Tsunami Hazards in California for Critical Structures

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Approach

- Source characterization
  - Distant large subduction earthquakes (M8 – M9.5)
  - Local earthquakes
  - Local landslides
  - Meteorite impacts in Pacific ocean
- Tsunami Waves
  - Based on numerical simulations of tsunami waves

Key Issues

- Validation of simulation methods (computer program)
- Maximum magnitudes for Pacific Rim subduction zones
- Size and rates of offshore landslides
- Aleatory variability of tsunami wave heights
- What is appropriate probability level to use for engineering applications?

Validation of simulation methods

- Issue
  - What is the range of the results from different simulation programs?
- Current study by National Tsunami Hazard Mitigation Program
- Planned evaluation by SCEC in 2012

Maximum Magnitudes

- Issue
  - Unlike ground motions, tsunami waves are sensitive to changes in large magnitudes (M9 vs M9.5)
  - This has not been the focus of source characterization for ground motion hazard studies
- Need:
  - Source characterization for Pacific Rim subduction zones focused on the upper end of the magnitude range

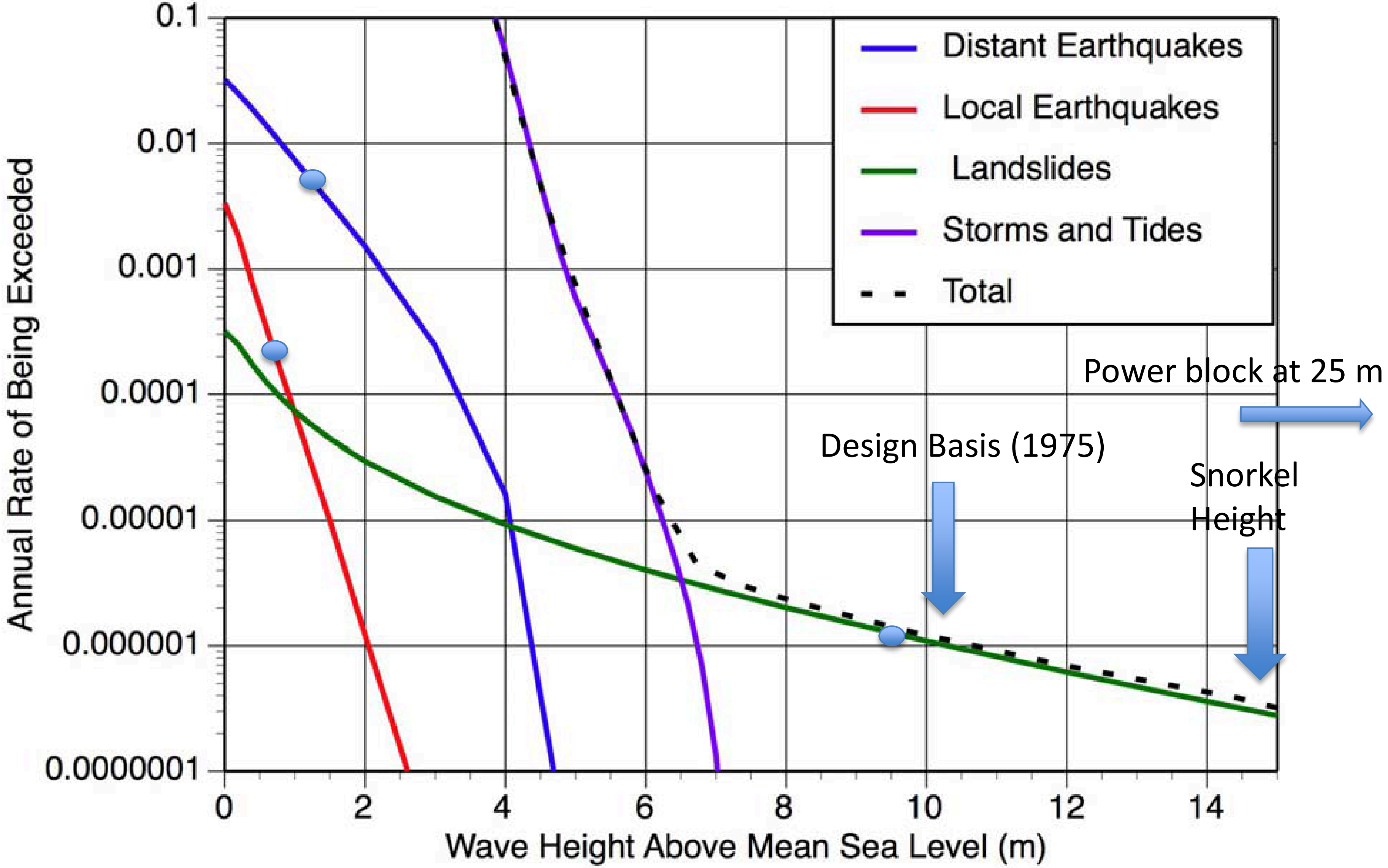
Offshore Landslides

- Issue
  - Landslides can lead to the largest local tsunamis
  - Difficult to characterize future slides
    - Slide dimensions and rates
  - How does this change with sea level?
    - Many slides seen in the offshore geology may have occurred during the last low sea stand (-120m from current level)
- Need:
  - Improved offshore data on past slides and relation to sea level

Aleatory Variability

- Issue
  - Aleatory variability control hazard at low probability level
  - Not well characterized in tsunami studies
- Need estimates of aleatory variability (two parts)
  - Parametric variability
    - Estimate from range of inputs into the numerical simulation
  - Modeling variability
    - Estimate from comparisons of simulated and observed tsunami waves
    - Similar to the standard deviation of ground motion prediction equations
  - Both are needed

Tsunami Hazard at DCPP



Engineering Issues for Tsunamis at NPPs

- No “ductility” for tsunami flooding
- Goal should be for similar risk from different natural hazards, not similar hazard levels
  - Need for lower probability levels for design basis for flooding events than for ground motion

Summary

- Tsunami hazards evaluated using numerical simulations for selected scenarios
- For emergency planning (e.g. evacuation routes), simulations using "maximum magnitude" and median simulated tsunami (no additional aleatory) may be appropriate
- For critical structures, aleatory variability needs to be considered
  - Both deterministic and probabilistic methods must address aleatory variability
    - Large subduction earthquakes around the Pacific Rim are frequent. Need to get to "rare enough" tsunamis.
  - Ignoring aleatory variability will lead to more surprises such as the Tohoku earthquake

Current NRC Guidance

- Probable Maximum Tsunami
  - Use best available scientific information to arrive at a set of scenarios reasonably expected to affect the nuclear power plant site
    - Identify tsunami sources
    - Conduct numerical simulation to estimate tsunami waves
  - "For determination of the PMT, conservative values and ranges of source parameters should be specified. This ensures that the design bases of the nuclear power plant will not be exceeded."
    - Gives appearance of worst-case, but it is not worst-case
    - Does not specifically address aleatory variability