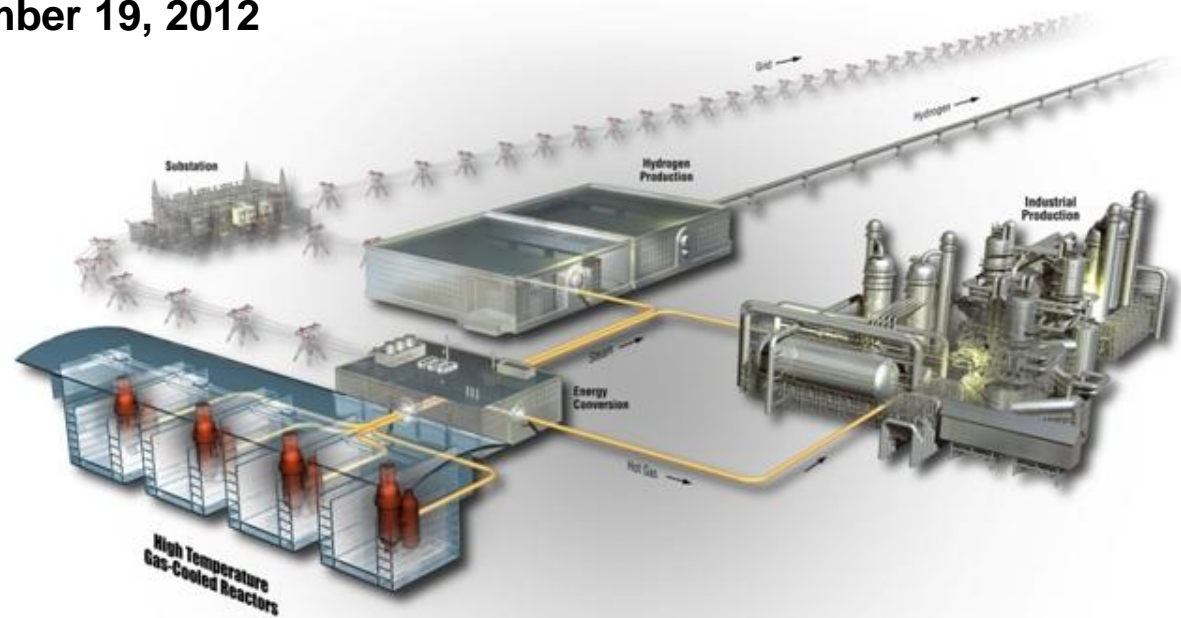


# *Next Generation Nuclear Plant*

## *LBE Selection/F-C Curve Discussions*

September 19, 2012

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## *Meeting Outline*

- Meeting Purpose
- Requested Staff Positions
- White Paper Outcome Objectives
- NGNP LBEs and Frequency-Consequence (F-C) Curve
- Meeting Summary

## *Today's Meeting Purpose*

- Achieve consensus on key issues related to the NGNP's proposed risk-informed performance-based licensing process related to LBE selection methodology
- Material to be discussed draws on:
  - Previous NGNP-NRC public meeting interactions
  - NRC documents
  - Insights based on NGNP review of the NRC Assessment Reports
  - NGNP responses to NRC RAIs
- Identify areas of consensus and establish next steps necessary for NRC development of staff positions

## ***Requested NRC Staff Positions***

- Agree with the placement of top level regulatory criteria (TLRC) on a frequency-consequence (F-C) curve
- Agree on the frequency cutoffs for the Design Basis Event (DBE) and Beyond Design Basis Event (BDBE) regions

*(As requested in INL to NRC letter CCN 227793 dated July 6, 2012)*

# ***LBE White Paper Outcome Objectives***

1. The structured process for selecting LBEs is an acceptable approach for defining the LBEs
2. LBEs cover a comprehensive spectrum of events from normal operation to rare, off-normal events. There are three categories of LBEs:
  - AEs, which encompass planned and anticipated events. The doses from AEs are required to meet normal operation public dose requirements. AEs are utilized to set operating limits for normal operation modes and states
  - DBEs encompass unplanned off-normal events not expected in the plant's lifetime, but which might occur in the lifetimes of a fleet of plants. The doses from DBEs are required to meet accident public dose requirements. DBEs are the basis for the design, construction, and operation of the structures, systems, and components (SSCs) during accidents
  - BDBEs, which are rare off-normal events of lower frequency than DBEs. BDBEs are evaluated to ensure that they do not pose an unacceptable risk to the public
  - The LBEs in all three categories will be evaluated individually to support the tasks of assessing the performance of SSCs with respect to safety functions in response to initiating events and collectively to demonstrate that the integrated risk of a multimodule plant design meets the NRC Safety Goals

## ***LBE White Paper Outcome Objectives, cont.***

3. The frequencies of LBEs are expressed in units of events per plant-year where a plant is defined as a collection of reactor modules having certain shared systems. The limits on the frequency ranges for the LBE categories are as follows:
  - AEs – event sequences with mean frequencies greater than  $10^{-2}$  per plant-year
  - DBEs – event sequences with mean frequencies less than  $10^{-2}$  per plant-year and greater than  $10^{-4}$  per plant-year
  - BDBEs – event sequences with mean frequencies less than  $10^{-4}$  per plant-year and greater than  $5 \times 10^{-7}$  per plant-year
4. Acceptable limits on the event sequence consequences and the analysis basis for the LBE categories are as follows:
  - AEs – 10CFR20: 100 mrem total effective dose equivalent (TEDE) mechanistically modeled and realistically calculated at the exclusion area boundary (EAB). For the NGNP facility, the EAB is expected to be the same area as the owner controlled area boundary
  - DBEs – 10CFR50.34 [10CFR52.79]: 25 rem TEDE mechanistically modeled and conservatively calculated at the EAB
  - BDBEs – NRC Safety Goal quantitative health objectives (QHOs) mechanistically modeled and realistically calculated at 1 mile (1.6 km) and 10 miles (16 km) from the plant

## ***LBE White Paper Outcome Objectives, cont.***

5. The frequency below which events are not selected as LBEs is  $5 \times 10^{-7}$  per plant-year. The PRA examines events to  $10^{-8}$  per plant-year to assure that there are none just below this de minimus frequency
6. The kinds of events, failures, and natural phenomena that are evaluated include:
  - Multiple, dependent, and common cause failures to the extent that these contribute to LBE frequencies
  - Events affecting more than one reactor module
  - Internal events (including transients and accidents) and internal and external plant hazards that occur in all operating and shutdown modes and potentially challenge the capability to satisfactorily retain any source of radioactive material
7. The DBAs for Chapter 15, “Accident Analyses,” of the license application are derived from the DBEs by assuming that only SSCs classified as safety-related are available to mitigate the consequences
  - The public consequences of DBAs are based on mechanistic source terms and are conservatively calculated
  - The upper bound consequence of each DBA must meet the 10CFR50.34 consequence limit at the EAB

## ***LBE White Paper Outcome Objectives, cont.***

8. Uncertainty distributions are evaluated for the mean frequency and the mean consequence for each LBE. The mean frequency is used to determine whether the event sequence family is an AE, DBE, or BDBE
  - If the upper or lower bound on the LBE frequency straddles two or more regions, the LBE is compared against the consequence criteria for each region
  - The mean, lower, and upper bound consequences are explicitly compared to the consequence criteria in all applicable LBE regions
  - The upper bound for the DBE and DBA consequences must meet the 10CFR50.34 dose limit at the EAB



# *NGNP LBEs and F-C Curve*

## *Licensing Basis Events*

- ➔ • **What** must be met:
  - Top Level Regulatory Criteria (TLRC)
- ➔ • **When** TLRC must be met:
  - Licensing Basis Events
- **How** TLRC must be met:
  - Safety Functions
  - SSC Safety Classification
- **How well** TLRC must be met:
  - Deterministic DBAs
  - Defense-in-Depth
  - Regulatory Special Treatment

## ***Top Level Regulatory Criteria (TLRC) for the Public***

- 10CFR20 annualized offsite dose guidelines
  - 100 mrem/yr total effective dose equivalent
  - Measured on a cumulative basis annually at the EAB of the site
  - For normal operation and anticipated events
- 10CFR50.34 (10CFR52.79) accident offsite doses
  - 25 rem total effective dose equivalent
  - Evaluated at the site EAB at 2 hr and at the site LPZ at 30 day
  - Design basis for off-normal events
- EPA-400-R-92-001 Protective Action Guides (PAGs) offsite doses
  - 1 rem total effective dose equivalent for sheltering
  - Evaluated at the site EPZs (10 miles for plume exposure and 50 miles for ingestion)
  - Emergency planning and protection during off-normal events
- 51 Federal Register (FR) 130 individual fatality risks
  - Prompt and latent Quantitative Health Objectives (QHOs) of  $5 \times 10^{-7}/\text{yr}$  and  $2 \times 10^{-6}/\text{yr}$   
Evaluated at 1 mile for prompt and 10 miles for latent
  - Overall assurance of negligible cumulative risks during normal operation and off-normal events

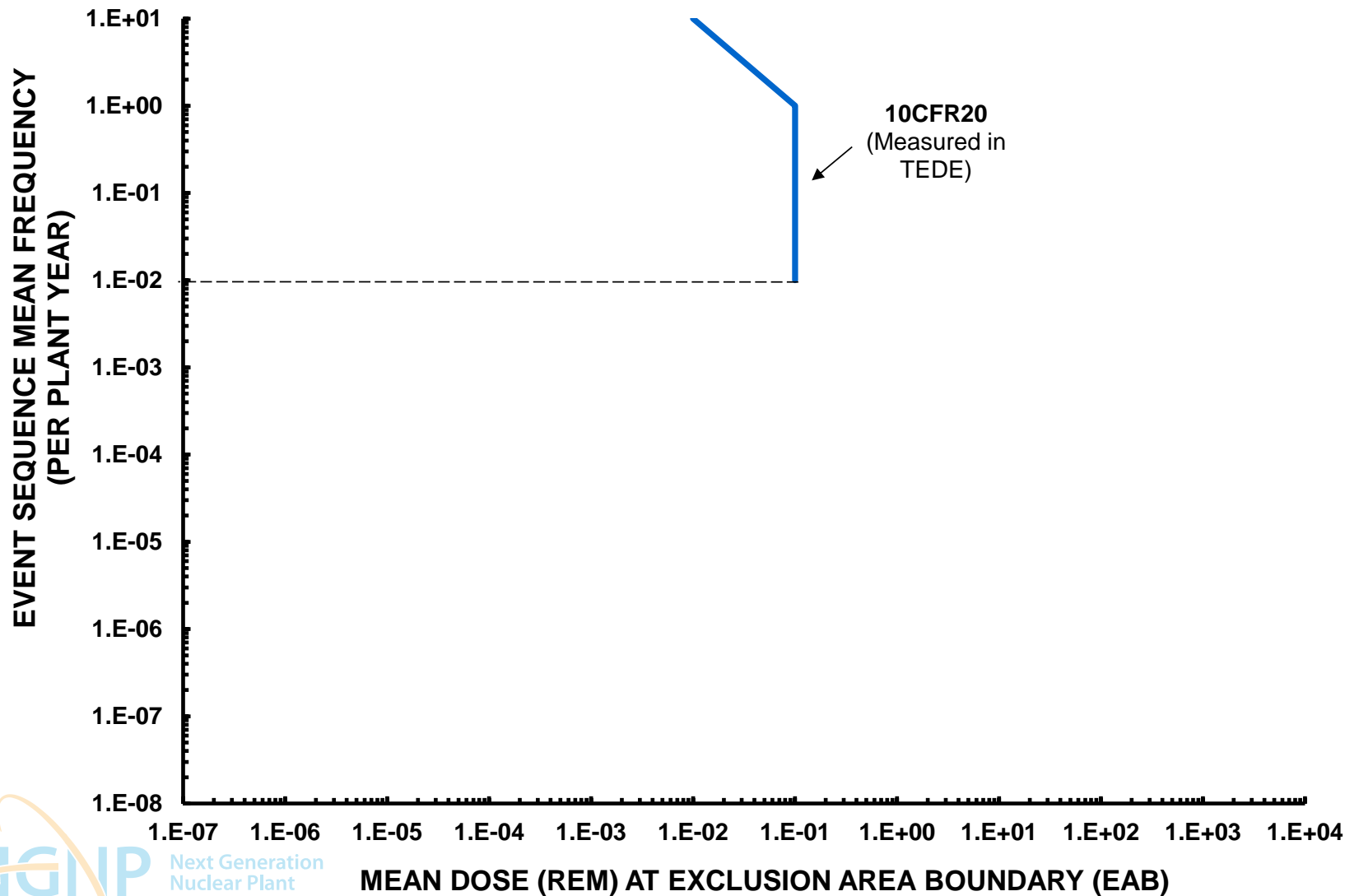
## ***Categories of Licensing Basis Events***

- TLRC apply to the full spectrum of normal operation and off-normal events
- Some specific TLRC apply to normal operation and anticipated events; others to design basis events; others to events less frequent than design basis events
- Design Basis Accidents (analyzed in Ch 15 of SARs deterministically assuming that only SSCs classified as safety-related are available)
- LBE categories selected:
  - Anticipated Events - AEs
  - Design Basis Events – DBEs
  - Beyond Design Basis Events – BDBEs

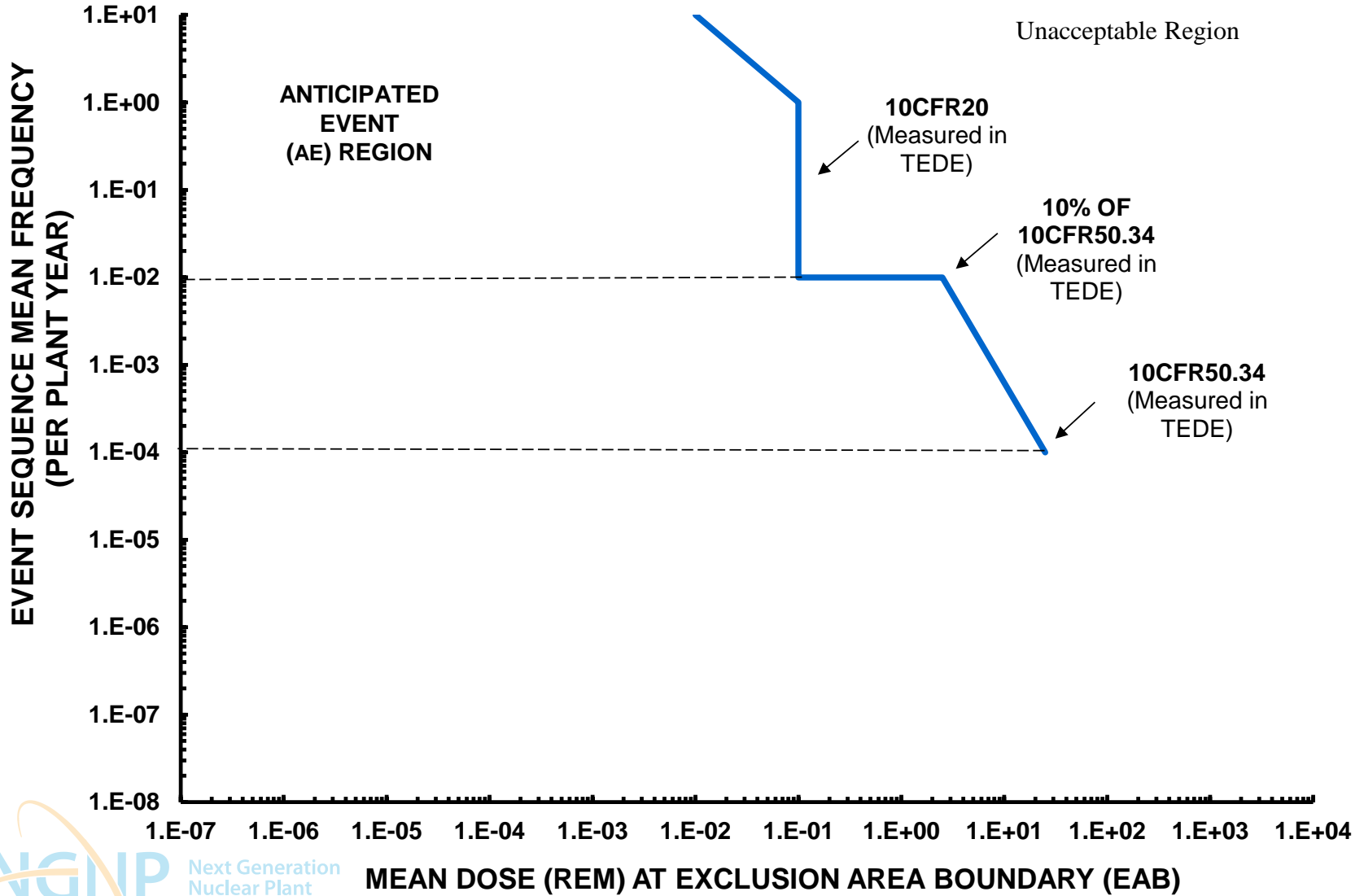
## *Placement of 10CFR20 on F-C Curve*

- Governs normal operation and events expected once or more in the plant lifetime
- Criterion specified as an annual limit of 100 mrem TEDE to an individual at the EAB
  - For events expected more than once in a plant year, assumed to be a constant risk limit
  - For events not expected in a plant year, assumed to be capped at 100 mrem
- Lowest frequency of 0.01/plant year based on a plant lifetime of 60 years

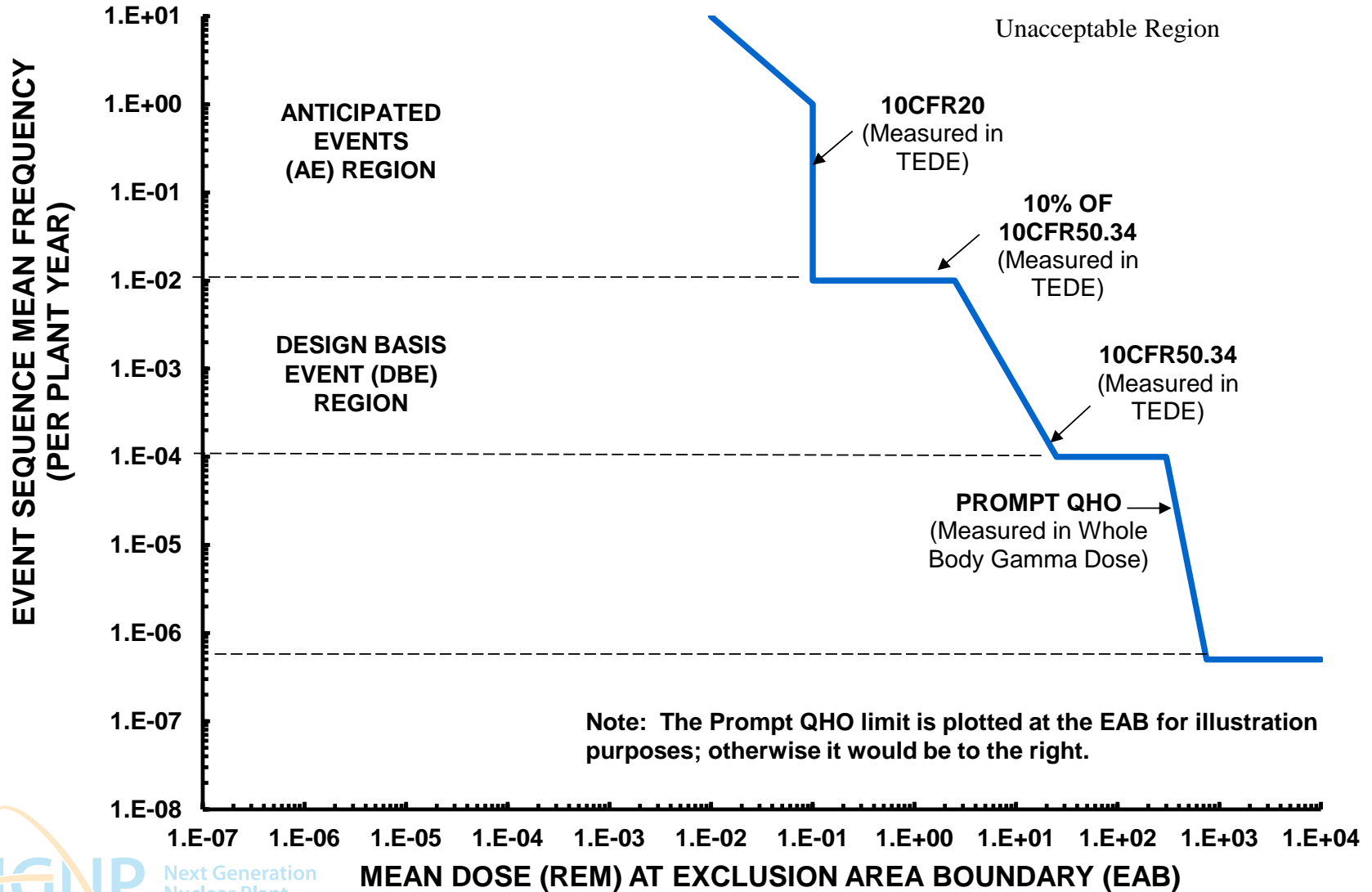
# Placement of 10CFR20 on F-C Curve



# Placement of 10CFR50.34 on F-C Curve

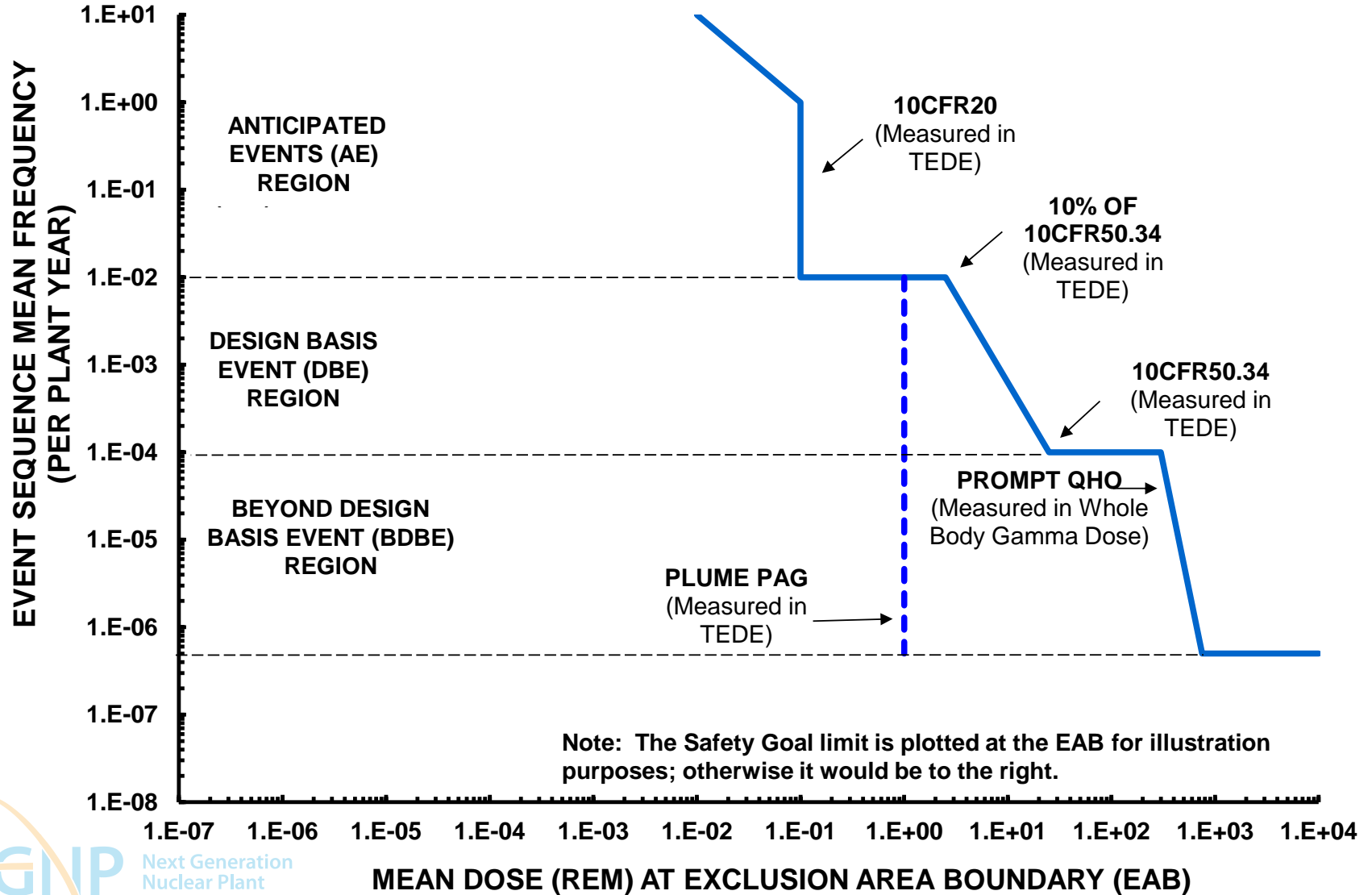


# Placement of 51FR130 Prompt QHO on F-C Curve





# NGNP F-C Curve



## ***Requested NRC Staff Positions***

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- Agree on the frequency cutoffs for the Design Basis Event (DBE) and Beyond Design Basis Event (BDBE) regions

*(As requested in INL to NRC letter CCN 227793 dated July 6, 2012)*

# ***NGNP F-C Curve Q&A***