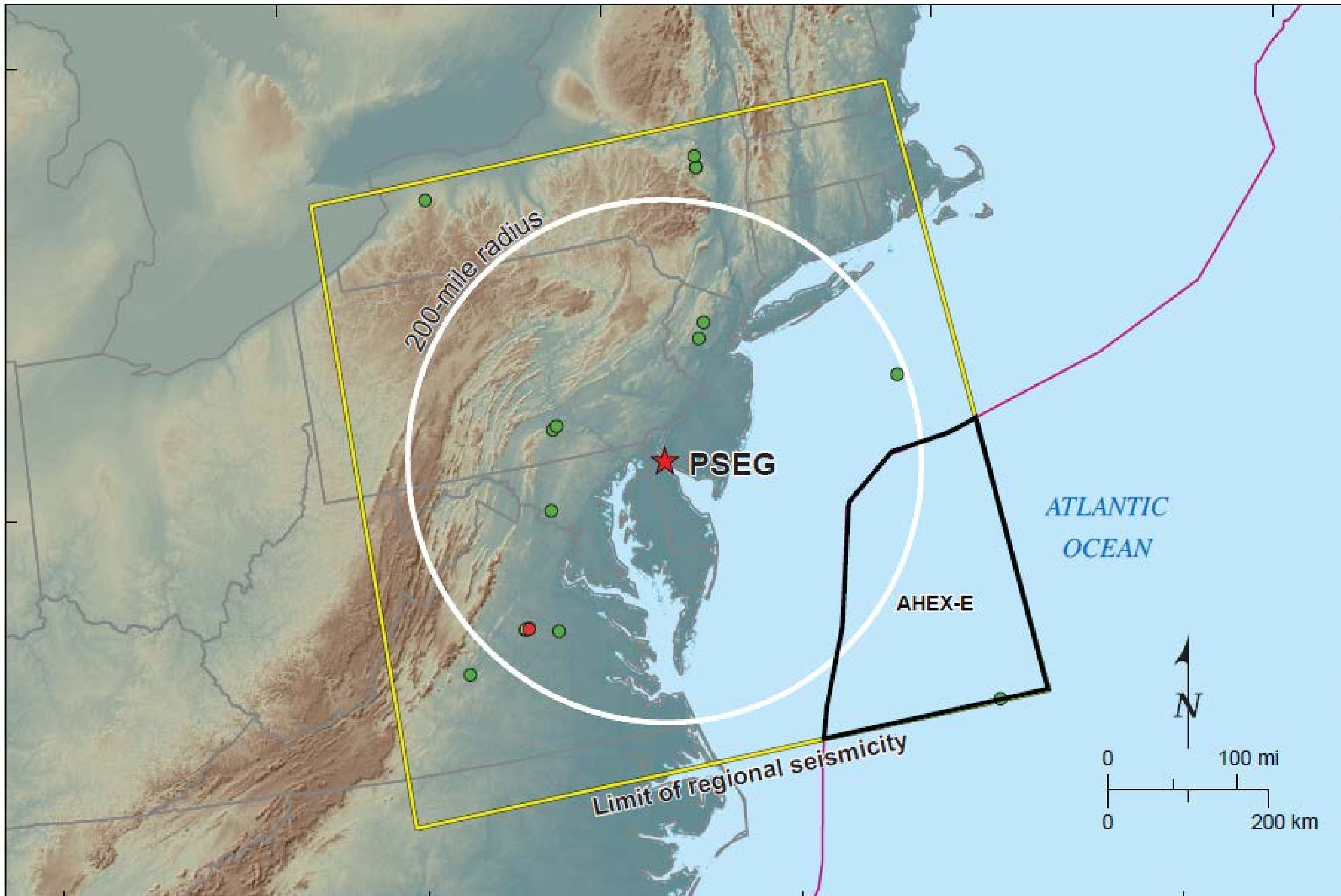
2.5.2 Vibratory Ground Motion

Regional Updated CEUS SSC Seismicity Catalog

CEUS seismotectonic zone

Earthquake Epicenters
(by estimated moment magnitude E[M])
Updated CEUS SSC Seismicity Catalog
(1/1/2009 to 12/31/2011)

- 2.90 - 3.99
- 4.00 - 4.99
- 5.00 - 5.80



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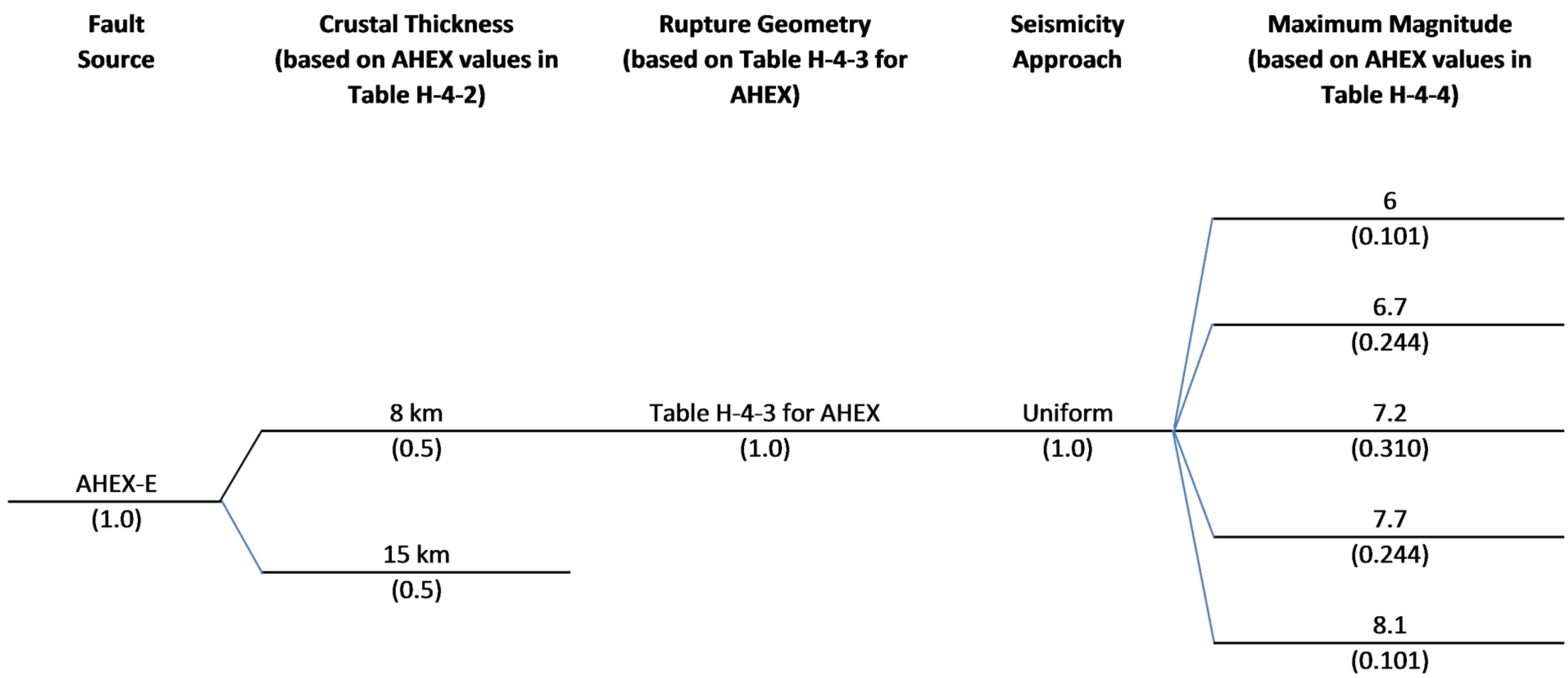
2.5.2 Vibratory Ground Motion

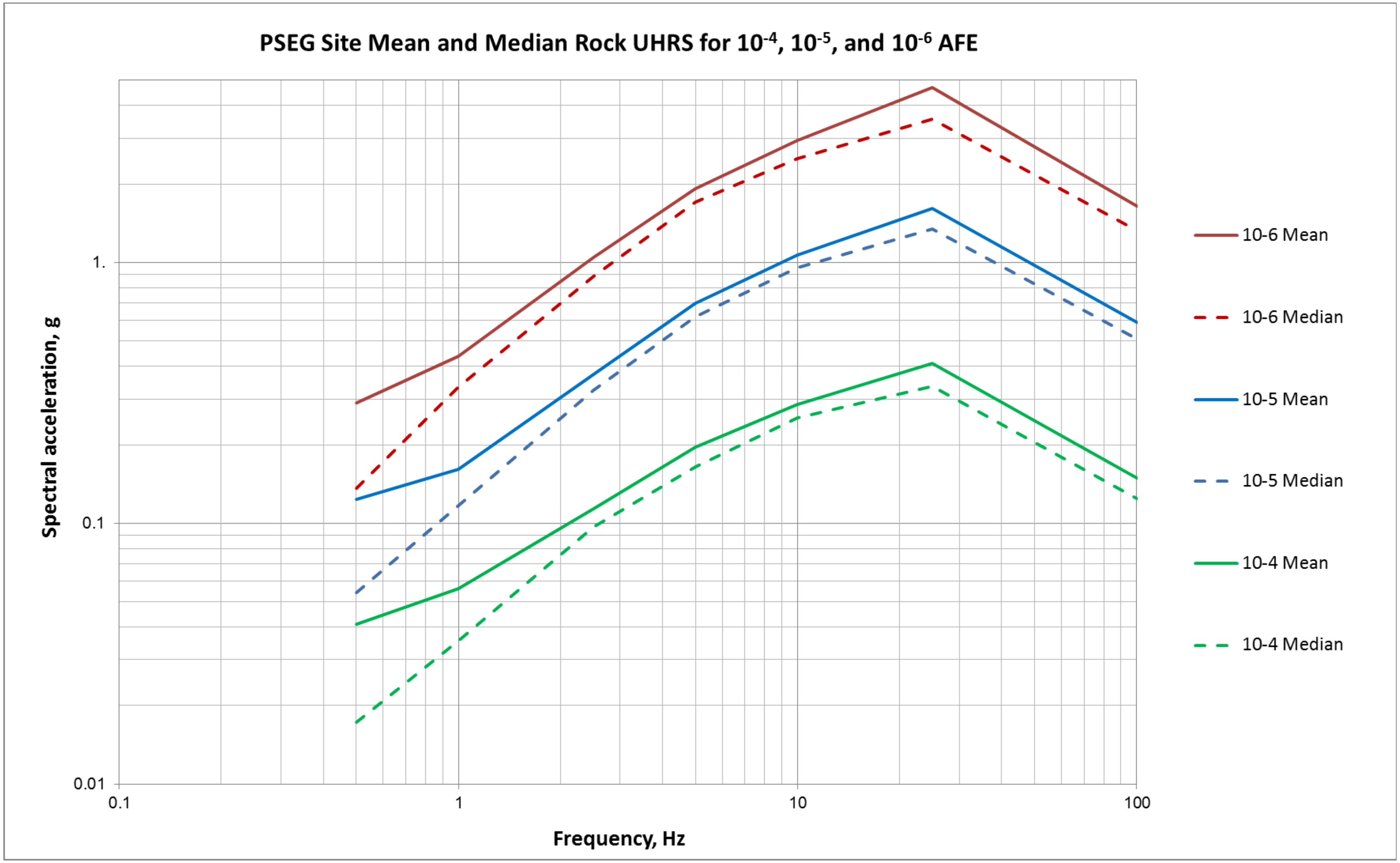
Incorporation of AHEX-E

- Applied Methodology consistent with Chapters 3 and 5 of NUREG-2115



2.5.2 Vibratory Ground Motion

Mean and median rock Uniform Hazard Response Spectra



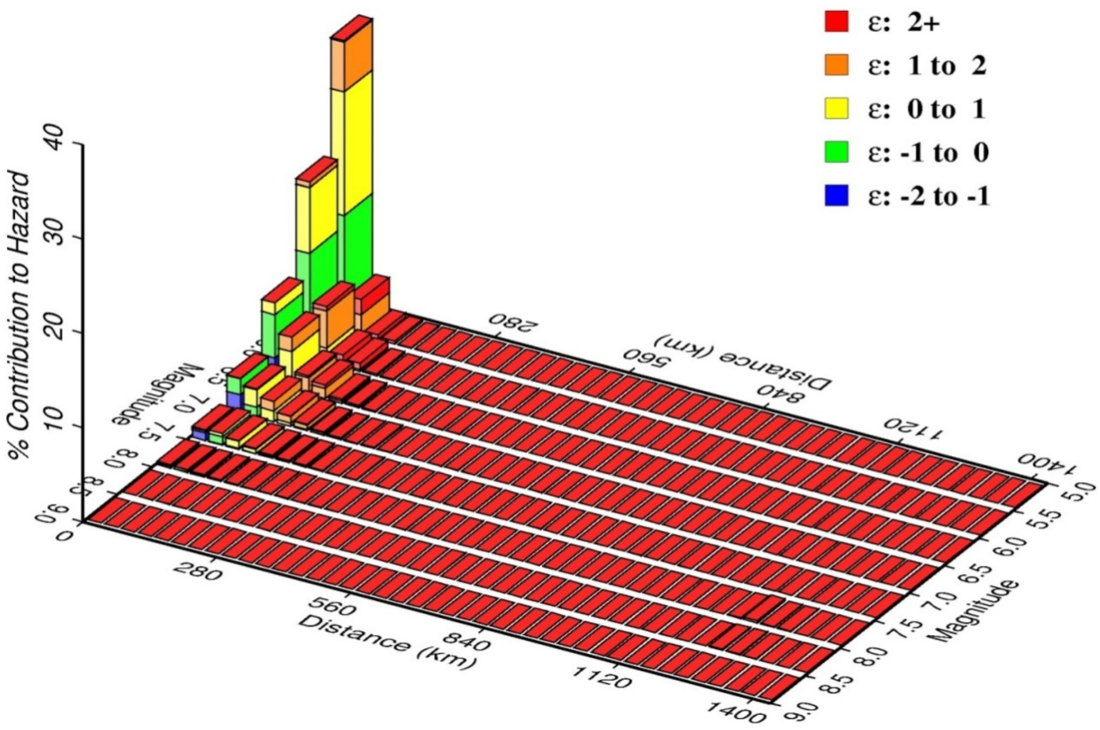
2.5.2 Vibratory Ground Motion

Develop Controlling Earthquakes

- Deaggregation of hazards using FRISK88 suite.
- Identified magnitudes and distances appropriate to represent rock spectral shapes (NUREG/CR-6728) for developing controlling EQs for site response calculations

	All R	R < 100 km	R > 100 km
Mean M	5.9	5.8	6.7
Mean R (km)	27	22	180
	Percent Contribution:		10%

PSEG: 5 Hz+10 Hz, 10^{-4}



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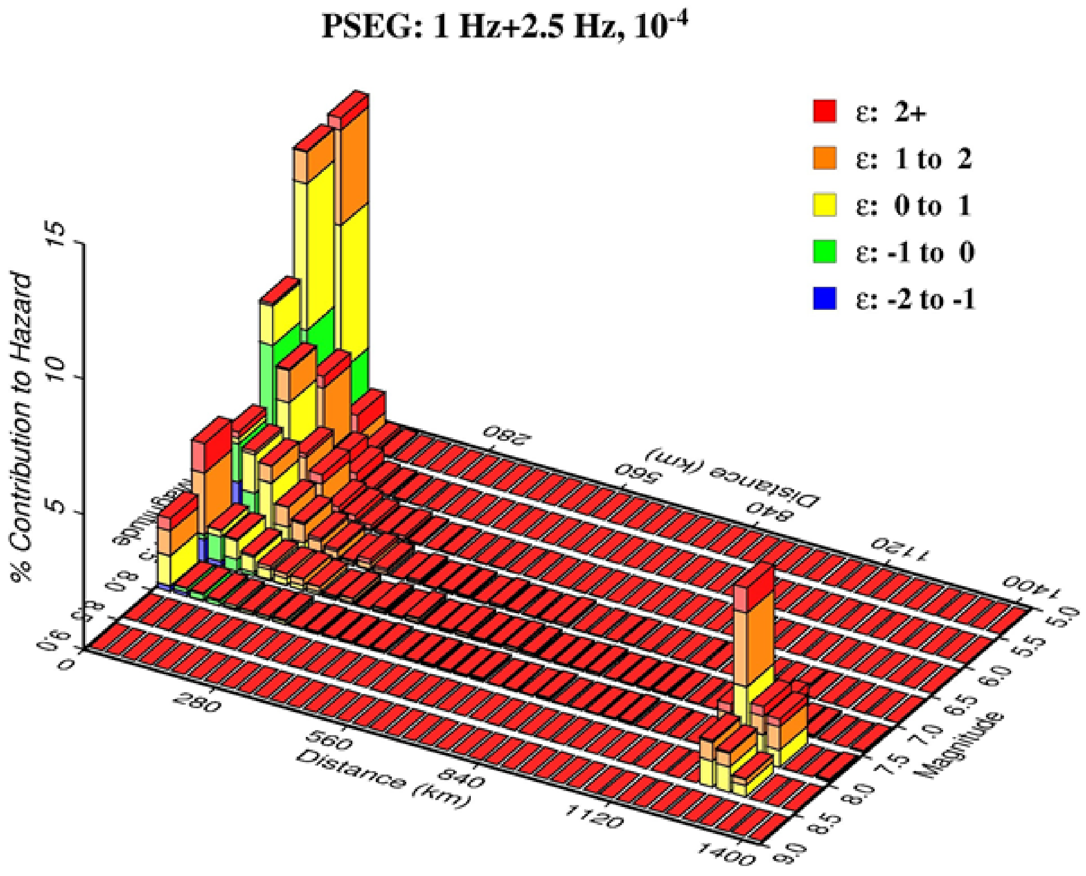
Develop Controlling Earthquakes (Cont.)

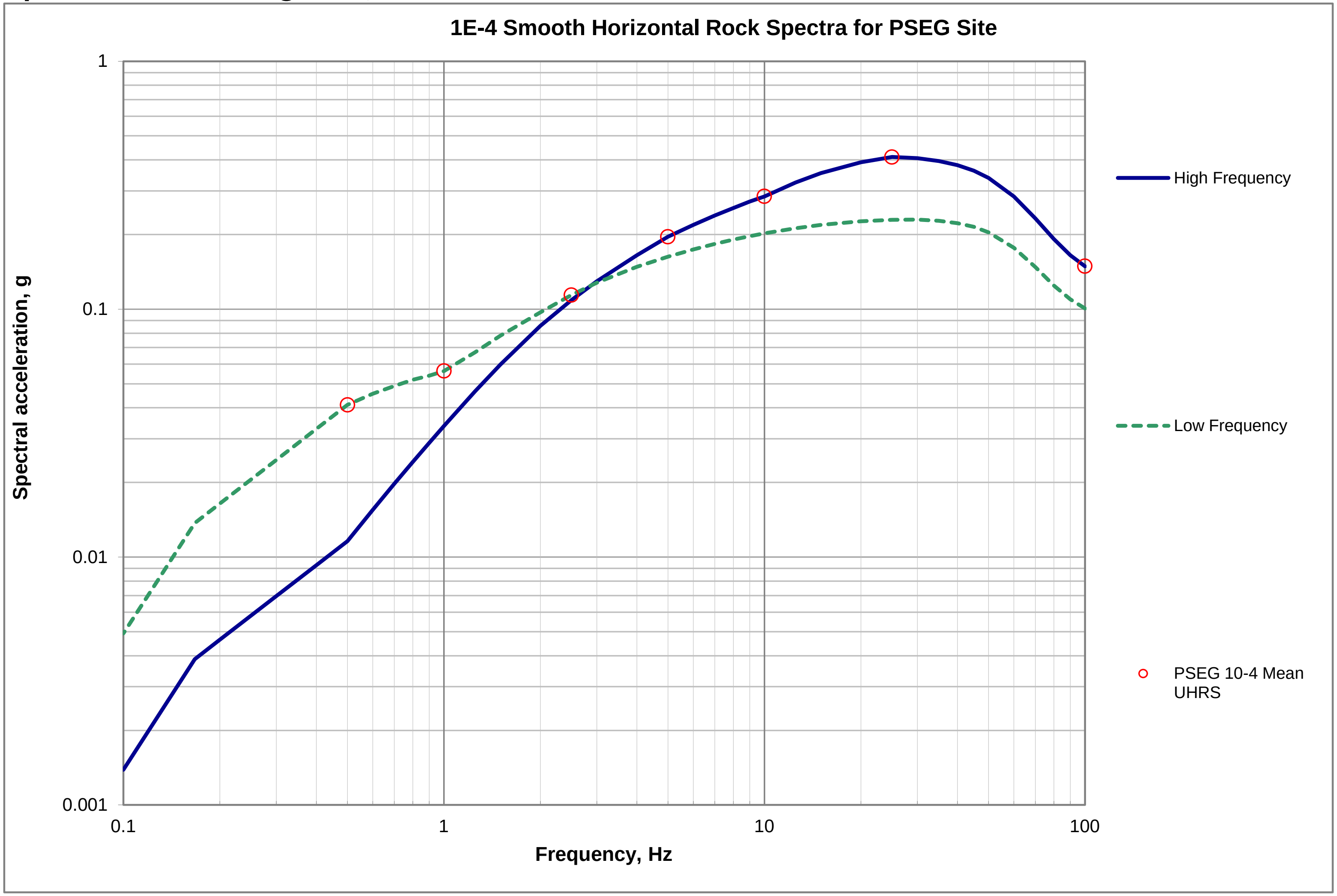
	All R	R < 100 km	R > 100 km
Mean M	6.6	6.2	7.3
Mean R (km)	68	21	540
	Percent Contribution:		36%



2.5.2 Vibratory Ground Motion

Develop Controlling Earthquakes (Cont.)

- Sample controlling EQ:



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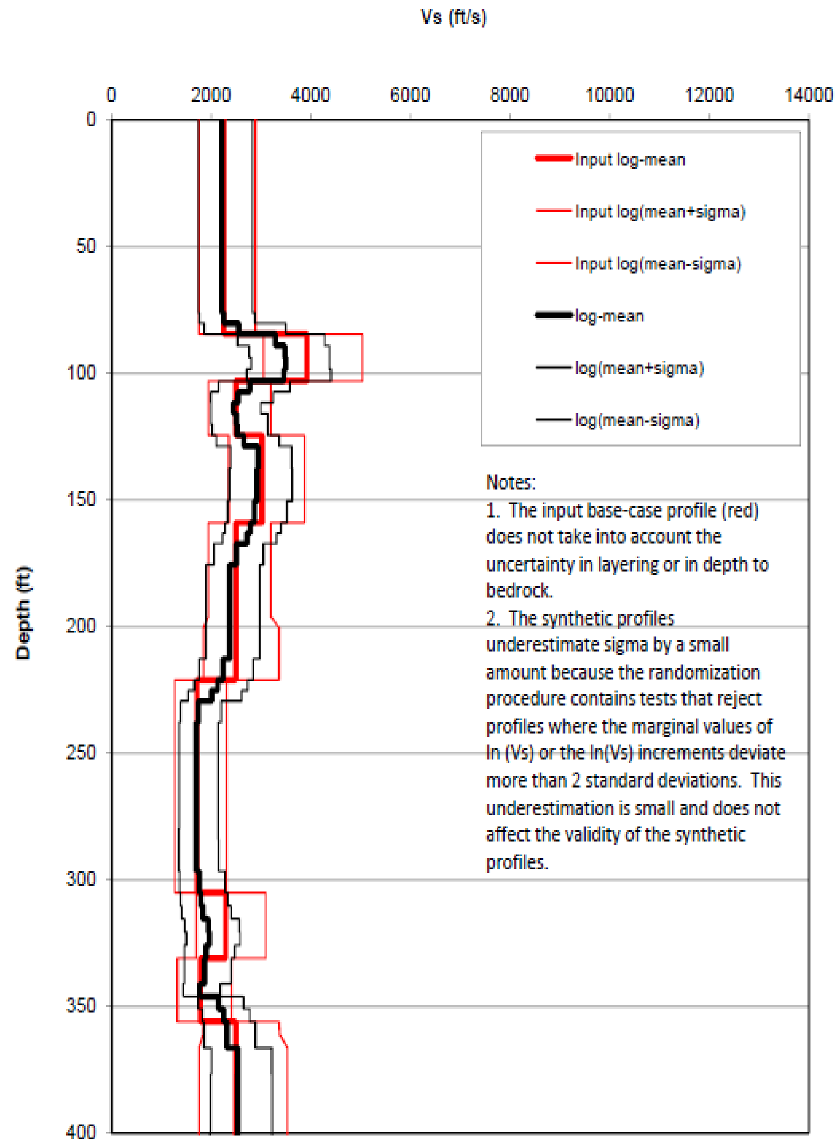
Site Response Calculations

- GMRS defined at top of competent layer (El. -67 ft, NAVD)
- 60 synthetic profiles generated taking into account uncertainty of shear wave velocity, G/Gmax curves, and damping curves



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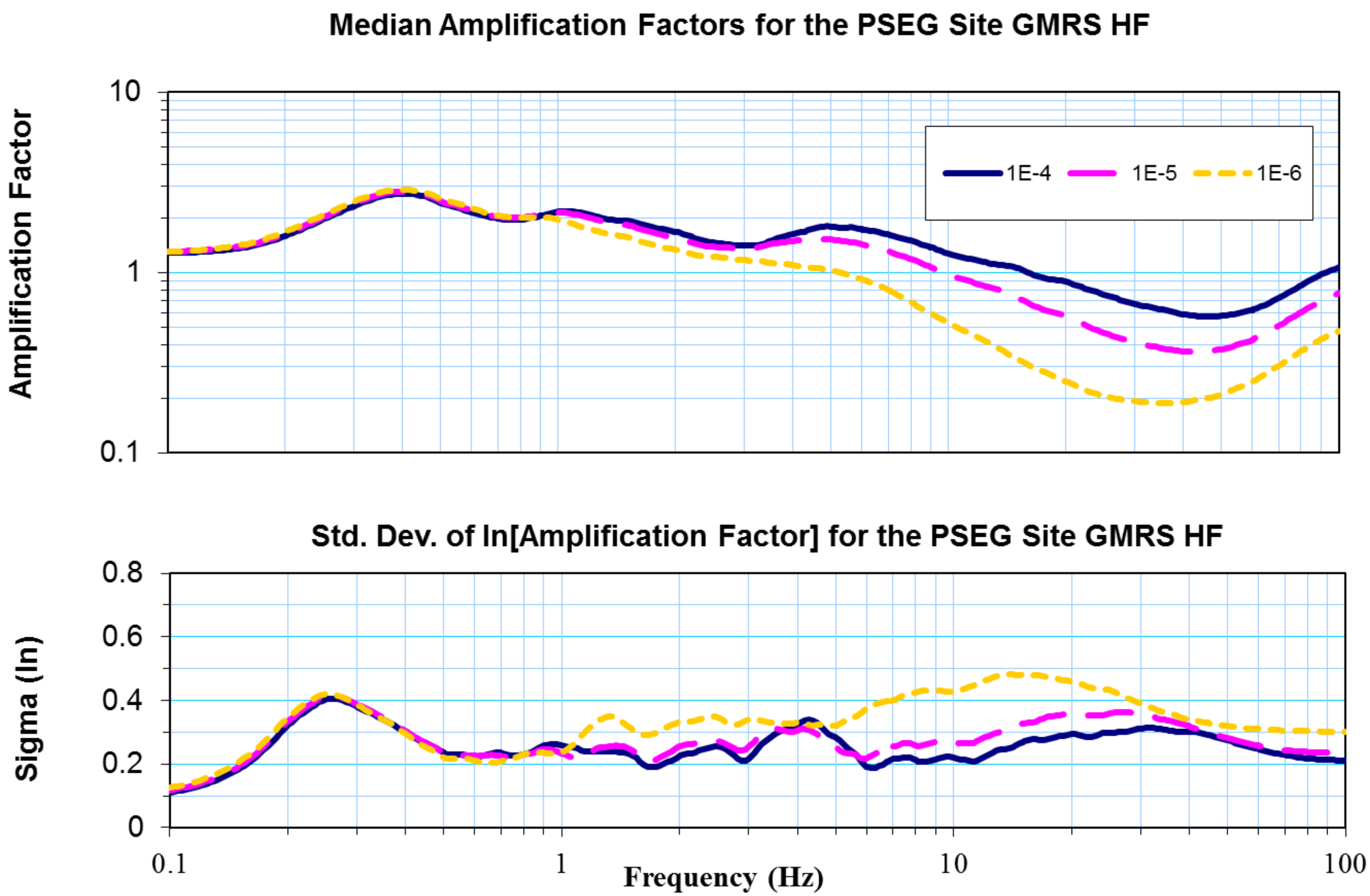
2.5.2 Vibratory Ground Motion

Site Response Calculations (Cont.)

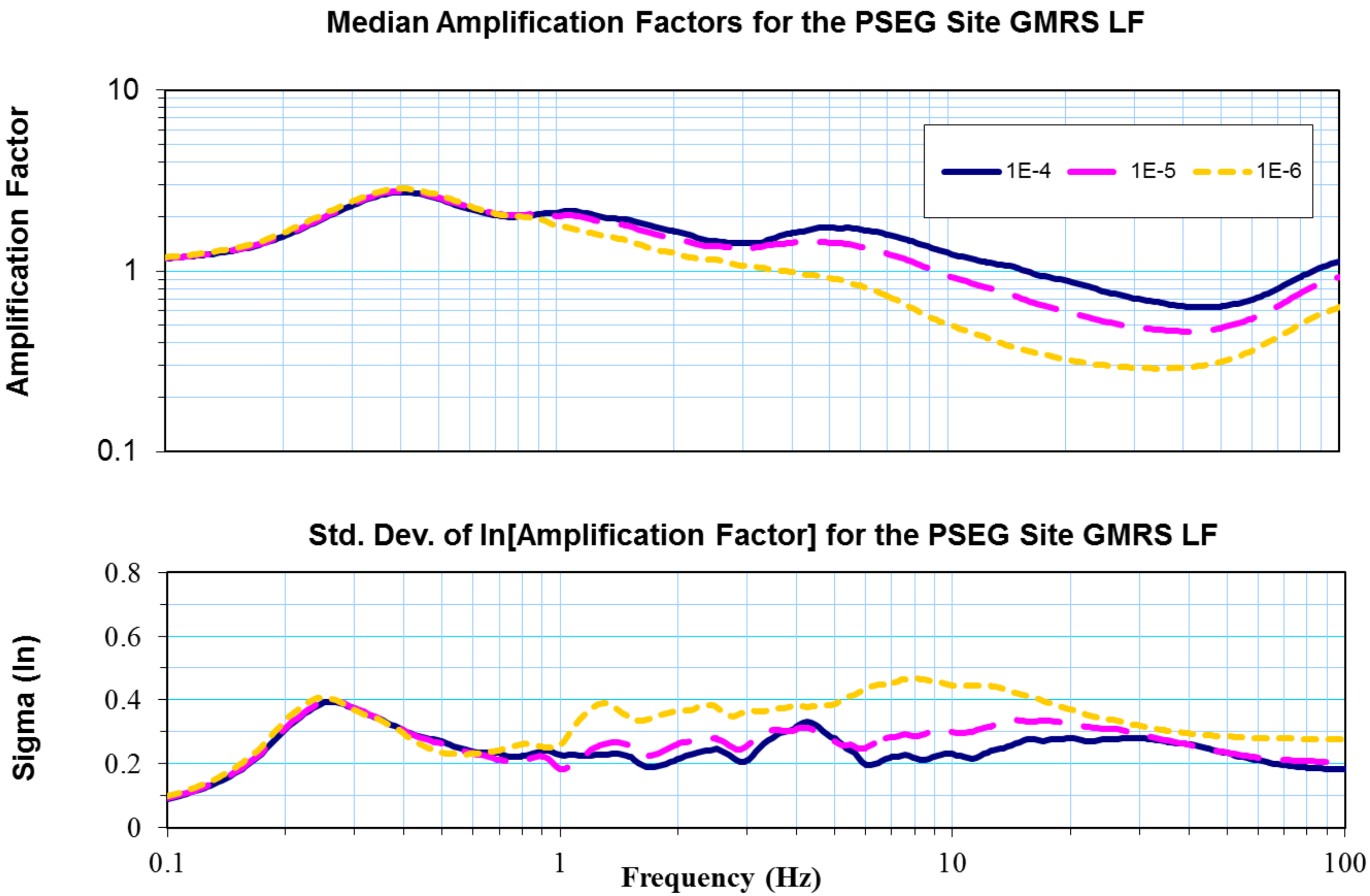
- HF median amplification factors and standard deviation:



2.5.2 Vibratory Ground Motion

Site Response Calculations (Cont.)

- LF median amplification factors and standard deviation:



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Soil PSHA

- Mean, median, and fractile hazard curves calculated at seven spectral frequencies
- Integrated site amplification factors and corresponding uncertainties with the rock GMPEs
- No CAV filter applied
- Minimum M_w of 5.0 used
- NUREG-2115 adopted in its entirety for the full CEUS
  - Included AHEX-E
  - Revised BPT renewal rates similar to the approach adopted in calculating the rock PSHA

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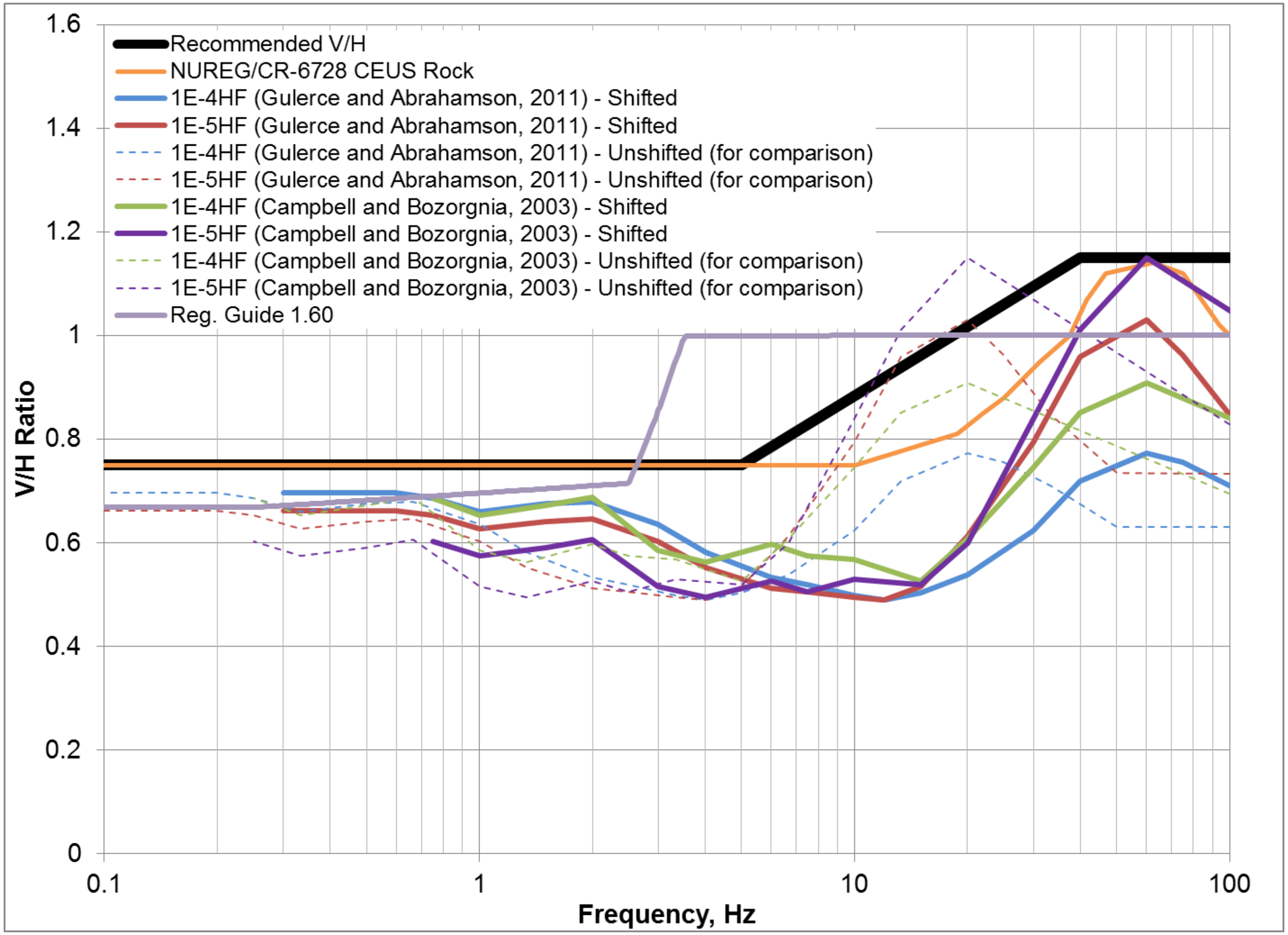
Horizontal GMRS Methodology

- Horizontal GMRS is calculated based on RG 1.208
- Smoothing of the horizontal GMRS:
  - Scale median HF and LF soil spectral shapes between 0.1 Hz and 100 Hz (PGA) at 7 spectral frequencies
  - Anchor soil spectral shape to 0.5 Hz for frequencies < 0.5 Hz
  - Perform at 335 spectral frequencies between 0.1 Hz and 100 Hz (PGA)
  - Tabulate at 38 spectral frequencies

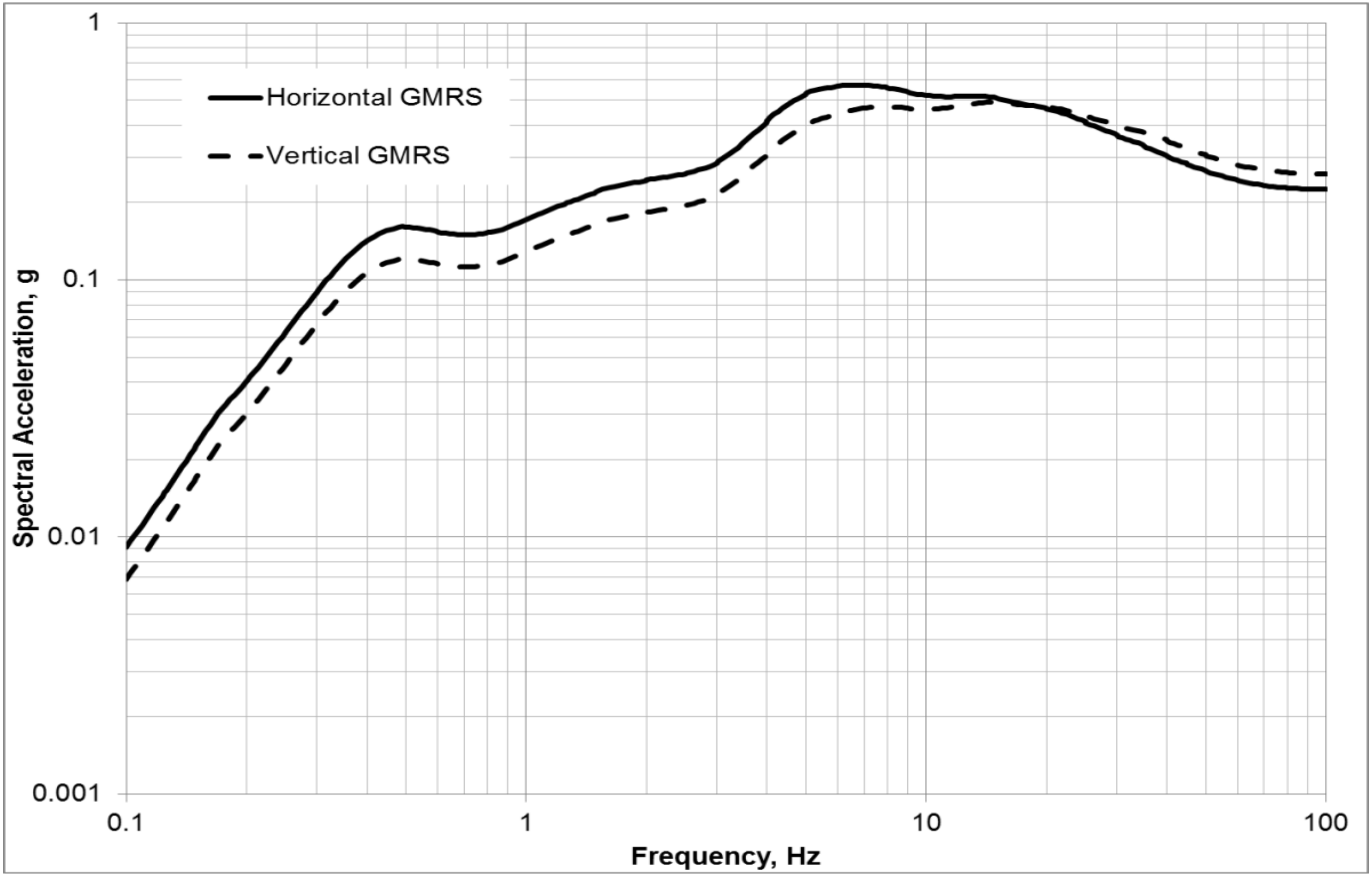
Vertical GMRS

- Recommended V/H ratio for PSEG Site:



2.5.2 Vibratory Ground Motion

Soil Hazard Results



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Chapter 2 – Section 2.5.4
Stability of Subsurface Materials and Foundations

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2.5.4 Stability of Subsurface Materials and Foundations

Focus on site geology and geotechnical characteristics

- Stratification variability
- Engineering properties
- Foundation support
- Dynamic properties for use in 2.5.2.

2.5.4 Stability of Subsurface Materials and Foundations

PSEG Site

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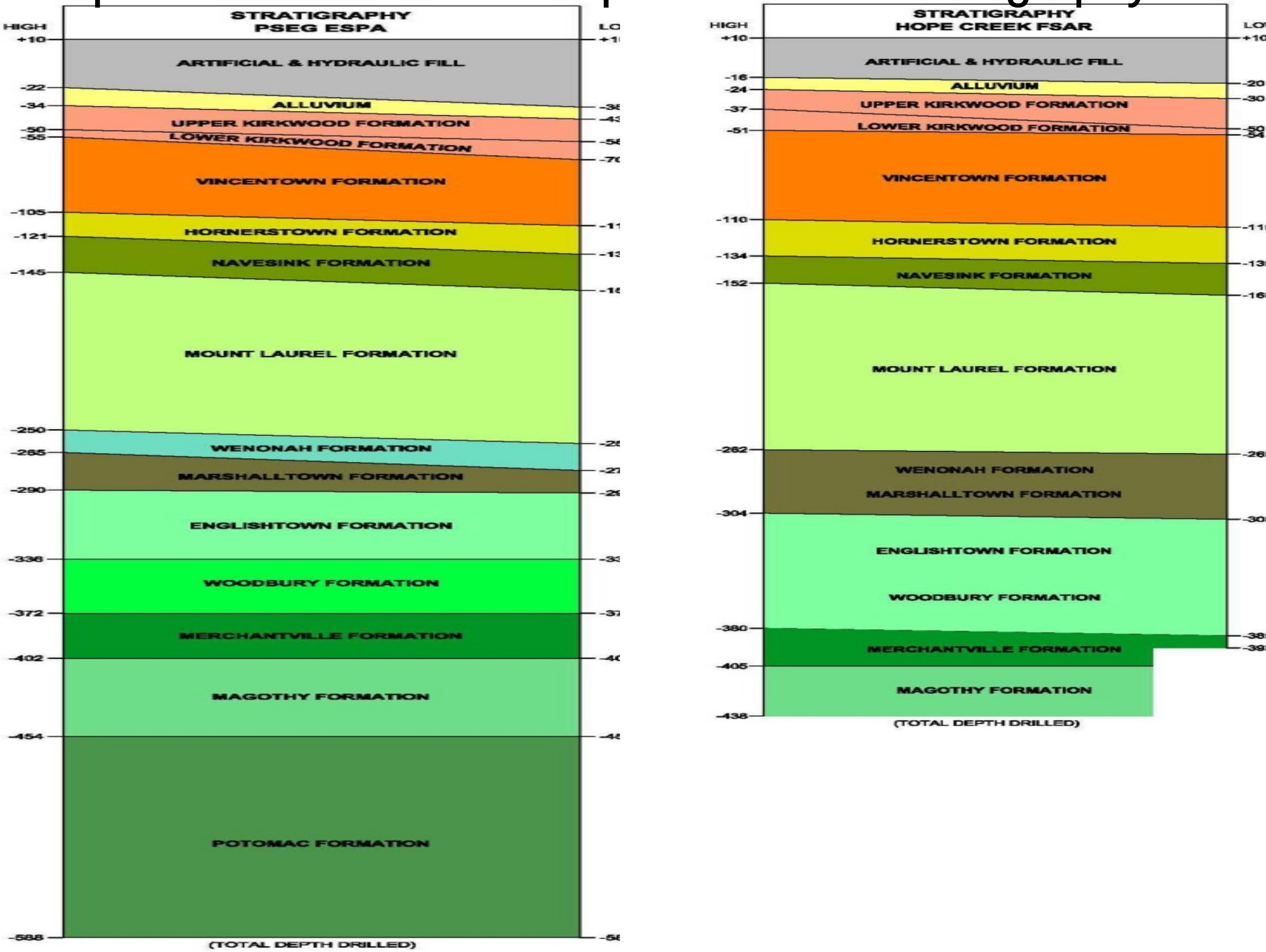
2.5.4 Stability of Subsurface Materials and Foundations

Exploration Approach

- Data collected in two areas (north, east)
- 16 borings 150 to 600 feet
  - SPT and UD sampling
- 4 borings with Geophysical and PS (shear wave velocity) logging
- 2 cross hole clusters (shear wave velocity)
- 32 water level observation wells
- Evaluation for geotechnical characteristics used data from all borings – north and east areas are consistent geologically

Comparison of PSEG and Hope Creek Site Stratigraphy



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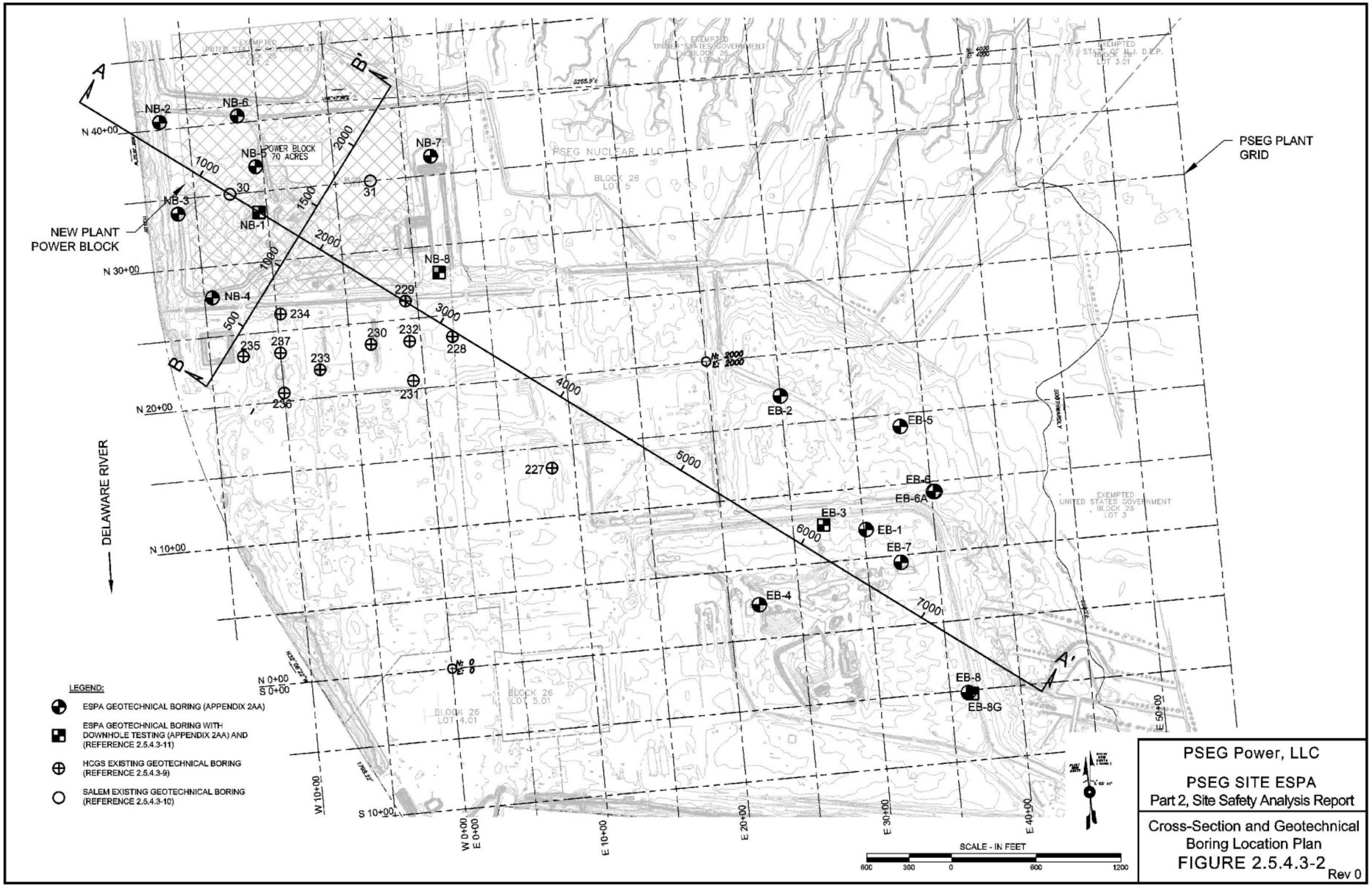
2.5.4 Stability of Subsurface Materials and Foundations

Boring Locations



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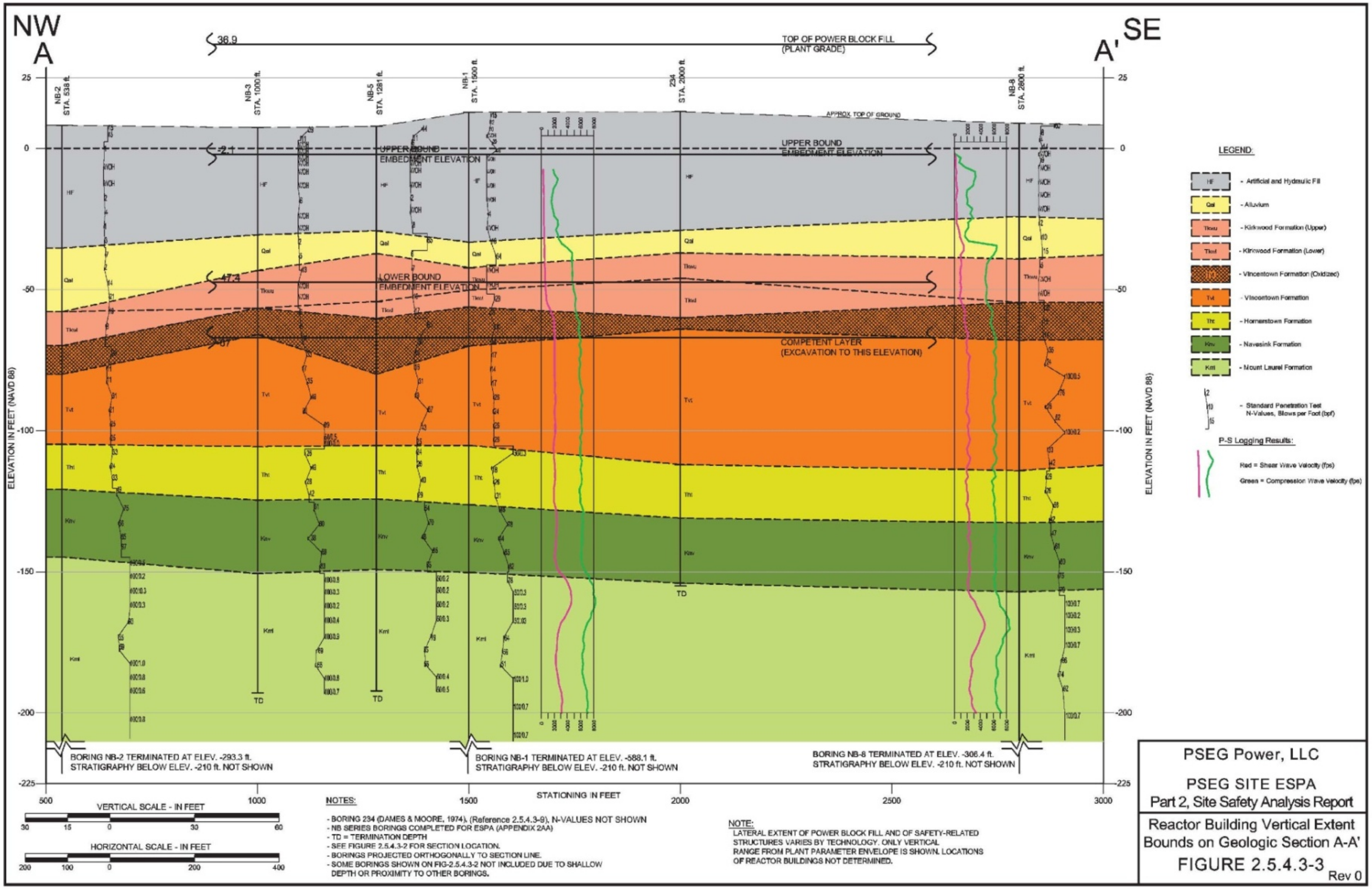
Geologic Geotechnical Section A-A (Down-dip)



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2.5.4 Stability of Subsurface Materials and Foundations

Geotechnical Summary

- Foundation Evaluation Approach
  - Soft fill, loose sands unsuitable
  - Identify Competent Layer for support
  - Excavate to competent layer and replace
  - Focus testing and analysis on materials below competent layer
- Laboratory Testing
  - Classification
  - Limited strength testing
- Geophysical Test Results
  - Shear wave velocity used to estimate elastic modulus

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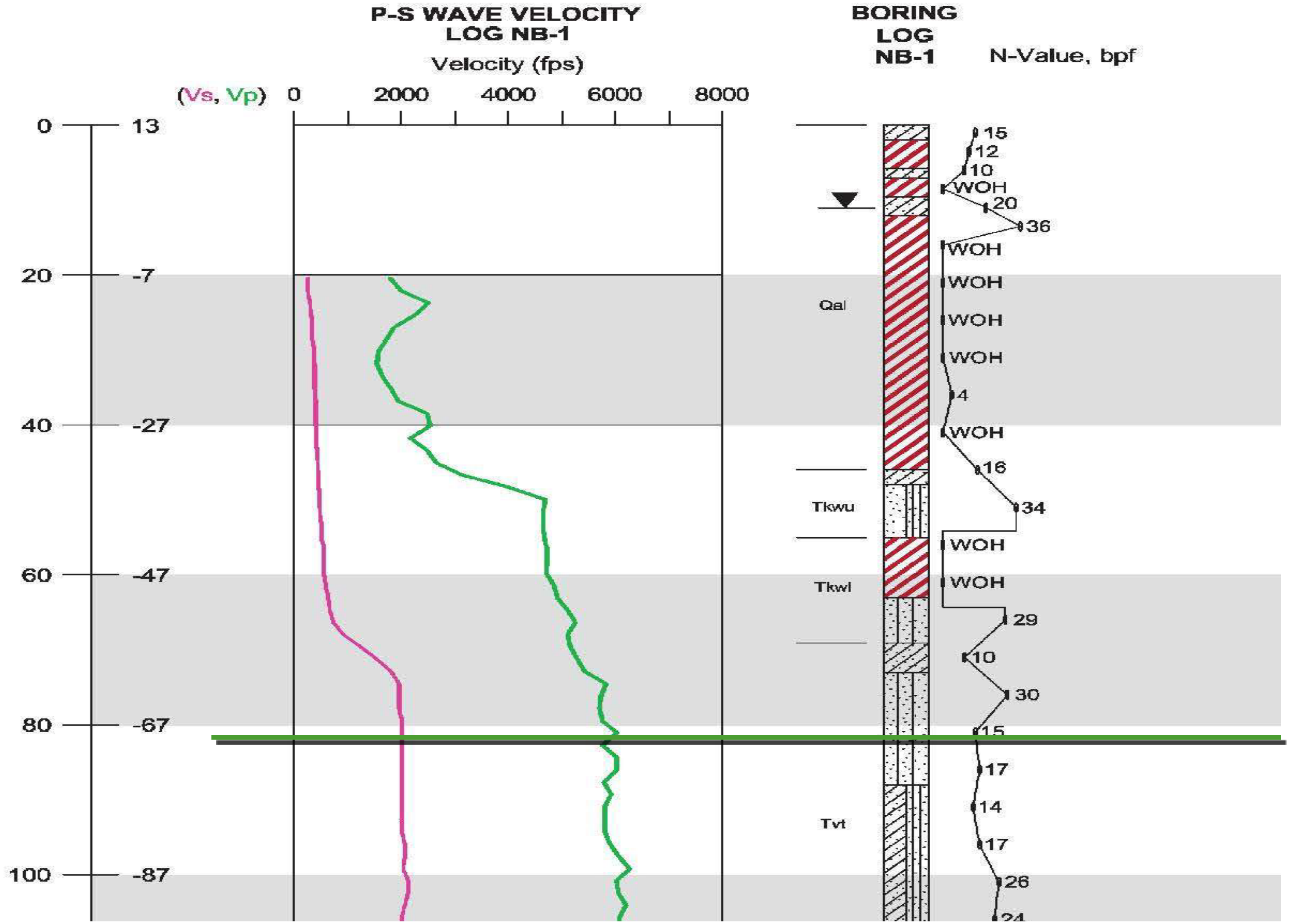
Basis of Competent Layer



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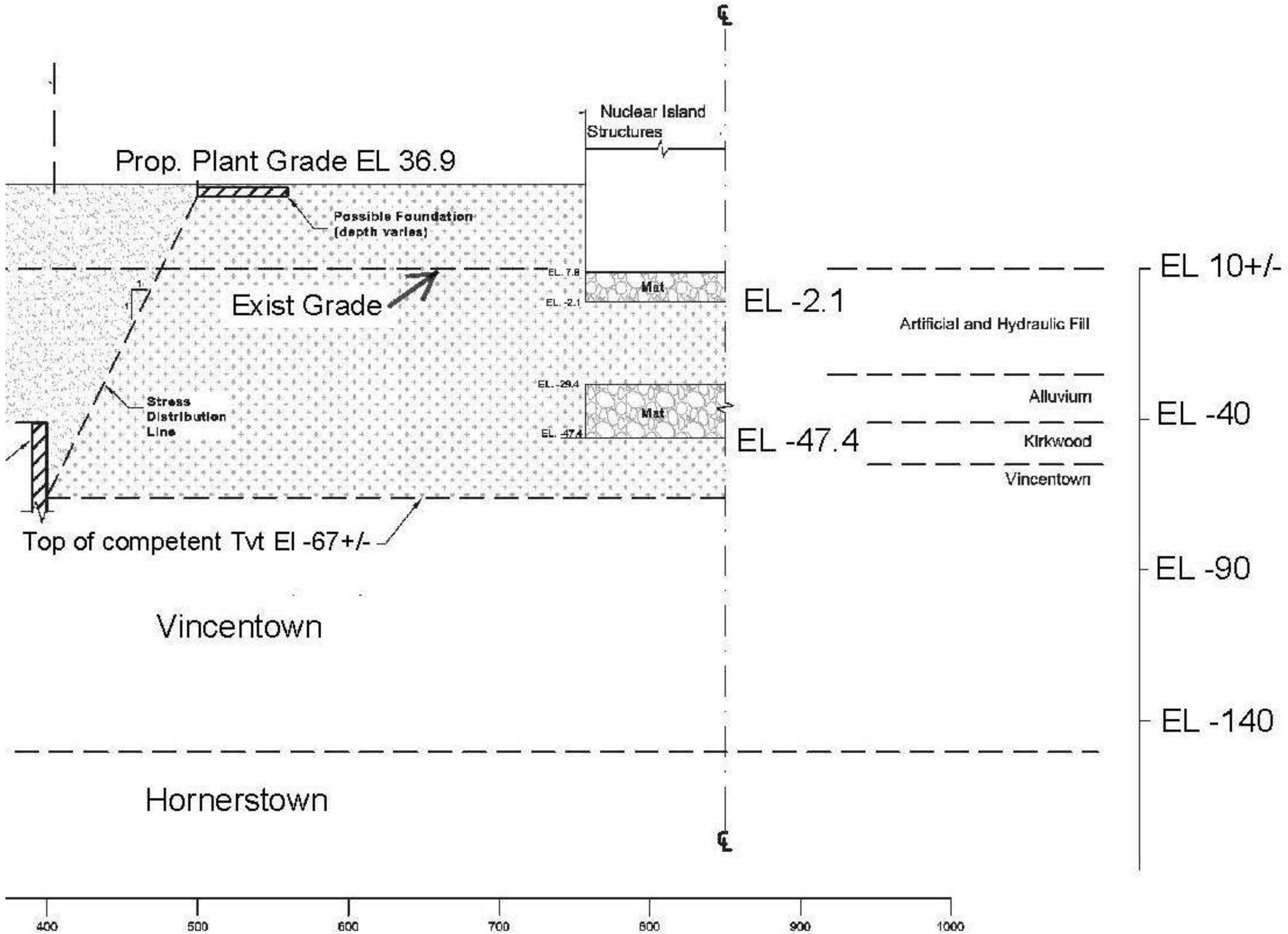
Variable Bearing Levels – 4 Technologies



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2.5.4 Stability of Subsurface Materials and Foundations

Bearing Capacity - Deep Mat Foundations

- Calculated ultimate bearing capacity
  - 420,000 to 678,000 psf static
  - Typical technology requires 15,000 to 35,000 psf static
  - Bearing capacity exceeds requirements by large margin
- Settlement
  - Elastic Methodology - sandy soils (two methods)
  - Used largest and heaviest technology
  - Approximately 2.6 inches at center, 1.5 at edge
  - Measured at Hope Creek – 1 to 1-1/2 with elastic response
  - Settlements are in acceptable range.

Liquefaction Summary

- Followed RG 1.198 methodology considered conditions below top of competent layer
- Evaluated on Composition, Geologic Age and SPT
- SPT Assessment most quantitative
  - “Simplified Procedure” (Youd, et al., 2001)
  - Updated based on new (higher) ground motions from CEUS-SSC
  - Two clayey formations not considered as liquefiable for SPT method (Woodbury and Merchantville)
  - 257 samples assessed; 32 had Factors of Safety <1.4 using Lower-bound Earthquake Magnitude Scaling Factor (MSF)

Conclusions

1. In ESP borings, some samples indicated potential for liquefaction in the Vincentown Formation in a conservative analysis.
2. Vincentown Formation is pre-Pleistocene age (~60 Ma); liquefaction not expected due to age.
3. Closer-spaced borings from Hope Creek and Salem also had instances of lower N-values on a isolated basis.
4. Site-wide liquefaction will not occur.
5. COLA borings will be closer spaced, and COLA studies will further evaluate liquefaction potential.
6. Foundation excavations will be inspected and local zones of concern will be excavated or remediated.
7. Items 5 and 6 above will addressed in the COLA.

2.5.4 Stability of Subsurface Materials and Foundations

Soil Dynamic Profile

- Developed below competent layer for use in 2.5.2
- Shear wave velocities within strata.
  - Based on geophysical logging down-hole and cross-hole
- Shear modulus degradation and damping variation with shear strain
  - Considered results from Resonant Column/Torsional Shear lab tests
    - Data inconsistent due to sampling difficulty and cemented layers in samples. Not representative of formations tested
    - Used computational methods of Darendeli (U. Texas)

Chapter 2 – Section 2.5.5
Stability of Slopes

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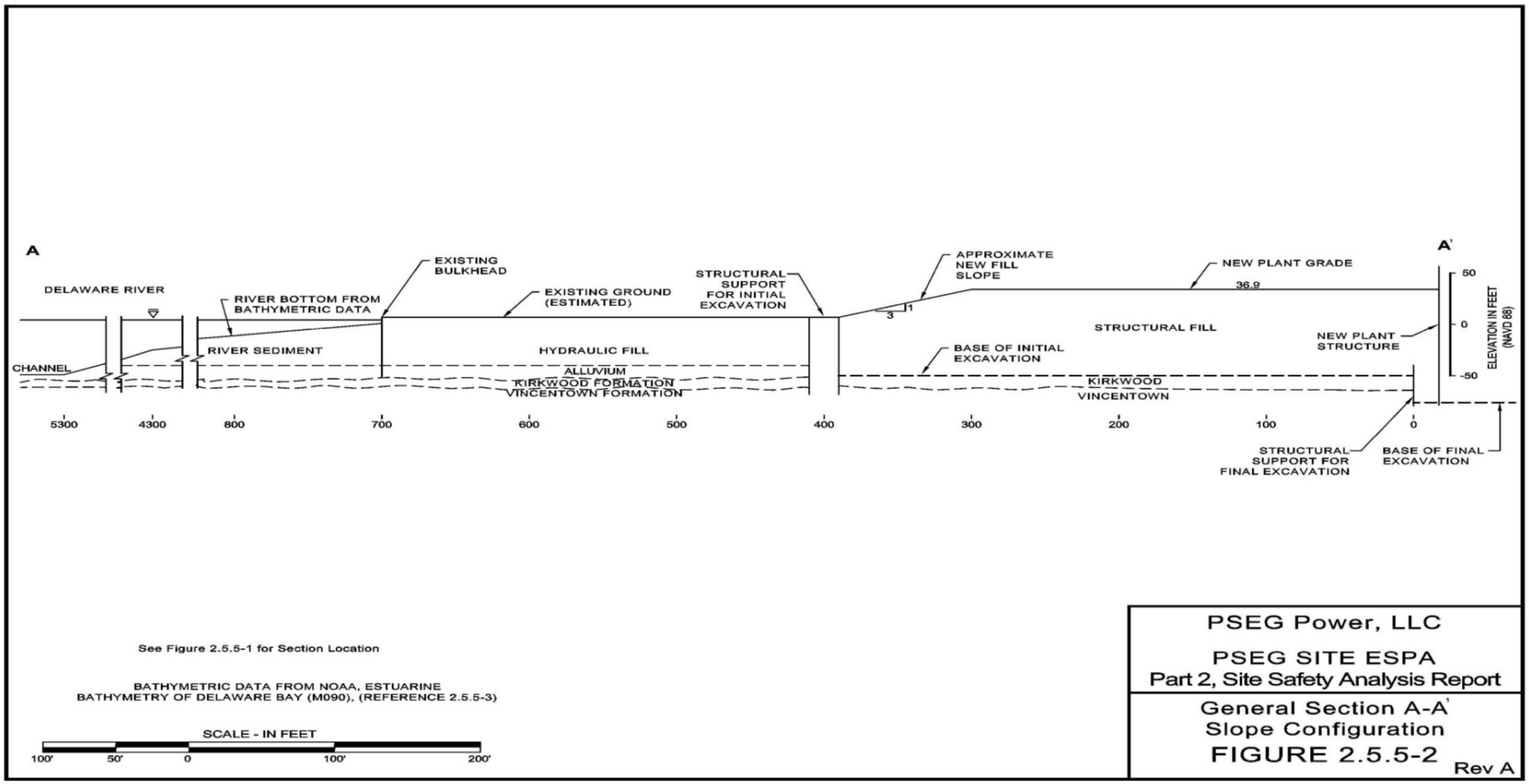
2.5.5 Stability of Slopes

Slope Stability

- Not calculated for ESP
- Permanent slopes planned at 3 (H):1(V), a typical slope



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Protecting People and the Environment

Presentation to the ACRS Subcommittee

Safety Review of the PSEG Site Early Site Permit Application

Presented by

Prosanta Chowdhury, Project Manager

NRO/DNRL/LB1

September 29 and 30, 2014

Chapter 2, Section 2.5

Geology, Seismology, and Geotechnical Engineering

(*ASE ADAMS Accession No. ML14226A921*)

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Site Visits / Audits

U.S.NRC
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- **January 2008 – Pre-application Site Visit**
  - Staff visited the site and interacted with the applicant regarding geologic, seismic, and geotechnical investigations being conducted for the ESP application
- **September 2011 – Site Audit**
  - Staff conducted an audit at the PSEG site to confirm interpretations, assumptions and conclusions presented by the applicant related to potential geologic and seismic hazards
- **September 2013 - Seismic Software Audit**
  - Staff also audited the seismic software used in seismic hazard calculations as part of its initiative to assess the industry's implementation of the new seismic source model described in NUREG-2115

Section 2.5.1 - Basic Geologic and Seismic Information

Section 2.5.3 - Surface Faulting

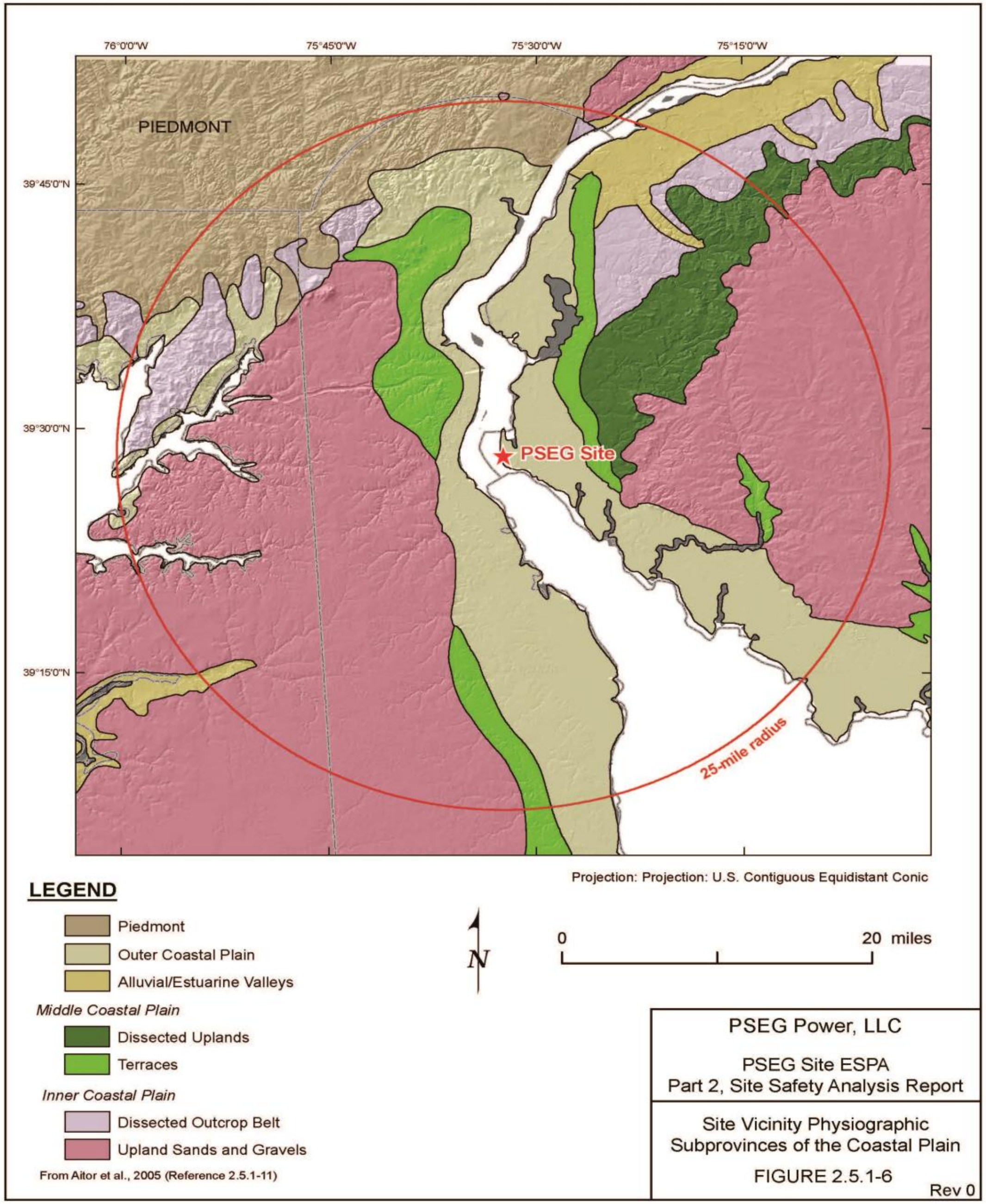
Content of PSEG ESP SSAR Sections 2.5.1 and 2.5.3

Section 2.5.1 - Basic Geologic and Seismic Information

- 2.5.1.1 on Regional Geology – Regional physiography and geomorphology, regional geologic history, regional stratigraphy, regional tectonic setting, seismic zones defined by regional seismicity, regional gravity and magnetic fields.
- 2.5.1.2 on Site Geology – Physiography and geomorphology, site stratigraphy and lithology, geologic history, structural geology, site engineering geology.

Section 2.5.3 - Surface Faulting

- 2.5.3.1 through 2.5.3.8 – Data related to potential for tectonic or non-tectonic surface deformation at the site.



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PSEG ESP site is located in the Outer Coastal Plain sub-province of the Coastal Plain physiographic province on the east side of the Delaware River.

Physiography of the PSEG ESP Site

Stratigraphic Column for the PSEG Site Area and Location

Era/Period	Epoch	Formation/Unit	Lithologies	Thickness
QUATERNARY	Holocene (recent)	Artificial fill	clays, silts, and sands of various proportions along with clayey and silty gravels	4.1 ± 5.1 feet
		Hydraulic fill	soft clayey silts, sandy silts and organic clays	33.5 ± 12.3 feet
	Pleistocene	Alluvium	fine to coarse sand and gravel; peat and organic rich soils; silt and clay near base	12.7 ± 12.3 feet
		~~ unconformity ~~~~~~~~		
TERTIARY	Upper Tertiary (Neogene)	Kirkwood Formation	*Upper member:* greenish-gray, silty, fine sand, fine sand and greenish-gray to brown organic clay with organic material and shell fragments; *Lower member:* fine to coarse sand and gravel with variable amounts of silt and clay	*Upper member:* 14.5 ± 7.7 feet; *Lower member:* 7.2 ± 7.8 feet
		~~ unconformity ~~~~~~~~		
	Lower Tertiary (Paleogene)	Vincentown Formation	greenish-gray, fine to medium grained silty sand with some zones of clayey sand; variably glauconitic; cemented zones	52.0 ± 26.1 feet
		Hornerstown Formation	greenish-gray to dark green silty and clayey quartz and glauconitic sand with indurated zones	18.6 ± 3.2 feet
CRETACEOUS	Upper Cretaceous	Navesink Formation	fossiliferous, dark green to greenish-black glauconitic sand; pelecypod fragments	24.3 ± 2.3 feet
		Mount Laurel Formation	brownish gray to dark green, fine to coarse grained sand; variable amounts of silt and clay; coarsening upward sequence	10.3 ± 3.5 feet
		Wenonah Formation	sandy clay with clayey sand	15 feet
		Marshalltown Formation	glauconitic, silty and clayey fine sand	25 feet
		Englishtown Formation	dark gray to black sandy clay to clayey sand with shell fragments grades to black silt with trace amounts of mica and glauconite	44 feet
		Woodbury Formation	black, micaceous clay	36 feet
		Merchantville Formation	dark greenish-black glauconitic silts and clays with variable amounts of sand	30 feet
		Magothy Formation	interbeds of gray to dark gray, locally mottled silts and clays that are interbedded with sands; trace amounts of lignite and carbonaceous material	52 feet
		~~ unconformity ~~~~~~~~		
	Lower Cretaceous	Potomac Group (Formation)	red, gray, and white mottled clay	1300 feet (Reference 2.5.1-17) PSEG No. 6 Production Well
		~~ pre-Cretaceous unconformity ~~~~~~~~		
PRECAMBRIAN TO PALEOZOIC	NeoProterozoic to Paleozoic	**Basement Complex**		
		Philadelphia Terrane	Wissahickon Schist – reported as residual clay (PSEG No. 6 Production Well)	undetermined

Foundation Unit (Vincentown Formation)

Staff Examining Samples from the PSEG ESP Site Location – 09/2011

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Vincentown Formation Is a Fine to Medium-Grained Silty Sand

Staff Conclusions for PSEG ESP SSAR Sections 2.5.1 and 2.5.3

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NRC staff makes the following upper level conclusions:

- Section 2.5.1 – No tectonic or non-tectonic features with the potential for adversely affecting suitability and safety of the PSEG site occur in the site region, site vicinity, or site area or at the site location.

- Section 2.5.3 – No potential for tectonic or non-tectonic surface deformation in the site vicinity or site area or at the site location that could adversely affect suitability of the PSEG site.

Key Review Topics of Interest for Section 2.5.1

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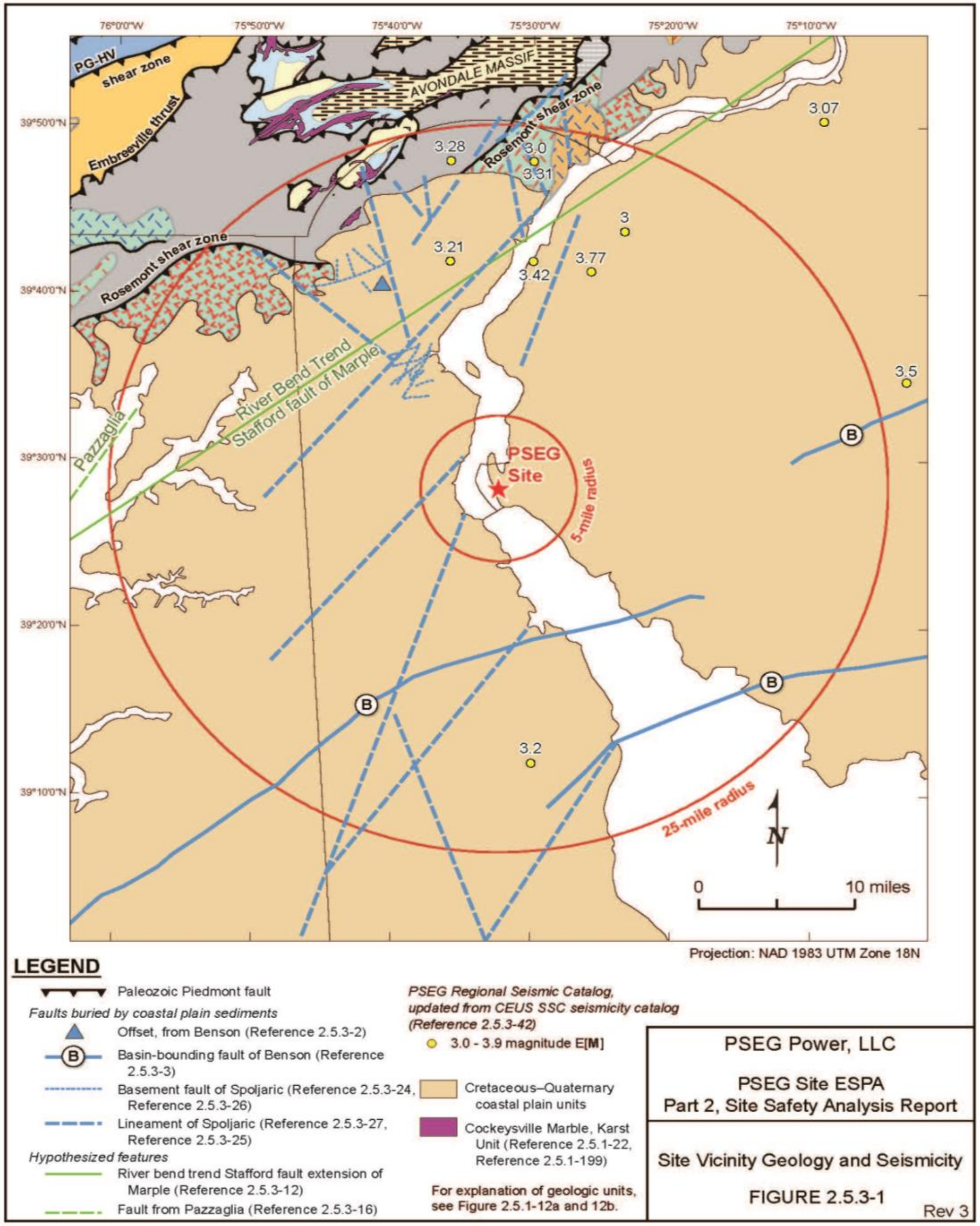
<u>Youngest regional faults hypothesized to extend into the PSEG site vicinity</u>, with primary focus on possible Quaternary (2.6 Ma to present) structures.

- Fault of Pazzaglia (1993) – Initially postulated to be Cenozoic (65.5 Ma to present) in age, if it exists. No geologic or geomorphic field evidence for Quaternary displacement, nor definitive spatially-associated seismicity, in the site vicinity.

- River Bend Trend/Stafford Fault of Marple (2004) – Initially postulated to be Tertiary (65.5 to 2.6 Ma) in age, if it exists. No geologic or geomorphic field evidence for Quaternary displacement, nor definitive spatially-associated seismicity, in the site vicinity.



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Locations of regional faults hypothesized by Pazzaglia (1993) and Marple (2004) to extend into the PSEG ESP site vicinity.

Based on field data, other proposed tectonic features shown in the site vicinity are not Quaternary in age, if they exist, and some features (i.e., the lineaments) are non-tectonic in origin.

Fault of Pazzaglia (1993)

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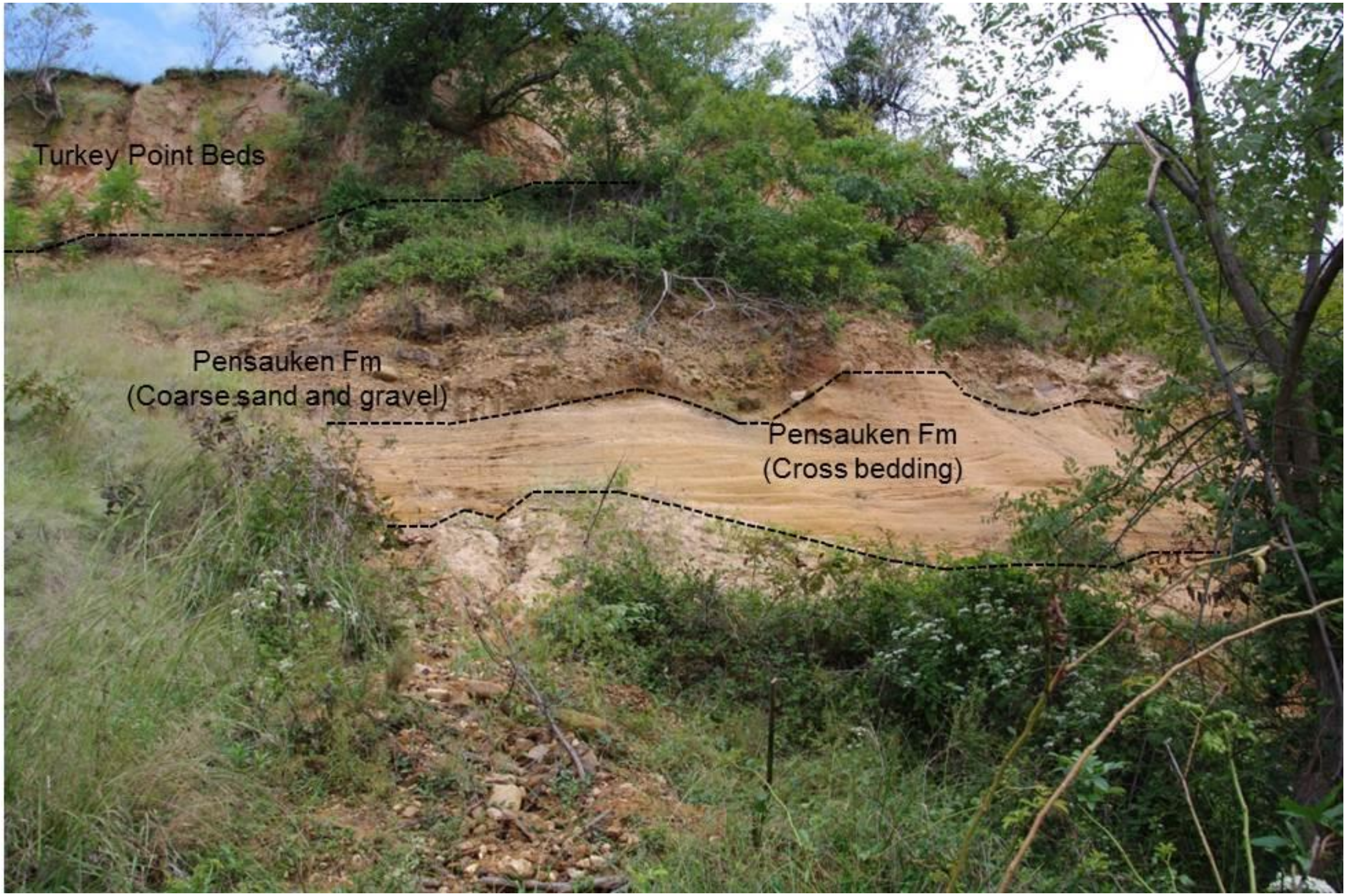
- Pazzaglia (1993) noted a variation of about 7.9 m (26 ft) for top of Pleistocene (2.6 to 0.01 Ma) sedimentary Turkey Point beds on opposite sides of the Chesapeake Bay west of the PSEG site, a distance of more than 15 km (9 mi). He postulated a fault as the cause of this elevation difference.
- Pazzaglia indicated to the applicant that original depositional relief was an equally plausible cause of the elevation difference and that no field evidence existed for a fault.
- Field reconnaissance and inspection of aerial imagery by the applicant also revealed no indicators of faulting along this hypothesized structure.
- During a site field audit in September 2011, staff examined undeformed Pliocene (5.3 to 2.6 Ma) sedimentary units of the Pensauken Formation and overlying Pleistocene (2.6 to 0.01 Ma) Turkey Point beds. No field evidence for faulting was indicated.

Exposure Examined by NRC Staff during a 09/2011 Site Audit – No Field Evidence for Faulting



Undeformed Pleistocene (2.6 to 0.01 Ma)Turkey Point beds overlying Pliocene (5.3 to 2.6 Ma) Pensauken Formation in the PSEG site vicinity

Key Review Topics of Interest for Section 2.5.3

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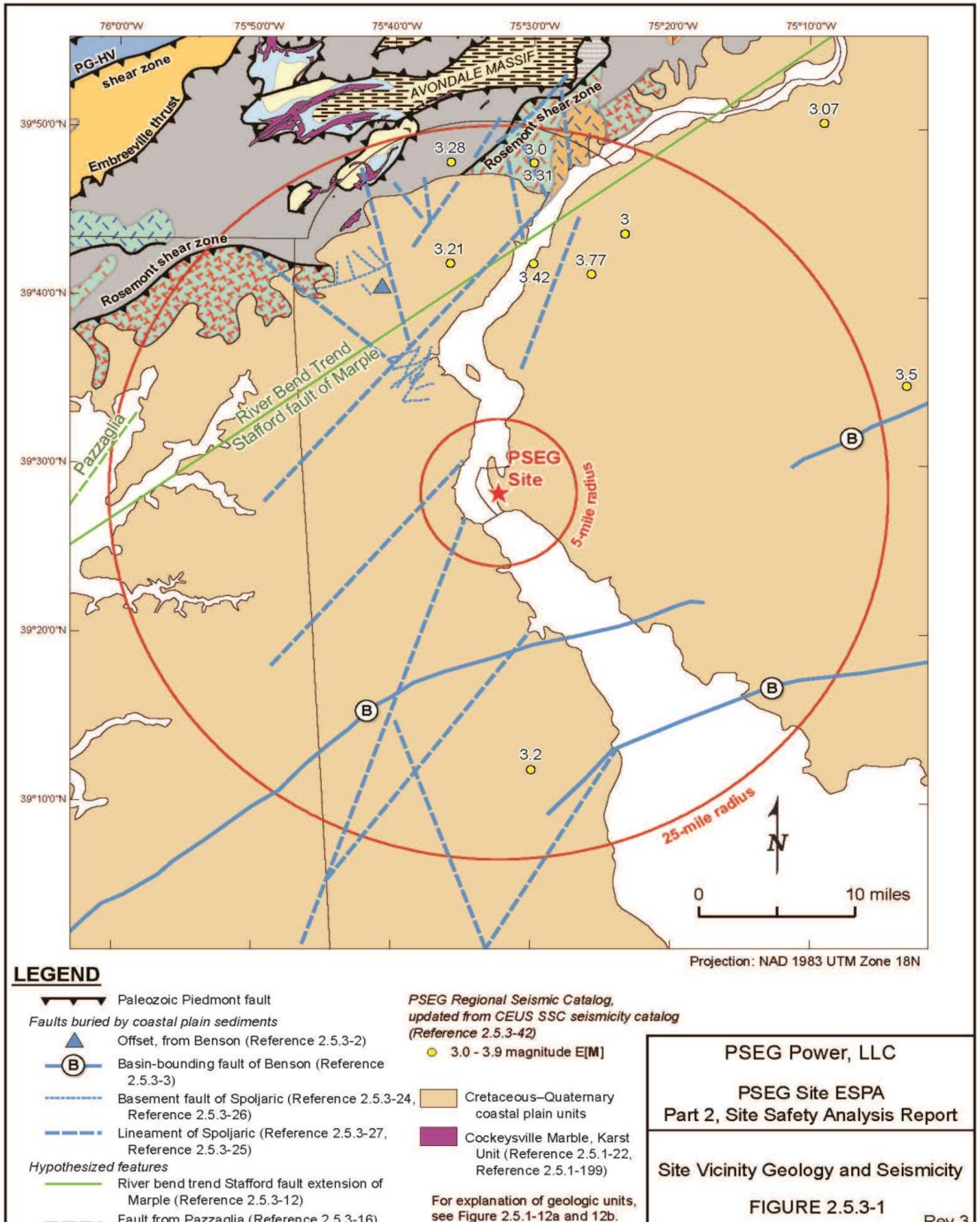
Interpreted buried faults and possible earthquake-induced paleoliquefaction features

- Faults buried beneath Coastal Plain sediments in the site vicinity – Mesozoic basin-bounding faults of Benson (1992); basement offset of Benson (2006); New Castle County faults, comprising surface lineaments and inferred pre-Cretaceous basement faults of Spoljaric (1972, 1973, 1974, 1979).

- Possible earthquake-induced paleoliquefaction features in and around the site vicinity – Light-colored “patches” with elliptical to rounded shapes northeast of the PSEG ESP site.



Locations of postulated buried faults in the PSEG ESP site vicinity.

Mesozoic basin-bounding faults (Benson,1992); basement offset (Benson, 2006); New Castle County faults, comprising surface lineaments and inferred pre-Cretaceous basement faults (Spoljaric, 1972, 1973, 1974, 1979).

No definitive spatially-associated seismicity.

Interpreted Buried Faults in the PSEG ESP Site Vicinity

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Interpreted faults buried beneath Coastal Plain sediments in the site vicinity

- Mesozoic (251 to 201.6 Ma) basin-bounding faults (Benson, 1992) – None underlie the site location.
- Offset basement rocks of Cretaceous (145.5 to 65.5 Ma) age (Benson, 2006) – No deformation of Quaternary deposits overlying basement based on geophysical well log data.
- New Castle County faults – Surface lineaments (Spoljaric, 1974 & 1979) and inferred subsurface pre-Cretaceous (> 65.5 Ma) basement faults (Spoljaric,1972 & 1973). No geologic or geomorphic data indicate they represent Quaternary (2.6 Ma to present) tectonic structures or are associated with surface faulting.

Possible Earthquake-Induced Paleoliquefaction Features

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Light-colored patches with elliptical to rounded shapes northeast of the PSEG ESP site

- Multiple features with these characteristics occur in the site vicinity and site area and along Delaware Bay.
- Occur over a broad area on both the Delmarva Peninsula, which includes most of Delaware and parts of Maryland and Virginia, and in the Coastal Plain of New Jersey.
- Reconnaissance by the applicant at one of the “patches” revealed no definitive evidence for an earthquake-induced (i.e., tectonic) liquefaction origin.
- Based on the broad distribution of these features, multiple authors interpret them as resulting from processes occurring at the immediate margins of former ice sheets or glaciers.

Permit Condition on Detailed Geologic Mapping of Excavations for Safety-Related Engineered Structures

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In SSAR Section 2.5.4.5.4.1 (“Mat Foundation Evaluation”), the applicant acknowledged the need to perform detailed geologic mapping for documenting the presence or absence of faults and shear zones in plant foundation materials. To address this need, the staff identified Permit Condition 1 in SE Section 2.5.3.5 as stated below:

- An applicant for a combined license (COL) or construction permit (CP) that references this early site permit shall perform detailed geologic mapping of excavations for safety-related structures; examine and evaluate geologic features discovered in those excavations; and notify the Director of the Office of New Reactors, or the Director’s designee, once excavations for safety-related structures are open for examination by NRC staff.

Section 2.5.2 – Vibratory Ground Motion

Content of PSEG ESP SSAR Section 2.5.2

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- Seismicity
- Geologic and tectonic characterization of the site and region
- Correlation of earthquake activity with seismic sources
- PSHA and controlling earthquakes
- Seismic wave transmission
- GMRS

Key Review Topics of Interest for Section 2.5.2

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- Original ESP SSAR, submitted in 2010, used the EPRI-SOG seismic source models
- January 2012 – New seismic source models were published in NUREG-2115 (CEUS-SSC model)
- Fukushima NTTF recommendations and subsequent RAI prompted a significant change in Section 2.5.2 as the applicant changed its seismic source models from the EPRI-SOG models to the newly published CEUS-SSC model
- This change in seismic source models resulted in complete reanalysis and revision of ESP SSAR Section 2.5.2
  - Many original RAIs became irrelevant. Two new RAIs were added and are now resolved by NRC Staff.

Seismicity Updates

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- NUREG-2115 SSC model includes an earthquake catalog complete through 2008
- Applicant provided quantitative analysis of earthquakes occurring within 320 km (200 mi) of the site from 2009 through 2011
- Staff developed its own updated earthquake catalog to conclude:
  - most recent earthquakes are located within identified active CEUS seismic regions and do not add any new information to the catalog used by applicant
  - the Mineral VA earthquake is the most important earthquake in the updated earthquake catalog

Seismicity Updates

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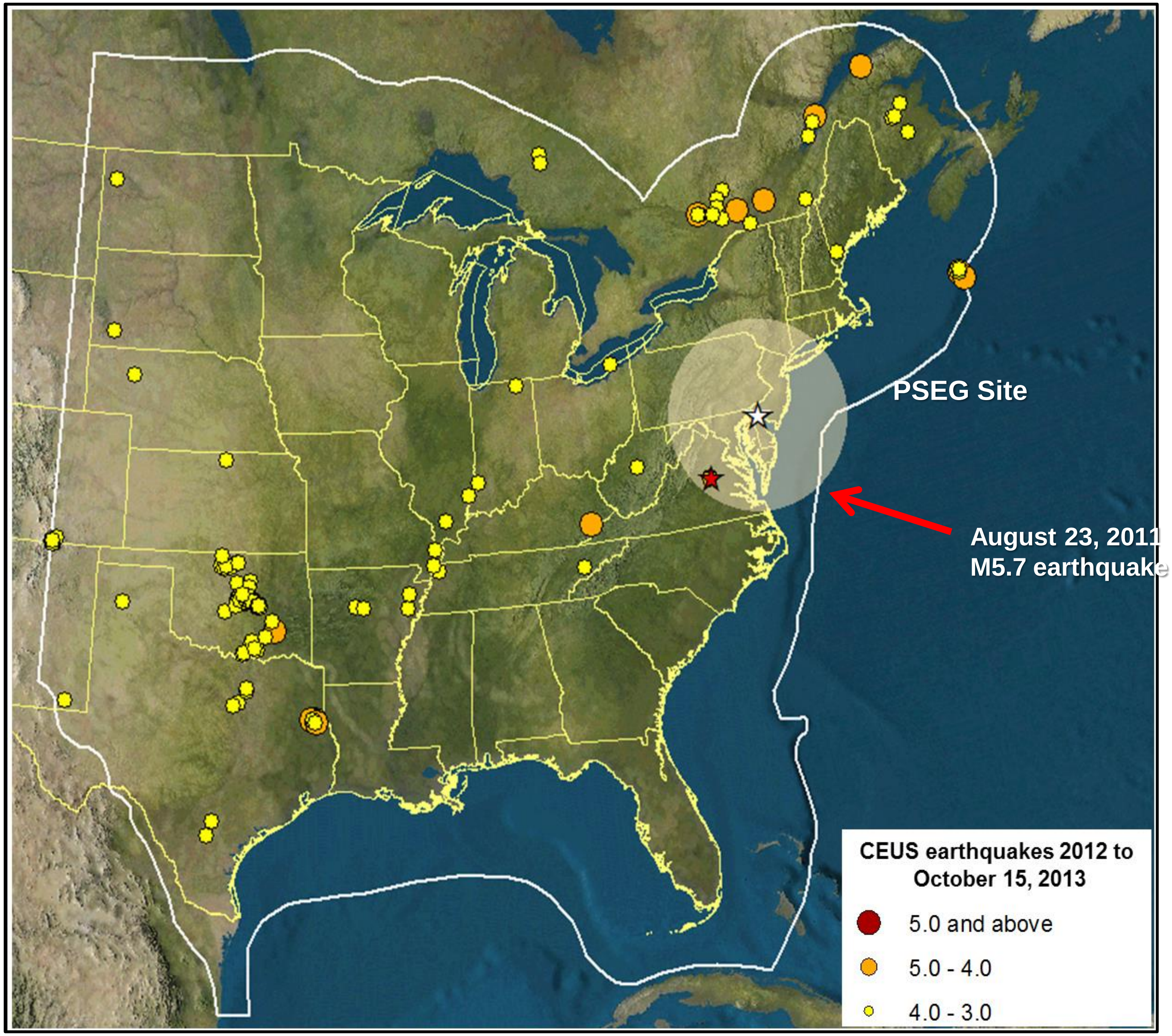
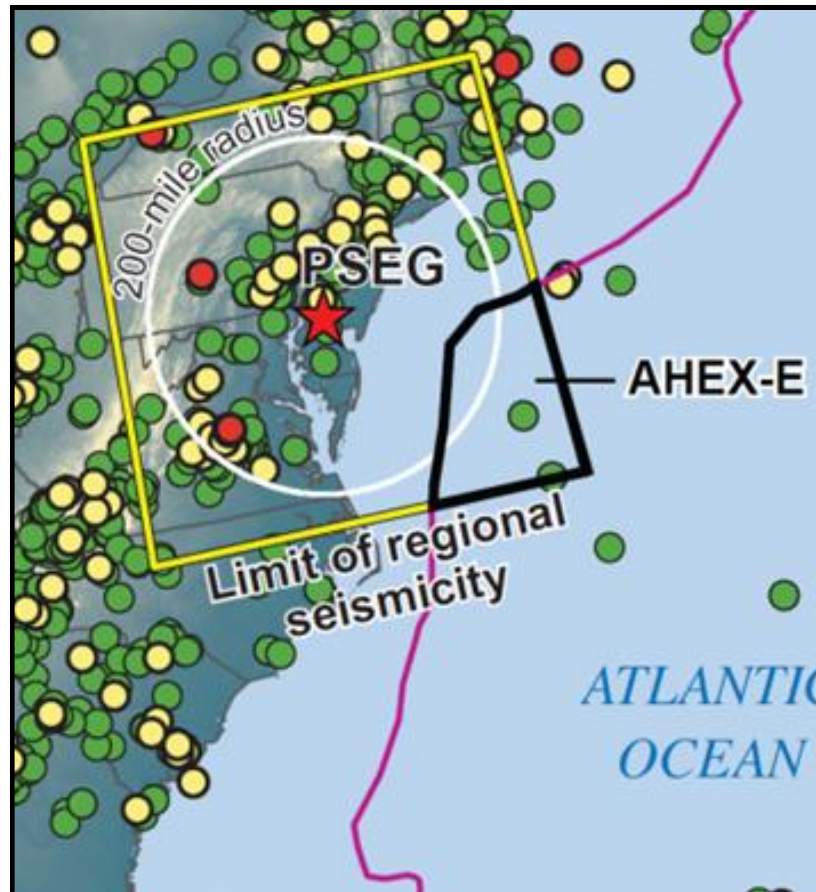


USGS Advanced National Seismic Network Catalog (ANSS)

Seismic Source Updates: AHEX-E

- NUREG-2115 model boundary does not cover the 320 km (200 mi) PSEG site region
- Applicant created a new seismic source zone (AHEX-E)
- Staff evaluation concluded that seismicity is very limited in this region, therefore there is no significant impact on the total seismic hazard calculations.
- Staff concludes PSHA inputs are consistent with RG 1.208



(Subset of Figure 2.5.2-57 from SSAR)

Potential Impact of Mineral VA Earthquake on PSEG Seismic Hazard

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- **Issue:** The Mineral earthquake (August 23, 2011, **M**5.7) is not included in the NUREG-2115 seismic source model. Staff asked the applicant to assess this earthquake's impact on the seismic hazard at the PSEG site

- **Resolution:** Applicant conducted a sensitivity study. Applicant's sensitivity studies indicated that this earthquake had little impact on the total seismic hazard calculated at the PSEG site.

Potential Impact of Mineral VA Earthquake on PSEG Seismic Hazard

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The applicant's sensitivity study showed:

- Earthquake modestly increased the recurrence rates at the vicinity of the epicenter
- The rate increases translated into 1.4% and 0.9% increases in the background and total seismic hazard values at the site, respectively
- NRC staff concluded that the effect of the Mineral earthquake on the total site hazard at the PSEG site is negligible and that the applicant's use of the original CEUS SSC model earthquake recurrence parameters are acceptable

Modification of NUREG-2115 Seismic Source Model

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- **Issue**: In accordance with NUREG-2115, staff asked the applicant to justify seismic source model simplifications used in PSEG seismic hazard calculations

- **Resolution**: The applicant performed sensitivity calculations and compared the hazard from using the simplified point source model for background sources in the PSHA analysis to the hazard from using the finite rupture model as described in the NUREG-2115 model to show that the impact is minimal

Modification of NUREG-2115 Seismic Source Model

- The applicant's sensitivity study specifically showed that for select individual seismic sources, the hazard curves at the 10^{-4} and 10^{-5} annual exceedance frequencies increase by up to 15% due to the use of full source rupture models
- Staff concluded that even though the individual seismic sources' hazard contributions maybe higher by up to 15%, the overall percentage increases in the total seismic hazard curves at the site are significantly lower
- Staff considers the differences calculated in this sensitivity study to be within the uncertainty in the overall PSHA calculations

PSHA Confirmatory Calculations

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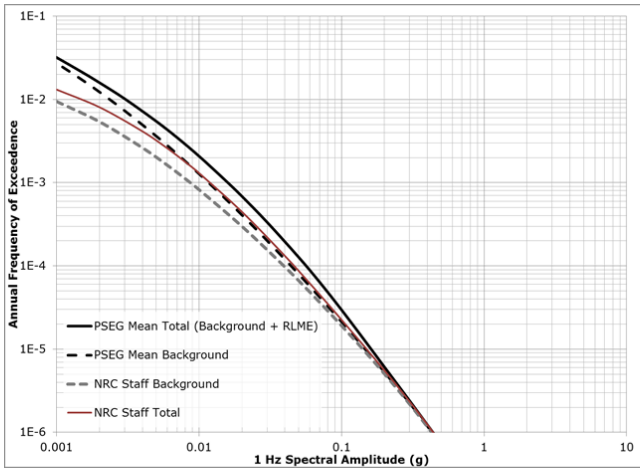
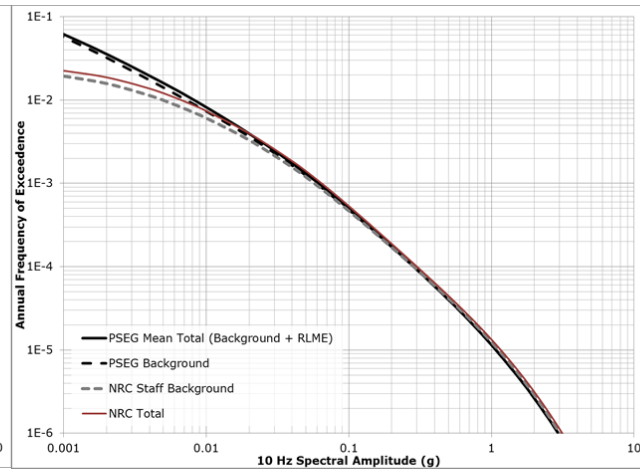
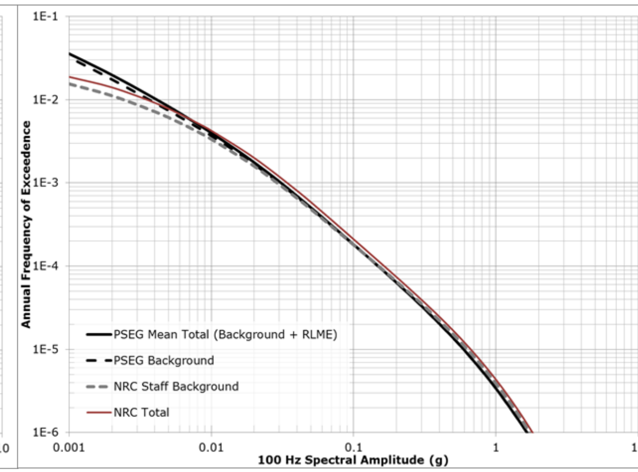
1 Hz



10 Hz

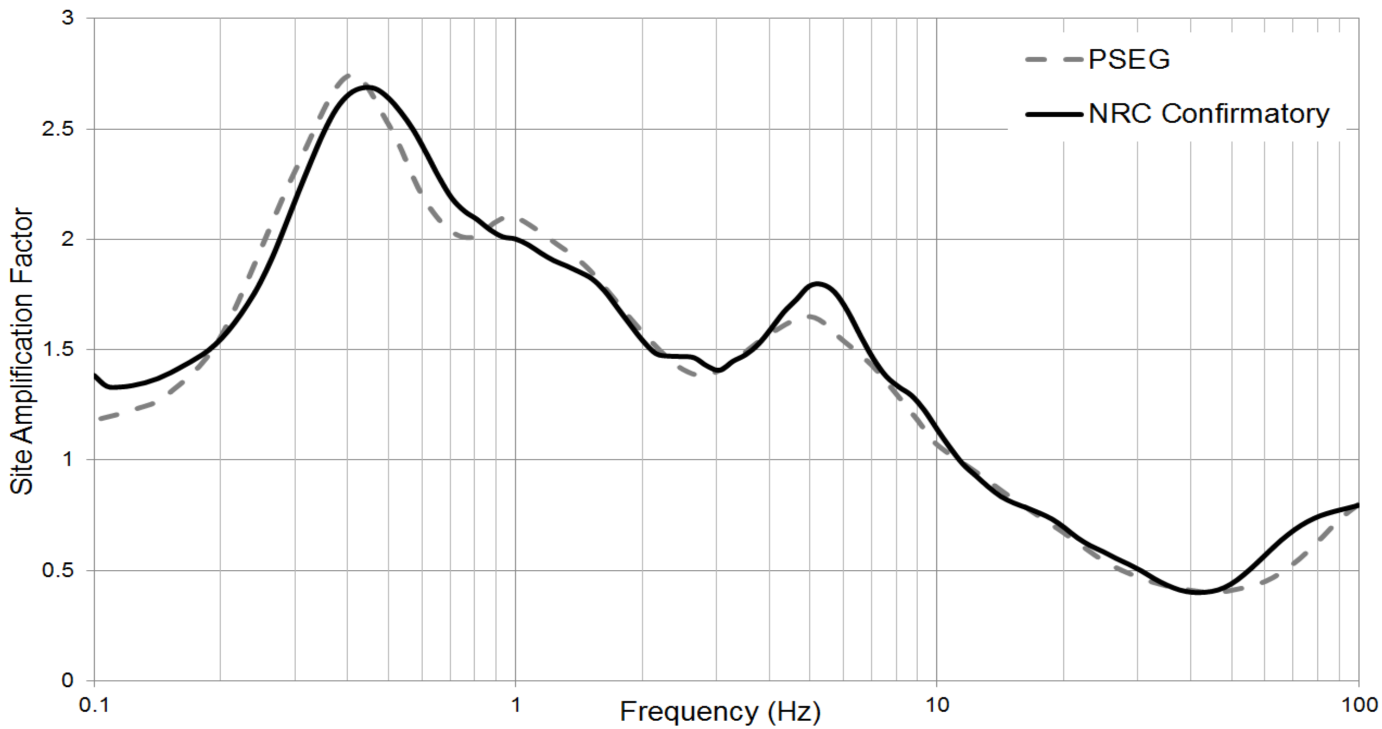


100 Hz



Staff independently calculated seismic hazard curves at the PSEG site. Comparisons show that the seismic hazard curves are in good agreement at the annual frequency of exceedances of interest: 10^{-4}, 10^{-5}, and 10^{-6}

Site Response Confirmatory Calculations



- Staff conducted confirmatory site response calculations using the same input parameters used by the applicant
- Staff also conducted alternative calculations to investigate potential impacts of parameter uncertainty in the calculations

Staff Conclusions - Section 2.5.2

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- The applicant provided a thorough characterization of the seismic sources surrounding the site, as required by 10 CFR 100.23
- The applicant adequately addressed the uncertainties inherent in the characterization of these seismic sources through a PSHA, and its PSHA follows the guidance provided in RG 1.208
- Applicant’s GMRS adequately represents the regional and local seismic hazards and accurately includes the effects of the local site subsurface properties

Section 2.5.4 - Stability of Subsurface Materials and Foundations

Summary of PSEG ESP SSAR Section 2.5.4

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- SSAR Section 2.5.4 presents the stability of subsurface materials and foundations related to the PSEG Site. The staff's review included the evaluation of:
  - Engineering properties of subsurface materials; Foundation Interfaces; Geophysical Surveys; Excavation and Backfill; Groundwater Conditions; Response of Soil and Rock Dynamic Loading; Liquefaction Potential; Static Stability
- SER Section 2.5.4 includes:
  - 19 COL Action Items
  - 1 Confirmatory Item
  - 1 Permit Condition – Liquefaction

PSEG ESP Site Exploration

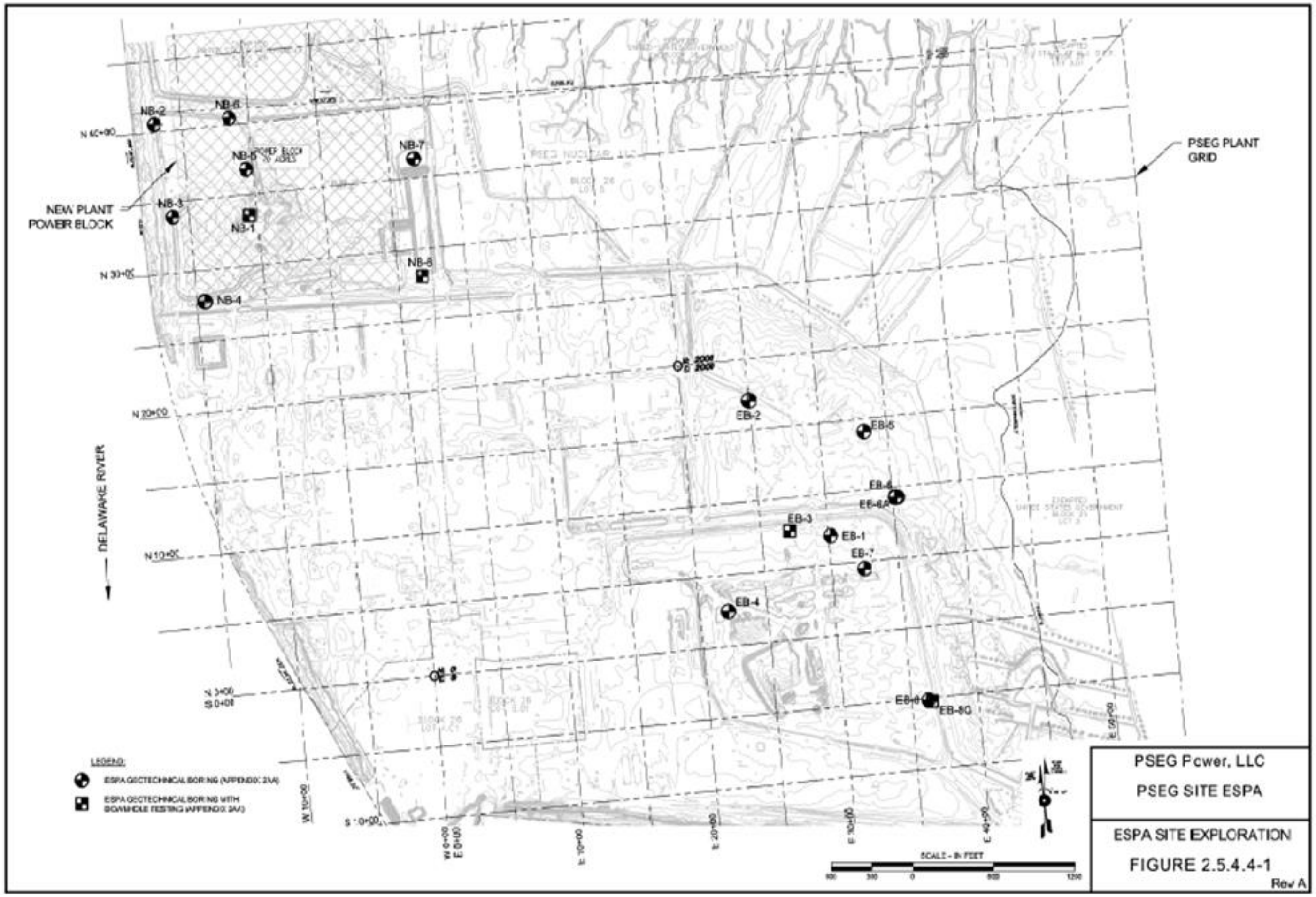

Figure 2.5.4-2 **(Reproduced from SSAR Figure 2.5.4.4-1)**

Site Stratigraphy

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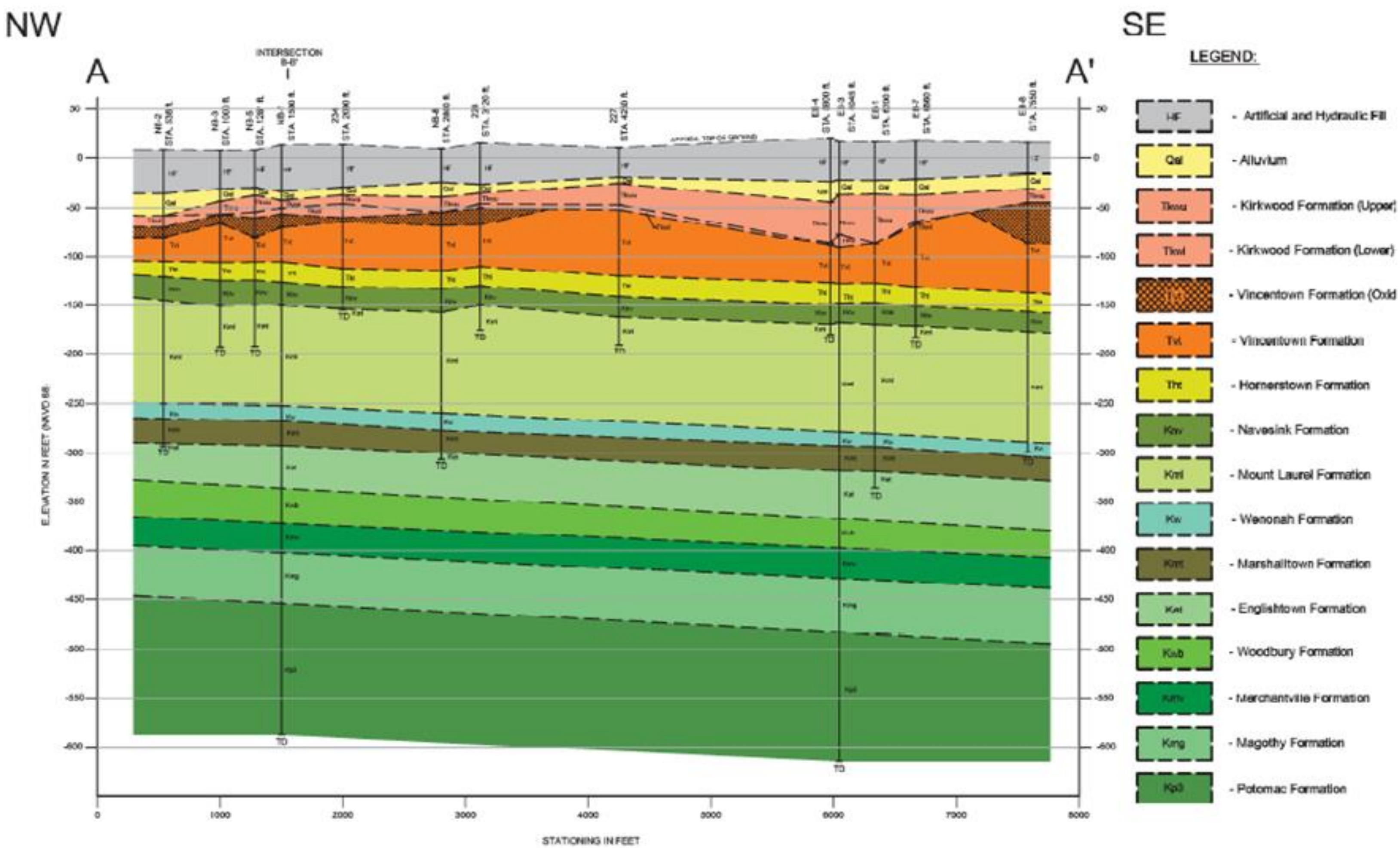

Figure 2.5.4-1 Stratigraphic Cross-Section **(Reproduced from SSAR Figure 2.5.4.1-4)**

Plant Parameter Envelope

- In order to provide sufficient geotechnical information at the site without having a specific design, the applicant provided a surrogate design in its application. The surrogate plant approach covers a set of bounding parameters: the plant parameter envelope (PPE).

- Under the PPE approach, ESP applicants do not reference any specific reactor technology and the resulting ESP is applicable for a range of reactor designs.

COL Action Items

COL Action Items 2.5-1 through 2.5-19 will need to be addressed at the COL stage based on selected reactor technology; these items are related to the following site characteristics -

- Static Properties
- Dynamic Properties
- Backfill Criteria
- Groundwater
- Liquefaction
- Static Stability
- Design Criteria

Permit Condition

The applicant stated that the soils above the Vincentown Formation (location of proposed safety related structures) present unsuitable engineering characteristics, and will be removed to reach the competent material and replaced with a suitable backfill. Consistent with the applicant's commitment, the staff identified **Permit Condition 2** in SE Section 2.5.4.4.8 as stated below:

> An applicant for a combined license (COL) or a construction permit (CP) that references this early site permit shall remove and replace the soils directly above the Vincentown Formation for soils under or adjacent to Seismic Category I structures to reduce any liquefaction potential.

ITAAC

- COL Action item 2.5-8 states:

An applicant for a combined license (COL) that references this early site permit should include in the COL application, an ITAAC for the soil backfill, with specifications to ensure a Vs of 304.8 m/s (1,000 ft/s) or higher below Seismic Category I structures.

Staff Conclusions – Section 2.5.4

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- The applicant adequately determined the site-specific engineering properties of the soil underlying the ESP site following state of the art methodology for its field and laboratory methods and in accordance with RG 1.132, RG 1.138, and RG 1.198.

- Subject to Permit Condition 2, the staff concludes that the applicant meets the requirements of 10 CFR Part 52, Subpart A, applicable to “Stability of Subsurface Materials and Foundations,” for an early site permit.

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Section 2.5.5 - Stability of Slopes

COL Action Item

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The NRC staff reviewed SSAR Section 2.5.5, which provides the applicant's general description of its plan for future slope stability analysis at the COL stage. While the general description was useful to the staff in performing the ESP application review, to address the need for slope stability analyses, the staff identified COL Action Item 2.5-20 as stated below:

> An applicant for a combined license (COL) that references this early site permit, should perform a slope stability analysis consistent with the selected reactor technology. Slope stability analysis will include the evaluation of deep slope failure surfaces that may extend into the Delaware River and various water level considerations.

Staff Conclusions – Section 2.5.5

The staff evaluation of slope stability will be performed as part of its review of the COL or CP application.

Questions?

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Presentation to the ACRS Subcommittee

Safety Conclusions from the Review of the PSEG Site Early Site Permit Application

Presented by

Prosanta Chowdhury, Project Manager

NRO/DNRL/LB1

September 29 and 30, 2014

SER Conclusions

- ASER defers general regulatory conclusion regarding site safety and suitability to FSER in Phase D
- Some Conclusions from individual sections:
  - Subject to Permit Conditions 1 and 2, the applicant has provided necessary and sufficient information to meet the regulatory requirements for determining the acceptability of the PSEG Site. (**Ch. 2.1&2.2**)
  - The identification and consideration of the climatic site characteristics are acceptable and meet the regulatory requirements (**Ch. 2.3.1**)
  - Applicant's identification and consideration of the meteorological, air quality, and topographical characteristics of the site and the surrounding area meet the regulatory requirements for determining the acceptability of the site. (**Ch. 2.3.2**)
  - Applicant has identified the most severe local weather phenomena at the proposed PSEG Site and surrounding area. (**Ch. 2.3.2**)

SER Conclusions

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- Staff concludes that the onsite meteorological monitoring system provides adequate data to represent onsite meteorological conditions as required by 10 CFR 100.20 and 10 CFR 100.21 (**Ch. 2.3.3**)
- Staff concludes that the applicant has established site characteristics and design parameters acceptable to meet the requirements of 10 CFR 52.17(a)(1)(ix), 10 CFR 100.21(c)(2), and 10 CFR 100.20(c) (**Ch. 2.3.4**)
- Staff concludes that representative atmospheric dispersion and deposition conditions have been calculated for specific locations of potential receptors of interest. The characterization of atmospheric dispersion and deposition conditions meet the requirements of 10 CFR 100.21(c)(1) and are appropriate for the evaluation to demonstrate compliance with the numerical guides for doses for any individual located offsite contained in 10 CFR Part 50, Appendix I. (**Ch. 2.3.5**)

SER Conclusions

- No tectonic or non-tectonic features with the potential for adversely affecting suitability and safety of the PSEG site occur in the site region, site vicinity, or site area or at the site location. (**Ch. 2.5.1**)
- No potential for tectonic or non-tectonic surface deformation in the site vicinity or site area or at the site location that could adversely affect suitability of the PSEG site. (**Ch. 2.5.3**)
- The applicant adequately addressed the uncertainties inherent in the characterization of these seismic sources through a PSHA, and its PSHA follows the guidance provided in RG 1.208. (**Ch. 2.5.2**)
- Applicant's GMRS adequately represents the regional and local seismic hazards and accurately includes the effects of the local site subsurface properties. (**Ch. 2.5.2**)

SER Conclusions

- The applicant adequately determined the site-specific engineering properties of the soil underlying the ESP site in accordance with RG 1.132, RG 1.138, and RG 1.198, and meets the regulatory requirements for an early site permit. (**Ch. 2.5.4**)

- Slope stability analysis to be performed by COL applicant (referencing this ESP) consistent with the selected reactor technology. The analysis will include the evaluation of deep slope failure surfaces that may extend into the Delaware River and various water level considerations. (**Ch. 2.5.5**)

Presentation Conclusion

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- ASE with no Open Items on Chapters 2, Sections 2.1 & 2.2 (combined), Section 2.3, and Section 2.5 Issued on 1/2014 and 7/2014:
  - 2 Permit Conditions and 2 COL Action Items (**Ch. 2.1 & 2.2**)
  - 1 COL Action Item (**Ch. 2.3**)
  - 2 Permit Conditions and 20 COL Action Items (**Ch. 2.5**)
- Next Interaction with ACRS – TBD