Information Exchange
WBN Seismic Hazard

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- **NRC May 9 Prioritization Letter**
  - Seismic Risk Evaluation
    - Prioritization Group 1
  - WBN Acknowledges
    - Prioritization Group 1
    - Seismic risk evaluation by June 30, 2017
    - ESEP – RLGM – 2 x SSE
- **NRC May 21 Support Document**
  - Preliminary graphical representation
    - NRC staff GMRS differs from Licensee GMRS

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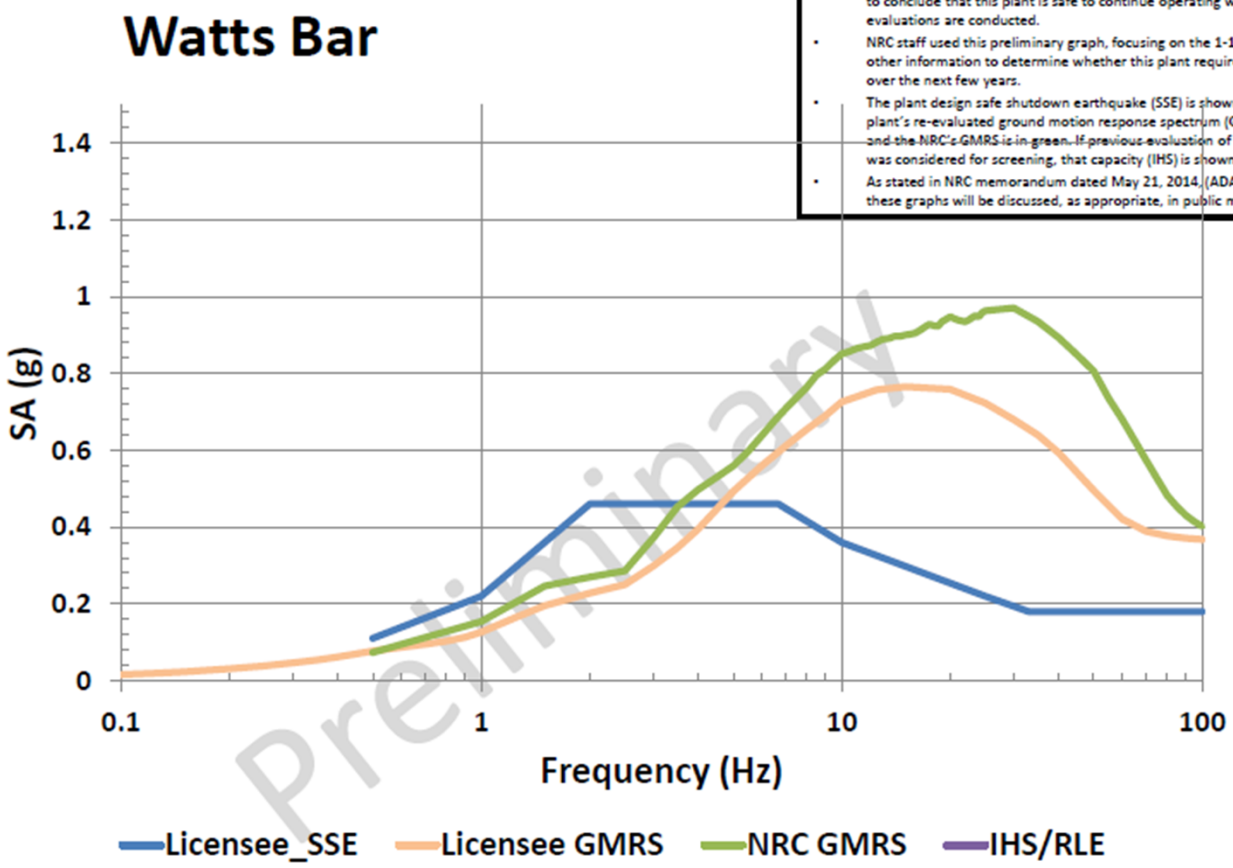
- As discussed in the May 9, 2014, letter (ADAMS ML14111A147), the NRC considered the re-evaluated hazard and previous estimates of plant capacity to conclude that this plant is safe to continue operating while additional evaluations are conducted.
- NRC staff used this preliminary graph, focusing on the 1-10 Hertz range, and other information to determine whether this plant requires a risk evaluation over the next few years.
- The plant design safe shutdown earthquake (SSE) is shown in blue; the plant's re-evaluated ground motion response spectrum (GMRS) is in orange and the NRC's GMRS is in green. If previous evaluation of a plant's capacity was considered for screening, that capacity (IHS) is shown in purple.
- As stated in NRC memorandum dated May 21, 2014, (ADAMS ML14136A126) these graphs will be discussed, as appropriate, in public meetings.



EPRI Maximum:
0.77g @ 15 Hz

NRC Maximum:
0.98 @ 30 Hz

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- **WBN understanding of the causes of the primary differences between the preliminary NRC and licensee results.**
  - Elements of NRC staff preliminary assessment
    - FSAR primary source for information on subsurface materials
      - narrower velocity profile
        - » 4,500 fps lower
        - » 6,500 fps upper
      - Hard rock at 1,000 ft.
    - Use of EPRI rock curves and low strain damping values
    - Kappa Values and weights

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- WBN additional data for subsurface materials
  - Expand site geologic profile due to current understanding of hard rock characteristics – shear wave velocity > 9200 fps.
  - Reduce uncertainty throughout profile to basement > 10,000 ft.
  - Support EPRI GMRS Development
  - Support Development of Seismic Hazard input for SPRA

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- **Utilized Academic/Industry Expertise**
  - AMEC – Program Management; regional / local geology
  - Dr. Robert Hatcher, Professor of Geology, University of Tennessee – Knoxville
    - » Regional / local geology
  - Dr. Ken Stokoe, Professor of Civil Engineering, University of Texas – Austin
    - » Spectra Analysis Surface Wave (SASW) Survey
    - » Rock Testing
  - Ivan Wong (URS) and
    - » Seismic Hazard & Evaluation of SASW / Rock Testing
  - Walt Silva (PE&A)
    - » Site Modeling/Characterization
  - Facility Risk Consultants
    - » 3rd party seismic consultant review

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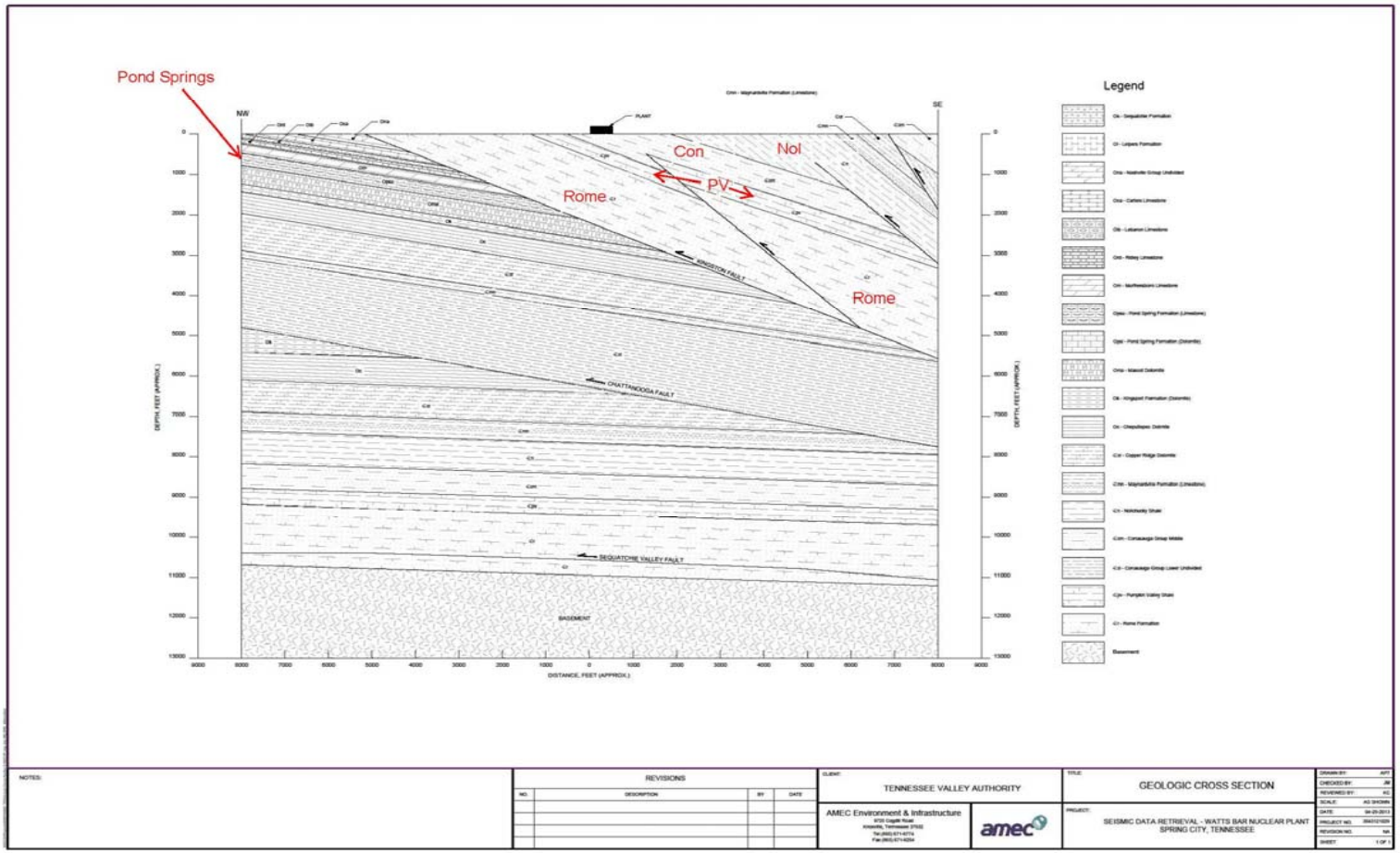

Source: AMEC (2013)

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Figure 11 Photograph of Liquidator Used in SASW Testing at Site 8 at Watts Bar #2 Nuclear Power Plant

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Figure 1 Map of the Approximate Locations of Eight, SASW Test Sites around Watts Bar #2 Nuclear Power Plant

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Figure 2 Map of Sites 6, 7 and 8 in the Vicinity of Watts Bar #2 Nuclear Power Plant

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- **SASW Survey (8 test sites)**
  - Sites 6 & 7 profiled depths of approx. 1400’ and 1700’
  - SASW Team believes results from Site 8 would have been similar had sufficient lateral space been available for a longer survey line.
  - Achieving profile depths of 1400-1700’ is uncommonly good results for SASW survey!
- **Rock Testing**
  - 6 Intact Rock Cores (URC - free-free unconfined resonant column tests)
  - Pumpkin Valley Shale (2), Consauga Middle, Pond Springs Formation, Nolichucky Shale, and Rome Formation

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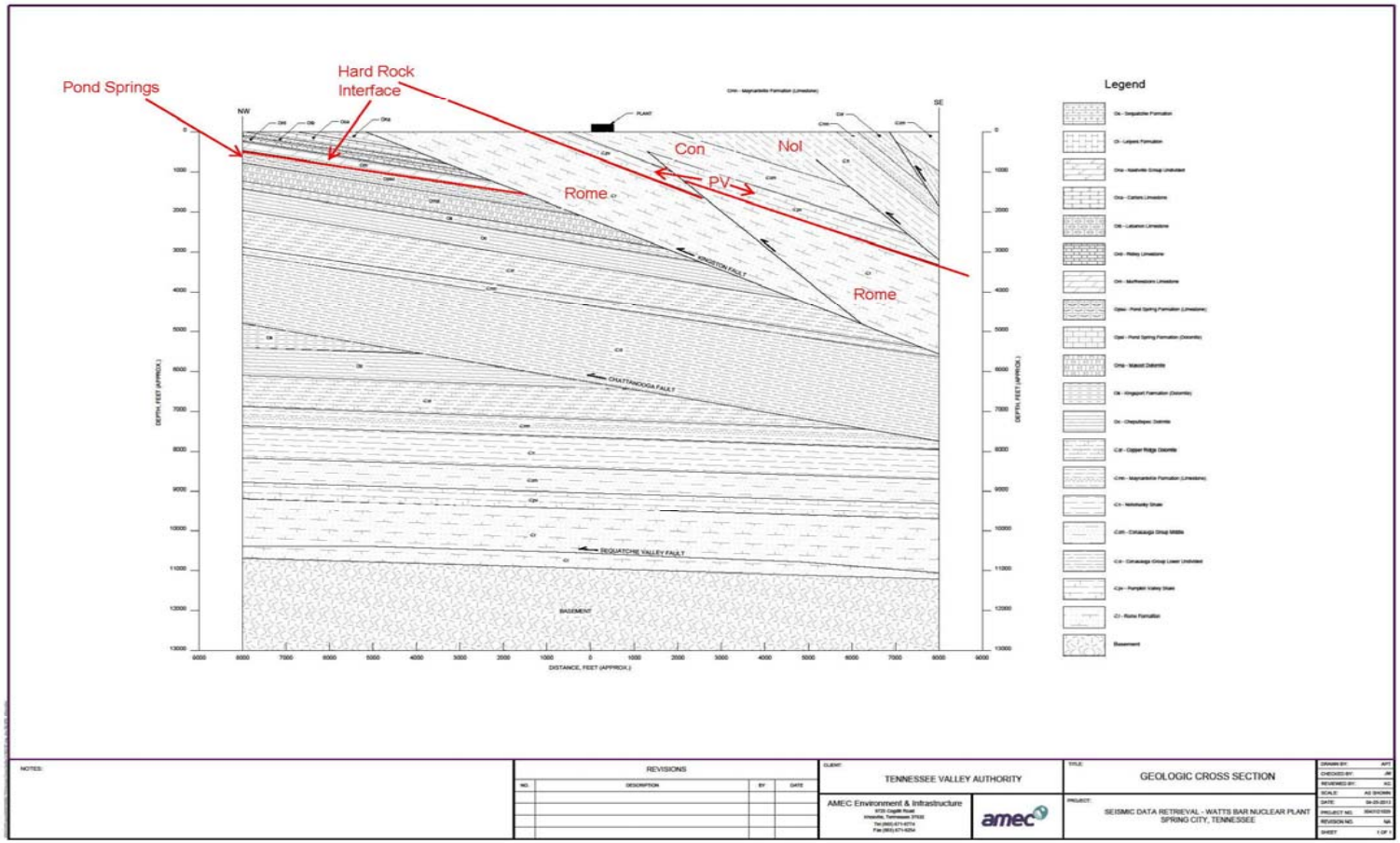

Source: AMEC (2013)

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- **Benefits Derived from SASW Survey / Rock Testing**
  - Provided shear-wave velocity data for important geologic formations beneath the site
  - Captured the variability in shear-wave velocity beneath the site
  - Provided site-specific measurements which reduced the epistemic uncertainty in the profiles (1.25 where appropriate)
  - Demonstrates that assumptions of shear-wave velocities from the type of rock would have been misleading. For example, it was surprising that the Rome sandstone was as fast as it was and the dolomite slower than was thought. *No substitute for real data!*
  - SASW measurements were performed to a depth up to 1700 ft right next to the reactor, some of the deepest measurements taken in the central and eastern US.

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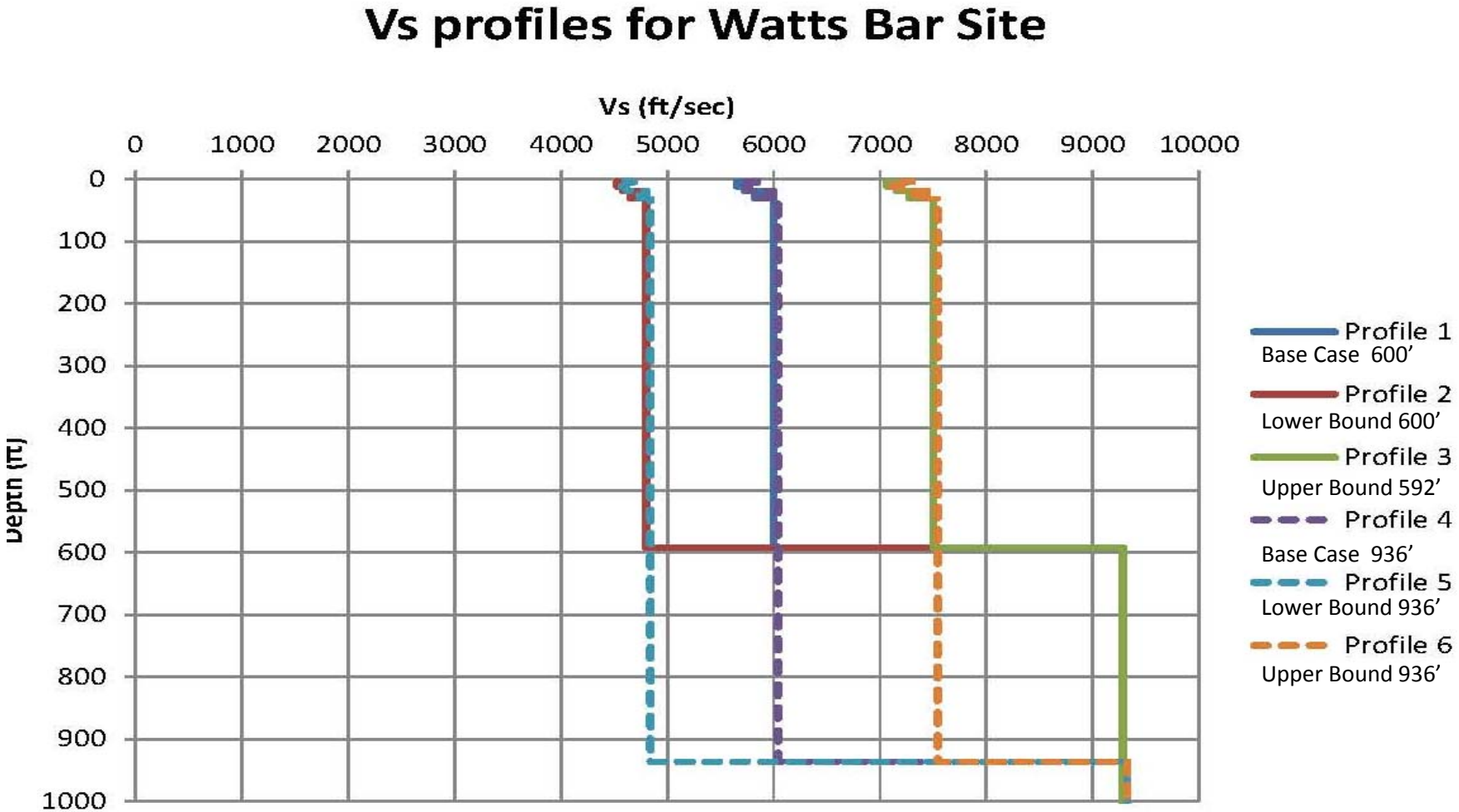

Figure 2.3.2-1 Shear-wave velocity profiles for Watts Bar Nuclear Plant (EPRI, 2014)

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- **Development Of Total Effective Kappa**
  - Following SPID Guidelines For Firm Rock Profile < 3,000 ft Deep
  - Total Effective Kappa Based on Firm Rock Damping of 1.25% (Q_S = 40)
  - Plus Hard Rock Contribution 0.006s
- **Uncertainty In Depth To Hard Rock Accommodated With Two Mean Depths 600 ft, 900 ft**
  - Results In Six Kappa Estimates For Base-Case, Upper-Range, Lower-Range Profiles and Two Depths to Hard Rock

- **Epistemic Uncertainty In Base-Case V_S Profiles Of 1.25 Results In Narrow Range Of Kappa**
  - Following SPID Guidelines, Epistemic Uncertainty In Kappa Taken as $\sigma_{\mu ln}$ 0.4 About Mean Estimate
  - Shallow Profile 0.012s ± σ_{μ}, range 0.007s to 0.020s
  - Deep Profile 0.013s ± σ_{μ}, range 0.008s to 0.022s

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- **Summary**
  - Watts Bar developed a significantly enhanced site geological profile to support site characterization
  - Supplemented by SASW survey to provide additional clarity for strata above Top of Hard Rock
  - Accounts for variation in the top of the Rome Formation underlying WBN
  - Rock testing of 6 intact cores to determine parameters for site characterization
  - Site characterization and EPRI GMRS performed in conformance with SPID and is appropriate characterization of seismic hazard for Watts Bar site.

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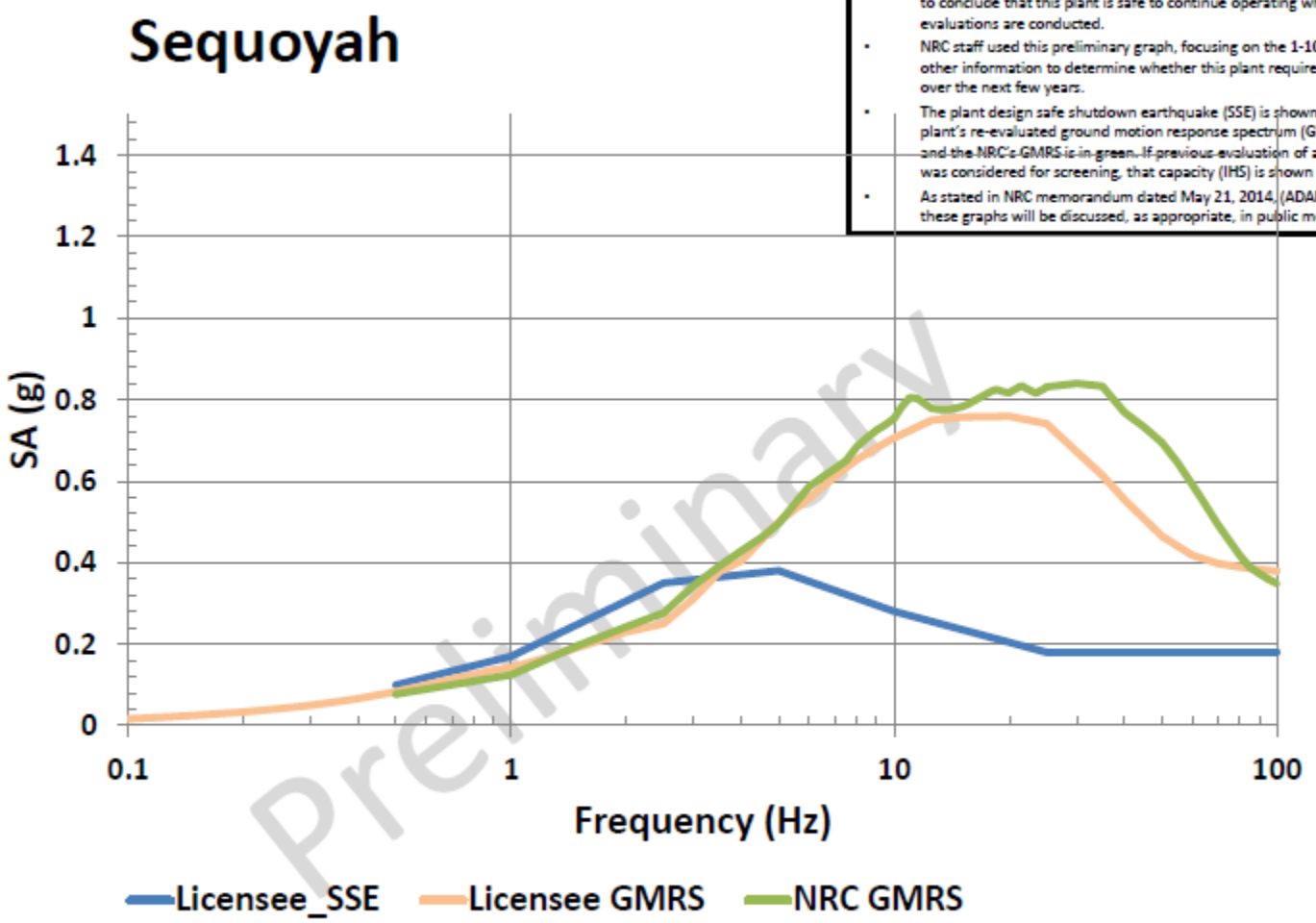
Information Exchange
SQN Seismic Hazard

- NRC May 9 Prioritization Letter
  - Seismic Risk Evaluation
    - Prioritization Group 2
  - SQN Acknowledges
    - Prioritization Group 2
    - Seismic risk evaluation by December 31, 2019
    - ESEP – RLGM = 2 x SSE
- NRC May 21 Support Document
  - Preliminary graphical representation
    - NRC staff GMRS differs from Licensee GMRS

Information Exchange
SQN Seismic Hazard

- As discussed in the May 9, 2014, letter (ADAMS ML14111A147), the NRC considered the re-evaluated hazard and previous estimates of plant capacity to conclude that this plant is safe to continue operating while additional evaluations are conducted.
- NRC staff used this preliminary graph, focusing on the 1-10 Hertz range, and other information to determine whether this plant requires a risk evaluation over the next few years.
- The plant design safe shutdown earthquake (SSE) is shown in blue; the plant's re-evaluated ground motion response spectrum (GMRS) is in orange and the NRC's GMRS is in green. If previous evaluation of a plant's capacity was considered for screening, that capacity (IHS) is shown in purple.
- As stated in NRC memorandum dated May 21, 2014, (ADAMS ML14136A126) these graphs will be discussed, as appropriate, in public meetings.



EPRI Maximum SA:
0.76g @ 20 Hz

NRC Maximum SA:
0.84g @ 40 Hz

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- **SQN understanding of the causes of the primary differences between the preliminary NRC and licensee results.**
  - Elements of NRC staff preliminary assessment
    - Velocity profile
    - Use of EPRI rock curves and low strain damping values
    - Kappa Values and weights

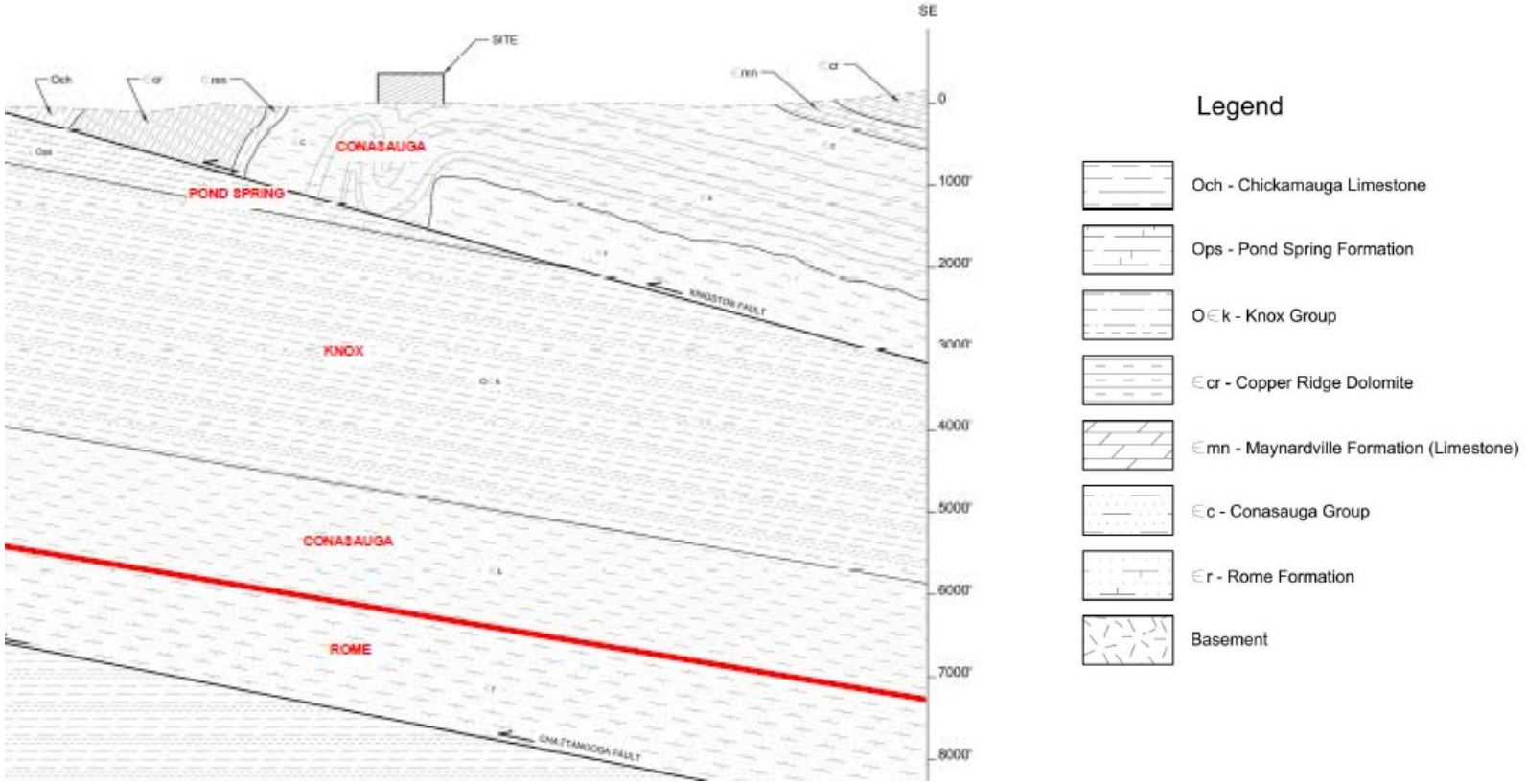
Information Exchange
SQN Seismic Hazard

- SQN additional data for subsurface materials
  - Expand site geologic profile due to current understanding of hard rock characteristics – shear wave velocity > 9200 fps.
  - FSAR had limited rock characteristics data available at depth (> 103 ft)
  - Definition of rock profile to basement ≈ 12,000 ft.
  - Support EPRI GMRS Development

Information Exchange
SQN Seismic Hazard

- **Utilized Academic/Industry Expertise**
  - AMEC – Program Management; regional / local geology
  - Dr. Robert Hatcher, Professor of Geology, University of Tennessee – Knoxville
    - » Regional / local geology
  - Dr. Ken Stokoe, Professor of Civil Engineering, University of Texas – Austin
    - » Spectra Analysis Surface Wave (SASW) Survey @ WBN
    - » Rock Testing
  - Ivan Wong (URS)
    - » Site Modeling/Characterization

Information Exchange
SQN Seismic Hazard



Source: AMEC (2013)

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SQN Seismic Hazard

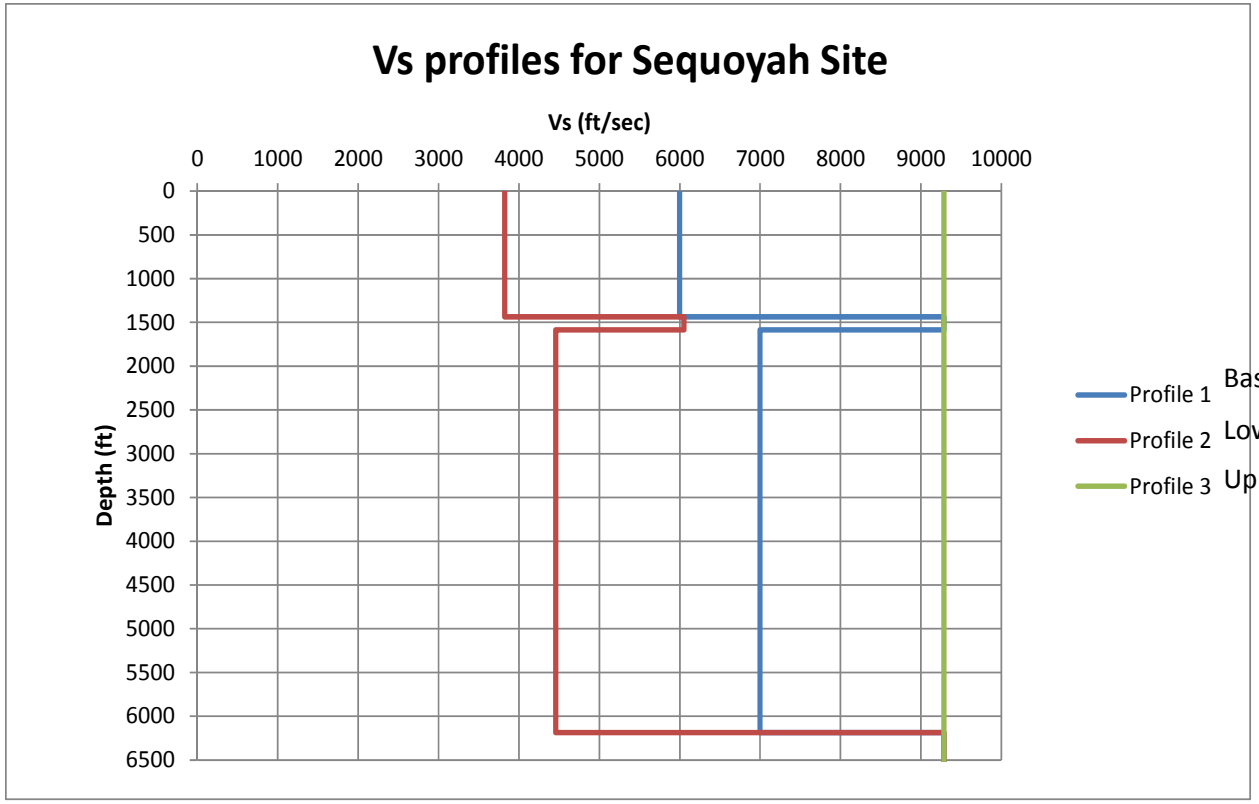

Figure 2.3.2-1 Shear-wave velocity profiles for Sequoyah Nuclear Plant (EPRI, 2014)

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- Development of Total Effective Kappa
- Following SPID Guidelines For Firm Rock Profile > 3,000 ft Deep
  - Total Effective Kappa Based on Avg. V_S over Top 100 ft, Surface Outcrop
  - P1 6,000 ft/s, 0.012s
  - P2 3,821 ft/s, 0.020s
  - P3 9,285 ft/s, 0.006s Hard Rock
  - Likely Conservative (low), 0 to 40 ft Soil, No Weathered Zone
- Range 0.006s to 0.020s Considered Sufficient Expression Of Epistemic Uncertainty

Information Exchange
SQN Seismic Hazard

- **Summary**
  - Sequoyah developed an enhanced site geological profile
    - Supplemented by regional geology maps, industry experts, and nearby SASW surveys
  - EPRI GMRS and site characterization performed in conformance with SPID and is appropriate characterization of seismic hazard for Sequoyah site.

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Information Exchange
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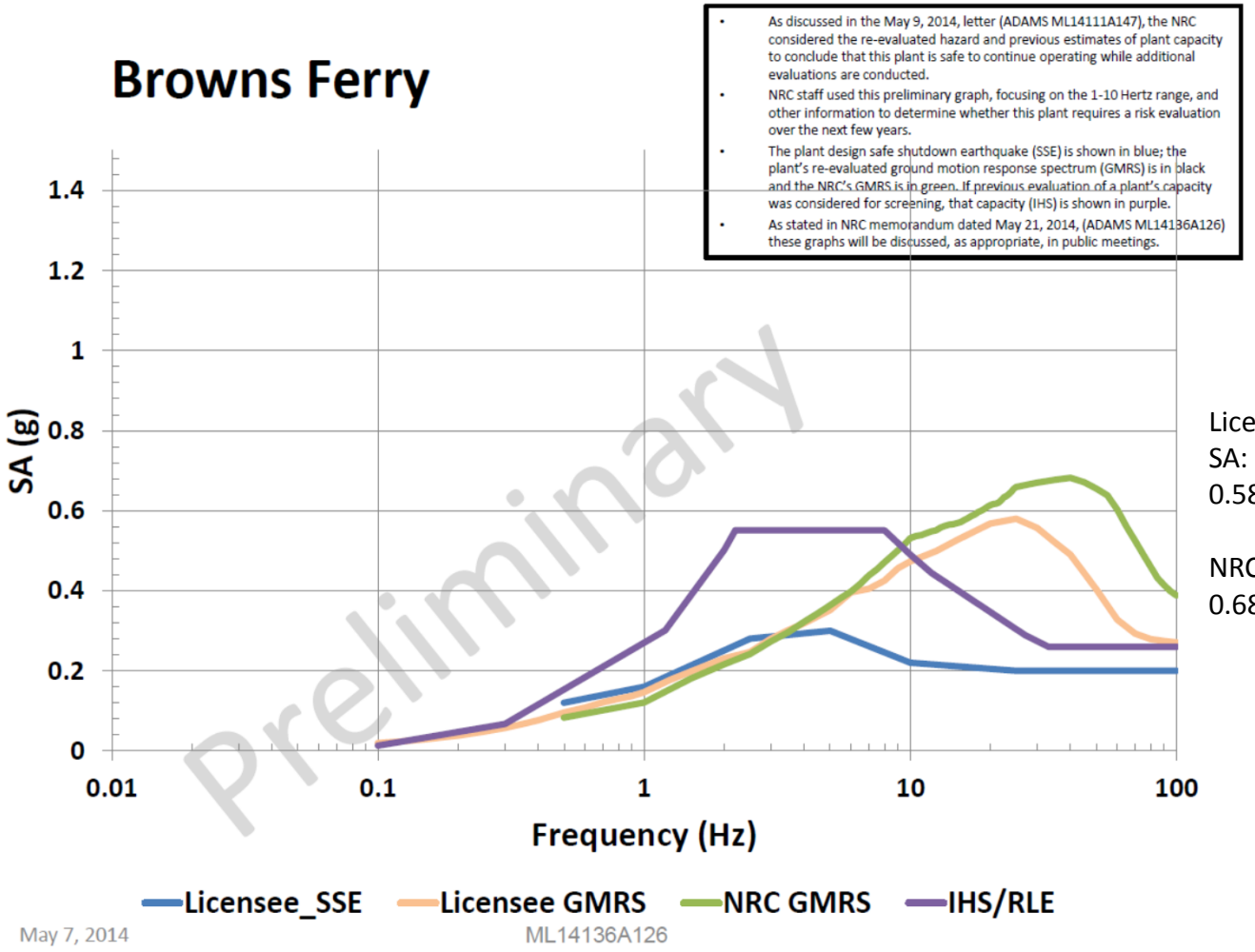
- NRC May 9 Prioritization Letter
  - Seismic Risk Evaluation
    - Prioritization Group 2
- NRC May 21 Support Document
  - Preliminary graphical representation
    - NRC staff GMRS differs from Licensee GMRS

Information Exchange
BFN Seismic Hazard



Licensee Maximum SA:
0.58g @ 25 Hz

NRC Maximum SA:
0.68g @ 40 Hz

Information Exchange
BFN Seismic Hazard

- **BFN understanding of the causes of the primary differences between the preliminary NRC and licensee results.**
  - Elements of NRC staff preliminary assessment
    - Narrower velocity profile
      - 7,000 fps lower bound
      - 9,285 fps upper bound (hard rock)
    - Use of EPRI rock curves and low strain damping values
    - Kappa Values and weights

Information Exchange
BFN Seismic Hazard

- BFN additional data for subsurface materials
  - Expand site geologic profile due to current understanding of hard rock characteristics – shear wave velocity > 9200 fps.
  - FSAR had limited rock characteristics data available at depth (> 200 ft)
  - Definition of rock profile to basement ≈ 5,000 ft.
  - Support EPRI GMRS Development

Information Exchange
BFN Seismic Hazard

- **Utilized Academic/Industry Expertise**
  - AMEC – Program Management; regional / local geology
  - Dr. Robert Hatcher, Professor of Geology, University of Tennessee – Knoxville
    - » Regional / local geology
  - Dr. Ken Stokoe, Professor of Civil Engineering, University of Texas – Austin
    - » Spectra Analysis Surface Wave (SASW) Survey @ WBN
    - » Rock Testing
  - Ivan Wong (URS)
    - » Site Modeling/Characterization

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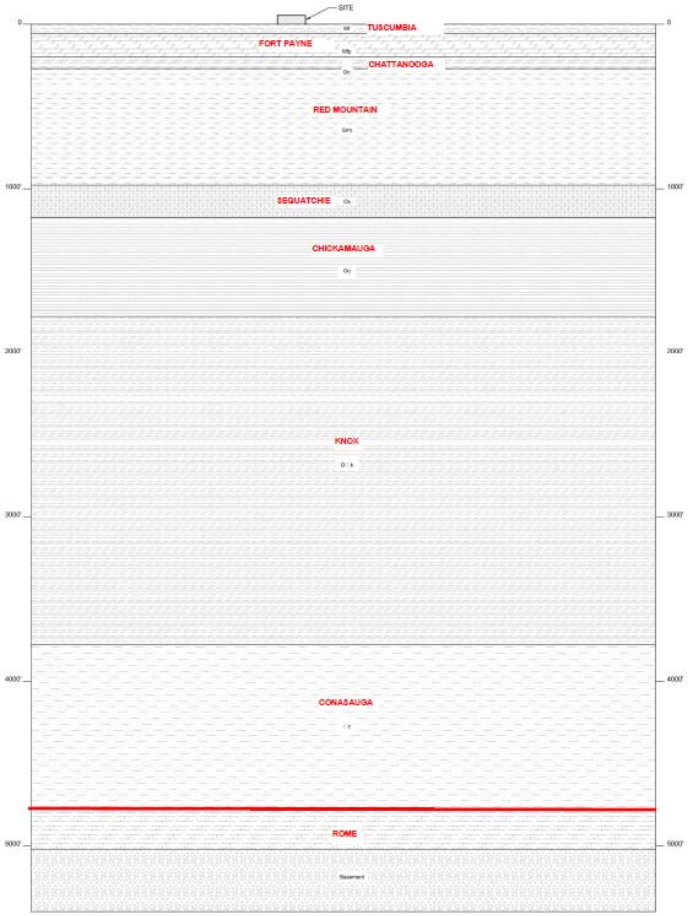
BFN Seismic Hazard



Source: AMEC (2013)

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BFN Seismic Hazard

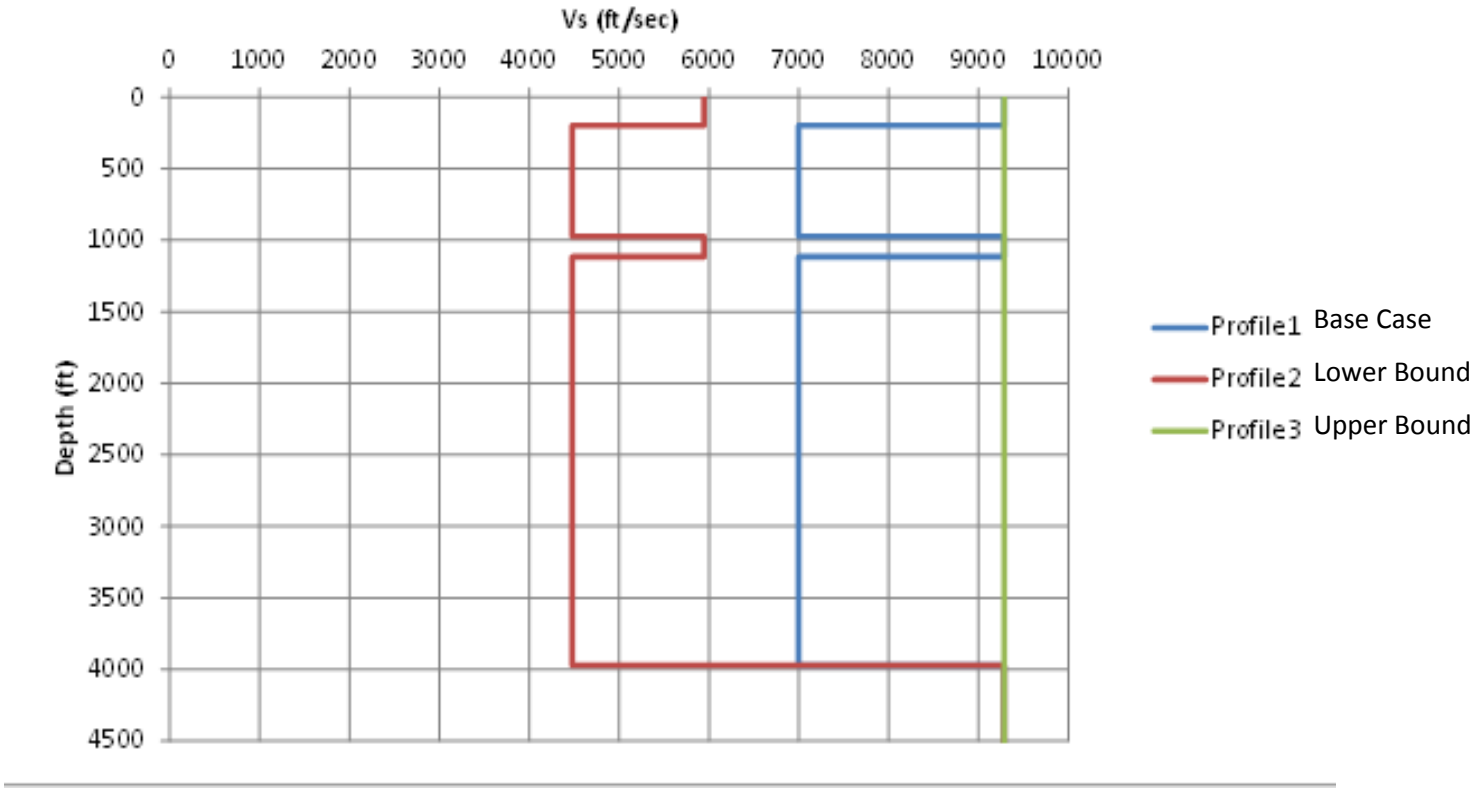

Figure 2.3.2-1 Shear-wave velocity profiles for Browns Ferry Nuclear Plant (EPRI, 2014)

Information Exchange
BFN Seismic Hazard

- Development of Total Effective Kappa
- Following SPID Guidelines For Firm Rock Profile > 3,000 ft Deep
  - Total Effective Kappa Based on Avg. Vs Over Top 100 ft, surface outcrop
  - Profiles P1, P3 Hard Rock Near Surface, $\kappa = 0.006s$
  - Profile P2 Vs(100 ft) 5,914 ft/s, $\kappa = 0.012s$
  - Likely Conservative (low), 0 to 50 ft Soil, No Weathered Zone
- Range 0.006s to 0.012s Considered Sufficient Expression of Epistemic Uncertainty

Information Exchange
BFN Seismic Hazard

- **Summary**
  - Browns Ferry developed an enhanced site geological profile
    - Supplemented by regional geology maps and industry experts
  - EPRI GMRS and site characterization performed in conformance with SPID and is appropriate characterization of seismic hazard for Browns Ferry site.

BFN Seismic Risk Evaluation Screening Results

- BFN understands the IPEEE evaluation did not meet NRC staffs expectation for screening purposes
  - Prerequisite #3
  - Adequacy Demonstration #3

- BFN adequacy review acknowledged the SER identified weakness and provided justification for addressing the weakness as part of the ESEP

- BFN has subsequently completed seismic capacity evaluations for the additional RCIC components
  - Minimum HCLPF > 0.50g

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- Additional information
  - BFN reevaluated minimum HCLPF SSC (Auxiliary Diesel Generator Transformers)
    - HCLPF > 0.30g in current configuration and replacement configuration
    - BFN commitment to complete transformer replacement by Sept 30, 2014 to resolve PCB/IPEEE screening capacity

- TVA requests that the NRC staff reconsider the May 9, 2014 screening result that BFN screens in for seismic risk evaluation