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Risk Informed Emergency Planning Protective Actions

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NRC EP Meeting
Washington, DC
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Basis for Research

- Support an updated, Risk Informed (RI) technical basis for Emergency Planning (EP).
- NRC Guidance are not RI, licensing basis is from 1970's.
  - NUREG 0396 provides current licensing basis.
  - NUREG 0654 provides current implementing guidance.
- Accident source terms are out of date.
- PAS are conservative and simplistic.
- No risk perspective from PRA knowledge integrated into process.

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Project Objectives

- Develop methodology for defining and evaluating the risk implications of various protective action strategies
  - Shelter-in-place.
  - Keyhole evacuation.
  - Evacuation with lateral direction component.
  - Early evacuation start near site.
  - Delayed evacuation start away from site.
  - Preferred shelters near site.
- Revise accident source terms to current NRC / industry values.

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Methodology

- Develop model which is based on NRC code MACCS2 plume dispersion and health effects, but with significant improvements.
  - Allow protective actions that account for wind direction at the time of the accident.
  - Allow more realistic description of evacuation
    - Account for lateral component of evacuation rather than just radial streamline directly under or very near plume centerline.
  - Allow more frequent weather data inputs (less than 1 hour Δt).
  - Permit consideration of increments in wind direction changes less than 22.5 degrees.

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Research Status

- Model / research software (DoRMET) completed and benchmarked against MACCS2.
  - Risk-informed accident sequence descriptions and source terms defined.
  - Protective action strategies defined.
  - Validation / MACCS2 benchmark runs completed.
  - Characterized individual early fatality, early injury and cancer fatality risk results.
- Research results.
  - Results documented in EPRI report currently in internal review.
  - Industry review March / April 2007.
  - Report publication Spring 2007.

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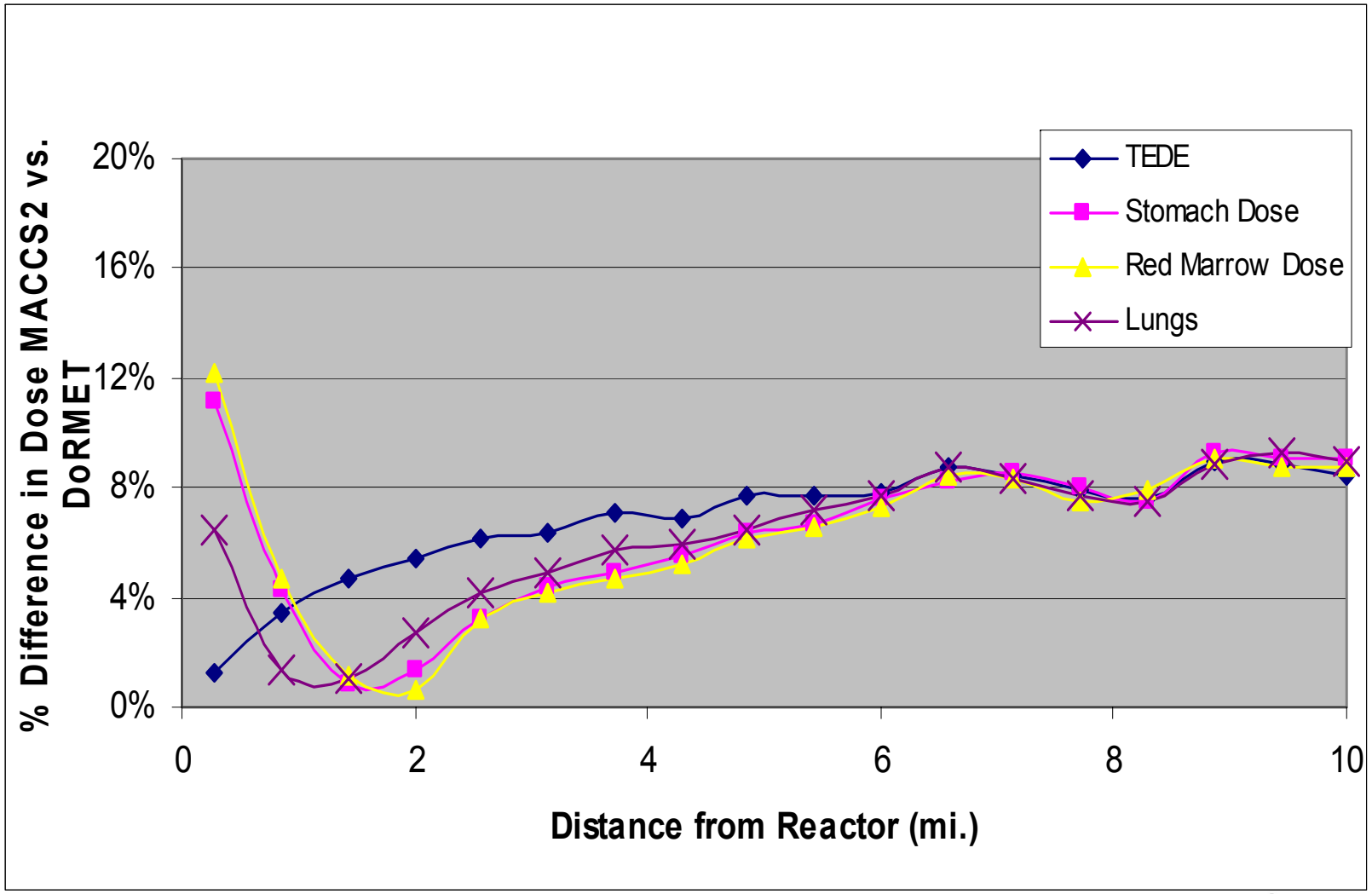
Example Comparison to MACCS2



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Protective Action Strategies Evaluated

- Primary Strategies.
  - Shelter in Place.
  - Away from Reactor Evacuation.
  - Away from Plume Evacuation.
  - Keyhole Evacuation.
- Secondary Strategies.
  - Early Evacuation.
  - Delayed Evacuation.
  - Use of Updated Met Data.
  - Use of Breathing Masks.
  - Preferred Shelter.

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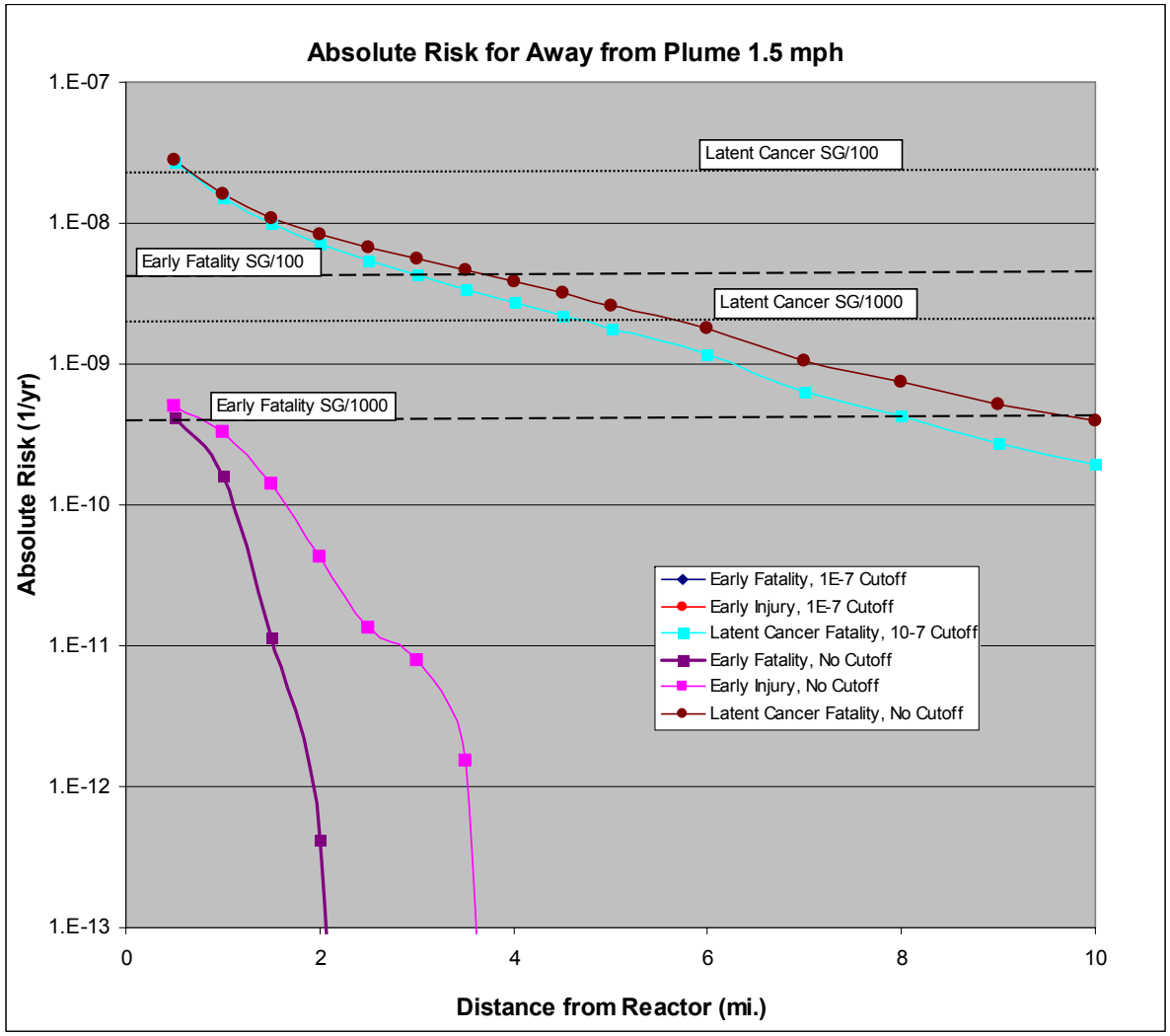
Example Results for Absolute Risk



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Results - I

Distance from Reactor

- Reduction in Early Fatality Risk: 1 to 2+ orders of magnitude per mile.
- Reduction in Latent Cancer Risk: ~1 order of magnitude per 5 miles.

Shelter-in-Place

- ~2 orders of magnitude higher risk than evacuation strategies for region inside 5 miles.

Keyhole Strategy

- Relatively ineffective from 2 to 5 miles compared to other evacuation strategies due to wind shift.

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Results - II

Away from Reactor Strategy

- Modeled as radial evacuation.
- Tendency to exaggerate risk.
- In a realistic road network, it would be almost impossible for an evacuee to remain on, or even relatively near, a radial streamline.

Away from Plume Strategy

- Should be considered
- Moving away from the plume is the shortest distance to safety and is the best strategy from the standpoint of risk reduction.
- Factor of 10 lower early risks than the Away from Reactor 1.5 mph strategy near the site.

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Results - III

Other Findings

- Delayed evacuation beyond 4 miles appears effective and should be considered.
- Updated information (i.e., Representative Individuals move in a direction lateral to the wind direction at the time of the start of evacuation vs. the wind direction at the time at which the ORO begins notification of the public), if practical as part of an Away from Plume strategy, would result in reduction of all risks by about an order of magnitude.
- Neither Breathing Masks nor Preferred Shelter appear to offer significant risk reduction.

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Status of NRC / Industry Interface

- EPRI contractor has had a productive exchanges with Sandia and NRC (met 4 times over the last 18 months)
  - Sandia study on protective actions complete; peer review being performed; publication in 2007?
  - Sandia now conducting series of focus groups to assess how people in the EPZ would behave in an actual emergency.
- NRC undertaking new EP-related work.

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Opportunities for Technical Collaboration

- Mechanism to engage NRC EP related research where appropriate.
- Peer review of methods / results.
- Possible further enhancements to MACCS2 code and / or DoRMET approach
  - Modeling of realistic road networks / traffic management within the EPZ.
- Expand model to calculate latent cancer population risk, not just latent cancer individual risk.
- Improvements in basis for EP decision-making.
  - Improved scientific basis / application of more realistic assumptions.
  - Consideration of R-I technical basis (e.g. evaluation of margin in the current 10 mile EPZ).

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Backup

Source Terms

Accident Sequence Type	Frequency (yr^{-1})	Beginning of Release (hr after scram)	TGE (hr after scram)	Iodine Release Fraction*
1. LOCA – Early Containment Failure	5E-7	3	1	0.1
2. Fast SBO – Early Containment Failure	3E-7	4.5	1	0.15
3. Spontaneous SGTR	2E-6	16	7	0.2
4. Induced SGTR	5E-9	3	1.5	0.2
5. ISLOCA	3E-8	4	1	0.25
6. LOCA – Auxiliary Building Release	5E-6	3	1	0.01
7. Core Damage Sequence - Intact Containment	5E-5	5	4	1E-5

*Fraction of core inventory released to environment
ISLOCA – inter-system loss-of-coolant accident
LOCA – loss-of-coolant accident
SBO – station blackout

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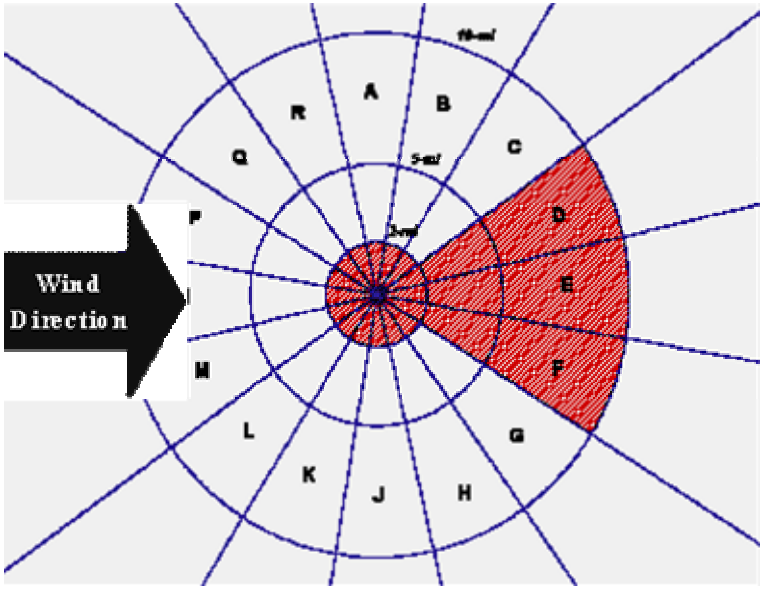
Primary Strategies

Four Primary Strategies

1. Shelter-in-Place
2. Away from Reactor Evacuation
3. Away from Plume Evacuation
4. "Keyhole" Evacuation (Note: three sectors/10 miles depicted, but five sectors/ 5 miles actually used):

Base Evacuation Assumptions

- Two hour delay for evacuation (includes notification delay and ORO/public response delay)
- Evacuation speeds of 1.5, 3, and 5 mph
- "Away from Plume" defined at time of public notification by ORO



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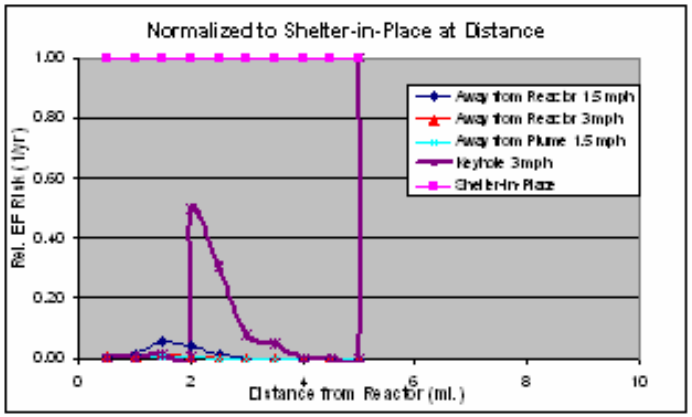
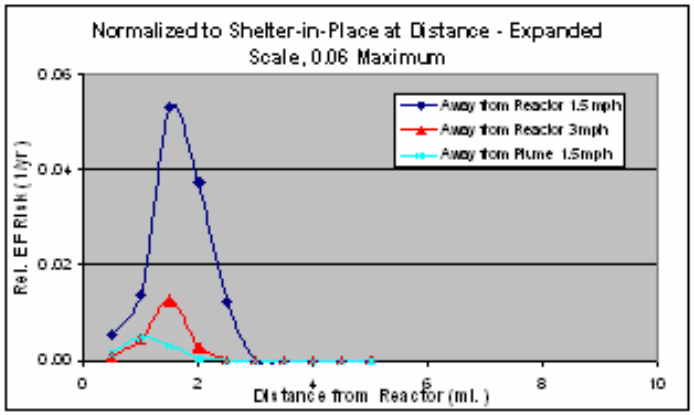
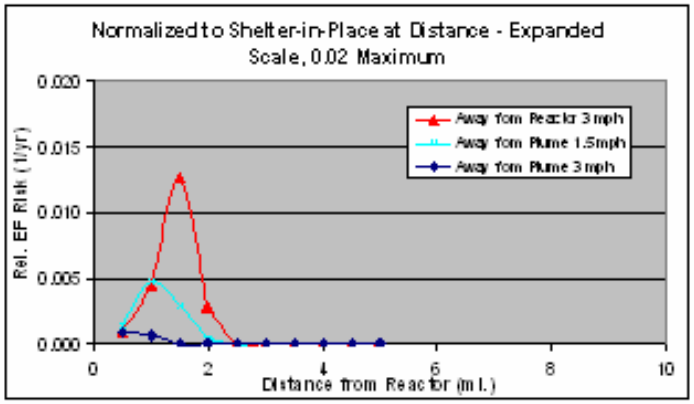
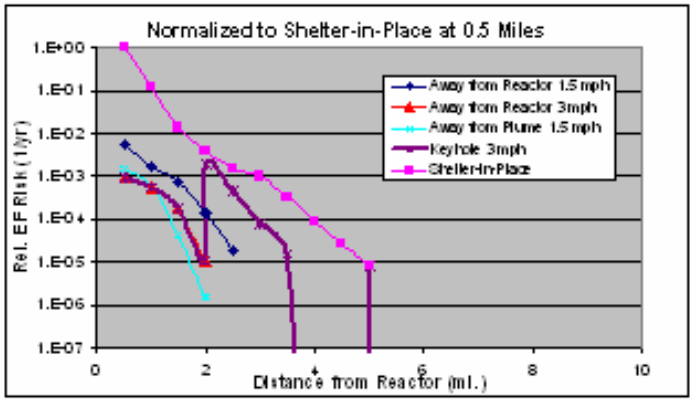
Example Protective Action Results

Risk vs. Distance (Early Fatality Risk)









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