



**Pacific Northwest**  
NATIONAL LABORATORY

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# GENII: Dose Estimation

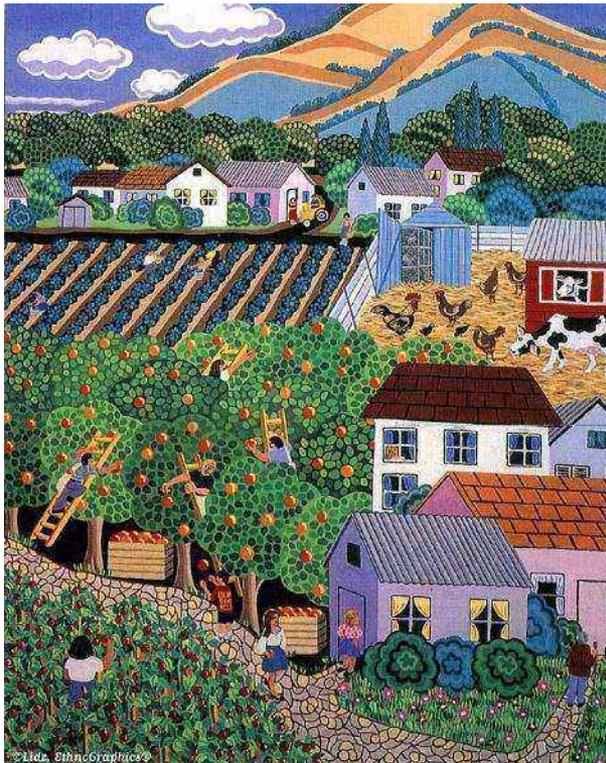
BRUCE NAPIER

RAMP GENII Training, Taipei, Taiwan

# Estimating Radiation Dose to Individuals

- ▶ **Primary components are radionuclides in:**
  - **Air**
  - **Water**
  - **Soil**
  - **Foods**
- ▶ **Level of human exposure to each**

# Converting Environmental Concentrations to Doses



# Doses



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- ▶ **Dose is a useful physical concept, but it is nearly impossible to measure for individuals**
- ▶ **Therefore, most dose estimates are made with non-individual-specific dose conversion factors, which are themselves the result of the application of a model**



# External Dosimetry

- ▶ **Estimation of radiation doses to organs from sources outside the body**
  - **Submersion in contaminated air**
  - **Immersion in contaminated water**
  - **Exposure to contaminated ground, sediment, or surfaces**

# External Dose Rate Factors

- ▶ Anatomical representation of reference individuals of different age, sex, ethnicity
- ▶ Distribution of radionuclides in source
  - Uniform, infinite planes or slabs often used
- ▶ Radiation transport from source to body
  - Shielding may be considered here or a correction added later
- ▶ Radiation transport to specific organs
- ▶ Energy absorbed in specific organs



# External Dose - Calculation

- ▶ External dose factors are used to estimate dose from simplified source configurations
- ▶ Usually a dose rate calculation
- ▶ Must consider buildup/decay of radionuclides, shielding, fraction of time exposed, etc., separately from dose rate factor



# Internal Exposure

- ▶ Estimation of dose from intakes of radionuclides into the body
  - Inhalation
  - Ingestion
  - Dermal absorption (e.g. tritium)
- ▶ Must consider patterns of deposition in specific organs



# Internal Dose Factors

- ▶ Anatomical representation of reference individuals of different ages, sexes, etc.
- ▶ Absorption of radionuclides into blood
  - Lung model
  - GI-Tract model
- ▶ Deposition/retention in different organs, accounting for biological elimination, decay
- ▶ Organ dosimetry



# Metabolic Models

- ▶ “Metabolic” or “biokinetic” models are used to describe absorption, deposition, and retention
- ▶ Functions of age
- ▶ Generally empirical, fitting limited data
- ▶ Behavior of decay progeny is often treated idealistically

# GENII V.2 Human Exposure

- ▶ Up to 6 age groups allowed, following ICRP-56,67,69

3 months	0-1 year
1 year	1-2 year
5 year	2-7 year
10 year	8-12 year
15 year	13-17 year
20 + year	17- 110 year



# External Exposure - Doses

- ▶ Dose rate conversion factors from Federal Guidance Report 12, provided by Keith Eckerman, ORNL
  - Air Submersion
  - Water Immersion
  - Soil Plane
  - Soil Volume



# Internal Exposure - Doses

- ▶ Effective dose equivalent: ICRP-30
  - Adult only
- ▶ Effective dose: ICRP-72
  - 6 age groups
  - 24 organs/tissues
  - Inhalation classes F, M, S

# Risk Calculations - FGR 13

- ▶ US Federal Guidance Report 13 provides coefficients for 15 cancer sites
  - Inhalation (risk/Bq)
    - Inhalation classes F, M, S
  - Ingestion (risk/Bq)
    - Accounts for different consumption patterns with age
      - ◆ Drinking water
      - ◆ Food crops

# GENII: Human Exposures

- ▶ Maximally-exposed individual (or population-average individual) intakes are determined in the Receptor Intakes Module



## Receptor\_Intakes

GENII Intake Module - rcp7

File Defaults Reference Help

Number of age groups 2

Age group selection 1

Age group lower bound 0.0 yr Ref: 0

Age group upper bound 10.0 yr Ref: 0

Pathway selection

- External exposure to air
- External ground exposure
- External exposure while swimming
- External exposure while boating
- External exposure to shoreline
- Food crop ingestion
- Animal product ingestion
- Aquatic food ingestion
- Drinking water ingestion
- Water ingestion while swimming
- Water ingestion while showering
- Inadvertent soil ingestion

External exposure to air

Daily plume immersion exposure time 24.0 hr Ref: 0

Yearly plume immersion exposure time 365.0 day Ref: 0



# GENII: Dose and Risk Estimation

- ▶ Doses and risks are calculated in the Health Impacts Module



## Health\_Impacts

The screenshot displays two overlapping windows of the GENII Health Impacts Module. The background window is in the 'Method Selection' tab, showing three radio button options for calculation methods. The foreground window is in the 'Method Parameters' tab, showing configuration options for the selected method.

**GENII Health Impacts Module - hei9**

File Reference Help

Method Selection | Method Parameters | Constituent Parameters

Calculate radiation dose and risk using ICRP - 30/48 factors (Federal Guidance Reports 11/12)

Calculate Dose and/or risk using ICRP - 60 and EPA risk factors (Federal Guidance Reports 12/13)

Calculate risk using EPA slope factors

**GENII Health Impacts Module - hei9**

File Reference Help

Method Selection | Method Parameters | Constituent Parameters

Calculate lifetime cancer incidence  
Conversion factor: 0.06 risk/Sv Ref: 0

Calculate cancer fatalities  
Conversion factor: 5.0e-2 risk/Sv Ref: 0

Calculate radiation effective dose equivalent commitment (CEDE)

Thickness of contaminated soil/sediment layer -- SOILT: 0.15 m Ref: 0

Density of contaminated soil/sediment layer -- SLDN: 1500 kg/m<sup>3</sup> Ref: 0

# GENII: Looking at the Answer

## ► There are many ways to see the results

- FRAMES-provided viewers
- Air/Water Report Generators



- Connect-Disconnect
- General Info
- User Input
- Run Model
- Rename
- Delete
- View/Print User Input
- View/Print Module Output

- HIF Graphical View
- HIF Population Viewer
- HIF Probability of Exceedence
- HIF Text View
- HIF by Exposure Pathway, Route
- HIF by Exposure Pathway and Route
- HIF by Target Organ and Age Group
- HIF Maximum Impacts by Target Organ and Age Group
- HIF Summary Views of Risk, Hazard and Dose

Summary of Risks/Hazard/Dose

Print Save Help

Dataset: exp12:Air Time Point (yr): 0  
Location: (0, 0.1) km Cancer organ: all sites  
Age Group: 0 to 70 Dose organ: total body  
Constituent: All Radionuclides Exposure duration: 1 yr

Show Totals Only

Exposure Route and Pathway	risk	risk	dose
All Radionuclides summation for exp12:Air at location (0, 0.1) km for ages 0 to 70 at time 0	cancer incidence (all sites)	cancer fatalities (all sites)	Sv (total body)
<b>TOTAL</b>	<b>5.57E-02</b>	<b>4.655E-02</b>	<b>9.29E-01</b>
external (total)	3.47E-02	2.9E-02	5.79E-01
Air	2.38E-10	1.99E-10	3.97E-09
Ground	3.47E-02	2.9E-02	5.79E-01
inhalation (total)	1.105E-07	9.221E-08	1.844E-06
Air	7.452E-09	6.212E-09	1.24E-07
Soil	1.03E-07	8.6E-08	1.72E-06
ingestion (total)	2.1E-02	1.755E-02	3.5E-01

# GENII: Report Generators



Report\_Generator

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Air Dose Report Generator UI - nes15

File Help

Inputs | Input Files

Provide only Individual Dose/Risk Results

Include Atmospheric Dispersion and Deposition Estimates

Include Population Dose/Risk Estimates (requires a file of population distribution around the release site)

Provide results by pathway and by nuclide

Select reporting units:

Input Facility Name:

Input Facility Mailing Address:

Input Facility City, State, ZIP Code:

Input User Name:

Air Dose Report Generator UI - nes15

File Help

Inputs | Input Files

Number of distances and units:

Number of directions and units:

Number of population age groups:

Population filename:

Use food production file

Food Production filename:

Food Production Products:

- Meat
- Poultry
- Milk
- Eggs
- Leafy Vegetables
- Root Vegetables
- Fruits
- Grains

Open Population File

Open Production file

Collective dose calculations require additional information in a format that matches the remainder of the calculation