



INTEGRATION OF NON-ERGOTIC SITE RESPONSE INTO NEHRP PROVISIONS & ASCE-7

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NEHRP Provisions

Chapter 21: Site-Specific Ground Motion Procedures for Seismic Design

- Chapter 21 serves as alternative to default design motions (Chapter 11)
- Section 21.1 pertains to site-specific site response, which can be applied in two contexts (Figure 1):
 - Option 1 (Figure 1a): Site-specific PSHA applied with ergodic site factors (in which case Section 21.1 is not used) or site-specific site response (Section 21.1)
 - Option 2 (Figure 1b): PSHA for reference site from NSHM (Petersen et al. 2024) for reference site with site-specific site response (Section 21.1)
- Section 21.1 can be applied using **Site-Specific Site Response** or **Hybrid Ground Motions** approaches.

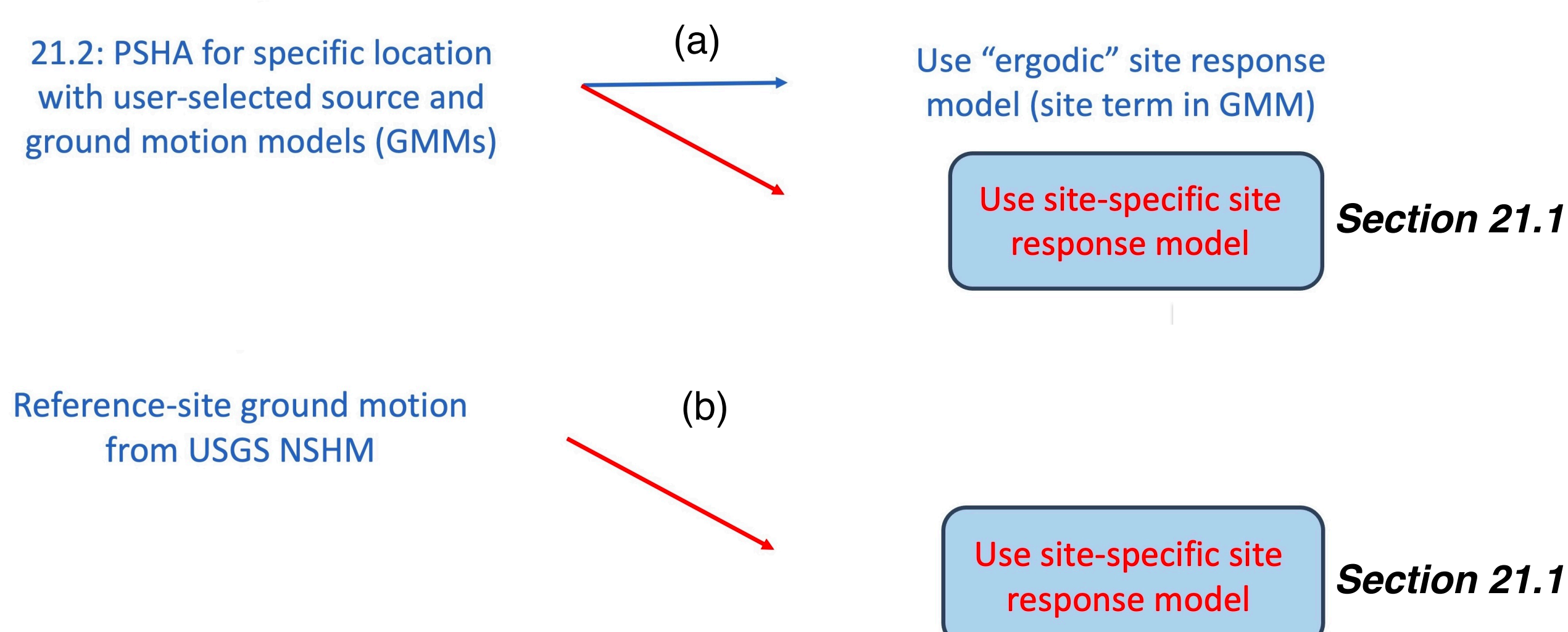


Figure 1. Demonstration of two contexts in which Section 21.1 can be invoked within Chapter 21

Site Specific Site Response

Required model elements:

- Mean model, μ_{lnAF}
- Aleatory variability
- Epistemic uncertainty
- f_2 represents the slope of the log amplification with the log of x_{IMr}
- f_3 (in the same units as x_{IMr}) represents a transitional level of x_{IMr} between linear and strongly nonlinear response.

Can be derived from:

- Approach 1: Ground motion data
- Approach 2: Ground response analyses
- Combinations of 1 & 2

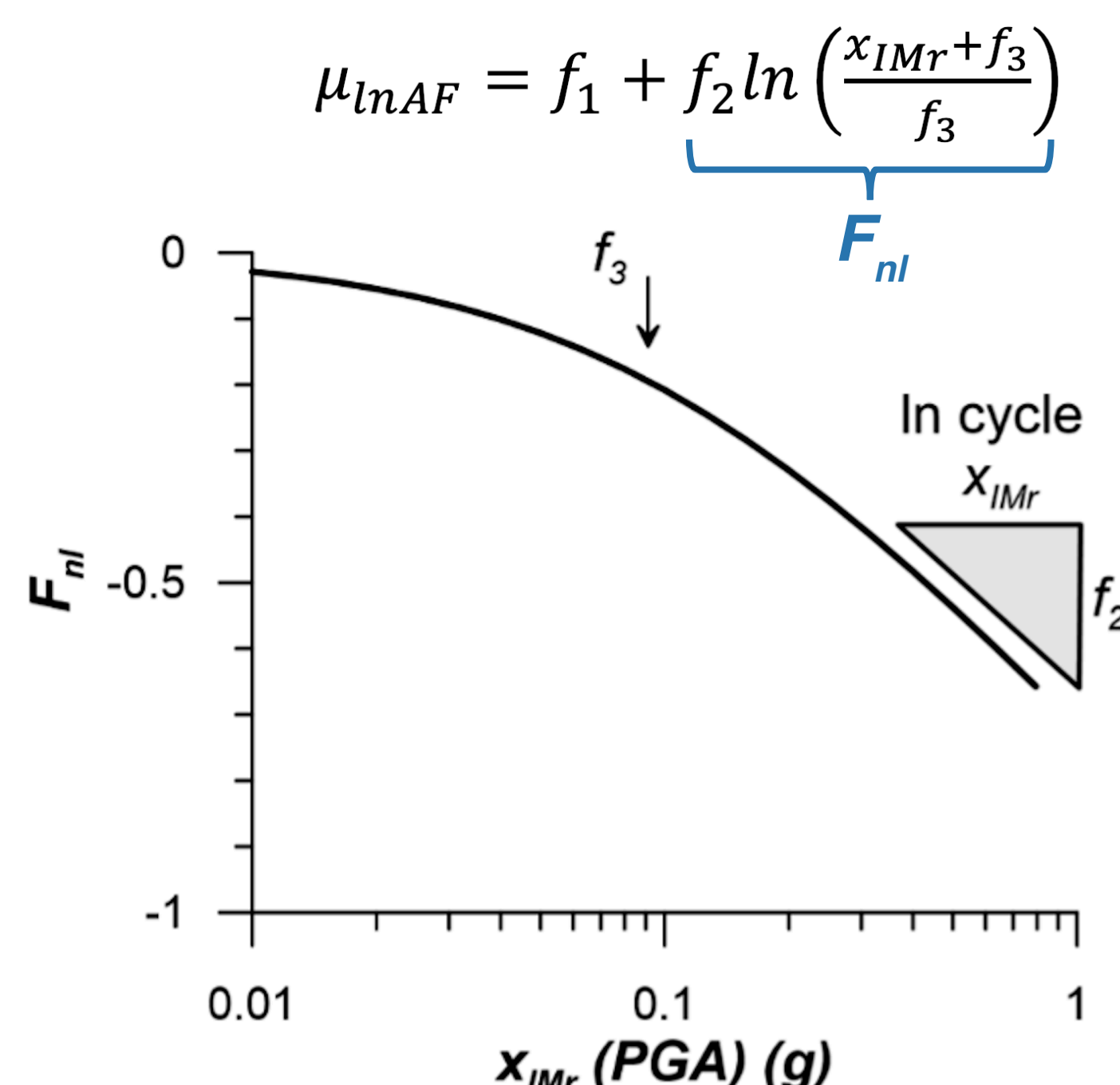


Figure 3. Mean site response model and physical representation of coefficients f_2 and f_3
Source: Kramer & Stewart (2025)

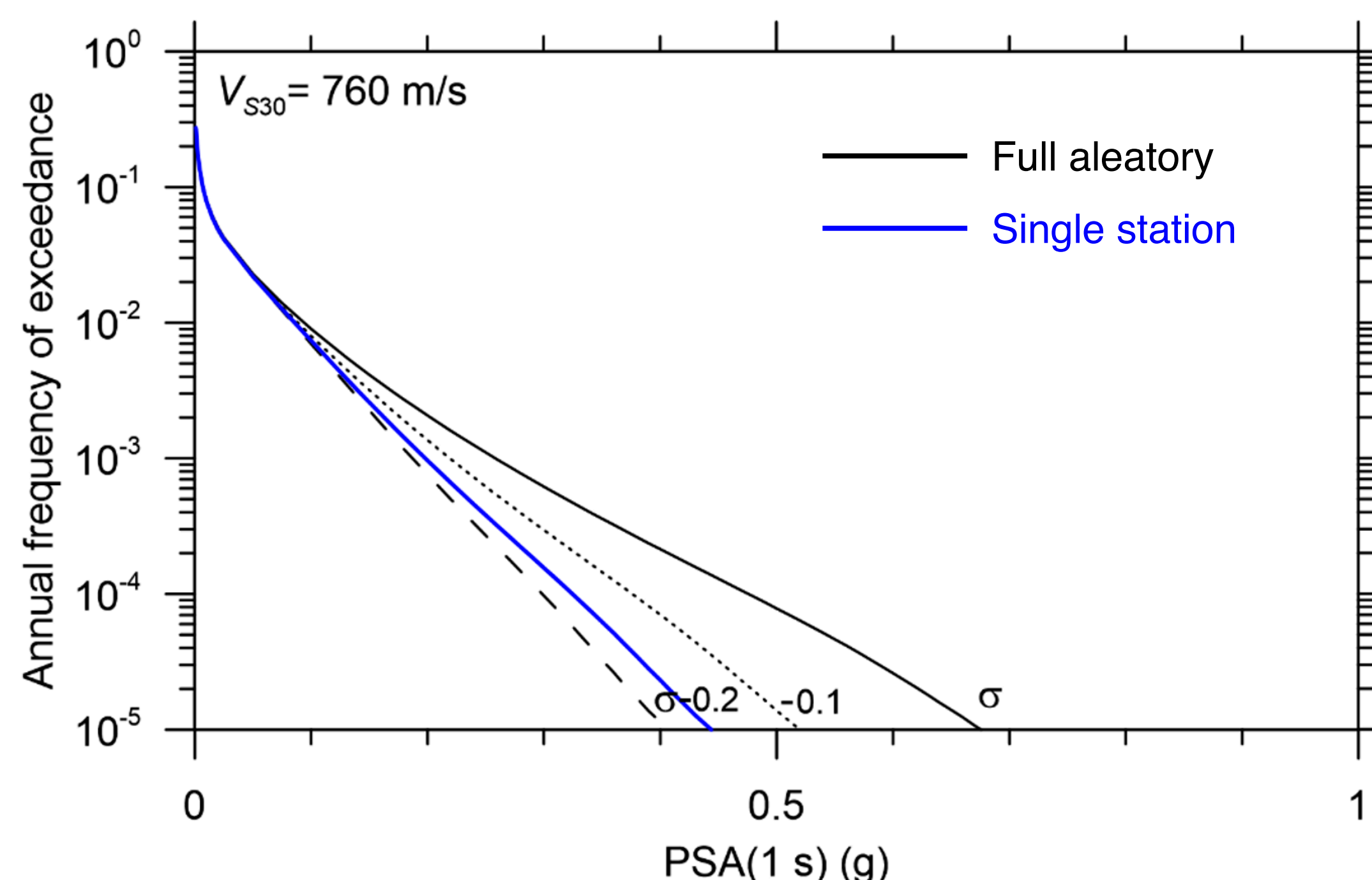


Figure 4. Hazard curve for reference site ($V_{S30} = 760 \text{ m/s}$) with full aleatory variability (σ), aleatory variability reduced by 0.1 and 0.2, and single-station sigma (blue)

Allowable reductions:

- Point of comparison is MCE_R spectrum from USGS seismic design Geo-Database
- NEHRP 2020 (ASCE-7/22) and before: maximum 20% reduction
- NEHRP 2026, site-specific approach: maximum 30% reduction

References:

Building Seismic Safety Council, BSSC (2020). *NEHRP Recommended Seismic Provisions for New Buildings and Other Structures*. Volume I: Part 1 Provisions, Part 2 Commentary. Report No. FEMA P-2082-1, Federal Emergency Management Agency, Washington DC.

Kramer SL and JP Stewart (2025). *Geotechnical Earthquake Engineering*, 2nd Edition. Taylor & Francis, New York, NY. 1060 pages.

Petersen, MD, AM Shumway, PM Powers, EH Field, MP Moschetti, KS Jaiswal, et al. (2024) The 2023 US 50-State National Seismic Hazard Model: Overview and implications, *Earthquake Spectra* 40 (1): 5–88.

Current Procedures (NEHRP 2020 and Before)

Requirements:

- Base motion
- Site condition model
- Ground response analyses (GRA)
- Applied with hybrid approach

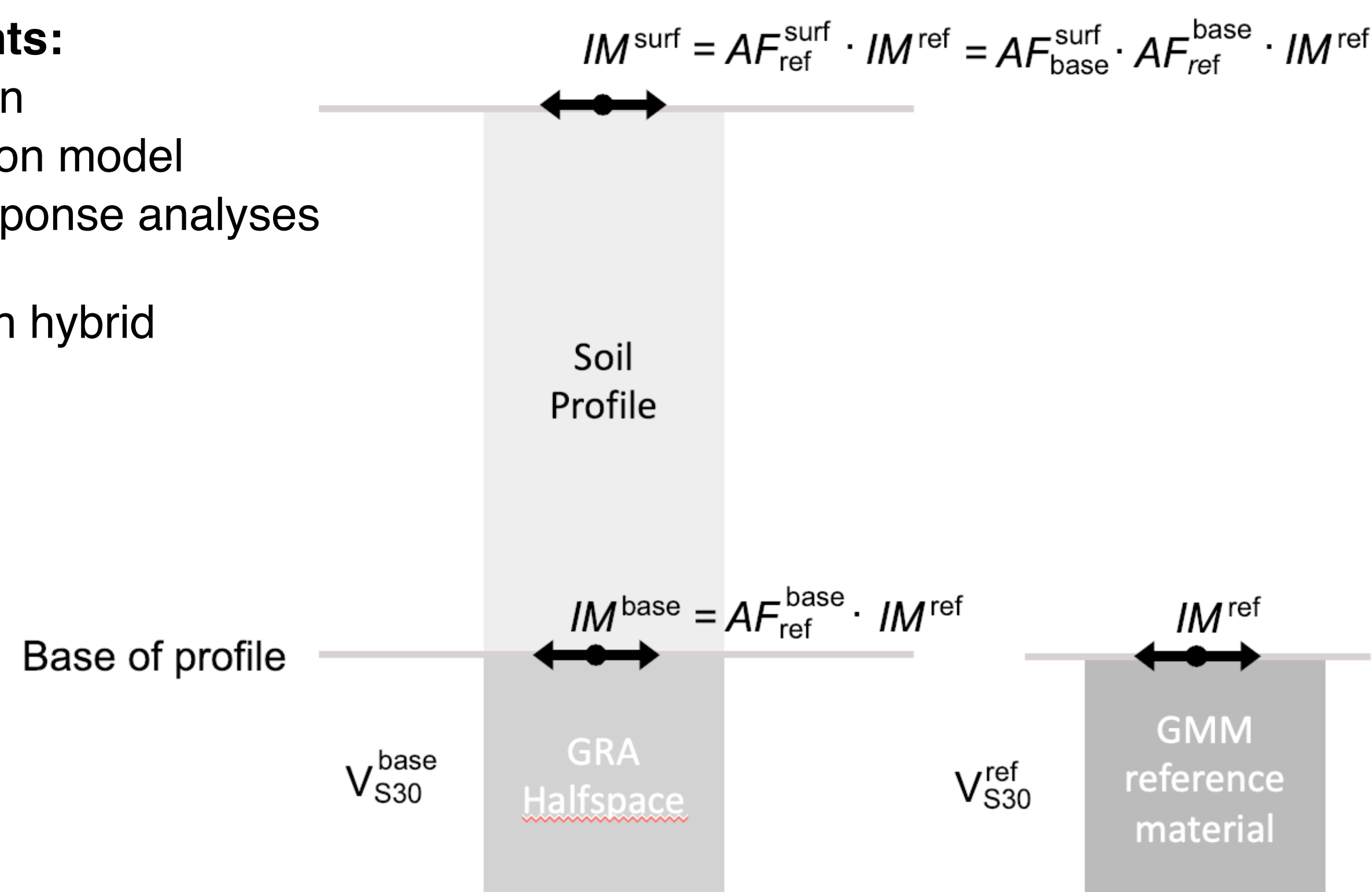


Figure 2. Schematic illustration of adjustments required to ensure consistency between halfspace velocity and reference site condition in calculation of surface intensity measure. The multiplication of base IMs by AF to estimate surface IMs represents the use of a hybrid approach.
Source: Kramer & Stewart (2025)

Issues Motivating New Procedures:

- Period limitation of GRA
- Lack of guidance on non-ergodic site response
- Hazard level not preserved

Hybrid Ground Motions

Hybrid Ground Motions Approach:

- Amplification computed using GRA with (MCE_R and $\frac{2}{3}MCE_R$)
- No amplification models (f_1, f_2, f_3) required
- Hazard computed using full ϕ_{S2S} (IM^{ref})
- Enveloped hybrid approach,
 $IM^{surf} = \max(AF^{MCE_R}, AF^{\frac{2}{3}MCE_R}) \times IM^{ref}$
- Max 20% reduction

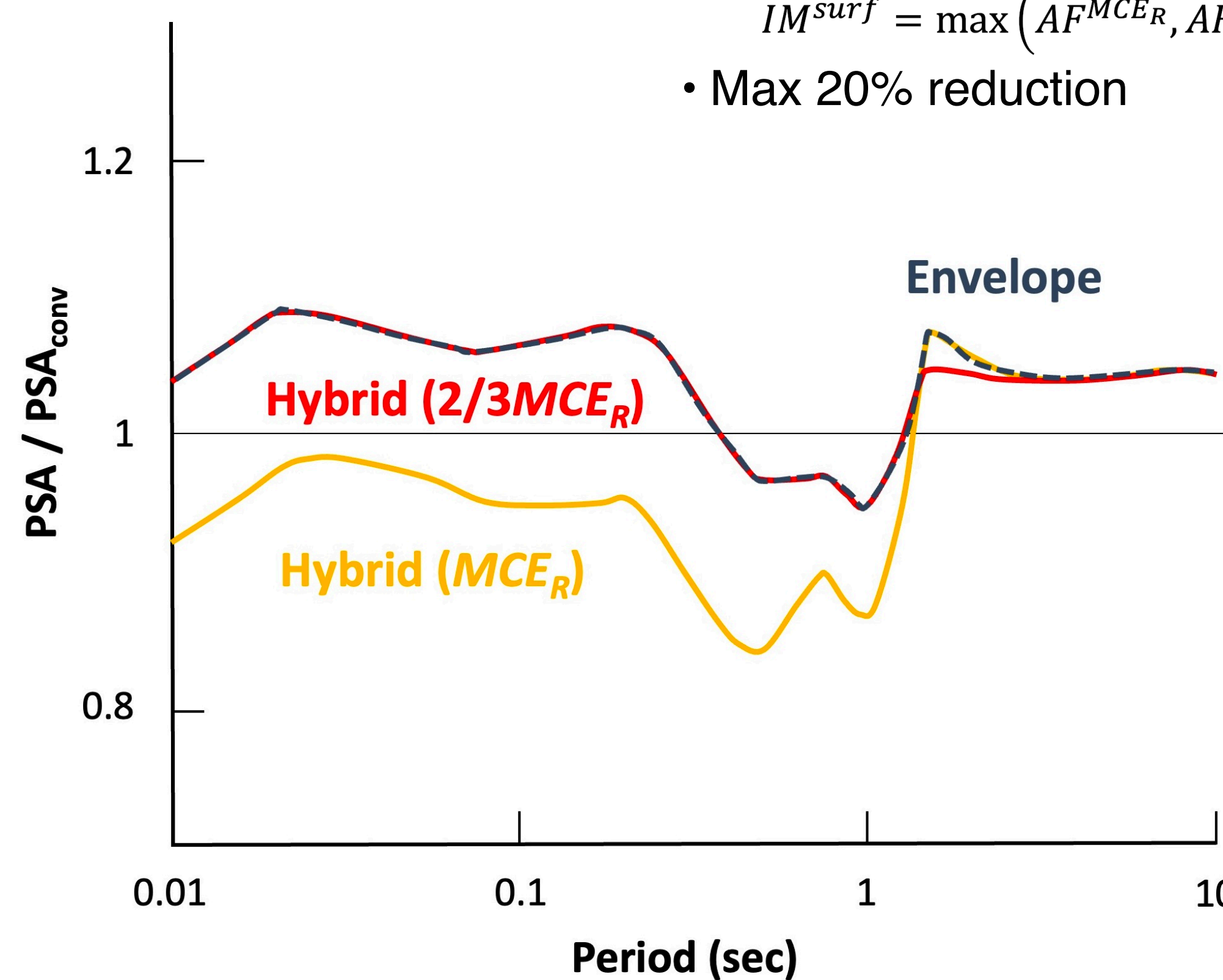


Figure 5. Ratio of pseudo-spectral acceleration (PSA) from hybrid procedures to PSA from convolution. Results shown using hybrid with full input motion amplitude (labeled MCE_R) and 2/3 of full input, along with recommended envelope of the two results

Closure

Approvals:

- Approved for 2026 *NEHRP Provisions and Commentary*. Publication expected November 2026
- Final approval for ASCE 7/28 pending

We advanced this proposal because:

- Non-ergodic site response is being used; needs to be reflected in *NEHRP Provisions and Commentary* for guidance / guardrails
- Current procedures in Sec. 21.1 are frequently unconservative
- Other improvements were needed