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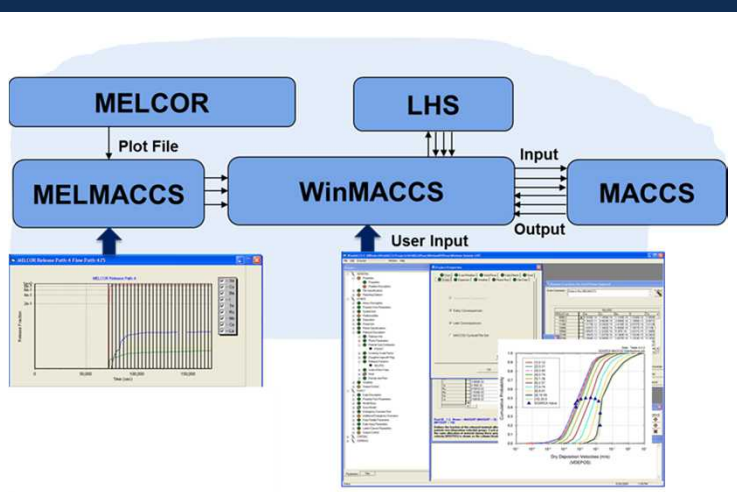

The SOARCA Surry Power Station STSBO Uncertainty Analysis: MACCS Parameter Development

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Overview

- Background
- Objectives
- Methodology
- Uncertain Level-3 Parameters
- Summary

Objectives

- **NRC's State-of-the-Art Reactor Consequence Analysis (SOARCA)**
  - **Evaluate consequences of most frequent accidents at two pilot plants (Peach Bottom and Surry)**
  - **Use best-estimate methodology**
  - **Capture current state of plant equipment and procedures**
  - **Provide best estimate update to compare with previous studies**
  - **Communicate risk to public (mean individual risk)**
- **NRC's SOARCA Surry Uncertainty Analysis (UA)**
  - **Continue to develop method for integrated Level-2/-3 Uncertainty Analysis**
  - **Estimate ranges of epistemic uncertainties**
  - **Characterize relationship between SOARCA point-estimate and the distribution of results derived from the uncertainty analysis**
  - **Determine most sensitive input parameters**

Strategy for Uncertainty Analysis

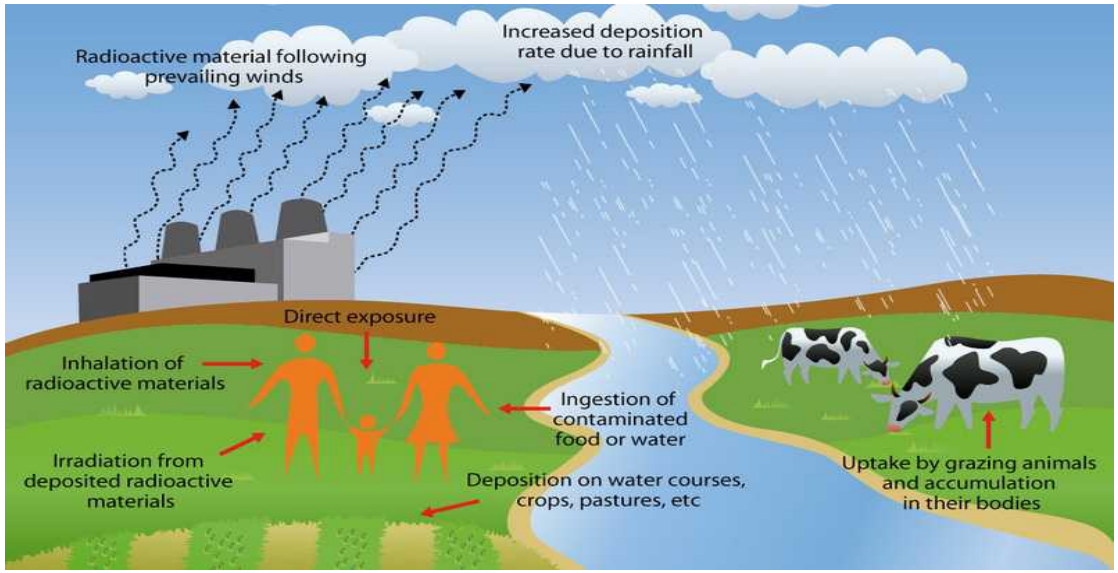
- Focus on a single accident scenario
  - The Surry Short-Term Station Blackout (STSBO) was chosen
  - Considered to be representative of other variations on PWR SBOs, including induced steam generator tube rupture
- Characterize only Level-2 and -3 uncertainties
- Develop distributions representing degree of belief in moderately to very important parameters based on
  - Previous studies, including Peach Bottom UA
  - Prior expert elicitation
  - Expert judgment
- Treat all epistemic uncertainty consistently
  - MELCOR source terms (corresponding to about 1000 realization)
  - Paired with a sampled set of MACCS uncertain parameters
- Treat aleatory uncertainty (weather) within each realization

Sources of Uncertainty

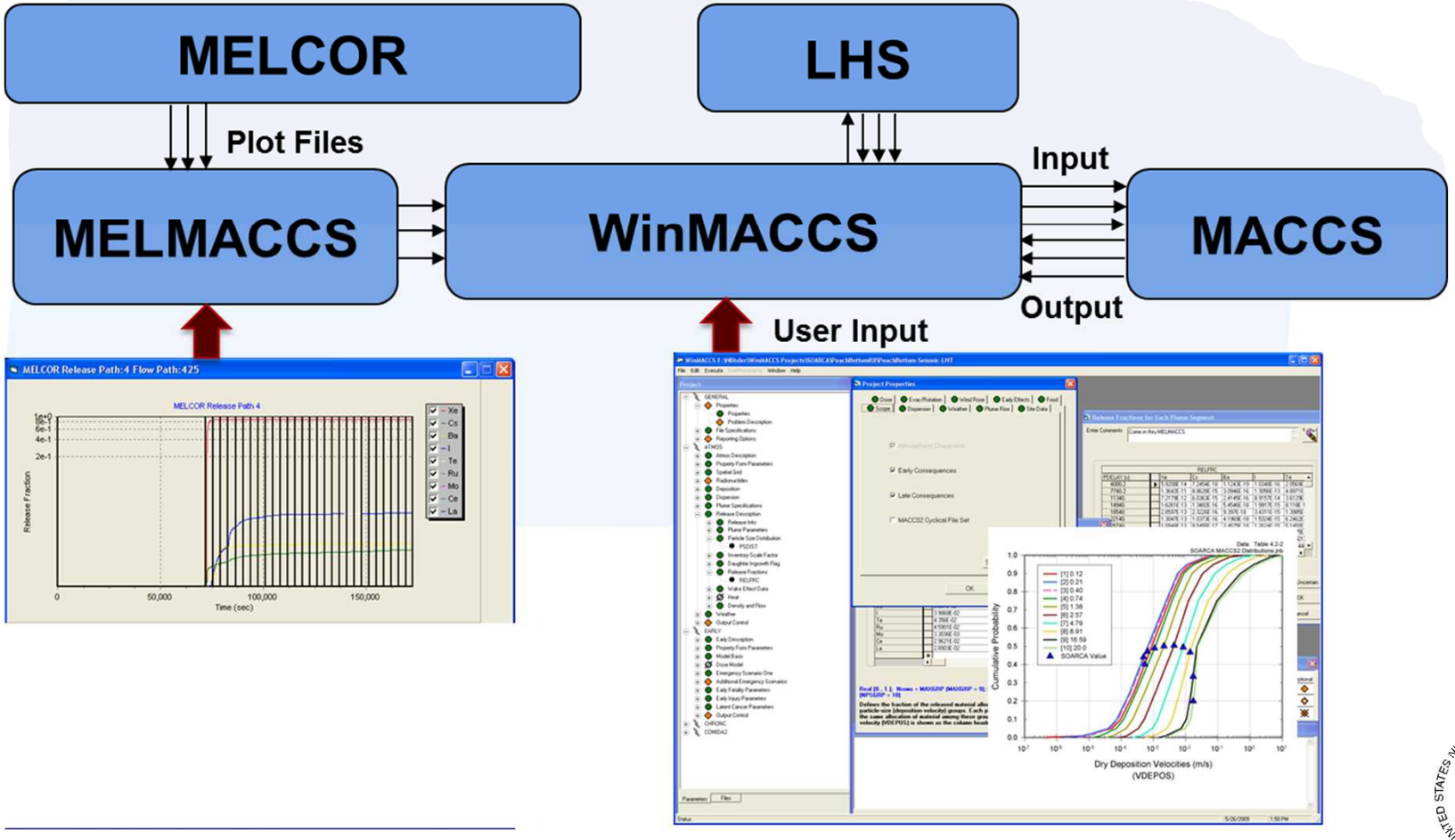
- Epistemic uncertainty from source term (Level 2) and its effect on consequences (Level 3)
  - 24 uncertain parameters
  - Represented by 1003 equally probable source terms
- Epistemic uncertainty in other parameters affecting consequence results (Level 3)
  - 18 uncertain parameter groups
  - Represented by 1003 LHS realizations
- Aleatory uncertainty from weather variability (Level 3)
  - Represented by 1020 weather trials

MACCS Overview

- **Atmospheric transport**
  - **Plume buoyancy**
  - **Building-wake effects**
  - **Dispersion**
  - **Trapping in mixing layer**
  - **Dry deposition**
  - **Wet deposition**
- **Dose pathways in study**
  - **Inhalation**
  - **Cloudshine**
  - **Groundshine**
- **Results Reported in Study**
  - **Individual risk of latent cancer fatality**
  - **Individual risk of early fatality**



MACCS Calculation Framework Used in SOARCA Uncertainty Analysis



Risk Metrics Used in Surry Uncertainty Analysis

- SOARCA best-estimate risk metrics
  - Mean, individual, latent-cancer-fatality (LCF) risk
    - Linear, no-threshold dose response
    - Linear dose response truncated below 620 mrem/yr
    - Dose truncation based on the Health Physics Society Position Statement – linear dose response truncated below 5 rem/yr when lifetime dose is less than 10 rem
    - Risks evaluated within 10, 20, 30, 40, and 50 miles from the plant
    - Risks evaluated in 10-mile rings, e.g., the annulus from 10 to 20 miles
  - Mean, individual early-fatality risk

Uncertain Parameters

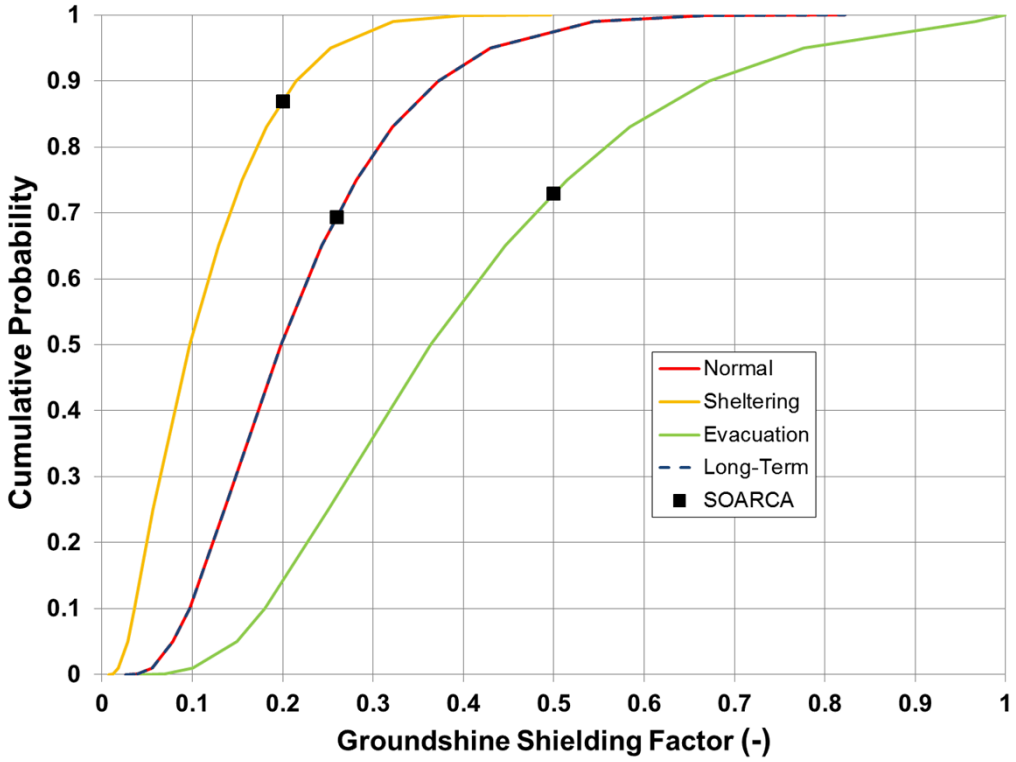
- Source term from MELCOR
- Deposition rates
  - Dry deposition
  - Wet deposition
- Shielding factors
  - Groundshine
  - Inhalation
- Relocation parameters
  - Hotspot (time and dose)
  - Normal (time and dose)
- Early health effect parameters (3)
- Weather conditions
- Dispersion parameters
  - Crosswind
  - Vertical
- Latent health effect parameters
  - Dose and dose-rate effectiveness factors
  - Risk coefficients
  - Inhalation DCFs
  - Groundshine DCFs
- Evacuation parameters
  - Delay times
  - Speeds

Development of Distributions

- An owner was assigned to each input parameter
- Owner developed a storyboard for distribution
  - Description of how parameter is used
  - Distribution for parameter
  - Rationale for distribution
- Owner defended distribution and rationale to other Sandia and NRC experts
- Process repeated until experts were satisfied that distribution and rationale were technically defensible

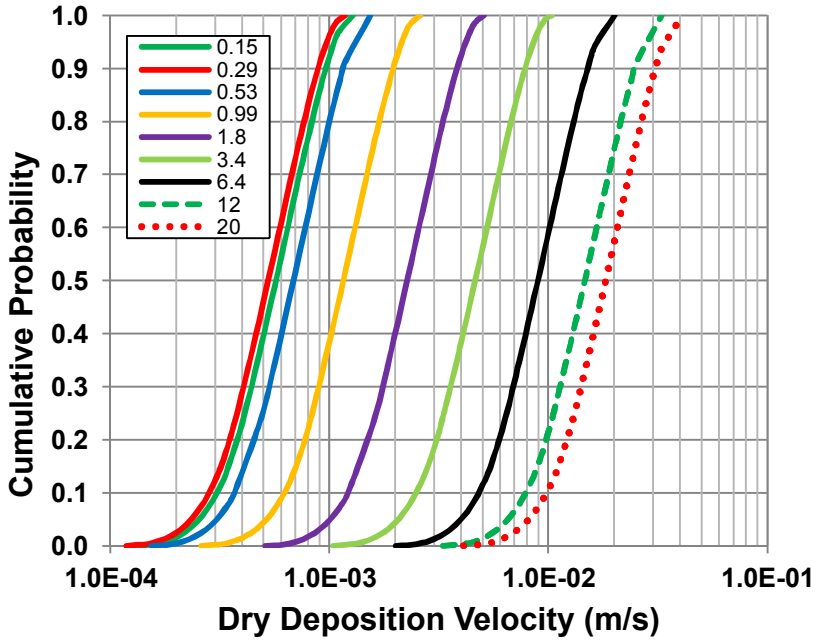
Distributions for Groundshine Shielding Factor

- Distributions of groundshine shielding factor represent two independent sources of uncertainty
  - Shielding between source and receptor
  - Energy deposition within receptor
- Source of distributions is NUREG/CR-6526 and report by Keith Eckerman



Distributions for Dry Deposition Velocities

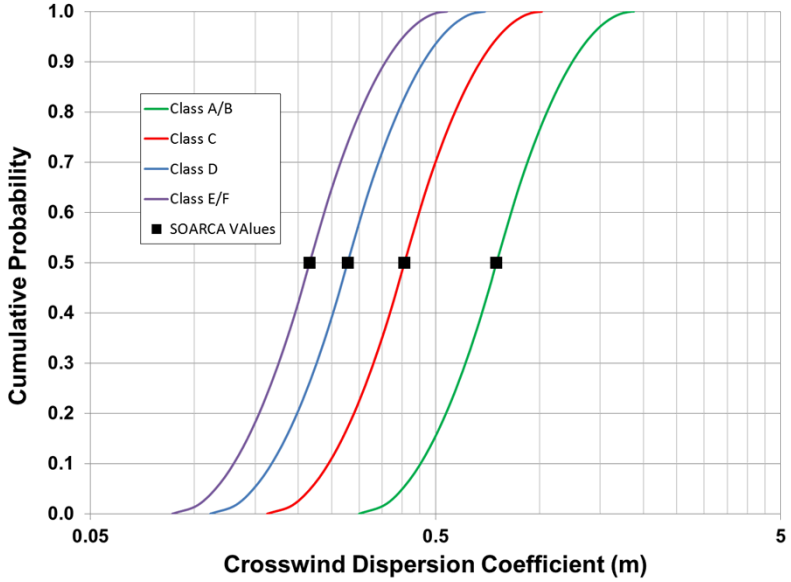
- **Starting point**
  - **Distributions used for Peach Bottom UA**
  - **Taken from NRC/CEC expert elicitation (NUREG/CR-7161)**
- **Evolved to be narrower**
  - **Expert data considered uncertainty for a single weather instance**
  - **MACCS uses a single value to evaluate weather variations representing one year**

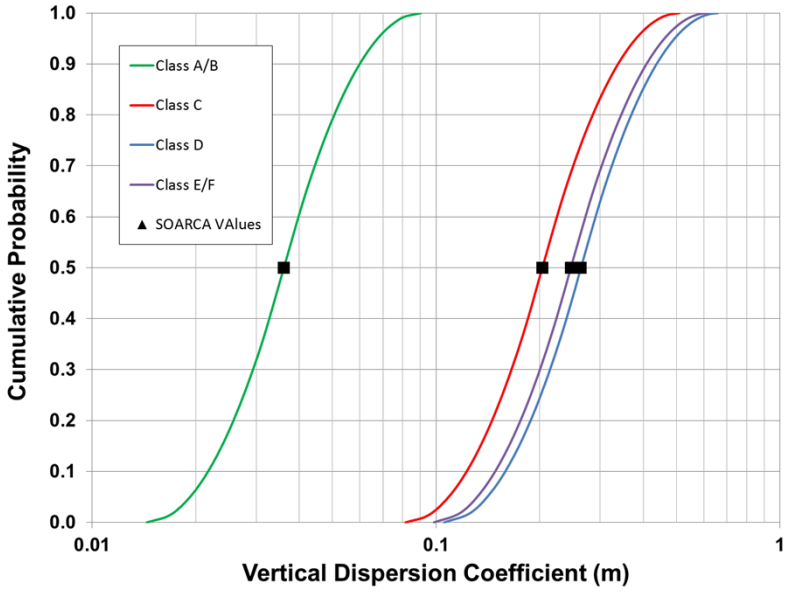


- **Triangular distributions UB/LB = 10**

Dispersion Parameters

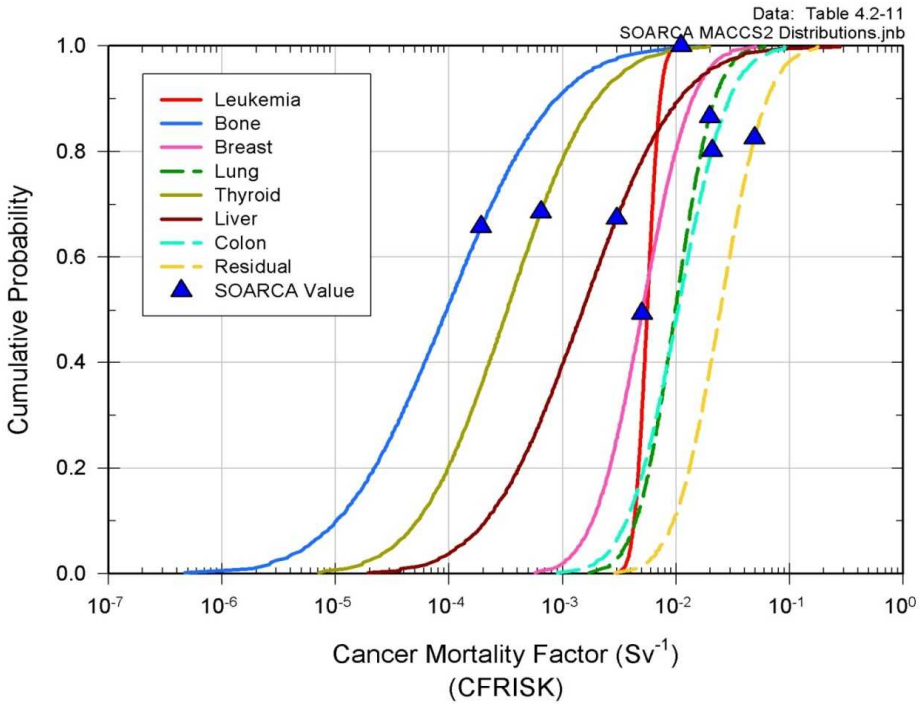
- **Starting point**
  - **Distributions used for Peach Bottom UA**
  - **Taken from NRC/CEC expert elicitation (NUREG/CR-7161)**
- **Evolved to be narrower**
  - **Expert data considered uncertainty for a single weather instance**
  - **MACCS uses a single value to evaluate weather variations representing one year**
- **Triangular distributions UB/LB = 2.5^2**





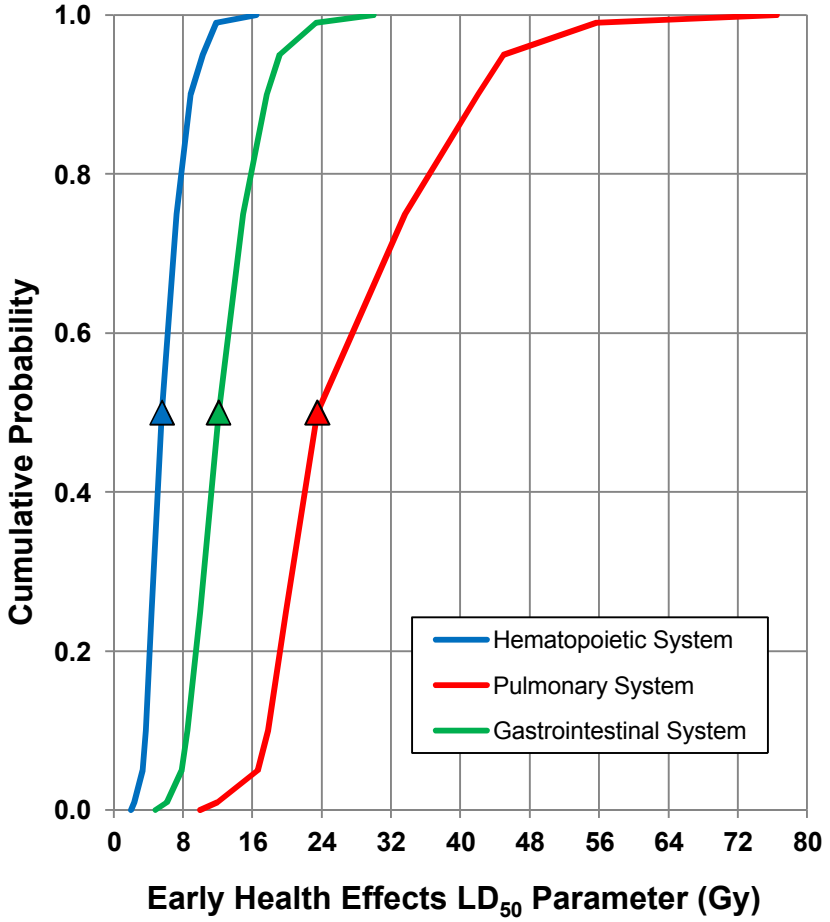
Cancer Risk Factors

- Cancer mortality risk factors were taken from a report written by Keith Eckerman



Early Fatality Parameters for LD_{50}

- Early health effect distributions were taken from the NRC/CEC expert elicitation (NUREG/CR-7161)
- Triangles in plot are SOARCA best estimate values



Summary

- Uncertainty analysis (UA) for Surry is following a similar path to the Peach Bottom UA, but taking advantage of lessons learned from the previous work
- Distributions representing degree of belief in a set of input variables have been developed
- Calculations and documentation of results are ongoing