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Sharing the Effectiveness of Turbo FRMAC Implementation of IAEA Radiological Assessment Methodologies

IAEA CRP J15002 Research Coordination Meeting

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Presentation Overview

- Introduction
- U.S. Federal Radiological Monitoring and Assessment Center (FRMAC)
- Turbo FRMAC software
- Coordinated Research Project goals

Introduction

- Sandia National Laboratories, located in Albuquerque, New Mexico, USA
- Government owned, contractor operated
- Provide research and technical solutions, expert analysis, and highly trained emergency response professionals to support the U.S. government's response to a nuclear or radiological accident

Sandia National Laboratories

Turbo FRMAC 2019

Federal Radiological Monitoring and Assessment Center (FRMAC)

Mission: Provide timely, high-quality predictions, measurements, analyses, and assessments to promote efficient and effective emergency response for the protection of the public from the consequences of nuclear or radiological incidents

Aerial Measurements

Field Monitoring

Sample Control and Analysis

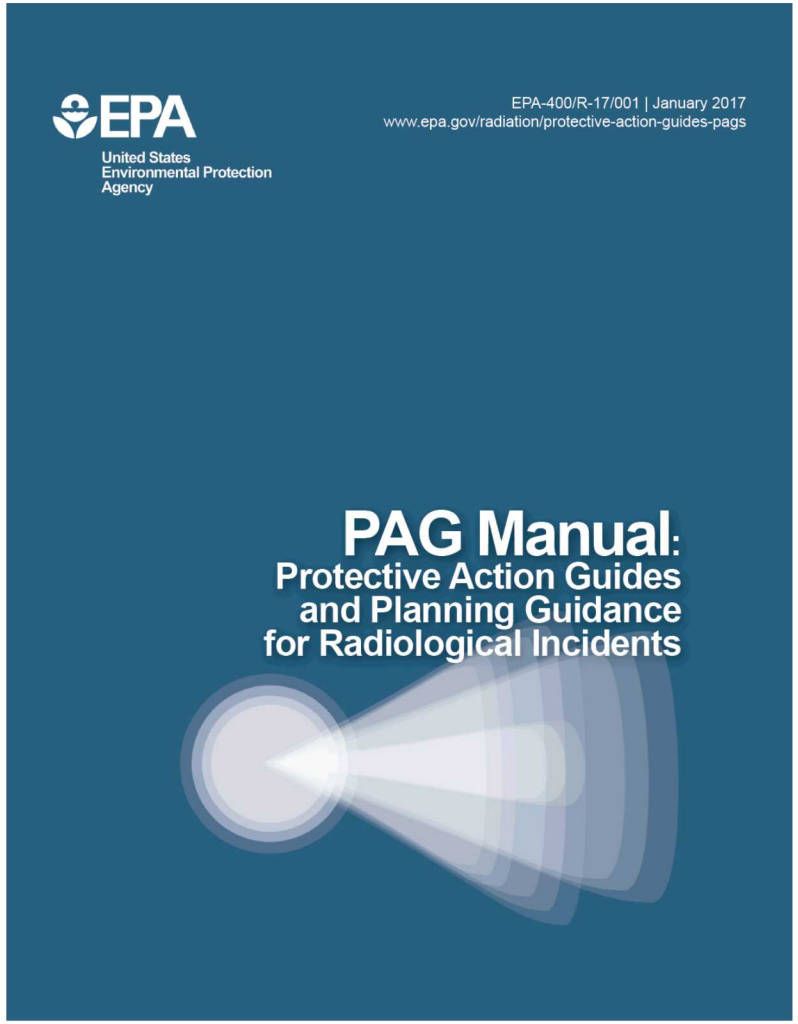
Data Assessment

FRMAC Participation

- Department of Agriculture (USDA)
- Department of Defense (DoD)
- Department of Energy (DOE)/National Nuclear Security Administration (NNSA)
- Department of Health & Human Services (DHHS)/Food & Drug Administration (FDA) and Centers for Disease Control & Prevention (CDC)
- Department of Homeland Security (DHS)/Federal Emergency Management Agency (FEMA)
- Environmental Protection Agency (EPA)
- Nuclear Regulatory Commission (NRC)
- Law Enforcement (FBI)
- State/Local/Tribal agencies

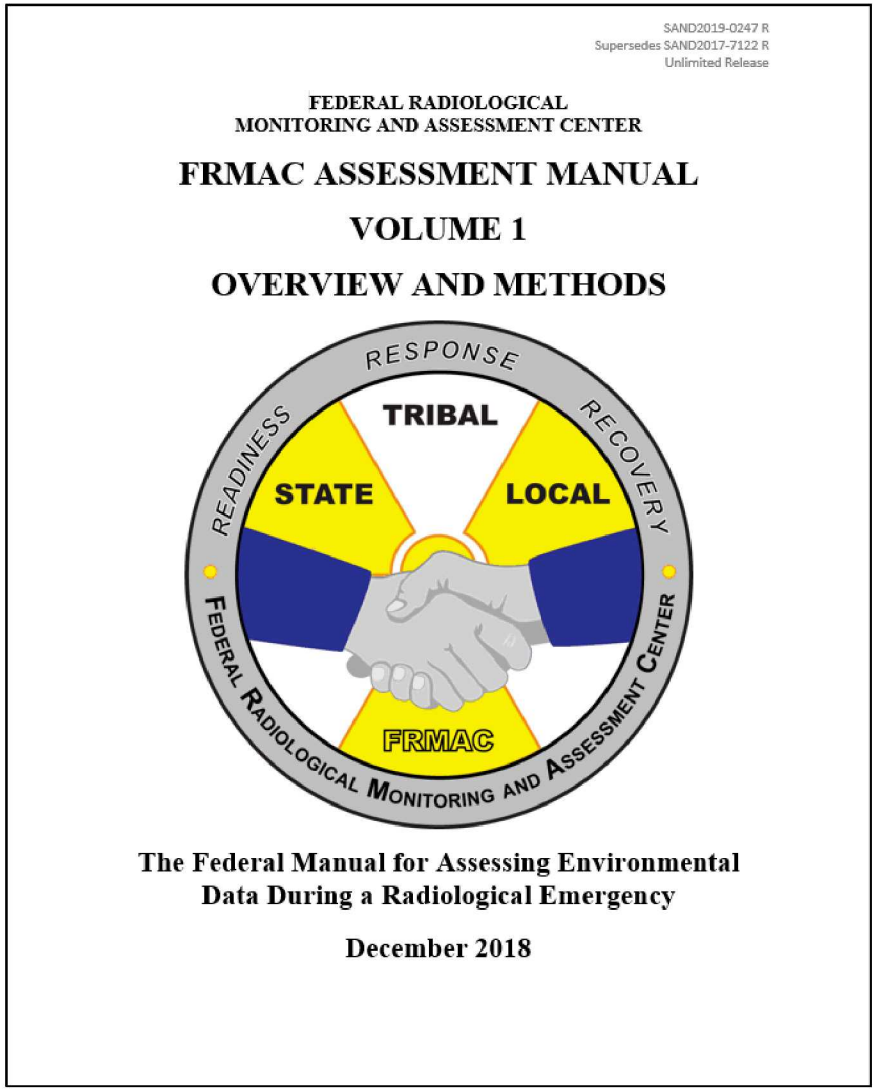
U.S. Protective Action Guidance

- Environmental Protection Agency (EPA) Protective Action Guide (PAG) Manual
- PAGs are based on 3 principles:
  - 1. Prevent acute effects
  - 2. Reduce risk of chronic effects
  - 3. Balance protection with other factors and ensure that actions result in more benefit than harm
- PAGs are predetermined for use in emergencies without regard to the magnitude or type of radiological release
- Decision makers may implement protective actions at higher or lower levels than the recommended PAGs



FRMAC Assessment Manual

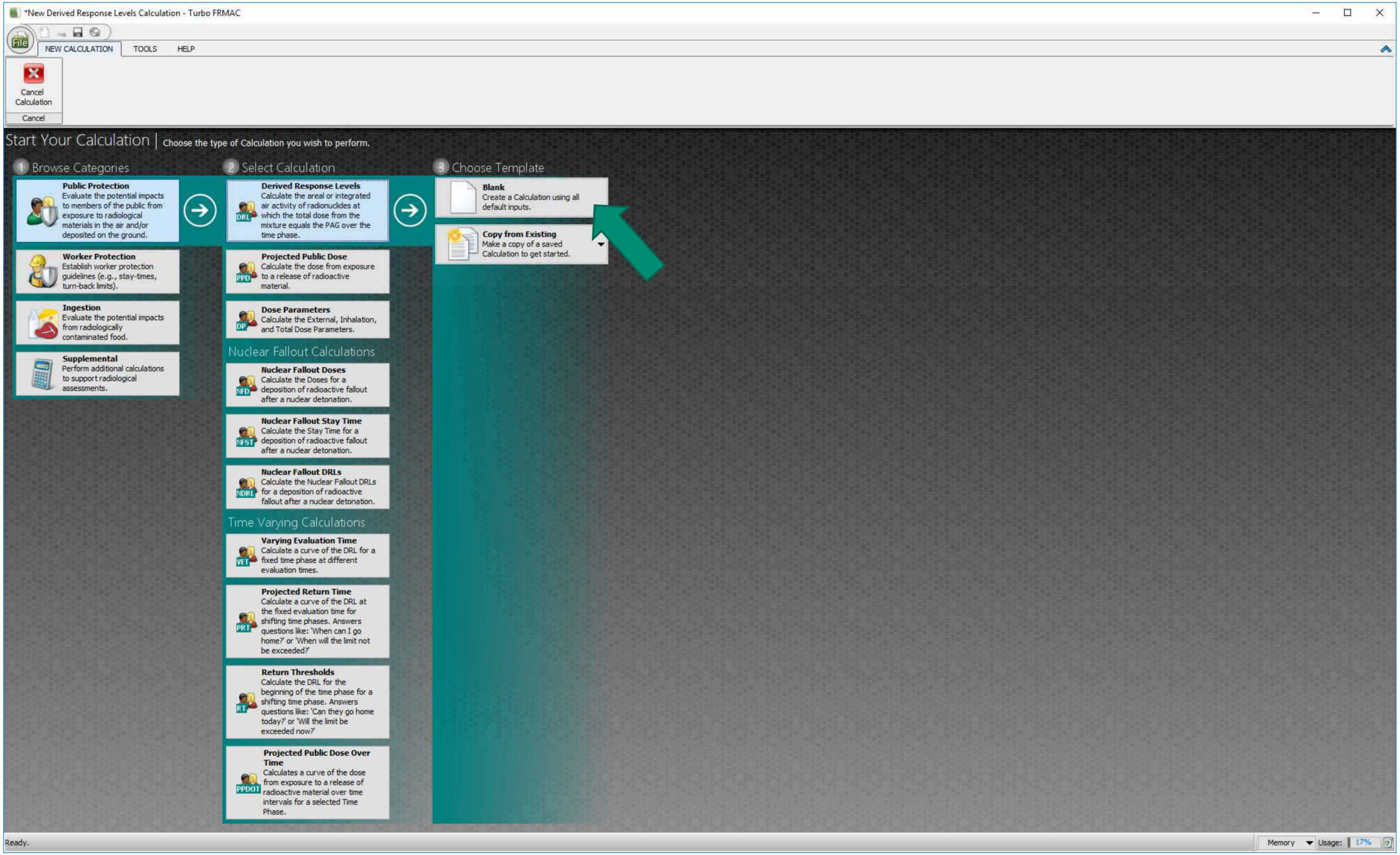
- The technical consensus of multiple U.S. federal agencies with expertise in and authority over aspects of radiological emergency response
- Referenced by the EPA PAG Manual
- Only addresses the early and intermediate phases of a radiological incident
- Default assumptions use the International Commission on Radiological Protection (ICRP) 60+ dosimetry models based on agreement with the EPA

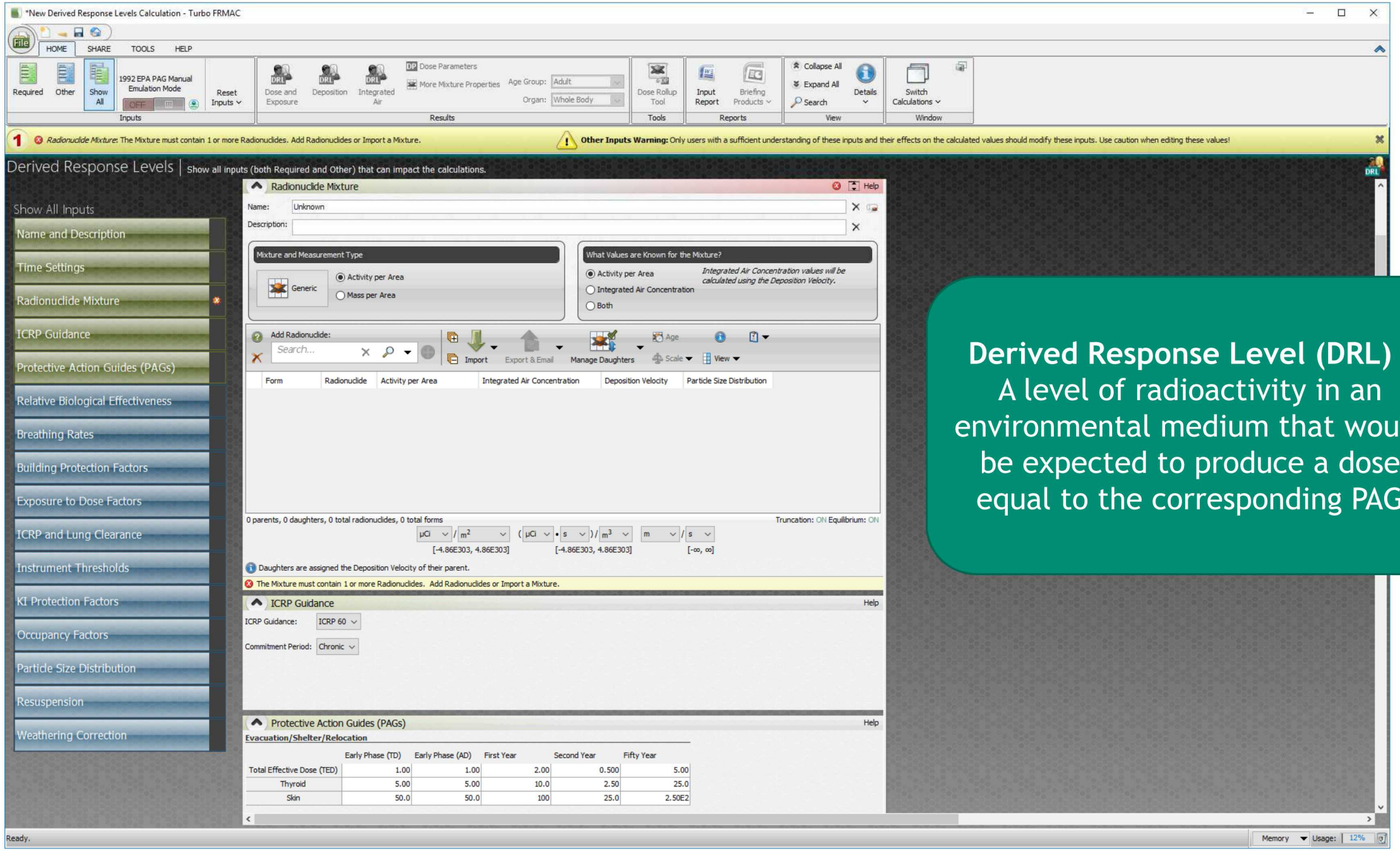


Turbo FRMAC

- Turbo FRMAC is a deployable software application developed by Sandia National Laboratories
- Turbo FRMAC automates FRMAC Assessment Manual methods
- Used by U.S. Federal, State, and Local radiological assessors for over 15 years
- Updated periodically to implement new and revised methods


Turbo FRMAC
File
HOME
SHARE
TOOLS
HELP
Reset Inputs
Results
Collapse All
Expand All
Search
Details
Switch Calculations
Inputs
Results
View
Window
Turbo FRMAC 2019
New Calculatio
Open Calculation
Watch Help Videos
National Nuclear Security Administration
FEMA
Sandia National Laboratories
Export Controlled Information (ECI)
Export Administration Regulations (EAR99)
Treat this material per Department of Commerce Export Administration regulations, 15 CFR 732.3.
Ready.
Memory
Usage:
1%

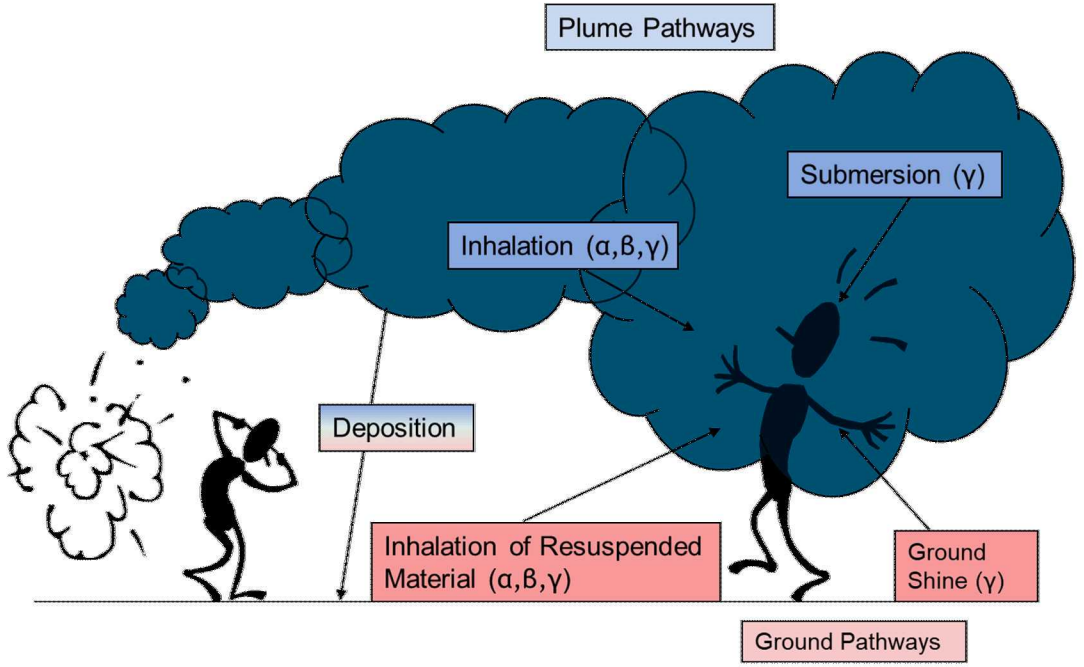

*New Derived Response Levels Calculation - Turbo FRMAC
File
NEW CALCULATION
TOOLS
HELP
Cancel Calculation
Cancel
Start Your Calculation | Choose the type of Calculation you wish to perform.
1 Browse Categories
Public Protection
Evaluate the potential impacts to members of the public from exposure to radiological materials in the air and/or deposited on the ground.
Worker Protection
Establish worker protection guidelines (e.g., stay-times, turn-back limits).
Ingestion
Evaluate the potential impacts from radiologically contaminated food.
Supplemental
Perform additional calculations to support radiological assessments.
2 Select Calculation
Derived Response Levels
Calculate the areal or integrated air activity of radionuclides at which the total dose from the mixture equals the PAG over the time phase.
Projected Public Dose
Calculate the dose from exposure to a release of radioactive material.
Dose Parameters
Calculate the External, Inhalation, and Total Dose Parameters.
Nuclear Fallout Calculations
Nuclear Fallout Doses
Calculate the Doses for a deposition of radioactive fallout after a nuclear detonation.
Nuclear Fallout Stay Time
Calculate the Stay Time for a deposition of radioactive fallout after a nuclear detonation.
Nuclear Fallout DRLs
Calculate the Nuclear Fallout DRLs for a deposition of radioactive fallout after a nuclear detonation.
Time Varying Calculations
Varying Evaluation Time
Calculate a curve of the DRL for a fixed time phase at different evaluation times.
Projected Return Time
Calculate a curve of the DRL at the fixed evaluation time for shifting time phases. Answers questions like: 'When can I go home?' or 'When will the limit not be exceeded?'
Return Thresholds
Calculate the DRL for the beginning of the time phase for a shifting time phase. Answers questions like: 'Can they go home today?' or 'Will the limit be exceeded now?'
Projected Public Dose Over Time
Calculates a curve of the dose from exposure to a release of radioactive material over time intervals for a selected Time Phase.
3 Choose Template
Blank
Create a Calculation using all default inputs.
Copy from Existing
Make a copy of a saved Calculation to get started.
Ready.
Memory
Usage:
17%



Derived Response Level (DRL) – A level of radioactivity in an environmental medium that would be expected to produce a dose equal to the corresponding PAG

How are Derived Response Levels calculated?

- Public protection calculations include four exposure pathways:
  - Plume Inhalation
  - Plume Submersion
  - Resuspension Inhalation
  - Groundshine
- Ingestion exposure pathways is handled separately
- Bateman equations used for decay and in-growth
- Dose is integrated over a user-specified time period



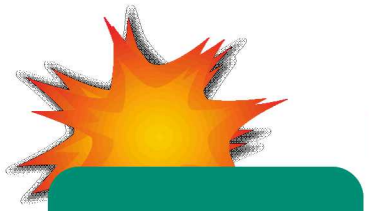
FRMAC Default Assumptions

- Adult receptor, Whole Body (Effective) dose
- The receptor is outside and unprotected
- The plume is in contact with the ground
- Airborne noble gases are not deposited
- Deposition is immediate
- Deposition is assumed to be dry particulates with a default particle size of 1-micron Activity Median Aerodynamic Diameter (AMAD)
- ICRP Recommended Lung Clearance Type
- ICRP 60 based dose coefficients and breathing rates
- Maxwell and Anspaugh (2011) resuspension model[1]
- Anspaugh (2002) weathering model[2]

Turbo FRMAC settings can be adjusted to use different models or event-specific data

[1] Maxwell, R. and Anspaugh, L., "An Improved Model for Prediction of Resuspension" in *Health Physics*, Vol. 101, pp. 722-730, December 2011
[2] Anspaugh, L., et al., "Movement of Radionuclides in Terrestrial Ecosystems by Physical Processes" in *Health Physics*, Vol. 82, pp. 670-679, April 2002

How are Derived Response Levels used?



Determine initial source term

Potential data sources include regulatory agencies, intel, models, and measurements

Calculate DRL

Turbo FRMAC is used to calculate DRLs

Run atmospheric dispersion models and contour DRL

Resulting map products are used by local officials to decide where to take protective actions

Collect field measurements and use to refine source term

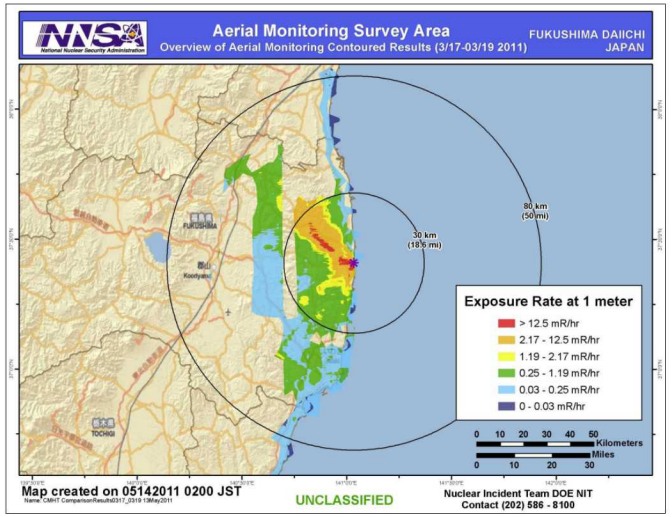
DRLs can also be calculated for specific areas and compared to field measurements

Model Limitations

- Turbo FRMAC is not an atmospheric dispersion model, so assumptions are used to estimate the relative radionuclide activities in the air and on the ground
- However, monitoring and sampling, and atmospheric dispersion model data can be entered to improve the accuracy and dose projections and DRLs
- Because Turbo FRMAC does not perform atmospheric dispersion, DRLs are calculated for a single radionuclide mixture that does not account for spatial variance

Examples of Turbo FRMAC Use

- Turbo FRMAC has proved to be a valuable tool to guide protective action decisions following real-world releases including the 2011 Fukushima Daiichi Nuclear Power Plant disaster, the 2017 Ru-106 release, and other accidental releases in the U.S.
- Turbo FRMAC is also used to support Federal, State, and Local emergency response planning and preparedness activities



Coordinated Research Project Goals

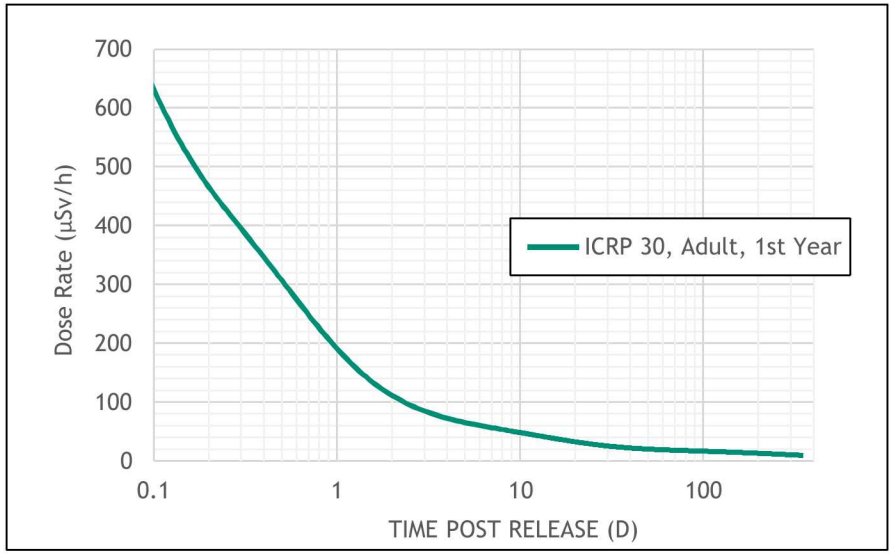
- Perform benchmark analysis of Turbo FRMAC implementation of IAEA methodology
- Acquire better understanding of emergency response dose assessment capabilities among IAEA Member States
- Work toward harmonizing international emergency response dose assessment methods to ensure effective and consistent dose and agricultural impact assessments are obtained

U.S. and IAEA Assumption Comparison

Input	U.S.	IAEA
Time Phase	Early Phase (Total Dose): 0-96 hours Early Phase (Avoidable Dose): 12-108 hours 1st Year: 12-8772 hours 2nd Year: 365-730 days	OIL1 – Urgent (Avoidable Dose): 0-168 hours OIL2 – Early (1st Year): 0-365 days
PAG/Generic Criteria	Early: 0.01 Sv 1st Year: 0.02 Sv 2nd Year: 0.005 Sv	OIL1&2: 0.1 Sv
Dose Pathways	Early Phase (Total Dose): Plume and Ground Other time phases: Ground only	Ground only
Dosimetry Model	ICRP 60	ICRP 30
Breathing Rate	Plume 1.5 m^3/h Resuspension 0.92 m^3/h	1.2 m^3/h
Deposition Velocity	Iodine 6.5E-03 m/s Particulate 3.0E-03 m/s Noble gases 0 m/s	Iodine 1.0E-02 m/s Particulate 3.0E-03 m/s
Building Protection Factors	None	2.5 for Groundshine
Ground Roughness Factor	0.82	0.7
Lung Clearance Type	ICRP Recommended	Maximum
Occupancy Factor	None	0.6 for inside, 0.4 for outside
Particle Size Distribution	1 µm AMAD	1 µm AMAD
Resuspension Factor	Maxwell-Anspaugh 2011	NCRP 129, Start Value = 1.00E-05 m-1
Weathering Factor	Anspaugh 2002	WASH 1400

Turbo FRMAC Implementation of IAEA Methodology

- In 2018, Mr Terry Kraus (SNL) worked with Mr Phillip Vilar Welter and Mr Sanjoy Mukhopadhyay of the IAEA's Incident and Emergency Centre to compare the dose projections made by Turbo FRMAC to those made by the IAEA's Excel-based tool
- The comparison demonstrated that Turbo FRMAC can essentially duplicate the results produced by the IAEA tool when the Turbo FRMAC inputs are set to match those specified by IAEA's "Operational Intervention Levels for Reactor Emergencies" (EPR-NPP-OILs, 2017) document



Thank You

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Additional Slides

FRMAC History

- Before the March 28, 1979 Three Mile Island Nuclear Power Plant accident radiological responses were largely led by local officials
- Uncoordinated event response highlighted inadequacies in planning for a large-scale nuclear emergency
  - Inadequate evacuation plans for the nearby cities
  - Significant confusion about protective actions
  - Lack of coordination between Federal agencies and levels of government
- FRMAC was formed in 1985

Three Mile Island Nuclear Power Plant

PAG Summary Table

Table 1-1. Summary Table for PAGs, Guidelines, and Planning Guidance for Radiological Incidents[a]

Phase	Protective Action Recommendation	PAG, Guideline, or Planning Guidance
Early Phase	Sheltering-in-place or evacuation of the public[b]	**PAG**: 1 to 5 rem (10 to 50 mSv) projected dose over four days[c]
	Supplementary administration of prophylactic drugs – KI[d]	**PAG**: 5 rem (50 mSv) projected child thyroid dose[e] from exposure to radioactive iodine
	Limit emergency worker exposure (total dose incurred over entire response)	**Guideline**: 5 rem (50 mSv)/year (or greater under exceptional circumstances)[f]
Intermediate Phase	Relocation of the public	**PAG**: ≥ 2 rem (20 mSv) projected dose[c] in the first year 0.5 rem (5 mSv)/year projected dose in the second and subsequent years
	Apply simple dose reduction techniques	**Guideline**: < 2 rem (20 mSv) projected dose[c] in the first year
	Food interdiction[g]	**PAG**: 0.5 rem (5 mSv)/year projected whole body dose, or 5 rem (50 mSv)/year to any individual organ or tissue, whichever is limiting
	Drinking water	**PAG:** 100 mrem (1 mSv or 0.1 rem) projected dose, for one year, to the most sensitive populations (e.g., infants, children, pregnant women and nursing women); 500 mrem (5 mSv or 0.5 rem) projected dose, for one year, to the general population
	Limit emergency worker exposure (total dose incurred over entire response)	**Guideline**: 5 rem (50 mSv)/year
	Reentry	**Guideline**: Operational Guidelines[h] (stay times and concentrations) for specific reentry activities (see Section 4.5)
Late Phase	Cleanup[i]	**Planning Guidance**: Brief description of planning process (see Section 5.1)
	Waste Disposal	**Planning Guidance**: Brief description of planning process (see Section 5.2)

[a] This guidance does not address or impact site cleanups occurring under other statutory authorities such as the United States Environmental Protection Agency's (EPA) Superfund program, the Nuclear Regulatory Commission's (NRC) decommissioning program, or other federal or state cleanup programs.

[b] Should begin at 1 rem (10 mSv); take whichever action (or combination of actions) that results in the lowest exposure for the majority of the population. Sheltering may begin at lower levels if advantageous.

[c] Projected dose is the sum of the effective dose from external radiation exposure (e.g., groundshine and plume submersion) and the committed effective dose from inhaled radioactive material.

Note: Footnotes continued on next page

Terminology

- **Protective Action** - An activity conducted in response to an incident or potential incident to avoid or reduce radiation dose to members of the public
- **Protective Action Guide (PAG)** - A projected dose to an individual from released radioactive material at which a specific protective action to reduce or avoid that dose is recommended
- **Projected Dose** - The prediction of the dose that a population or individual might receive
- **Derived Response Level (DRL)** - A level of radioactivity in an environmental medium that would be expected to produce a dose equal to the corresponding PAG

Types of Derived Response Levels (DRL)

- **Integrated Air DRLs** - The integrated air activity of a radionuclide at which the total dose from all radionuclides in a release would equal the PAG over the time phase under consideration
- **Deposition DRLs** - The areal activity at a specific evaluation time of a radionuclide at which the total dose from all radionuclides in a release would equal the PAG over the time phase under consideration
- **Dose Rate/Exposure Rate DRLs** - The external dose or exposure rate from all radionuclides in a release that would produce a dose equal to the PAG over the time phase under consideration

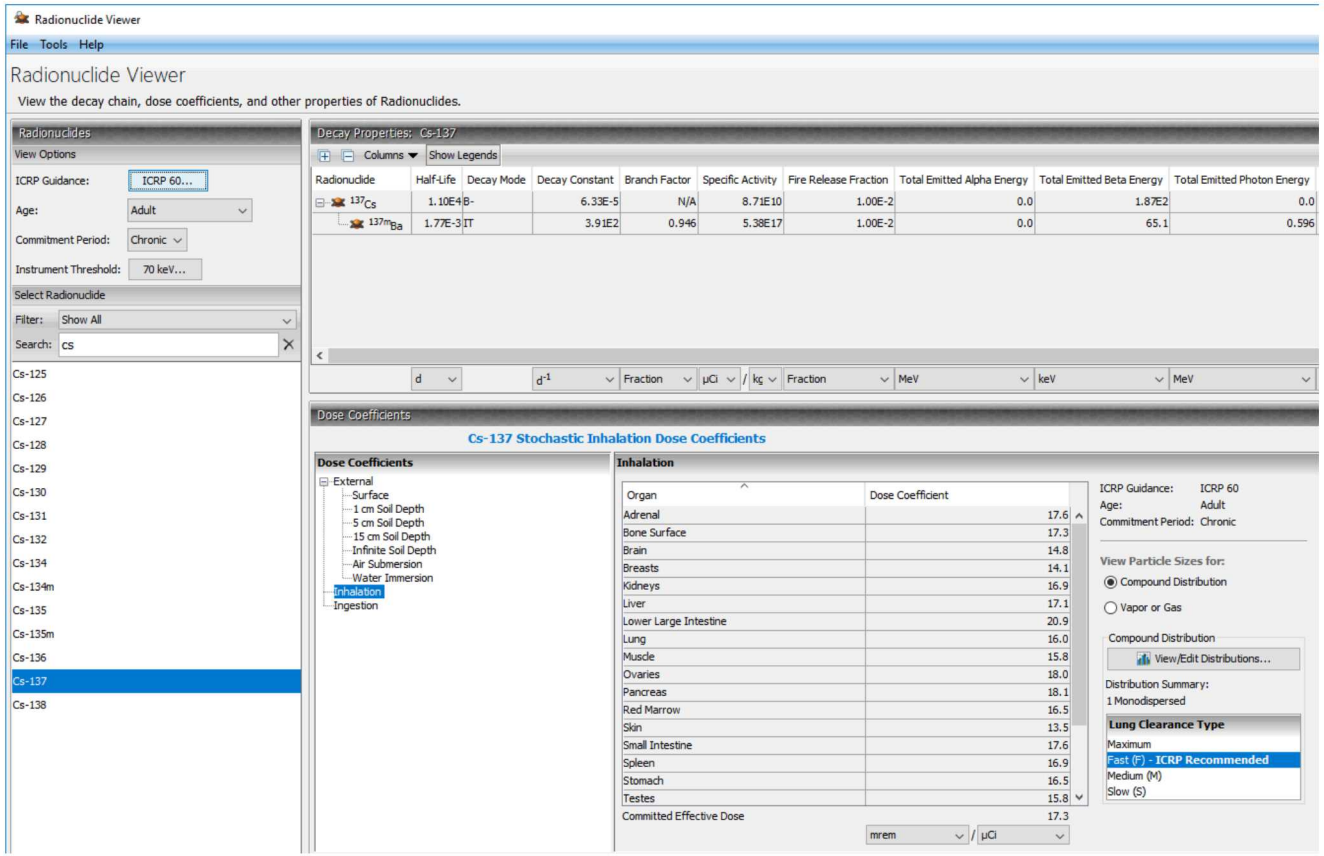
Which flavor of DRL to use depends on the question being asked

Accessing Turbo FRMAC

- Final approval of Turbo FRMAC Copyright from DOE
- Registration required via the following site: https://nirp.sandia.gov

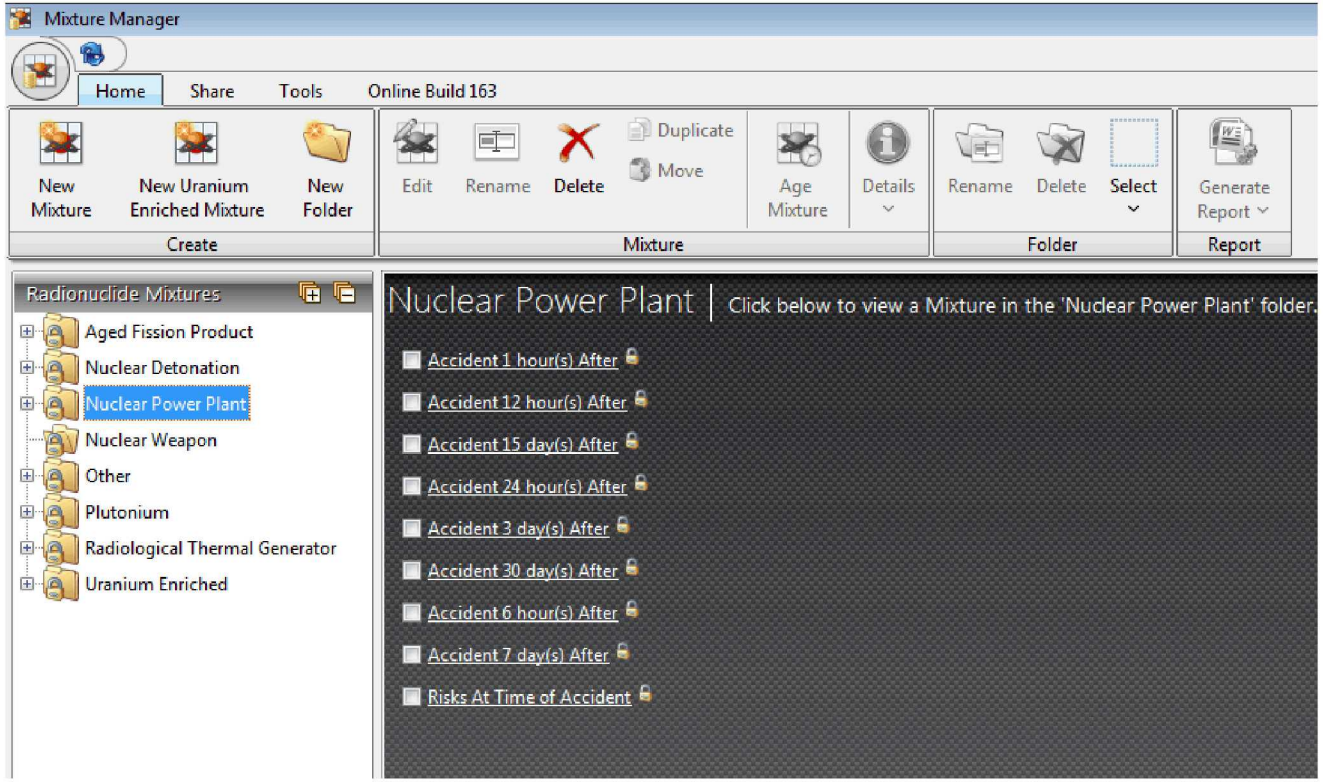
Radionuclide Viewer

- Tool that comes with Turbo FRMAC
- Displays full radionuclide decay chain
- Displays basic radionuclide data (half life, decay mode)
- Provides access to dose coefficients for each radionuclide



Mixture Manager

- Tool that comes with Turbo FRMAC
- Allows user to create, save, export, and import custom radionuclide mixtures
- Pre-determined radionuclide mixtures are also provided



Computer Requirements

- Turbo FRMAC has been designed for Windows 10 and is compatible with Windows Vista, 7, 8, and 10
- Compatible with Mac OS 10.6 or newer

- Minimum 2 GHz Pentium 4 Processor
  - Recommended: Dual- or Quad-Core or higher
- Minimum 2 GB RAM Memory
  - Recommended: 4 GB RAM or higher
- Minimum 15 GB Free Disk Space
  - Recommended: 25 GB Free or higher
- Minimum 1024 x 768 Screen Resolution
  - Recommended: 1280 x 1024 or higher

- Other Software
  - MS Excel 2007 or newer (for special data export capabilities)
  - MS Outlook 2007 or newer (for built-in email attachment support)
  - MS PowerPoint 2007 or newer (for briefing products)
  - MS Word 2007 or newer (for report generation)
  - Adobe Acrobat Reader (for viewing related documents)