

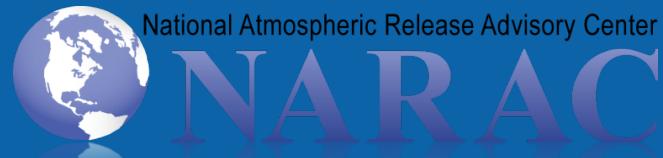
# *Overview of Briefing Products*

## *Part 1: Radiological/Nuclear*

December 17, 2014

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and Harvey Clark (RSL)

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Brenda Pobanz, and Connee Foster (LLNL)



LLNL-PRES-609133 (IND +CB)

LLNL-PRES-659598 (NPP)

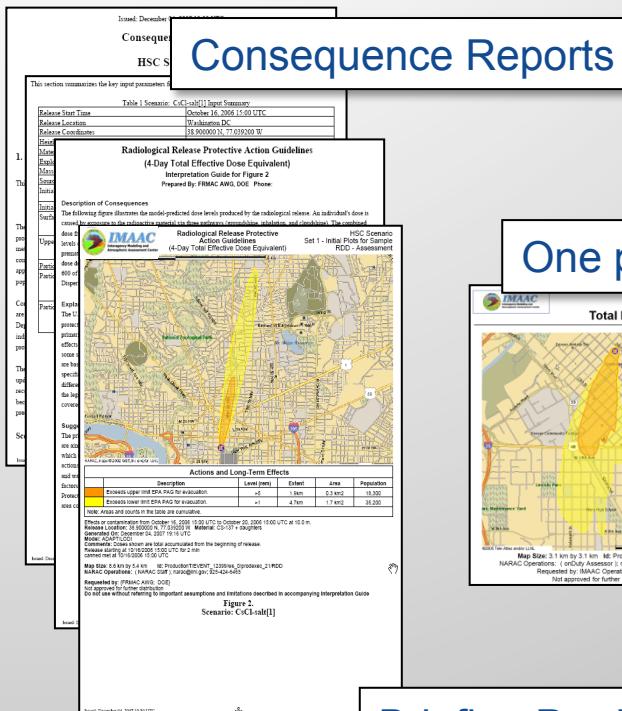
LLNL-PRES- 665558 (RDD)

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344. The Department of Homeland Security sponsored part of the production of this material.

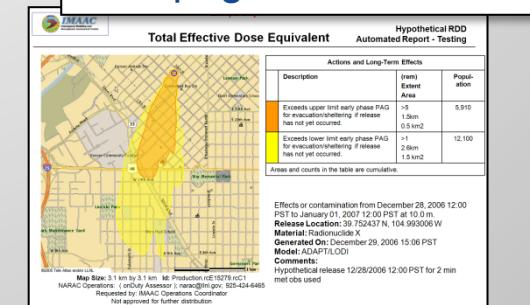


# Products Inform Decisions on Evacuation, Sheltering, Relocation, Worker Protection, and Sampling Plans

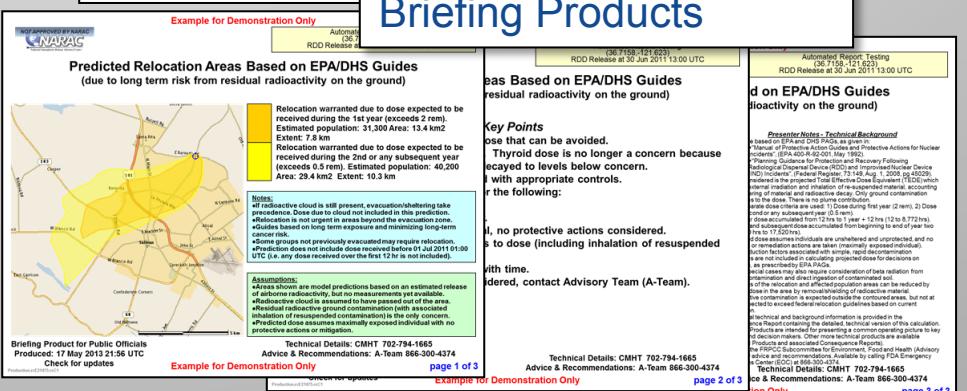
- Standard plot sets
    - Plume hazard areas
    - Affected population numbers
    - Expected health effects
    - Protective action guide levels
    - Geographical information
  - One-page map summary plots
  - Multi-page consequence reports
    - Expanded descriptions
    - Input data and assumptions
    - Interpretation guides
  - Briefing Products
    - Focus on actions and decisions that need to be considered
    - RDD, IND, nuclear power plants, chemicals, and biological agents
    - Developed with interagency consensus



## One page summaries



## Briefing Products



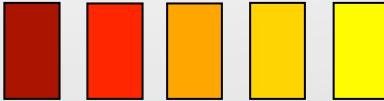
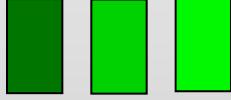
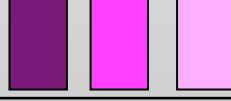
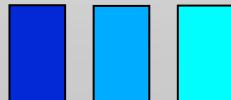
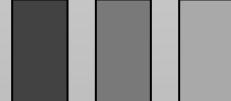
# Standard Plots Are Derived From Interagency Input and Consensus

- Plot standards are developed with user input and agency consensus
  - Standard plot format and color schemes
  - Standard plot types and contamination/dose levels of concern
  - Consequence reports documenting model inputs and assumptions and providing interpretational guidance
  - Maps showing areas reaching health effect levels, and protective action guides from DHS/EPA, if available
- Default plots produced automatically when a model request is made
  - Web users may directly initiate a modeling request
  - NARAC Operations can produce and share results with designated users
- NARAC Operations provides reach-back support to:
  - Develop additional event-specific plots
  - Refine predictions based on field data and event information
  - Provide subject matter expertise on plots and analyses

# A Standard Default Plot Set is Provided For Each Type of Release Developed with Interagency Input

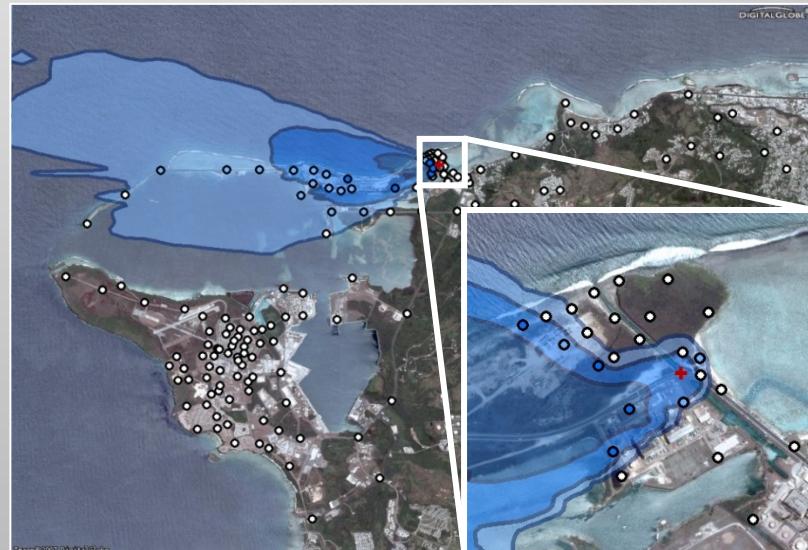
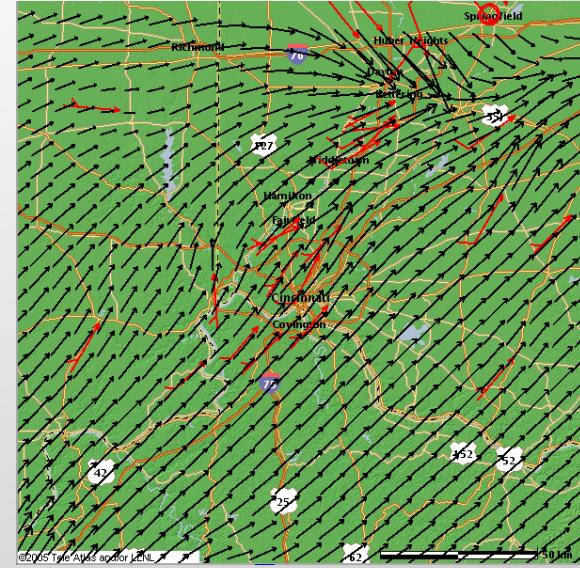
<b><i>Release Type</i></b>	<b><i>Default Plot Type</i></b>
Unknown source material	Hourly average air concentration Deposition if particulate is used
Industrial chemical	“Peak” average air concentration, deposition
Chemical agent	“Peak” average air concentration, deposition
Biological agent	Time-integrated air concentration, deposition
Explosive	Health effects from blast overpressure
Radiological	Dose, dose rate, deposition
Nuclear	Prompt effects, dose, dose rate

# Standard Product Contour Level and Color Schemes are Used for Ease of Interpretation

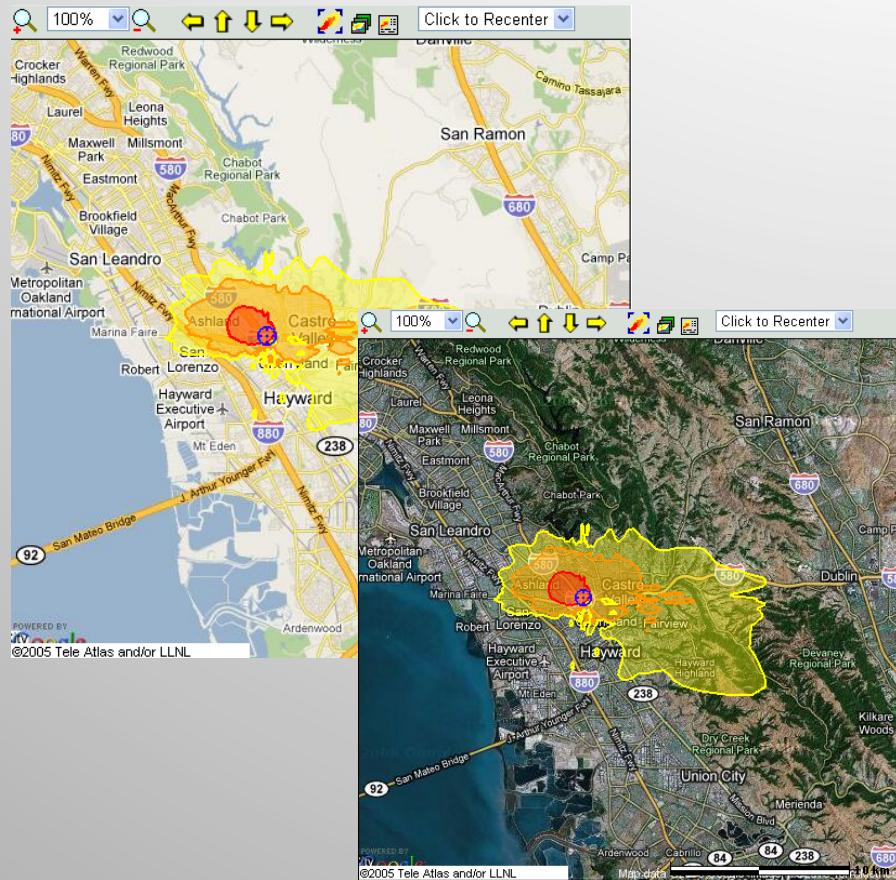
Model Contour Levels	Have levels been reached?	Contour Colors	Description Wording
Acute/Chronic exposure/dose or protective action guideline levels exist in the NARAC database (release amount assumed to be known)	Yes		Consistent with EPA, NRC, FDA or other guidance.
	No		Values below health effect or PAG levels. Possibly contaminated area. Confirm with monitoring surveys.
Customer specified levels	Yes		Customer specified levels.
	No		Values are below customer specified levels.
No levels exist in NARAC database (or no release amount known)			No guidelines specified. Possibly contaminated area.

# Auxiliary Analyses Are Provided For Situational Awareness

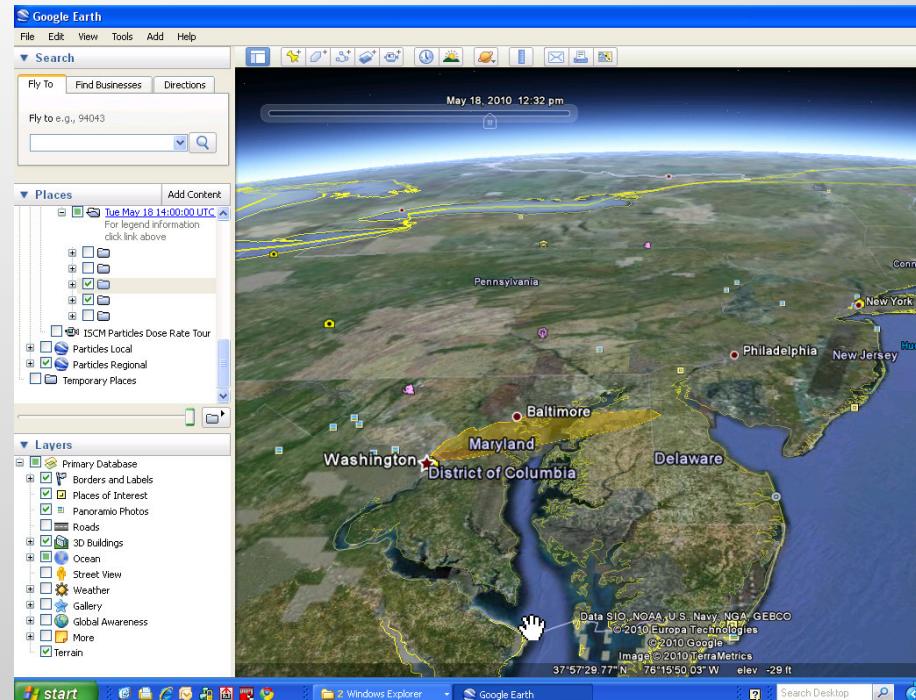
- Wind observations and fields
- Numerical weather prediction forecasts
- Field measurement data
- Deposition
- Time series, particle, or plume animations



# Products and Map Layers are Provided in Multiple Formats (PDF, ESRI, Google)



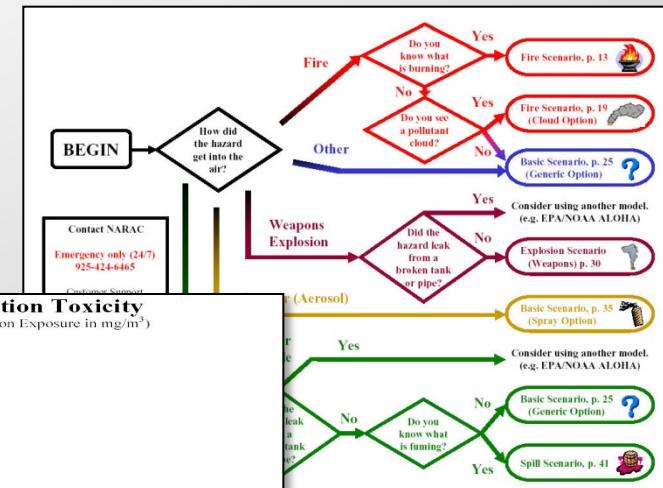
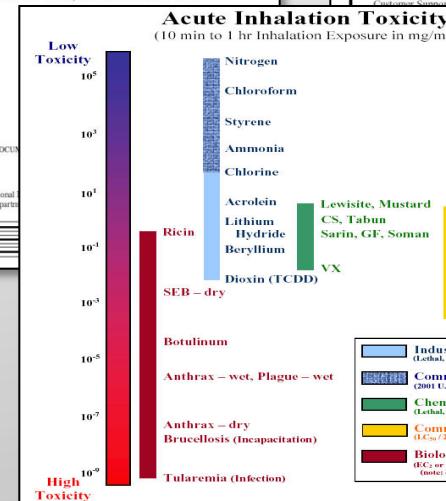
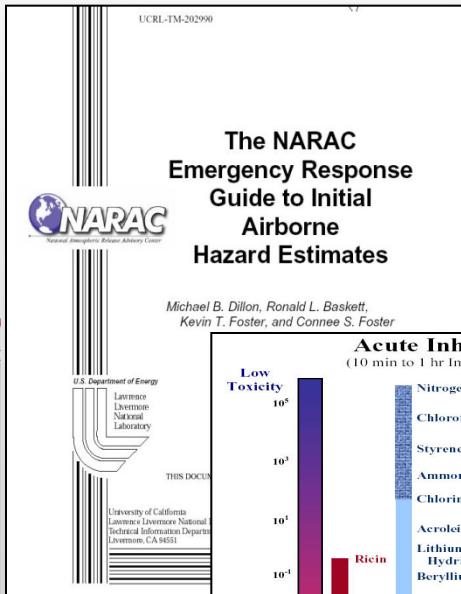
Worldwide Google Street and satellite displays



Export plumes to Google Earth (FEMA)

Available on NARAC/CM Web  
PDF, PowerPoint, HTML/XML, JPG/PNG graphics,  
ESRI Shape and Google Earth KMZ GIS files with  
plume areas

# Extensive User Documentation Includes User Guides and Web-Based Training

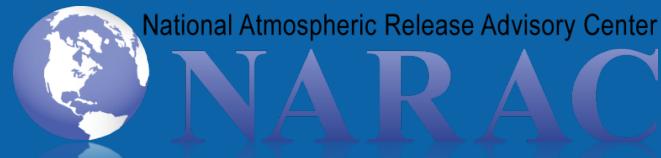


**Explosion Scenario (Weapons):**  
Use when a weapon has exploded.

1. Run iClient to open the Session Manager Window.
2. Select "Explosive Dispersal" from the Scenarios menu.

- Technical manuals
- Web-based training
- Step-by-step guide to software use
- Guide books for determining model inputs from known information

# *Summary of NARAC/IMAAC Briefing Products*



LLNL-PRES-609133 (IND +CB)

LLNL-PRES-659598 (NPP)

LLNL-PRES- 665558 (RDD)

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344. The Department of Homeland Security sponsored part of the production of this material.



# Interagency Briefing Products Are Used to Communicate Key Information to Decision Makers

- Homeland Security Council tasked DOE / DHS to produce hazard area graphics targeted at officials, decision makers, and public affairs officers
  - Present information on effects in plain, non-technical language
  - Explain actions that need to be considered and why (e.g., sheltering, evacuation, relocation, worker protection, agricultural embargoes)
  - List assumptions and limitations
- Based on existing pertinent agency-published documents for guidance
- Developed with extensive interagency input with on-going updates based on interagency feedback and recommendations
- Designed for Subject Matter Experts to use in briefing officials and responders (not intended for direct briefing of the general public)

The development of Briefing Products has been sponsored by DOE/NNSA and DHS, and involved a collaboration of LLNL, RSL, Sandia, EPA, DHS, NRC, and HHS/CDC

# Briefing Products Use a Standard Three Slide Format With Information Developed Via Interagency Consensus

**Example for Demonstration Only**

Automated Report: Testing  
RDD Explosion at 30 Jun 2011 06:00 PDT

**Predicted Evacuation and Sheltering Areas Based on EPA/DHS Guides**  
Applicable within first hours while radioactive cloud is present  
(Based on thyroid dose from a 4-day exposure beginning at 30 Jun 2011 06:00 PDT)

**Notes:**  
• Prompt evacuation and/or sheltering reduces radiation dose and cancer risk.  
• Sheltering-in-place can be more protective than evacuation while radioactive cloud is present.  
• Radiation doses predicted for maximally exposed individuals and includes doses from inhalation of contaminated air and deposition of resuspended contaminated dust over four days.  
• Protective actions are only based on dose that can be avoided.  
• Protection does not include doses received before 30 Jun 2011 06:00 PDT.  
• Refer to Predicted Areas for Considering Potassium Iodide (KI) Administration product for guidance on possible mitigating action.

**Assumptions:**  
• Areas shown are model predictions based on an estimated source term, but no measurements are available.  
• Plume Phase - Radioactive cloud may still be present or imminent.  
• Four days exposure to only airborne contamination.

Technical Details: CMHT 702-794-1665  
Advice & Recommendations: A-Team 770-488-7100  
Check for updates

Example for Demonstration Only

page 1 of 3

**Example for Demonstration Only**

Automated Report: Testing  
RDD Explosion at 30 Jun 2011 06:00 PDT

**Predicted Evacuation and Sheltering Areas Based on EPA/DHS Guides**  
Applicable within first hours while radioactive cloud is present

**Key Points**

- Protective actions are based on dose that can be avoided.
- Areas shown do not include dose received before 30 Jun 2011 06:00 PDT.
- Greatest hazard is due to exposure to the radioactive cloud. Evacuation before radioactive cloud is present is best, but avoid evacuation in the radioactive cloud.
- Radioactive cloud is expected to clear the contoured areas by 30 Jun 2011 15:30 PDT.
- Sheltering-in-place may be preferable to evacuation in some situations
  - If radioactive cloud is present or its arrival is imminent.
  - For certain populations needing special consideration (hospitals/nursing homes, prisoners, elderly, etc.).
  - Other hazards are present which complicate or impede evacuation (severe weather, competing disasters, etc.).
- Sheltering followed by delayed evacuation may be best if radioactive decay is very rapid.
- Predicted dose is accumulated over 4 days (30 Jun 2011 06:00 PDT to 04 Jul 2011 06:00 PDT).
- Predicted dose assumes individuals are unsheltered and unprotected.
- Use the "Radioactive Cloud has Passed" map after radioactive cloud passes.

Technical Details: CMHT 702-794-1665  
Advice & Recommendations: A-Team 770-488-7100  
Check for updates

Example for Demonstration Only

page 2 of 3

**Example for Demonstration Only**

Automated Report: Testing  
RDD Explosion at 30 Jun 2011 06:00 PDT

**Predicted Evacuation and Sheltering Areas Based on EPA/DHS Guides**  
Applicable within first hours while radioactive cloud is present

**Presenter Notes - Additional Information**

\*PAG - Protective Action Guideline, projected dose at which a specific protective action is recommended.  
•Protective actions are based only on dose that can be avoided, not dose accrued prior to implementation of the protective action.  
•Areas shown are model predictions based on an estimated source term. No measurements are made.  
•Model radiation exposure to minimize long-term cancer risk. Evacuation and sheltering-in-place reduce the dose received from the radioactive cloud.  
•Exposure to the radioactive cloud presents the greatest hazard, because total dose received is proportional to time spent in the radioactive cloud. Therefore, plan radiation from contamination on the ground.  
•Sheltering-in-place is the preferred protective action until the radioactive cloud may move in closer & pose an immediate threat. Evacuation in radioactive cloud may result in more dose than sheltering until it passes. Evacues in cloud should cover mouth & nose with available filter material.  
•Evacuation and sheltering are the primary protective actions for Early Phase guidelines.  
•Evacuation (or, for some situations, sheltering) should normally be implemented as soon as possible.  
•Sheltering may be the preferred protective action when it will provide protection from radioactive cloud and other hazards. Consideration of factors such as source term characteristics, and temporal or other variables, may influence the protective action.  
•Because of the higher risk associated with evacuation of some special groups in the population (e.g., those who are at risk for heart attack), the protective action for these groups should be considered as a protective action at projected thyroid doses up to 25 rem.  
•Evacuation and sheltering are the primary protective actions for Late Phase of sheltering at projected thyroid doses up to 25 rem in the general population.  
•Sheltering followed by delayed evacuation may be best if radioactive decay is very rapid.  
•Radioactive cloud expected to clear contoured area by 30 Jun 2011 15:30 PDT.  
•A different map, based only on the radioactively deposited and excluding the radioactive cloud, will be provided once the radioactive cloud has passed.

Technical Details: CMHT 702-794-1665  
Advice & Recommendations: A-Team 770-488-7100  
Check for updates

Example for Demonstration Only

page 3 of 3

## Slide 1. Plot

- Map of the areas of concern
- Plot legend (associated with actionable guidance)
- Important notes, assumptions, and limitations

## Slide 2. Key Points

- Expanded list of key information concerning relevant actions for consideration (evacuation, sheltering, relocation, worker protection)
- Highlights key points to present

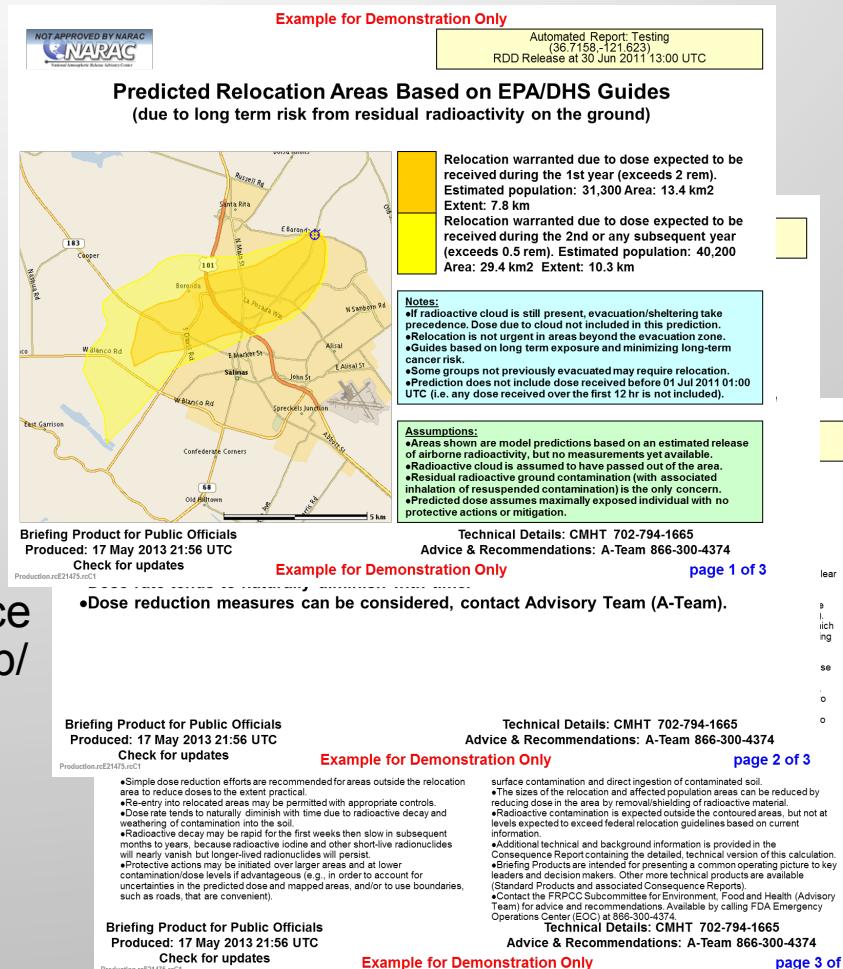
## Slide 3. Presenter Notes

- Background and technical
- Intended for use by the presenter (not for display)

All slides include product titles and sub-titles, short scenario description, product creation date/time, and contact phone numbers for technical details and advice (e.g., NARAC/IMAAC, CMHT/FRMAC or Federal Advisory Team for Environment, Food and Health for radiological advice, EPA for chemical advice)

# NARAC Automated Software Allows Users to Quickly Generate Briefing Products

- NARAC software can generate Briefing Products for these scenarios:
  - Nuclear detonations (e.g., Improvised Nuclear Device [IND])
  - Radiological Dispersion Device (RDD)
  - Nuclear Power Plant (NPP) accidents
  - Chemicals (toxic industrial materials/ chemicals and chemical agents)
  - Biological agents
- LLNL NARAC software can quickly produce briefing products for distribution on CMweb/ NARAC Web, HSIN, ECN or email
- Briefing Products available in two formats
  - PowerPoint
  - PDF

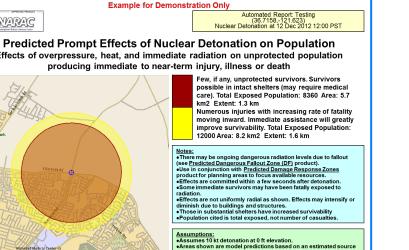
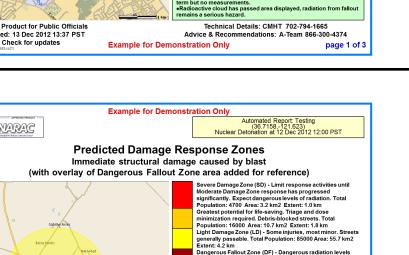


# Comparison of Technical and Briefing Products

<b><i>Characteristic</i></b>	<b>Technical Products</b>	<b>Briefing Products</b>
<i>User and purpose</i>	For use by subject matter experts to support the decision-making process	To assist subject matter experts in the communication of consequences and guidance to decision-making officials
<i>Language</i>	Technical terminology	Plain language
<i>Content</i>	Complex: Includes data used to develop products such as source term, meteorology, measurements	Streamlined: Includes only essential details and focuses on explaining results
<i>Protective action criteria and guidelines</i>	Use established agency guidelines for standard default products, but may have information specified by subject matter experts for a special purpose	Use established agency guidelines to focus user's attention on potential actions for consideration
<i>Training needed to use products</i>	Requires a technical background and training before using	Each product includes two pages of key notes and background information, but training is still strongly suggested.

Neither type of product is intended for distribution or presentation to the general public

# Nuclear Detonation Briefing Products – Prompt Effects: Summary

Time Phase	Product		Purpose
Early (minutes)	Predicted Prompt Effects on Population	 <p>The report includes a header: "Example for Demonstration Only", "Automated Report Testing Nuclear Detonation at 12 Dec 2012 12:00 PST", and a footer: "Briefing Product for Public Officials Produced: 13 Dec 2012 13:37 PST Check for updates". It also contains notes, assumptions, technical details, and advice/recommendations.</p>	<ul style="list-style-type: none"> <li>Estimate areas with immediate near-term injury, illness or death</li> <li>Prioritize rescue</li> </ul>
	Predicted Damage Response Zones	 <p>The report includes a header: "Example for Demonstration Only", "Automated Report Testing Nuclear Detonation at 12 Dec 2012 12:00 PST", and a footer: "Briefing Product for Public Officials Produced: 13 Dec 2012 13:36 PST Check for updates". It also contains notes, assumptions, technical details, and advice/recommendations.</p>	<ul style="list-style-type: none"> <li>Estimate immediate structural damage and related consequences</li> <li>Inform search &amp; rescue</li> <li>Time-varying dangerous fallout zone included</li> </ul>

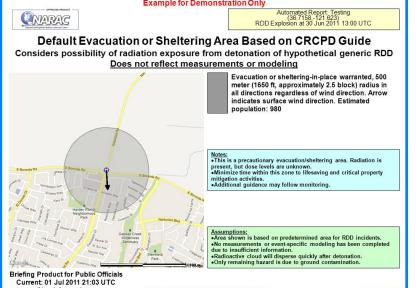
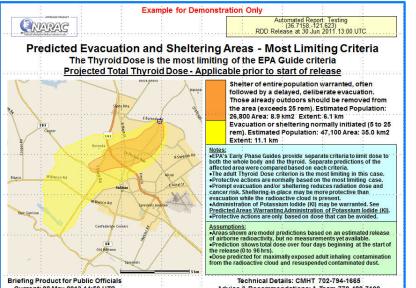
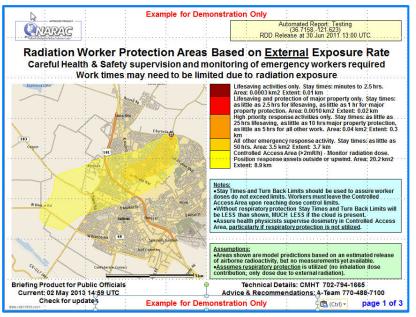
# Nuclear Detonation Briefing Products – Fallout: Summary (1) Multiple Times Shown Due to Rapid Fallout Decay

Time Phase	Product		Purpose
Early (minutes)	Predicted Area for Potential Fallout Casualties		<ul style="list-style-type: none"> <li>Estimate total fallout casualties/injuries</li> <li>Estimate external groundshine dose from radioactive fallout during first hours to days of exposure leading to near-term (days to weeks) health effects</li> <li>Presented for multiple times</li> </ul>
	Predicted Dangerous Fallout Zone		<ul style="list-style-type: none"> <li>Estimate high dose fallout zone posing immediate fatality threat to survivors and responders</li> <li>&gt;10 R/h</li> <li>Presented for multiple times</li> </ul>
	Predicted Hot Zone /Worker Protection Areas		<ul style="list-style-type: none"> <li>Use for worker protection and stay time guidance</li> <li>Determine access control area</li> <li>&gt; 10 mR/hr</li> <li>Presented for multiple times</li> </ul>

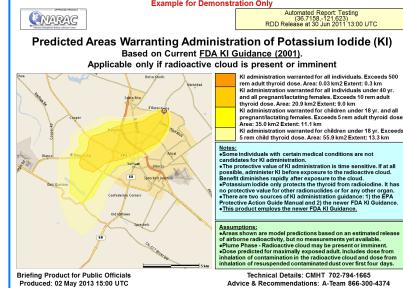
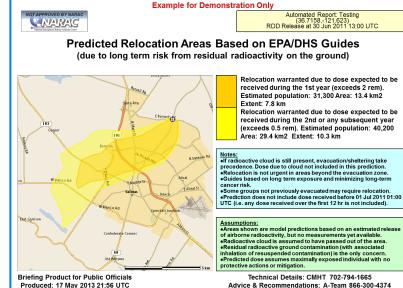
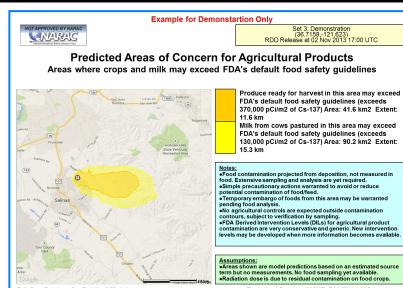
# Nuclear Detonation Briefing Products – Fallout: Summary (2) Multiple Times Shown Due to Rapid Fallout Decay

Time Phase	Product		Purpose
Early (hours to days)	Predicted EPA/ DHS Sheltering/ Evacuation Areas		<ul style="list-style-type: none"> <li>Guide sheltering and evacuation decisions</li> <li>Assess avoidable additional long-term cancer risk, not acute radiation injury or death (1-5 Rem and &gt;5 Rem in 4 days)</li> <li>Presented for multiple times</li> </ul>
Intermediate (days to months)	Predicted EPA/ DHS Relocation Areas		<ul style="list-style-type: none"> <li>Guide population relocation decisions</li> <li>Assess avoidable additional long-term cancer risk, not acute radiation injury or death (2 Rem in first year and 0.5 Rem in subsequent or later year)</li> </ul>
Late Phases (days to years)	Predicted Areas of Concern for Agricultural Products		<ul style="list-style-type: none"> <li>Guide crop sampling</li> <li>Guide crop/food control decisions</li> <li>Predict areas where crops and milk may exceed FDA's food safety guidelines based on fallout</li> </ul>

# RDD Briefing Products: Summary (1)

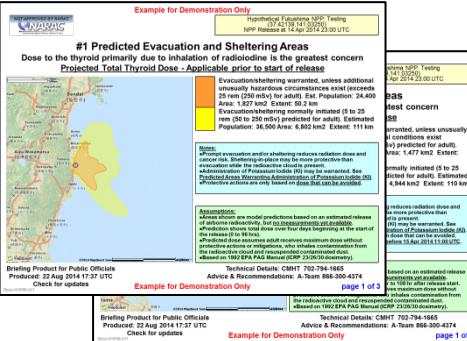
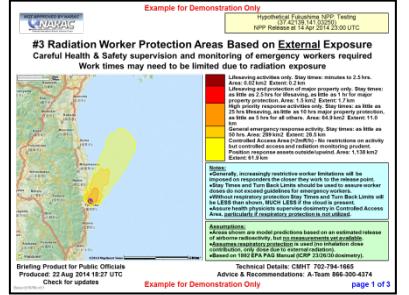
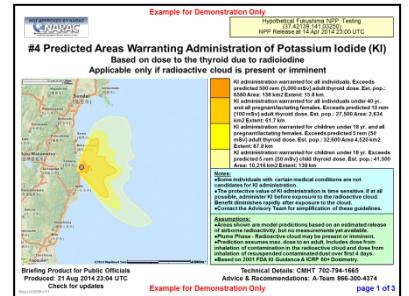
Time Phase	Product		Purpose
<b>Early (minutes)</b>	Default Evacuation or Sheltering Area		<ul style="list-style-type: none"> <li>Guide precautionary sheltering and evacuation decision</li> <li>Guide access control and monitoring</li> </ul>
<b>Early (hours to days)</b>	Predicted EPA/DHS Sheltering/ Evacuation Areas (TED or Thyroid CDE)		<ul style="list-style-type: none"> <li>Update guide for sheltering and evacuation decisions</li> <li>Assess avoidable additional long-term cancer risk</li> <li>Uses most-limiting 4-day dose (Whole-body Total Effective Dose [TED] of 5 Rem and 1-5 Rem or Adult Thyroid Committed Dose Equivalent [CDE] of &gt; 25 Rem and 5-25 Rem)</li> </ul>
	Predicted Worker Protection Areas		<ul style="list-style-type: none"> <li>Use for worker protection and stay time guidance</li> <li>Determine access control area</li> </ul>

# RDD Briefing Products: Summary (2)

Time Phase	Product	Sample	Purpose
Early (hours to days)	Predicted Potassium Iodide Administration Areas	 <p><b>Example for Demonstration Only</b> Automated Report: Testing RDD Release at 30 Jun 2011 13:00 UTC <b>Predicted Areas of Warnings Administration of Potassium Iodide (KI) Based on Current FDA KI Guidance (2001)</b> Applicable only if radioactive cloud is present or imminent</p> <p>KI administration warranted for all individuals. Estimate 500 mg KI per day for 14 days. Area: 10 km Extent: 0.3 km</p> <p>KI administration warranted for all individuals under 18 years of age. Estimate 500 mg KI per day for 14 days. Area: 20 km Extent: 0.9 km</p> <p>Estimated thyroid dose: 10 mrem/day for 14 days. Total thyroid dose: 140 mrem. All individuals receive 500 mg adult thyroid dose. Area: 20 km Extent: 0.9 km</p> <p>Estimated child thyroid dose: 10 mrem/day for 14 days. Total child thyroid dose: Area: 50 km Extent: 15.3 km</p> <p><b>Notes:</b> Individuals with certain medical conditions are not candidates for KI administration. KI administration is dose selective. If all individuals receive KI, there is no benefit to those individuals who have received their recommended dose. Benefit diminishes rapidly after exposure to the cloud.</p> <p><b>Assumptions:</b> Areas shown are model predictions based on an estimated release of all potassium iodide available on the market. No measurements yet available. <b>Phase:</b> Radiactive cloud may be present or imminent. Radiation levels are low enough to warrant KI administration. This has protective value for other radionuclides or for any other organ. There is no protection for the thyroid from other radionuclides. See Protective Action Manual and the newer POM KI Guidance.</p> <p><b>Technical Details:</b> CMIT 702-794-1655 Advice &amp; Recommendations: A-Team 866-300-4374 page 1 of 3</p>	<ul style="list-style-type: none"> <li>Guidance for potassium iodide administration to reduce thyroid dose and long-term cancer risk from inhaled radioactive iodine</li> <li>Based on FDA 2001 (age-dependent dose levels) publications</li> </ul>
Intermediate (days to months) and Late Phases (months to years)	Predicted EPA/DHS Relocation Areas	 <p><b>Example for Demonstration Only</b> Automated Report: Testing RDD Release at 30 Jun 2011 13:00 UTC <b>Predicted Relocation Areas Based on EPA/DHS Guides (due to long term risk from residual radiation on the ground)</b></p> <p>Relocation warranted due to dose expected to be received during the 1st year (exceeds 2 rem). Estimated population: 13,400 Area: 7.8 km Extent: 1.2 km</p> <p>Relocation warranted due to dose expected to be received during the 2nd or any subsequent year (exceeds 0.5 rem). Estimated population: 40,200 Area: 20.4 km Extent: 10.3 km</p> <p><b>Notes:</b> Relocation is still present, evacuation/sheltering take place. Relocation is an urgent move to areas beyond the evacuation zone. This has protective value for other radionuclides or for any other organ. There is no protection for the thyroid from other radionuclides.</p> <p><b>Assumptions:</b> Areas shown are model predictions based on an estimated release of all potassium iodide available on the market. No measurements yet available. Relocation is assumed to have passed out of the area. There is no protection for the thyroid from other radionuclides. This has protective value for other radionuclides or for any other organ. There is no protection for the thyroid from other radionuclides.</p> <p><b>Technical Details:</b> CMIT 702-794-1655 Advice &amp; Recommendations: A-Team 866-300-4374 page 1 of 3</p>	<ul style="list-style-type: none"> <li>Guide population relocation decisions</li> <li>Assess avoidable additional long-term cancer risk, not acute radiation injury or death (2 Rem in first year and 0.5 Rem in second or later year)</li> </ul>
	Predicted Areas of Concern for Agricultural Products	 <p><b>Example for Demonstration Only</b> Set 3: Demonstration RDD Release at 02 Nov 2013 17:00 UTC <b>Predicted Areas of Concern for Agricultural Products Areas where crops and milk may exceed FDA's default food safety guidelines</b></p> <p>Products ready for harvest in this area may exceed FDA's default food safety guidelines (exceeds 370,000 pCi/m<sup>2</sup> of C-137) Area: 4.16 km<sup>2</sup> Extent: 11.3 km</p> <p>Milk from cows pastured in this area may exceed FDA's default food safety guidelines (exceeds 130,000 pCi/m<sup>2</sup> of C-137) Area: 9.62 km<sup>2</sup> Extent: 15.3 km</p> <p><b>Notes:</b> Food contamination projects from deposition, not emanation food. External sampling and analysis are yet required. Contamination may be present in areas where no food is currently being produced/consumed by food feed.</p> <p><b>Assumptions:</b> Areas shown are model predictions based on an estimated source term and a conservative estimate of the potential for external emanation doses to residual contamination on food crops.</p> <p><b>Technical Details:</b> CMIT 702-794-1655 Advice &amp; Recommendations: A-Team 866-300-4374 page 1 of 3</p>	<ul style="list-style-type: none"> <li>Guide crop sampling</li> <li>Guide crop/food control decisions</li> <li>Predict areas where crops and milk may exceed FDA's food safety guidelines based on ground contamination</li> </ul>

Note: ICRP60 dose conversion factors are used for radiological dispersal device products

# NPP Briefing Products: Summary (1)

Time Phase	Product	Sample	Purpose
Early (hours to days)	Predicted EPA/DHS Sheltering/Evacuation Areas (TED or Thyroid CDE)	 <p><b>#1 Predicted Evacuation and Sheltering Areas</b>  <b>Dose to the thyroid primarily due to inhalation of radioactive iodine is the greatest concern</b>  <b>Projected Total Thyroid Dose - Applicable prior to start of release</b></p> <p><b>Assumptions:</b> Assumes no sheltering or evacuation. Protective actions are only based on dose that can be avoided.</p> <p><b>Technical Details:</b> CMHT 702-794-1665  <b>Advice &amp; Recommendations:</b> A-Team 866-300-4374  <b>Page 1 of 3</b></p>	<ul style="list-style-type: none"> <li>Guide for sheltering and evacuation decisions based on most-limiting organ dose criteria</li> <li>Assess avoidable additional long-term cancer risk (4-day Total Effective Dose Equivalent: 1-5 Rem and &gt;5 Rem levels; or Adult Thyroid Committed Dose Equivalent: &gt;25 Rem and 5-25 Rem levels)</li> </ul>
	Predicted Worker Protection Areas	 <p><b>#3 Radiation Worker Protection Areas Based on External Exposure</b>  <b>Careful Health &amp; Safety supervision and monitoring of emergency workers required</b>  <b>Work times may need to be limited due to radiation exposure</b></p> <p><b>Assumptions:</b> Assumes no model predictions based on an estimated release of radioactive iodine, but no requirements exist to limit or restrict work times or areas. Protective actions are only based on dose that can be avoided.</p> <p><b>Technical Details:</b> CMHT 702-794-1665  <b>Advice &amp; Recommendations:</b> A-Team 866-300-4374  <b>Page 1 of 3</b></p>	<ul style="list-style-type: none"> <li>Use for worker protection and stay time guidance</li> <li>Determine access control area</li> </ul>
	Predicted Potassium Iodide Administration Areas	 <p><b>#4 Predicted Areas Warranting Administration of Potassium Iodide (KI)</b>  <b>Based on dose to the thyroid due to radioactive iodine</b>  <b>Applicable only if radioactive cloud is present or imminent</b></p> <p><b>Assumptions:</b> Assumes no model predictions based on an estimated release of radioactive iodine, but no measurements are available. Protective actions are only based on dose that can be avoided.</p> <p><b>Technical Details:</b> CMHT 702-794-1665  <b>Advice &amp; Recommendations:</b> A-Team 866-300-4374  <b>Page 1 of 3</b></p>	<ul style="list-style-type: none"> <li>Guidance for potassium iodide administration to reduce thyroid dose and long-term cancer risk from inhaled radioactive iodine</li> <li>Customer-specific guidance based on FDA 2001 (age-dependent dose levels) publications</li> </ul>

# NPP Briefing Products: Summary (2)

Time Phase	Product	Sample	Purpose
<b>Intermediate (days to months) and Late Phases (months to years)</b>	<b>Predicted EPA/DHS Relocation Areas</b>		<ul style="list-style-type: none"> <li>Guide population relocation decisions</li> <li>Assess avoidable additional long-term cancer risk (2 rem in first year, 0.5 rem in subsequent or later year and 5 rem over 50 years)</li> </ul>
	<b>Predicted Areas of Concern for Agricultural Products</b>		<ul style="list-style-type: none"> <li>Guide for areas to sample crops</li> <li>Guide crop/food control decisions</li> <li>Predict areas where crops and milk may exceed FDA's food safety guidelines based on ground contamination</li> </ul>

Note: ICRP26/30 dose conversion factors are currently used for nuclear reactor release products, apart from the FDA 2001 potassium iodide administration product which is based on ICRP 60

## Layout of Briefing Products (1)

Italicized text  
describes type of information  
that will appear here, and varies  
from product to product

### Product Title

Product Sub-Title 1

Product Sub-Title 2

[Product Set #:] [Event Name]  
[Location Name and/or Coordinates]  
[Event Type] at [Date/Time]

Blue text is substituted in the  
actual product with appropriate text  
based on response-, scenario- or  
material-dependent information

*One or more shaded  
contoured areas  
overlaid onto a  
geographic map  
of the affected area*

Non-Italicized text  
shows text as it is  
displayed in the  
actual product

Contour Legend Area: one or more color-coded areas  
with associated descriptive text applicable to the area  
covered by the contour. This text preferably reflects  
appropriate actions for consideration by the decision-  
maker.

#### Notes

- A list of bulleted key items of interest concerning this product, the area it covers, and/or relevant actions for consideration.

#### Assumptions:

- A statement of whether this product is based only on estimated source term, or if initial source term assumptions have been modified to better match available measurement data.
- A statement of whether the airborne plume is still expected to be present in the area, or if the initial plume has passed.

## Layout of Briefing Products (2)

[Product Set #:] [Event Name]  
[Location Name and/or Coordinates]  
[Event Type] at [Date/Time]

### Product Title

Product Sub-Title 1

Product Sub-Title 2

### Key Points

- An expanded list of bulleted key items of interest concerning this product, the area it covers, and/or relevant actions for consideration. Some of these points may repeat Notes from slide one.

## Layout of Briefing Products (3)

[Product Set #:] [Event Name]  
[Location Name and/or Coordinates]  
[Event Type] at [Date/Time]

### Product Title

Product Sub-Title 1

Product Sub-Title 2

#### Presenter Notes – Additional Information:

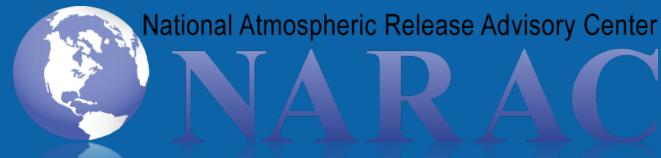
- A bulleted list of background information items relevant to briefing this product. These items are meant to provide context and reference for the presenter, and not for display to the audience.

#### Presenter Notes - Technical Background:

- A bulleted list of more technically-oriented background information items relevant to briefing this product. These items are meant to provide context and optional reference for the presenter, and not for display to the audience.

# *NARAC/IMAAC Briefing Products for a Nuclear Detonation*

Kevin Foster (LLNL) and Harvey Clark (RSL)



LLNL-PRES-609133 (IND +CB)

LLNL-PRES-659598 (NPP)

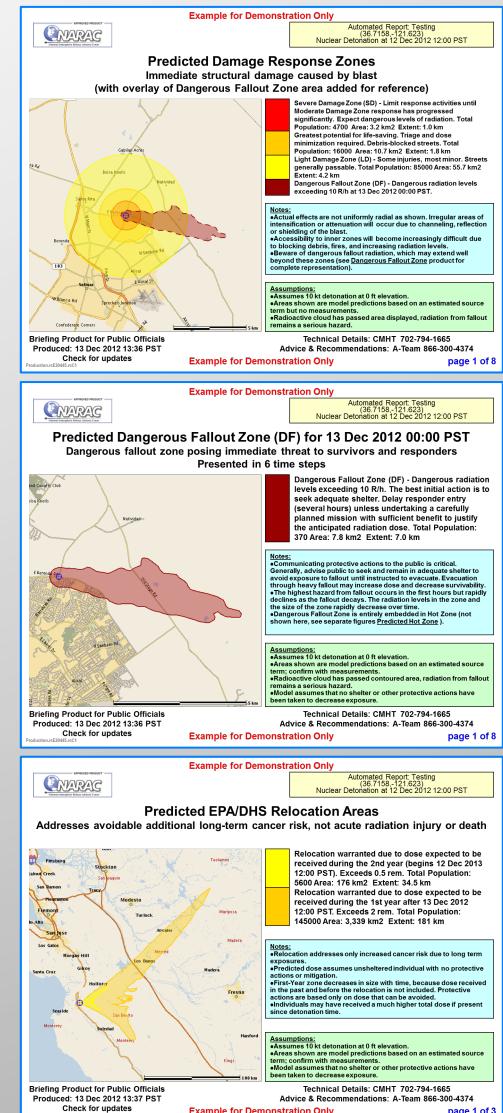
LLNL-PRES- 665558 (RDD)

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344. The Department of Homeland Security sponsored part of the production of this material.  
Based on LLNL-TR-454371



# Nuclear Detonation Briefing Product Set

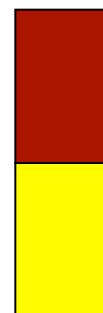
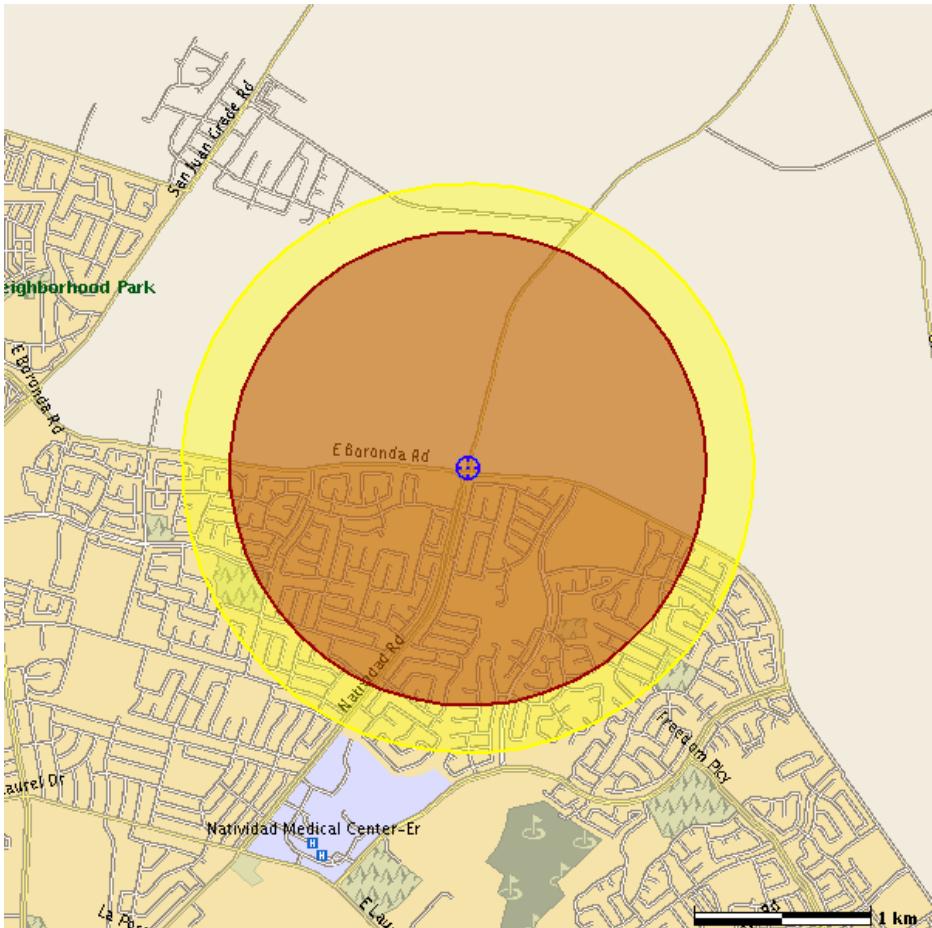
- **Early Phase (minutes)**
  - Prompt Effects on Population (single time only)
  - Predicted Damage Response Zones (with Dangerous Fallout Zone)
  - Predicted Dangerous Fallout Zone
  - Predicted Hot Zone /Worker Protection Areas
  - Predicted Area for Potential Fallout Casualties
- **Early Phase (hours to days)**
  - Predicted EPA/DHS Sheltering/ Evacuation Areas
- **Intermediate Phase (days to months)**
  - Predicted EPA/DHS Relocation Areas
- **Late Phase (days to years)**
  - Predicted Areas of Concern for Agricultural Products



All plots apart from the Prompt Effects product may be shown for multiple times due to the rapid changes in impacts resulting from radioactive decay

# Predicted Prompt Effects of Nuclear Detonation on Population

## Effects of overpressure, heat, and immediate radiation on unprotected population producing immediate to near-term injury, illness or death



Few, if any, unprotected survivors. Survivors possible in intact shelters (may require medical care). Total Exposed Population: 8360 Area: 5.7 km<sup>2</sup> Extent: 1.3 km

Numerous injuries with increasing rate of fatality moving inward. Immediate assistance will greatly improve survivability. Total Exposed Population: 12000 Area: 8.2 km<sup>2</sup> Extent: 1.6 km

### Notes:

- There may be ongoing dangerous radiation levels due to fallout (see [Predicted Dangerous Fallout Zone \(DF\) product](#)).
- Use in conjunction with [Predicted Damage Response Zones](#) product for planning areas to focus available resources.
- Effects are committed within a few seconds after detonation.
- Some immediate survivors may have been fatally exposed to radiation.
- Effects are not uniformly radial as shown. Effects may intensify or diminish due to buildings and structures.
- Those in substantial shelters have increased survivability
- Population cited is total exposed, not number of casualties.

### Assumptions:

- Assumes 10 kt detonation at 0 ft elevation.
- Areas shown are model predictions based on an estimated source term but no measurements.
- Radioactive cloud has passed area displayed, radiation from fallout remains a serious hazard.



APPROVED PRODUCT

## Example for Demonstration Only

Automated Report: Testing  
(36.7158,-121.623)

Nuclear Detonation at 12 Dec 2012 12:00 PST

# Predicted Prompt Effects of Nuclear Detonation on Population

Effects of overpressure, heat, and immediate radiation on unprotected population producing immediate to near-term injury, illness or death

## Key Points

- Number of casualties will depend on many factors (e.g. sheltering at time of detonation, construction quality, etc.). Expect a mix of fatalities, major injuries, and minor injuries.
- Most prompt casualties will lie within the predicted Moderate and Severe Damage Response Zones (see [Predicted Damage Response Zones](#) product).
- Expect greater than 90% fatality rate for unprotected individuals inside the red area. Survival for some may be possible, if shelter adequate.
- Expect declining fatality rate in the yellow area with few fatalities and as little as only 10% of the population suffering major injuries at its outer boundary.
- Levels of radiation dangerous to first responders and survivors can be expected in portions of the affected area, (see [Predicted Dangerous Fallout Zone \(DF\) product](#)).
- Outside radiation levels may be too dangerous for immediate escape/evacuation.
- Life-saving efforts have greatest potential value in the outer ring, except in the DF Zone.
- Injuries will include a spectrum of blast, radiation, and thermal effects (separately or in combination). Some victims, and areas displayed, are contaminated with fallout.
- Special victim triage procedures may be necessary. Some relatively uninjured victims may have severe or lethal radiation exposures and/or be contaminated by fallout.
- Treatment of serious or life-threatening injuries takes precedent over decontamination.

Briefing Product for Public Officials  
Produced: 13 Dec 2012 13:37 PST

Check for updates

Technical Details: CMHT 702-794-1665  
Advice & Recommendations: A-Team 866-300-4374

Example for Demonstration Only

page 2 of 3



APPROVED PRODUCT

## Example for Demonstration Only

Automated Report: Testing  
(36.7158,-121.623)

Nuclear Detonation at 12 Dec 2012 12:00 PST

# Predicted Prompt Effects of Nuclear Detonation on Population

## Effects of overpressure, heat, and immediate radiation on unprotected population producing immediate to near-term injury, illness or death

### **Presenter Notes - Additional Information**

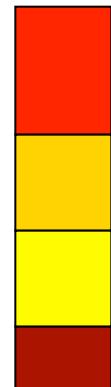
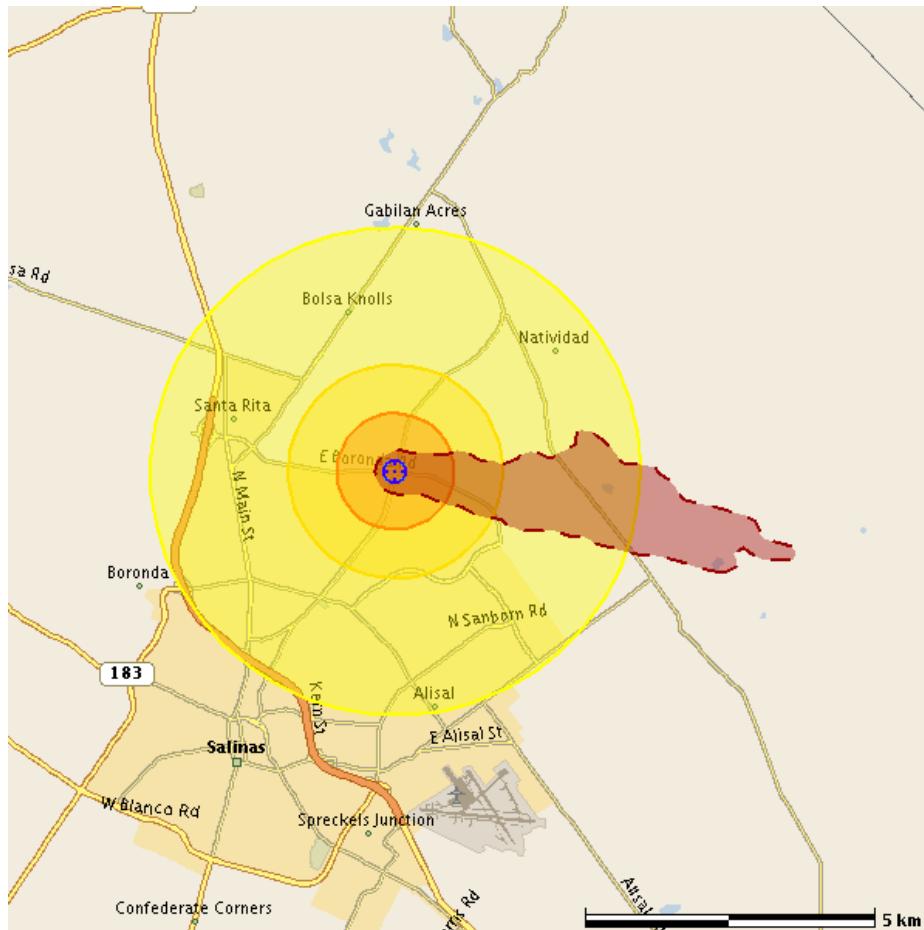
- This product estimates the total casualties by sequentially applying the health effects of each hazard, one hazard at a time, associated with the prompt heat, blast (overpressure) and radiation consequences. These estimates do not include any additional compounding of health effects which may occur from simultaneous exposure to combinations of the individual effects, which would be expected to increase casualties by an unknown amount.
- This product only considers effects committed at the moment of detonation. It does not include effects of radioactive fallout.
- While these prompt effects are committed in the few moments following detonation, some fatalities may be delayed until much later.
- The size of these prompt effects zones are determined immediately after detonation and do not change with time.
- Subsequent sheltering or evacuation of the affected population will not alter these effects, but will reduce additional health effects caused by radioactive material deposited onto the surface (fallout).
- Some individuals in uncontaminated areas of the regions shown will have substantial, if not severe, radiation exposures during the instant of detonation.
- Dangerous levels of radioactive contamination (fallout) will be present. A cloud of visible radioactive dust will surround the detonation site (base surge cloud). This radioactive dust will be carried downwind for miles (fallout). The most dangerous fallout will be visible as dust and fine particles.
- Most contamination can be removed by changing into uncontaminated clothes and washing exposed skin. At a minimum, brush off radioactive dust or remove contaminated clothes.
- Initial triage will be based in part on the victim's post-detonation location history, physical examination, and dosimetry predictions from initial models.
- Initial triage (or sorting) should not replace follow-on clinical triage for more specific medical management.
- Because of probable damage to infrastructure, the limited availability of resources, and the presence of radiation, paramedics and clinicians will have to bypass conventional clinical standards of care in order to maximize the overall preservation of life.

### **Presenter Notes - Technical Background**

- Guidance based on:
  - ♦ "Planning Guidance for Response to a Nuclear Detonation", Second Edition, June, 2010. Developed by the Homeland Security Council Interagency Policy Coordination Subcommittee for Preparedness & Response to Radiological and Nuclear Threats.
- Area where unprotected survivors are unlikely is defined where 90% or more of those in the open (i.e. not sheltered) are expected to receive fatal injuries.
- Area where numerous injuries and some fatalities occur is defined as where expected effects experienced by unsheltered population range from 10% major injuries to 90% fatal injuries.
- Overpressure, thermal, and radiation injuries in combination are likely, and may result in fatalities above those estimated.
- The "Total Exposed Population" is the total estimated population in the zone adjusted for day/night variations due to commuting based on "LandScan" data.
- Briefing Products are intended for presenting a common operating picture to key leaders and decision makers. Other more technical products are available (Standard Products).
- Contact the FRPCC Subcommittee for Environment, Food and Health (Advisory Team) for advice and recommendations by calling FDA Emergency Operations Center (EOC) at 866-300-4374.

## Predicted Damage Response Zones

### Immediate structural damage caused by blast (with overlay of Dangerous Fallout Zone area added for reference)



**Severe Damage Zone (SD)** - Limit response activities until Moderate Damage Zone response has progressed significantly. Expect dangerous levels of radiation. Total Population: 4700 Area: 3.2 km<sup>2</sup> Extent: 1.0 km Greatest potential for life-saving. Triage and dose minimization required. Debris-blocked streets. Total Population: 16000 Area: 10.7 km<sup>2</sup> Extent: 1.8 km

**Light Damage Zone (LD)** - Some injuries, most minor. Streets generally passable. Total Population: 85000 Area: 55.7 km<sup>2</sup> Extent: 4.2 km

**Dangerous Fallout Zone (DF)** - Dangerous radiation levels exceeding 10 R/h at 13 Dec 2012 00:00 PST.

#### Notes:

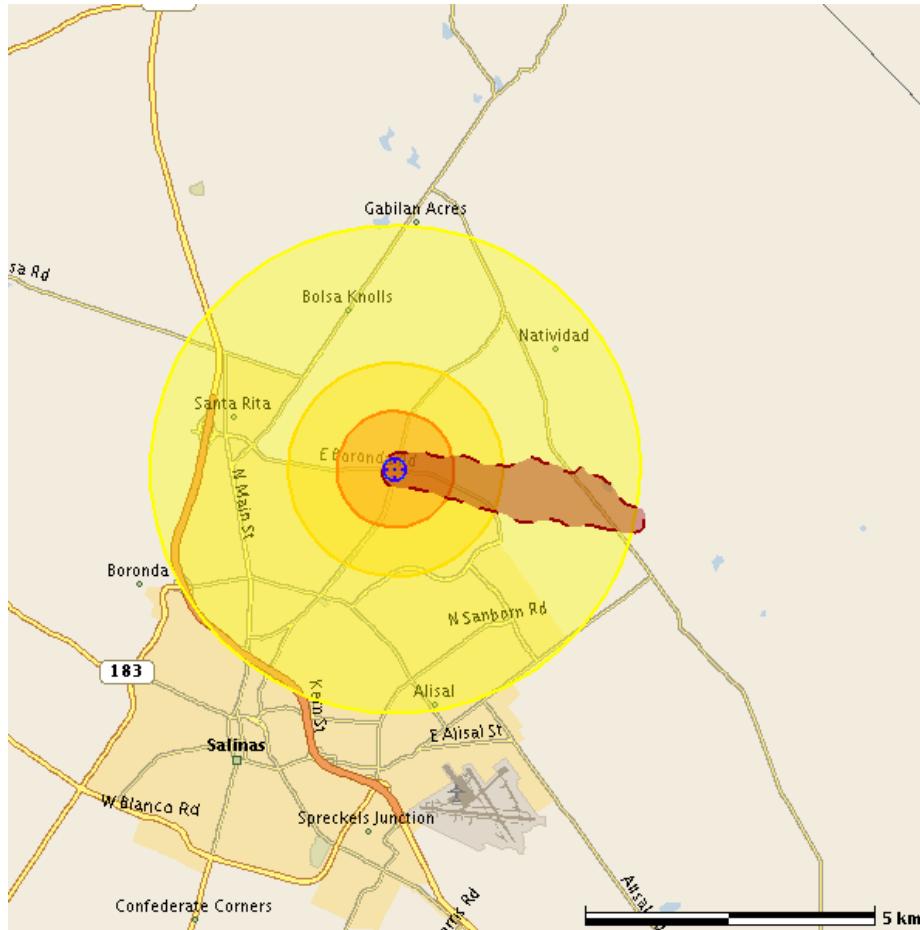
- Actual effects are not uniformly radial as shown. Irregular areas of intensification or attenuation will occur due to channeling, reflection or shielding of the blast.
- Accessibility to inner zones will become increasingly difficult due to blocking debris, fires, and increasing radiation levels.
- Beware of dangerous fallout radiation, which may extend well beyond these zones (see Dangerous Fallout Zone product for complete representation).

#### Assumptions:

- Assumes 10 kt detonation at 0 ft elevation.
- Areas shown are model predictions based on an estimated source term but no measurements.
- Radioactive cloud has passed area displayed, radiation from fallout remains a serious hazard.

## Predicted Damage Response Zones

### Immediate structural damage caused by blast (with overlay of Dangerous Fallout Zone area added for reference)



	Severe Damage Zone (SD) - Limit response activities until Moderate Damage Zone response has progressed significantly. Expect dangerous levels of radiation. Total Population: 4700 Area: 3.2 km <sup>2</sup> Extent: 1.0 km
	Greatest potential for life-saving. Triage and dose minimization required. Debris-blocked streets. Total Population: 16000 Area: 10.7 km <sup>2</sup> Extent: 1.8 km
	Light Damage Zone (LD) - Some injuries, most minor. Streets generally passable. Total Population: 85000 Area: 55.7 km <sup>2</sup> Extent: 4.2 km
	Dangerous Fallout Zone (DF) - Dangerous radiation levels exceeding 10 R/h at 13 Dec 2012 12:00 PST.

#### Notes:

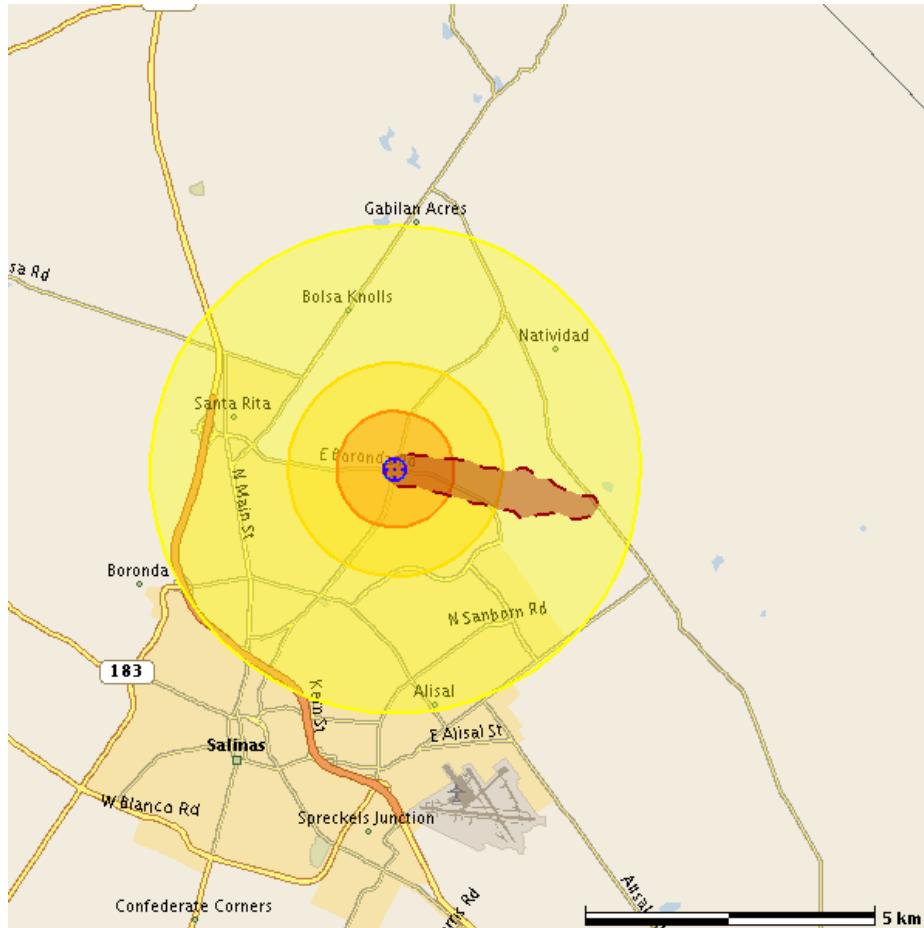
- Actual effects are not uniformly radial as shown. Irregular areas of intensification or attenuation will occur due to channeling, reflection or shielding of the blast.
- Accessibility to inner zones will become increasingly difficult due to blocking debris, fires, and increasing radiation levels.
- Beware of dangerous fallout radiation, which may extend well beyond these zones (see Dangerous Fallout Zone product for complete representation).

#### Assumptions:

- Assumes 10 kt detonation at 0 ft elevation.
- Areas shown are model predictions based on an estimated source term but no measurements.
- Radioactive cloud has passed area displayed, radiation from fallout remains a serious hazard.

## Predicted Damage Response Zones

### Immediate structural damage caused by blast (with overlay of Dangerous Fallout Zone area added for reference)



	Severe Damage Zone (SD) - Limit response activities until Moderate Damage Zone response has progressed significantly. Expect dangerous levels of radiation. Total Population: 4700 Area: 3.2 km <sup>2</sup> Extent: 1.0 km
	Greatest potential for life-saving. Triage and dose minimization required. Debris-blocked streets. Total Population: 16000 Area: 10.7 km <sup>2</sup> Extent: 1.8 km
	Light Damage Zone (LD) - Some injuries, most minor. Streets generally passable. Total Population: 85000 Area: 55.7 km <sup>2</sup> Extent: 4.2 km
	Dangerous Fallout Zone (DF) - Dangerous radiation levels exceeding 10 R/h at 14 Dec 2012 00:00 PST.

#### Notes:

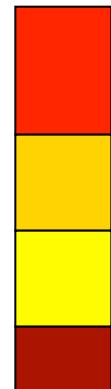
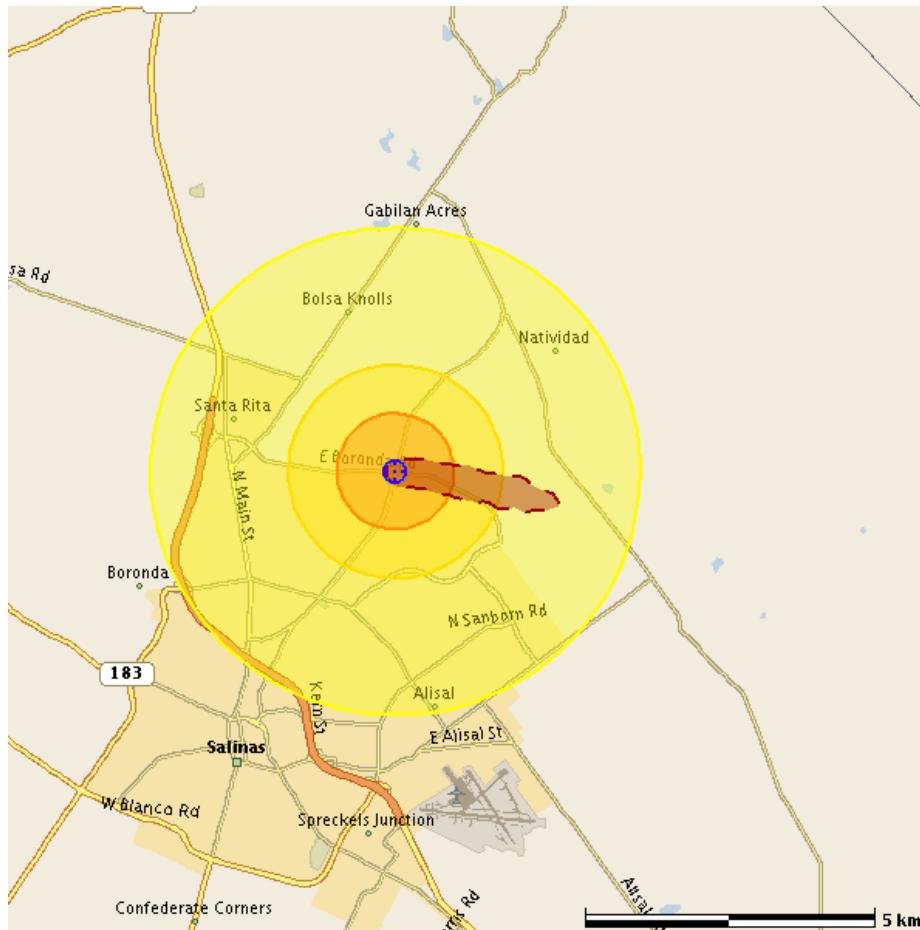
- Actual effects are not uniformly radial as shown. Irregular areas of intensification or attenuation will occur due to channeling, reflection or shielding of the blast.
- Accessibility to inner zones will become increasingly difficult due to blocking debris, fires, and increasing radiation levels.
- Beware of dangerous fallout radiation, which may extend well beyond these zones (see Dangerous Fallout Zone product for complete representation).

#### Assumptions:

- Assumes 10 kt detonation at 0 ft elevation.
- Areas shown are model predictions based on an estimated source term but no measurements.
- Radioactive cloud has passed area displayed, radiation from fallout remains a serious hazard.

## Predicted Damage Response Zones

### Immediate structural damage caused by blast (with overlay of Dangerous Fallout Zone area added for reference)



**Severe Damage Zone (SD)** - Limit response activities until Moderate Damage Zone response has progressed significantly. Expect dangerous levels of radiation. Total Population: 4700 Area: 3.2 km<sup>2</sup> Extent: 1.0 km Greatest potential for life-saving. Triage and dose minimization required. Debris-blocked streets. Total Population: 16000 Area: 10.7 km<sup>2</sup> Extent: 1.8 km

**Light Damage Zone (LD)** - Some injuries, most minor. Streets generally passable. Total Population: 85000 Area: 55.7 km<sup>2</sup> Extent: 4.2 km

**Dangerous Fallout Zone (DF)** - Dangerous radiation levels exceeding 10 R/h at 14 Dec 2012 12:00 PST.

#### Notes:

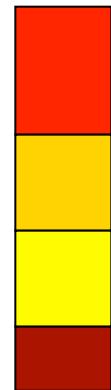
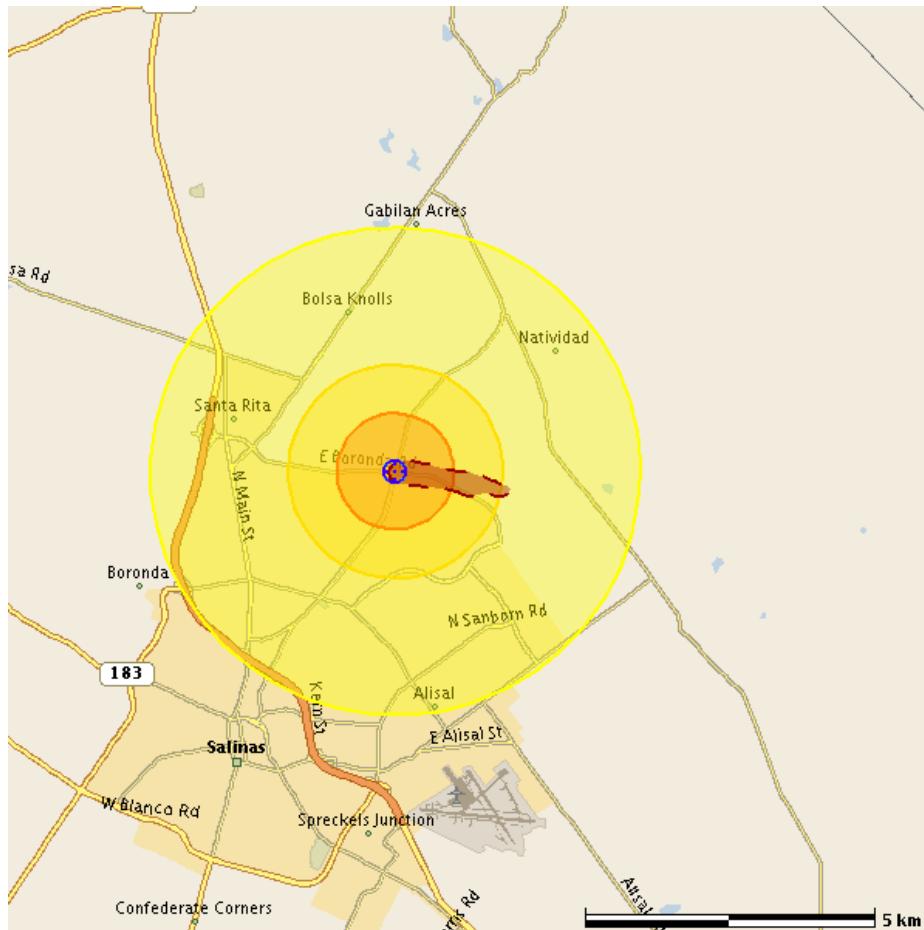
- Actual effects are not uniformly radial as shown. Irregular areas of intensification or attenuation will occur due to channeling, reflection or shielding of the blast.
- Accessibility to inner zones will become increasingly difficult due to blocking debris, fires, and increasing radiation levels.
- Beware of dangerous fallout radiation, which may extend well beyond these zones (see Dangerous Fallout Zone product for complete representation).

#### Assumptions:

- Assumes 10 kt detonation at 0 ft elevation.
- Areas shown are model predictions based on an estimated source term but no measurements.
- Radioactive cloud has passed area displayed, radiation from fallout remains a serious hazard.

## Predicted Damage Response Zones

### Immediate structural damage caused by blast (with overlay of Dangerous Fallout Zone area added for reference)



**Severe Damage Zone (SD) - Limit response activities until Moderate Damage Zone response has progressed significantly. Expect dangerous levels of radiation.** Total Population: 4700 Area: 3.2 km<sup>2</sup> Extent: 1.0 km Greatest potential for life-saving. Triage and dose minimization required. Debris-blocked streets. Total Population: 16000 Area: 10.7 km<sup>2</sup> Extent: 1.8 km

**Light Damage Zone (LD) - Some injuries, most minor. Streets generally passable.** Total Population: 85000 Area: 55.7 km<sup>2</sup> Extent: 4.2 km

**Dangerous Fallout Zone (DF) - Dangerous radiation levels exceeding 10 R/h at 15 Dec 2012 12:00 PST.**

#### Notes:

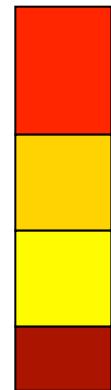
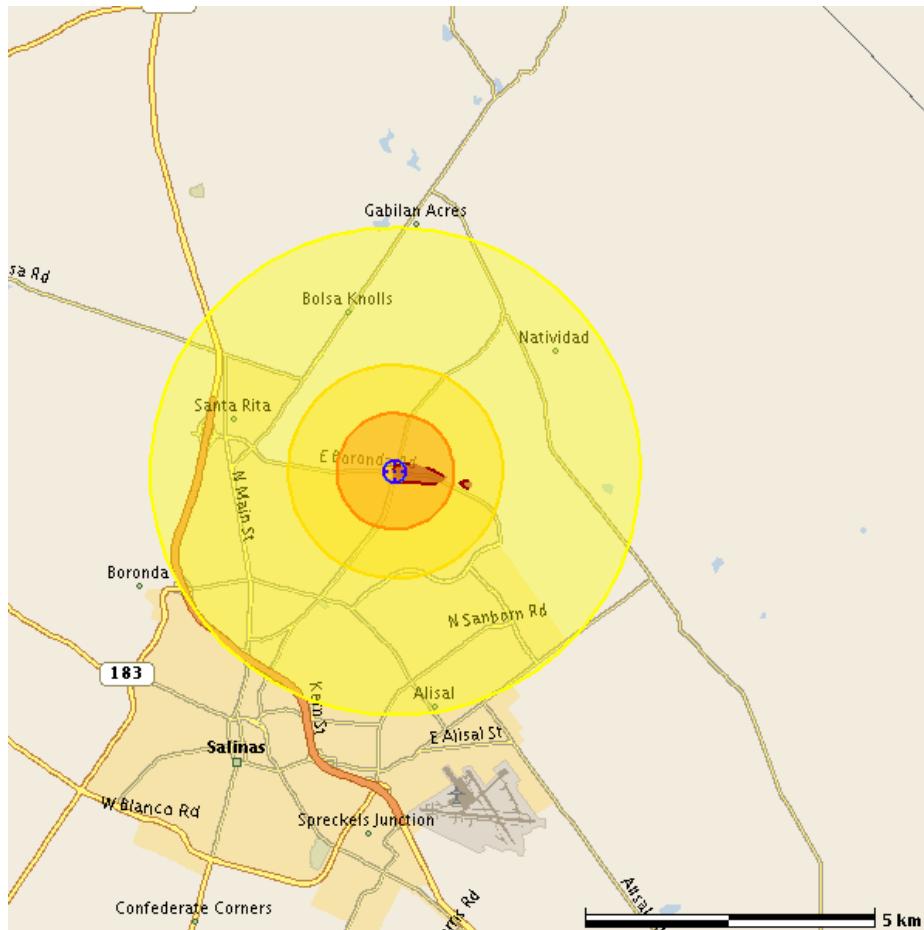
- Actual effects are not uniformly radial as shown. Irregular areas of intensification or attenuation will occur due to channeling, reflection or shielding of the blast.
- Accessibility to inner zones will become increasingly difficult due to blocking debris, fires, and increasing radiation levels.
- Beware of dangerous fallout radiation, which may extend well beyond these zones (see Dangerous Fallout Zone product for complete representation).

#### Assumptions:

- Assumes 10 kt detonation at 0 ft elevation.
- Areas shown are model predictions based on an estimated source term but no measurements.
- Radioactive cloud has passed area displayed, radiation from fallout remains a serious hazard.

## Predicted Damage Response Zones

### Immediate structural damage caused by blast (with overlay of Dangerous Fallout Zone area added for reference)



**Severe Damage Zone (SD) - Limit response activities until Moderate Damage Zone response has progressed significantly. Expect dangerous levels of radiation.** Total Population: 4700 Area: 3.2 km<sup>2</sup> Extent: 1.0 km Greatest potential for life-saving. Triage and dose minimization required. Debris-blocked streets. Total Population: 16000 Area: 10.7 km<sup>2</sup> Extent: 1.8 km

**Light Damage Zone (LD) - Some injuries, most minor. Streets generally passable.** Total Population: 85000 Area: 55.7 km<sup>2</sup> Extent: 4.2 km

**Dangerous Fallout Zone (DF) - Dangerous radiation levels exceeding 10 R/h at 16 Dec 2012 12:00 PST.**

#### Notes:

- Actual effects are not uniformly radial as shown. Irregular areas of intensification or attenuation will occur due to channeling, reflection or shielding of the blast.
- Accessibility to inner zones will become increasingly difficult due to blocking debris, fires, and increasing radiation levels.
- Beware of dangerous fallout radiation, which may extend well beyond these zones (see Dangerous Fallout Zone product for complete representation).

#### Assumptions:

- Assumes 10 kt detonation at 0 ft elevation.
- Areas shown are model predictions based on an estimated source term but no measurements.
- Radioactive cloud has passed area displayed, radiation from fallout remains a serious hazard.

## Predicted Damage Response Zones

Immediate structural damage caused by blast

(with overlay of Dangerous Fallout Zone area added for reference)

### *Key Points*

- This map shows blast damage, and at least part of the area of high radiation hazard. There is dangerous fallout in this area and possibly beyond (see Dangerous Fallout Zone product for a complete representation).
- Dangerous fallout may be carried in directions other than expected by surface winds.
- The actual damage areas are not circular, but irregularly shaped, due to the effect of buildings on the blast.
- Severe Damage Zone (formerly No-Go Zone): Practically all structures severely damaged or collapsed. Rubble will make streets and roads impassable. Some survivors possible in stable, adequate structures. Adequate shelter (tunnels, basements...) required to survive prompt radiation and effects of radioactive fallout (see Dangerous Fallout Zone product).
- Moderate Damage Zone: Substantial damage to most light structures, minor damage to heavily-reinforced structures, most single-family dwellings destroyed. Rubble and disabled vehicles will make use of streets difficult to impossible. Many casualties due to flying debris/glass, burns, building collapse and accidents. Urgent medical care required.
- Light Damage Zone: Glass breakage and distorted window/door frames, little to no damage to reinforced structures. Stalled/crashed vehicles will slow movement of emergency vehicles. Mostly non-life threatening injuries requiring self/out-patient care.

# Predicted Damage Response Zones

## Immediate structural damage caused by blast

### (with overlay of Dangerous Fallout Zone area added for reference)

#### Presenter Notes - Additional Information

- Dangerous fallout may be present, particularly in the Severe Damage Zone and in the Dangerous Fallout Zone downwind of the detonation site (see [Dangerous Fallout Zone](#) product).
- Response in the Severe Damage Zone should be avoided, if possible, until radiation levels decline.
- Serious, although lower, radiation levels (up to 10 R/hr) may be encountered in the area surrounding the Dangerous Fallout Zone, particularly downwind of the blast site.
- Early life-saving operations should focus on the Moderate Damage Zone, because that is where the greatest benefit can be achieved.
- Response within the Moderate Damage zone requires preparation for elevated radiation levels, unstable buildings and other structures, downed power lines, ruptured gas lines, hazardous chemicals, sharp metal objects, broken glass, and fires.
- Light Damage Zone - Encourage those with minor injuries to shelter in safe locations to expedite access to the severely injured.
- Treatment of life threatening injuries takes precedence over decontamination of patients or equipment.
- Some surviving individuals in uncontaminated (from fallout) areas of the regions shown may have already received substantial, if not severe, radiation exposures during the instant of detonation.
- Predicted Damage Response Zones are defined in terms of blast overpressure for which characteristic degrees of structural damage can be expected for yields of 1 to 100kT.
- Overpressure levels for the zones shown chosen as:
  - Severe Damage Zone = exceeds 5 psi overpressure
  - Moderate Damage Zone = exceeds 2 psi overpressure
  - Light Damage Zone = exceeds 0.5 psi overpressure
- Modeled size and shape only depend on yield and burst height and do not reflect effects of buildings, subsequent damage or restoration work.

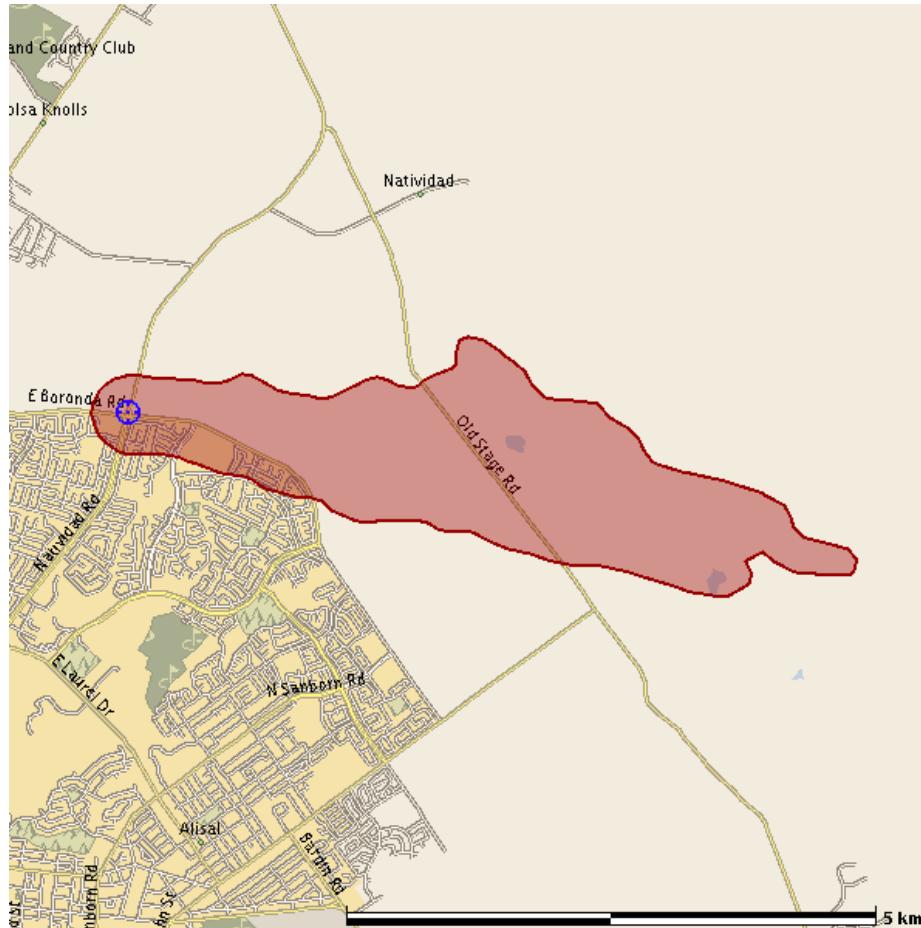
#### Presenter Notes - Technical Background

- Guidance based on:
  - Planning Guidance for Response to a Nuclear Detonation", Second Edition, June, 2010. Developed by the Homeland Security Council Interagency Policy Coordination Subcommittee for Preparedness & Response to Radiological and Nuclear Threats.
- Severe Damage Zone (SD, formerly No-Go Zone) - Region in which structural damage is severe, survival prospects are very poor and hazards to responders are extreme. Damage in this zone is characteristic of overpressures exceeding 5 to 8 psi. Even heavily constructed buildings are destroyed inside the inner half of the SD Zone, but most should survive to some degree in the outer half of the SD Zone. Approximately 50% of light structures will suffer moderate damage at the boundary. Rubble piles may reach as much as 30 feet in height.
- Moderate Damage Zone (MD) - Significant building damage to light structures (minor damage to heavily-reinforced structures) characteristic of overpressures exceeding 2 to 3 psi.
- Light Damage Zone (LD) - A relatively large zone in which damage is primarily broken windows and crushed doors due to over pressures at about 0.5 psi. Expect approximately 25% of the windows broken at the outer boundary of the LD Zone. Injuries are generally minor, requiring only self or out-patient treatment.
- The "Total Population" is the total estimated population in the zone adjusted for day/night variations due to commuting based on "Landscan" data.
- Briefing Products are intended for presenting a common operating picture to key leaders and decision makers. Other more technical products are available (Standard Products).
- Contact the FRPCC Subcommittee for Environment, Food and Health (Advisory Team) for advice and recommendations by calling FDA Emergency Operations Center (EOC) at 866-300-4374.

# Predicted Dangerous Fallout Zone (DF) for 13 Dec 2012 00:00 PST

Dangerous fallout zone posing immediate threat to survivors and responders

Presented in 6 time steps



**Dangerous Fallout Zone (DF)** - Dangerous radiation levels exceeding 10 R/h. The best initial action is to seek adequate shelter. Delay responder entry (several hours) unless undertaking a carefully planned mission with sufficient benefit to justify the anticipated radiation dose. Total Population: 370 Area: 7.8 km<sup>2</sup> Extent: 7.0 km

#### Notes:

- Communicating protective actions to the public is critical. Generally, advise public to seek and remain in adequate shelter to avoid exposure to fallout until instructed to evacuate. Evacuation through heavy fallout may increase dose and decrease survivability.
- The highest hazard from fallout occurs in the first hours but rapidly declines as the fallout decays. The radiation levels in the zone and the size of the zone rapidly decrease over time.
- Dangerous Fallout Zone is entirely embedded in Hot Zone (not shown here, see separate figures [Predicted Hot Zone](#)).

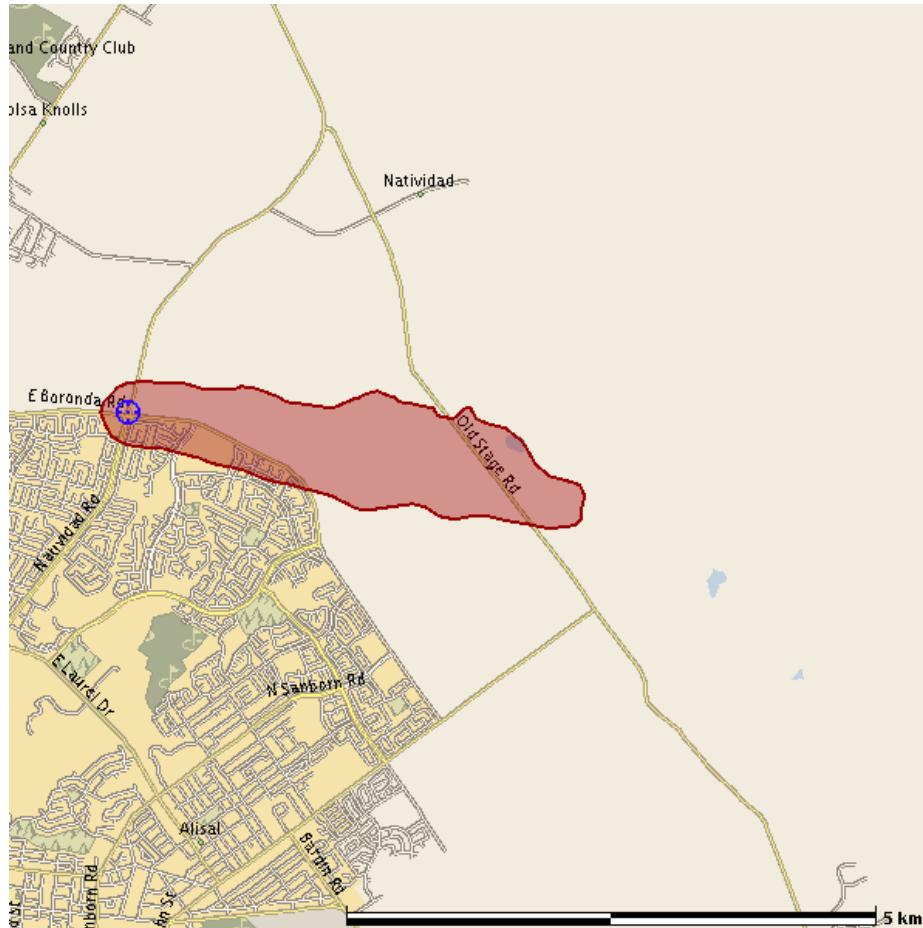
#### Assumptions:

- Assumes 10 kt detonation at 0 ft elevation.
- Areas shown are model predictions based on an estimated source term; confirm with measurements.
- Radioactive cloud has passed contoured area, radiation from fallout remains a serious hazard.
- Model assumes that no shelter or other protective actions have been taken to decrease exposure.

# Predicted Dangerous Fallout Zone (DF) for 13 Dec 2012 12:00 PST

Dangerous fallout zone posing immediate threat to survivors and responders

Presented in 6 time steps



**Dangerous Fallout Zone (DF)** - Dangerous radiation levels exceeding 10 R/h. The best initial action is to seek adequate shelter. Delay responder entry (several hours) unless undertaking a carefully planned mission with sufficient benefit to justify the anticipated radiation dose. Total Population: 250 Area: 3.5 km<sup>2</sup> Extent: 4.4 km

#### Notes:

- Communicating protective actions to the public is critical. Generally, advise public to seek and remain in adequate shelter to avoid exposure to fallout until instructed to evacuate. Evacuation through heavy fallout may increase dose and decrease survivability.
- The highest hazard from fallout occurs in the first hours but rapidly declines as the fallout decays. The radiation levels in the zone and the size of the zone rapidly decrease over time.
- Dangerous Fallout Zone is entirely embedded in Hot Zone (not shown here, see separate figures [Predicted Hot Zone](#)).

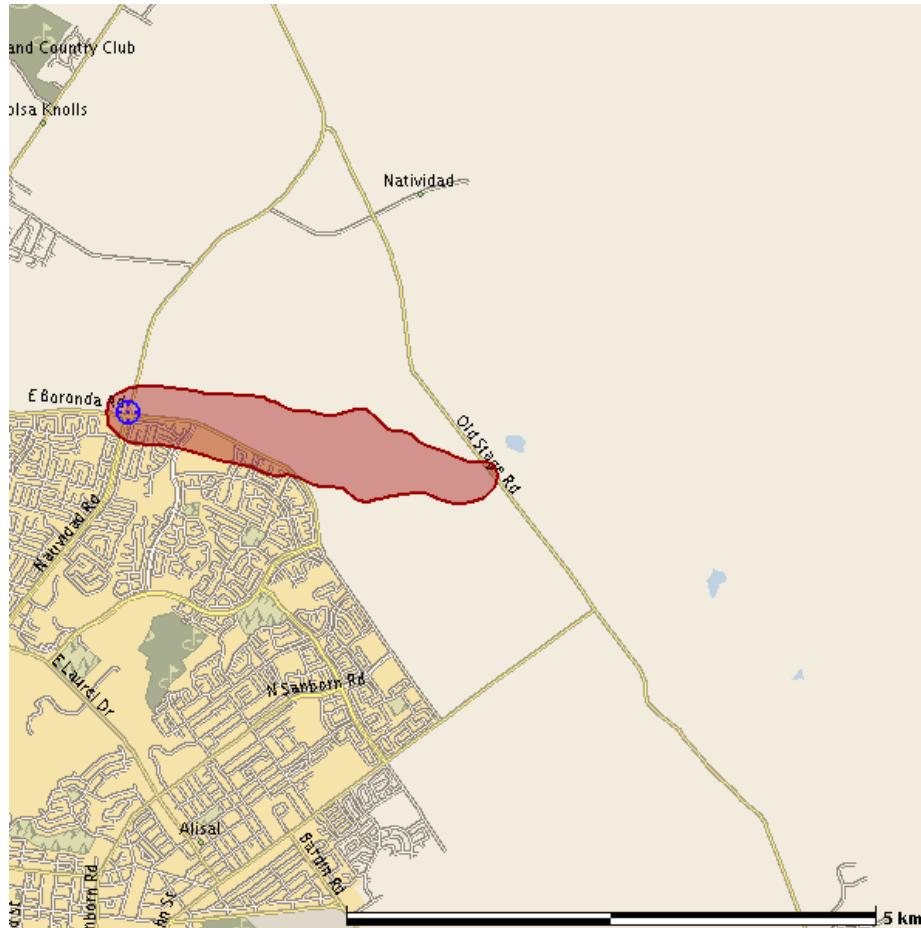
#### Assumptions:

- Assumes 10 kt detonation at 0 ft elevation.
- Areas shown are model predictions based on an estimated source term; confirm with measurements.
- Radioactive cloud has passed contoured area, radiation from fallout remains a serious hazard.
- Model assumes that no shelter or other protective actions have been taken to decrease exposure.

# Predicted Dangerous Fallout Zone (DF) for 14 Dec 2012 00:00 PST

Dangerous fallout zone posing immediate threat to survivors and responders

Presented in 6 time steps



**Dangerous Fallout Zone (DF)** - Dangerous radiation levels exceeding 10 R/h. The best initial action is to seek adequate shelter. Delay responder entry (several hours) unless undertaking a carefully planned mission with sufficient benefit to justify the anticipated radiation dose. Total Population: 180 Area: 2.1 km<sup>2</sup> Extent: 3.5 km

#### Notes:

- Communicating protective actions to the public is critical. Generally, advise public to seek and remain in adequate shelter to avoid exposure to fallout until instructed to evacuate. Evacuation through heavy fallout may increase dose and decrease survivability.
- The highest hazard from fallout occurs in the first hours but rapidly declines as the fallout decays. The radiation levels in the zone and the size of the zone rapidly decrease over time.
- Dangerous Fallout Zone is entirely embedded in Hot Zone (not shown here, see separate figures [Predicted Hot Zone](#)).

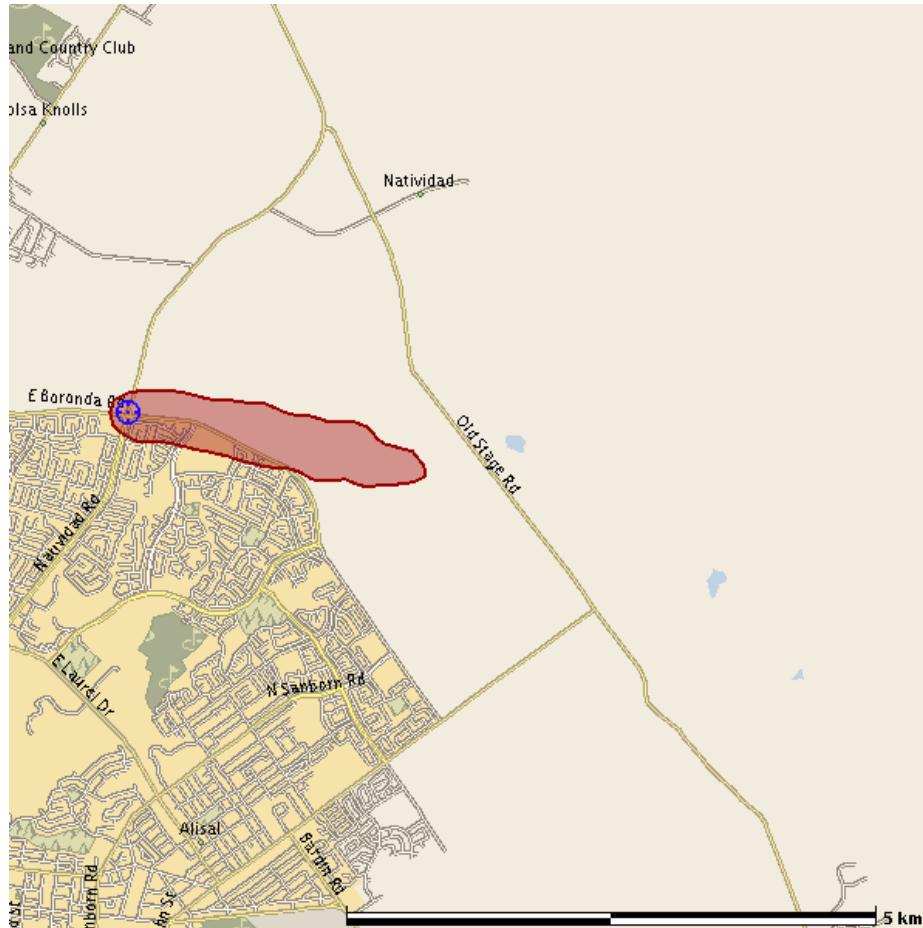
#### Assumptions:

- Assumes 10 kt detonation at 0 ft elevation.
- Areas shown are model predictions based on an estimated source term; confirm with measurements.
- Radioactive cloud has passed contoured area, radiation from fallout remains a serious hazard.
- Model assumes that no shelter or other protective actions have been taken to decrease exposure.

# Predicted Dangerous Fallout Zone (DF) for 14 Dec 2012 12:00 PST

Dangerous fallout zone posing immediate threat to survivors and responders

Presented in 6 time steps



**Dangerous Fallout Zone (DF)** - Dangerous radiation levels exceeding 10 R/h. The best initial action is to seek adequate shelter. Delay responder entry (several hours) unless undertaking a carefully planned mission with sufficient benefit to justify the anticipated radiation dose. Total Population: 160 Area: 1.4 km<sup>2</sup> Extent: 2.9 km

#### Notes:

- Communicating protective actions to the public is critical. Generally, advise public to seek and remain in adequate shelter to avoid exposure to fallout until instructed to evacuate. Evacuation through heavy fallout may increase dose and decrease survivability.
- The highest hazard from fallout occurs in the first hours but rapidly declines as the fallout decays. The radiation levels in the zone and the size of the zone rapidly decrease over time.
- Dangerous Fallout Zone is entirely embedded in Hot Zone (not shown here, see separate figures [Predicted Hot Zone](#)).

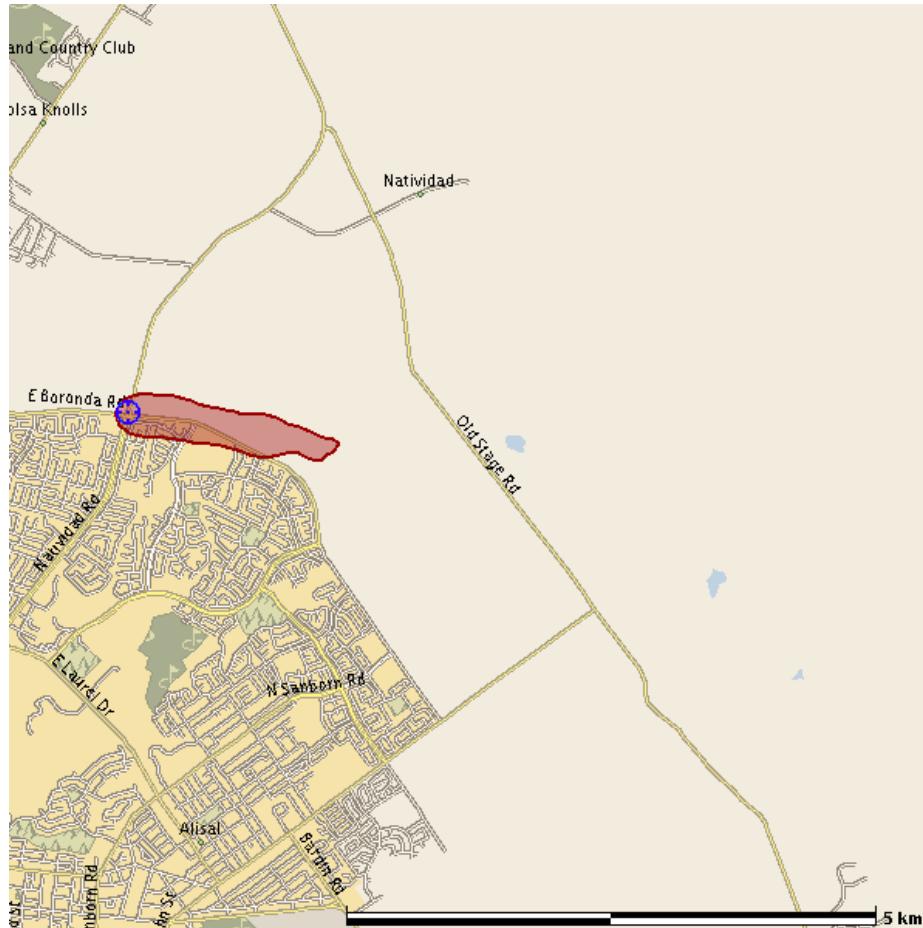
#### Assumptions:

- Assumes 10 kt detonation at 0 ft elevation.
- Areas shown are model predictions based on an estimated source term; confirm with measurements.
- Radioactive cloud has passed contoured area, radiation from fallout remains a serious hazard.
- Model assumes that no shelter or other protective actions have been taken to decrease exposure.

# Predicted Dangerous Fallout Zone (DF) for 15 Dec 2012 12:00 PST

Dangerous fallout zone posing immediate threat to survivors and responders

Presented in 6 time steps



**Dangerous Fallout Zone (DF)** - Dangerous radiation levels exceeding 10 R/h. The best initial action is to seek adequate shelter. Delay responder entry (several hours) unless undertaking a carefully planned mission with sufficient benefit to justify the anticipated radiation dose. Total Population: 60 Area: 0.7 km<sup>2</sup> Extent: 2.0 km

#### Notes:

- Communicating protective actions to the public is critical. Generally, advise public to seek and remain in adequate shelter to avoid exposure to fallout until instructed to evacuate. Evacuation through heavy fallout may increase dose and decrease survivability.
- The highest hazard from fallout occurs in the first hours but rapidly declines as the fallout decays. The radiation levels in the zone and the size of the zone rapidly decrease over time.
- Dangerous Fallout Zone is entirely embedded in Hot Zone (not shown here, see separate figures [Predicted Hot Zone](#)).

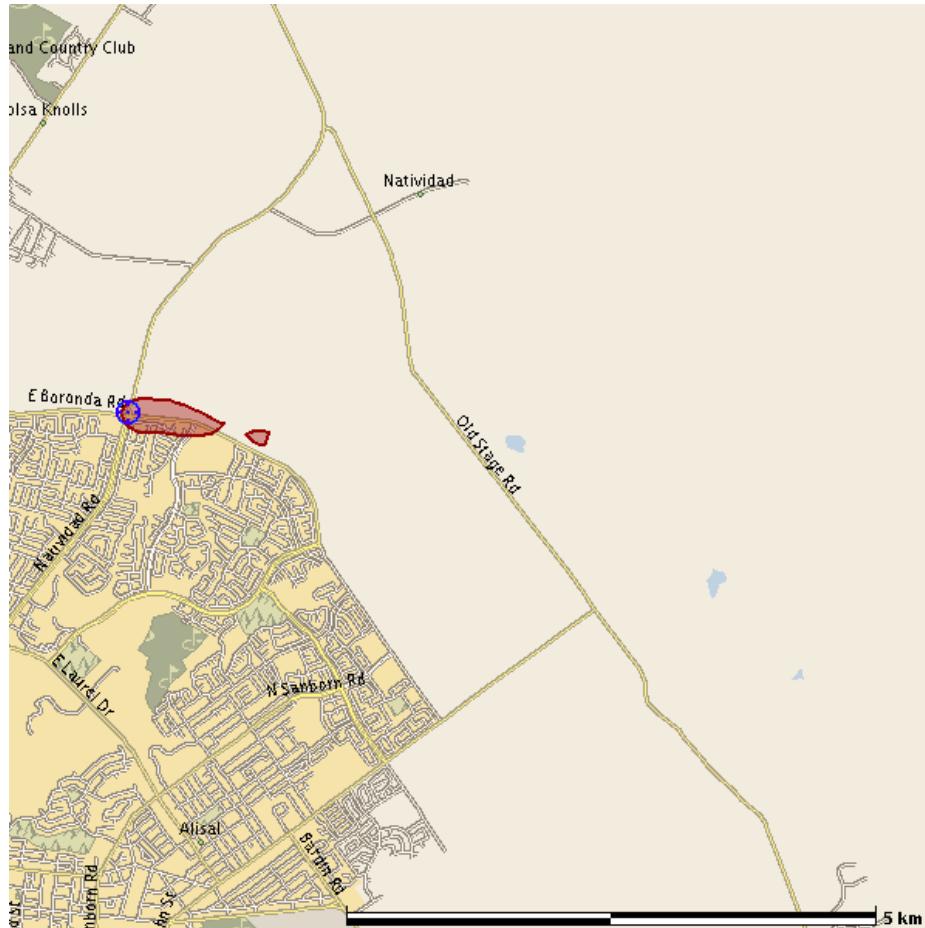
#### Assumptions:

- Assumes 10 kt detonation at 0 ft elevation.
- Areas shown are model predictions based on an estimated source term; confirm with measurements.
- Radioactive cloud has passed contoured area, radiation from fallout remains a serious hazard.
- Model assumes that no shelter or other protective actions have been taken to decrease exposure.

# Predicted Dangerous Fallout Zone (DF) for 16 Dec 2012 12:00 PST

Dangerous fallout zone posing immediate threat to survivors and responders

Presented in 6 time steps



**Dangerous Fallout Zone (DF)** - Dangerous radiation levels exceeding 10 R/h. The best initial action is to seek adequate shelter. Delay responder entry (several hours) unless undertaking a carefully planned mission with sufficient benefit to justify the anticipated radiation dose. Total Population: 0 Area: 0.3 km<sup>2</sup> Extent: 1.3 km

#### Notes:

- Communicating protective actions to the public is critical. Generally, advise public to seek and remain in adequate shelter to avoid exposure to fallout until instructed to evacuate. Evacuation through heavy fallout may increase dose and decrease survivability.
- The highest hazard from fallout occurs in the first hours but rapidly declines as the fallout decays. The radiation levels in the zone and the size of the zone rapidly decrease over time.
- Dangerous Fallout Zone is entirely embedded in Hot Zone (not shown here, see separate figures [Predicted Hot Zone](#)).

#### Assumptions:

- Assumes 10 kt detonation at 0 ft elevation.
- Areas shown are model predictions based on an estimated source term; confirm with measurements.
- Radioactive cloud has passed contoured area, radiation from fallout remains a serious hazard.
- Model assumes that no shelter or other protective actions have been taken to decrease exposure.



## Predicted Dangerous Fallout Zone (DF)

Dangerous fallout zone posing immediate threat to survivors and responders

### **Key Points**

- The best initial action is to seek adequate shelter before fallout arrives.
- Delayed evacuation is the preferred protective action, except for those lacking adequate shelter. Sheltering time depends on shelter quality and cloud arrival time. Adequate shelter means being significantly shielded from radiation (intact basements, thick walls...).
- Allowing time for fallout to decay significantly reduces exposure during evacuation.
- Communicating protective actions to the public in the DF Zone is generally more important than immediate attempts at lifesaving, decontamination of people or protection of critical infrastructure and key resources.
- Zone generally reaches maximum size in 1-3 hours but then decreases (rapidly at first). DF Zone radiation levels can reach 1,000s of R/h and be quickly fatal or injurious.
- Fallout at lower levels extends well beyond this zone, particularly downwind.
- Responders must have personal dosimetry and alarming dosimeters, plus instruments that can measure radiation levels up to 1000 R/h. Supervisors must monitor responder doses and adjust mission tasks accordingly.

# Predicted Dangerous Fallout Zone (DF)

## Dangerous fallout zone posing immediate threat to survivors and responders

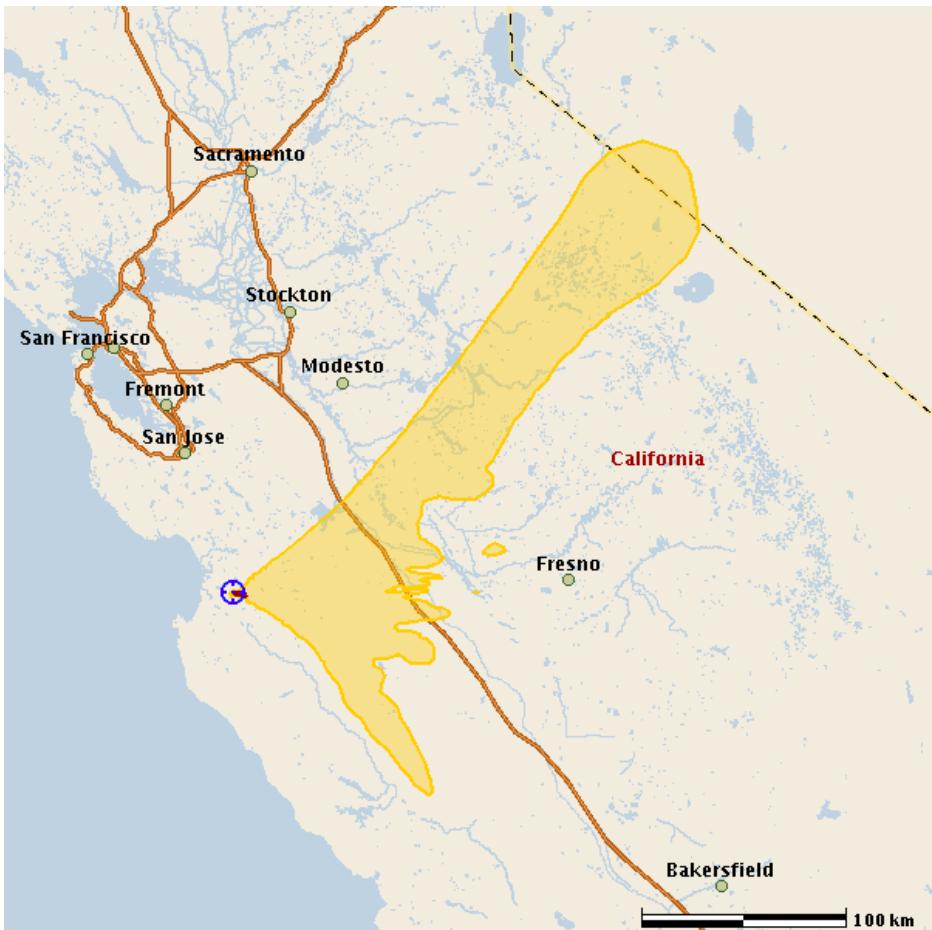
### Presenter Notes - Additional Information

- Seeking and remaining in adequate shelter is critical to reducing radiation dose and improving survival. It is good practice even at lower radiation levels.
- The DF Zone normally overlaps much of the Severe Damage Zone (SD) and portions of the Moderate Damage (MD) and Light Damage (LD) Zones (which are defined by varying levels of structural blast damage). The Dangerous Fallout (DF) Zone will shrink over time due to radioactive decay.
- The highest radiation hazard occurs in the first few hours.
- Plan to shelter for a few hours to a day or more before attempting evacuation.
- Evacuation egress may be much slower than expected due to rubble, injuries and traffic congestion.
- Fallout will primarily occur downwind along the path of upper level winds (not surface winds), but surface winds may significantly widen the fallout footprint.
- Visible fallout (dust and fine particles) is strong evidence for dangerous fallout radiation levels. Fallout may not be visible on rough or dirty surfaces.
- Lack of visible fallout does not indicate the absence of fallout. Appropriate radiation measurements are required.
- Most fallout contamination can be eliminated by a change of clothes and washing exposed skin. Even simple brushing reduces contamination.
- Measured radiation levels of 10 R/h suggest that much higher radiation levels may be close by.
- Treatment of life threatening injuries takes precedence over decontamination of patients or equipment.
- Careful supervision and monitoring of emergency workers required. Assure health physics professionals are involved in worker safety oversight.
- Total radiation dose accumulated by responders must be monitored frequently and work assignments adjusted to avoid over exposure.
- Radiation detection equipment and dosimetry is essential for responders.
- Radiation dose is cumulative hour-by-hour and day-by-day.
- Emergency dose limits attempt to balance risk from radiation against benefit of an activity.
  - ♦ Limits vary depending on activity (lifesaving, protection of major property, general response work).
  - ♦ Turn back limits may be at levels other than 10 R/h.
  - ♦ Plan work to minimize exposure time, avoid high exposure rate areas.

# Predicted Hot Zone for 13 Dec 2012 00:00 PST

## Use for worker protection and to prioritize shelter/evacuation

### Presented in 6 time steps



**Dangerous Fallout Zone (DF) - Dangerous radiation levels exceeding 10 R/h.** Refer to Predicted Dangerous Fallout Zone product for details. Total Population: 370 Area: 7.8 km<sup>2</sup> Extent: 7.0 km

**Hot Zone (10 mR/h to 10 R/h) - Monitor worker dose carefully and limit worker stay times in this area. Stage response assets outside of the Hot Zone.**

Total Population: 263000 Area: 15,989 km<sup>2</sup> Extent: 305 km

**Notes:**

- Immediate adequate shelter, possibly followed by evacuation, is strongly preferred, particularly in the first hours.
- Plan evacuation routes away from the DF/Hot Zones to minimize dose during transit. Shortest route may not guarantee minimal dose.
- Size of Hot Zone grows for 1-3 days then shrinks with time.
- Fallout and radiation extend well beyond the Hot Zone, particularly downwind, but at a reduced level of concern.
- Assure health physics professionals supervise emergency workers in the Hot Zone, workers must not exceed dose limits.

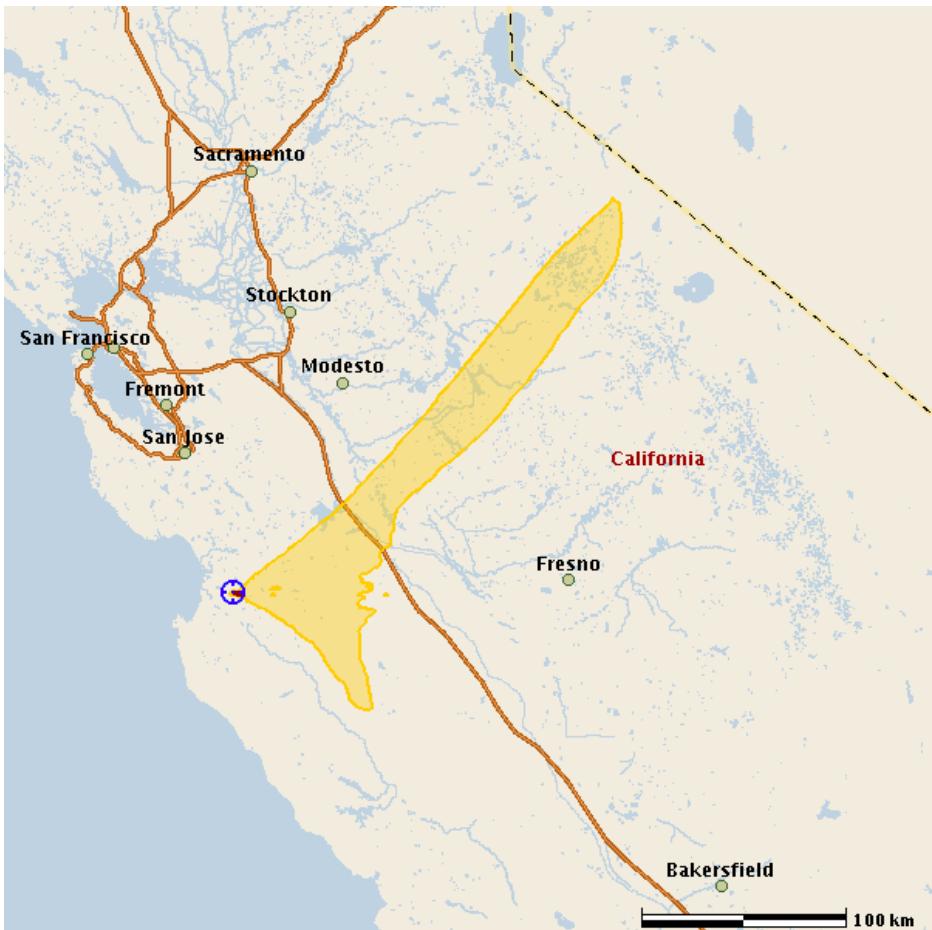
**Assumptions:**

- Assumes 10 kt detonation at 0 ft elevation.
- Areas shown are model predictions based on an estimated source term; confirm with measurements.
- Radioactive cloud still passing through area displayed.
- Model assumes that no shelter or other protective actions have been taken to decrease exposure.

# Predicted Hot Zone for 13 Dec 2012 12:00 PST

## Use for worker protection and to prioritize shelter/evacuation

### Presented in 6 time steps



**Dangerous Fallout Zone (DF) - Dangerous radiation levels exceeding 10 R/h.** Refer to Predicted Dangerous Fallout Zone product for details. Total Population: 250 Area: 3.5 km<sup>2</sup> Extent: 4.4 km

**Hot Zone (10 mR/h to 10 R/h) - Monitor worker dose carefully and limit worker stay times in this area.** Stage response assets outside of the Hot Zone. Total Population: 216000 Area: 8,215 km<sup>2</sup> Extent: 268 km

**Notes:**

- Immediate adequate shelter, possibly followed by evacuation, is strongly preferred, particularly in the first hours.
- Plan evacuation routes away from the DF/Hot Zones to minimize dose during transit. Shortest route may not guarantee minimal dose.
- Size of Hot Zone grows for 1-3 days then shrinks with time.
- Fallout and radiation extend well beyond the Hot Zone, particularly downwind, but at a reduced level of concern.
- Assure health physics professionals supervise emergency workers in the Hot Zone, workers must not exceed dose limits.

**Assumptions:**

- Assumes 10 kt detonation at 0 ft elevation.
- Areas shown are model predictions based on an estimated source term; confirm with measurements.
- Radioactive cloud still passing through area displayed.
- Model assumes that no shelter or other protective actions have been taken to decrease exposure.

# Predicted Hot Zone for 14 Dec 2012 00:00 PST

## Use for worker protection and to prioritize shelter/evacuation

### Presented in 6 time steps



**Dangerous Fallout Zone (DF) - Dangerous radiation levels exceeding 10 R/h.** Refer to Predicted Dangerous Fallout Zone product for details. Total Population: 180 Area: 2.1 km<sup>2</sup> Extent: 3.5 km

**Hot Zone (10 mR/h to 10 R/h) - Monitor worker dose carefully and limit worker stay times in this area.** Stage response assets outside of the Hot Zone. Total Population: 212000 Area: 5,255 km<sup>2</sup> Extent: 207 km

**Notes:**

- Immediate adequate shelter, possibly followed by evacuation, is strongly preferred, particularly in the first hours.
- Plan evacuation routes away from the DF/Hot Zones to minimize dose during transit. Shortest route may not guarantee minimal dose.
- Size of Hot Zone grows for 1-3 days then shrinks with time.
- Fallout and radiation extend well beyond the Hot Zone, particularly downwind, but at a reduced level of concern.
- Assure health physics professionals supervise emergency workers in the Hot Zone, workers must not exceed dose limits.

**Assumptions:**

- Assumes 10 kt detonation at 0 ft elevation.
- Areas shown are model predictions based on an estimated source term; confirm with measurements.
- Radioactive cloud has passed contoured area.
- Model assumes that no shelter or other protective actions have been taken to decrease exposure.

# Predicted Hot Zone for 14 Dec 2012 12:00 PST

## Use for worker protection and to prioritize shelter/evacuation

### Presented in 6 time steps



**Dangerous Fallout Zone (DF) - Dangerous radiation levels exceeding 10 R/h.** Refer to Predicted Dangerous Fallout Zone product for details. Total Population: 160 Area: 1.4 km<sup>2</sup> Extent: 2.9 km

**Hot Zone (10 mR/h to 10 R/h) - Monitor worker dose carefully and limit worker stay times in this area.** Stage response assets outside of the Hot Zone. Total Population: 150000 Area: 3,768 km<sup>2</sup> Extent: 183 km

**Notes:**

- Immediate adequate shelter, possibly followed by evacuation, is strongly preferred, particularly in the first hours.
- Plan evacuation routes away from the DF/Hot Zones to minimize dose during transit. Shortest route may not guarantee minimal dose.
- Size of Hot Zone grows for 1-3 days then shrinks with time.
- Fallout and radiation extend well beyond the Hot Zone, particularly downwind, but at a reduced level of concern.
- Assure health physics professionals supervise emergency workers in the Hot Zone, workers must not exceed dose limits.

**Assumptions:**

- Assumes 10 kt detonation at 0 ft elevation.
- Areas shown are model predictions based on an estimated source term; confirm with measurements.
- Radioactive cloud has passed contoured area.
- Model assumes that no shelter or other protective actions have been taken to decrease exposure.

# Predicted Hot Zone for 15 Dec 2012 12:00 PST

## Use for worker protection and to prioritize shelter/evacuation

### Presented in 6 time steps



**Dangerous Fallout Zone (DF) - Dangerous radiation levels exceeding 10 R/h.** Refer to Predicted Dangerous Fallout Zone product for details. Total Population: 60 Area: 0.7 km<sup>2</sup> Extent: 2.0 km

**Hot Zone (10 mR/h to 10 R/h) - Monitor worker dose carefully and limit worker stay times in this area.** Stage response assets outside of the Hot Zone. Total Population: 95000 Area: 2,200 km<sup>2</sup> Extent: 128 km

**Notes:**

- Immediate adequate shelter, possibly followed by evacuation, is strongly preferred, particularly in the first hours.
- Plan evacuation routes away from the DF/Hot Zones to minimize dose during transit. Shortest route may not guarantee minimal dose.
- Size of Hot Zone grows for 1-3 days then shrinks with time.
- Fallout and radiation extend well beyond the Hot Zone, particularly downwind, but at a reduced level of concern.
- Assure health physics professionals supervise emergency workers in the Hot Zone, workers must not exceed dose limits.

**Assumptions:**

- Assumes 10 kt detonation at 0 ft elevation.
- Areas shown are model predictions based on an estimated source term; confirm with measurements.
- Radioactive cloud has passed contoured area.
- Model assumes that no shelter or other protective actions have been taken to decrease exposure.

# Predicted Hot Zone for 16 Dec 2012 12:00 PST

## Use for worker protection and to prioritize shelter/evacuation

### Presented in 6 time steps



**Dangerous Fallout Zone (DF) - Dangerous radiation levels exceeding 10 R/h.** Refer to Predicted Dangerous Fallout Zone product for details. Total Population: 0 Area: 0.3 km<sup>2</sup> Extent: 1.3 km

**Hot Zone (10 mR/h to 10 R/h) - Monitor worker dose carefully and limit worker stay times in this area.** Stage response assets outside of the Hot Zone. Total Population: 58000 Area: 1,585 km<sup>2</sup> Extent: 112 km

**Notes:**

- Immediate adequate shelter, possibly followed by evacuation, is strongly preferred, particularly in the first hours.
- Plan evacuation routes away from the DF/Hot Zones to minimize dose during transit. Shortest route may not guarantee minimal dose.
- Size of Hot Zone grows for 1-3 days then shrinks with time.
- Fallout and radiation extend well beyond the Hot Zone, particularly downwind, but at a reduced level of concern.
- Assure health physics professionals supervise emergency workers in the Hot Zone, workers must not exceed dose limits.

**Assumptions:**

- Assumes 10 kt detonation at 0 ft elevation.
- Areas shown are model predictions based on an estimated source term; confirm with measurements.
- Radioactive cloud has passed contoured area.
- Model assumes that no shelter or other protective actions have been taken to decrease exposure.



## Predicted Hot Zone

Use for worker protection and to prioritize shelter/evacuation

### **Key Points**

- Immediate adequate sheltering preferred in Hot Zone, possibly followed by a planned evacuation via the most expedient route after a period of substantial radioactive decay.
- The size of the Hot Zone will grow at first, reaching maximum size in 1-3 days as fallout is deposited downwind. After the radioactive cloud leaves the area, radioactive decay will cause radiation levels to decline and the footprint to shrink.
- The Hot Zone is defined as 10 mR/h to 10 R/h.
- Lower levels of radiation and fallout extend well beyond the Hot Zone.
- Stage response assets outside Hot Zone, but do not expect "background" levels nearby.
- Equipment and supplies taken into the Hot Zone may be contaminated such that they cannot be taken out of this zone.
- Strive to keep worker exposures As-Low-As-Reasonably-Achievable (ALARA).
  - Plan work to minimize exposure time,
  - Avoid lingering in areas with elevated radiation levels,
  - Provide dosimetry, alarming dosimeters and radiation monitoring instruments,
  - Respiratory protection may increase radiation dose, if it increases exposure time.
- Engage assistance of health physics professionals ASAP.

## Predicted Hot Zone

### Use for worker protection and to prioritize shelter/evacuation

#### **Presenter Notes - Additional Information**

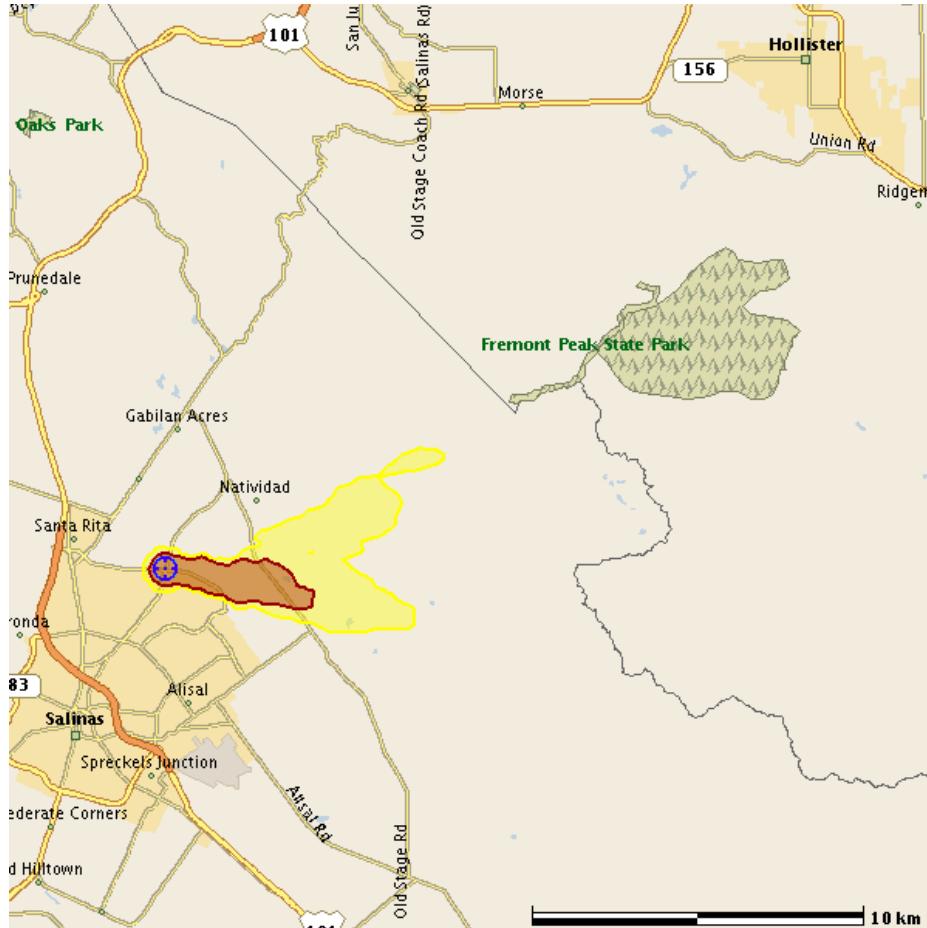
- Visible fallout (dust and fine particles) is strong evidence for dangerous fallout radiation levels. Fallout may not be visible on rough or dirty surfaces. Lack of visible fallout does not indicate the absence of fallout. Appropriate radiation measurements are required.
- Most contamination can be eliminated by a change of clothes and washing exposed skin. Even simple brushing reduces contamination.
- Treatment of life threatening injuries takes precedence over decontamination of patients or equipment.
- Substantial radiological safety measures are required inside the Hot Zone. Assure health physics professionals are involved in worker safety oversight.
- Various dose limits are used depending on the nature of the emergency response activity. These various limits attempt to balance risk from radiation against benefit of an activity.
- Emergency responders are prohibited from performing work in a radiation area after their dose limit has been reached. This may remove them from service for up to a year.
- All exposures exceeding routine occupational limits require informed consent of the worker (for lifesaving or protection of valuable property activities).
- An individual's radiation dose is a cumulative total of their dose received each day.
- Plan activities to make exposures As-Low-As-Reasonably-Achievable (ALARA).
  - ◆ Plan work to minimize exposure time,
  - ◆ Implement Stay Times and Turn Back Limits,
  - ◆ Avoid lingering in areas with radiation levels over 10 mR/h,
  - ◆ Position assets outside the Hot Zone and upwind if possible,
  - ◆ Take advantage of available shelter and shielding (buildings,walls...).
- Radiation detection equipment and dosimetry is essential for responders. If sufficient dosimeters, alarming dosimeters or radiation measuring instruments are not available for each responder in the Hot Zone, then equip each responder team instead.
- Evaluate necessity of respiratory protection because it can actually increase dose if its use slows work and results in longer exposure times. External dose normally dominates inhalation dose.

#### **Presenter Notes - Technical Background**

- Guidance based on:
  - ◆ "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents", (EPA 400-R-92-001, May 1992).
  - ◆ "Key Elements of Preparing Emergency Responders for Nuclear and Radiological Terrorism, Commentary No. 19", 2005, National Council on Radiation Protection and Measurements.
  - ◆ "Key Response Planning Factors for the aftermath of Nuclear Terrorism", LLNL-TR-410067, 2009, Lawrence Livermore National Laboratory.
  - ◆ "Handbook for Responding to a Radiological Dispersal Device", CRCPD Pub. 06-6.
- DF Zone is shown to provide comparison of relative size. See Predicted Dangerous Fallout Zone product for detailed view and discussion.
- The Hot Zone perimeter is the same area as the NCRP Commentary 19 "Outer Perimeter", the CRCPD "Low Radiation Boundary", and the "Safe Area" cited in "Key Response Planning Factors."
- Lifesaving dose limit is 25 rem for the event, which assures exposures will not produce acute health effects.
- Protection of valuable property dose limit is 10 rem for the event.
- Occupational dose limit of 5 rem per year applies to all other work.
- Emergency dose limits apply to emergency response workers. Lower dose limits apply to the general public.
- The "Total Population" is the total estimated population in the zone adjusted for day/night variations due to commuting based on "Landscan" data.
- Briefing Products are intended for presenting a common operating picture to key leaders and decision makers. Other more technical products are available (Standard Products).
- Contact the FRPCC Subcommittee for Environment, Food and Health (Advisory Team) for advice and recommendations by calling FDA Emergency Operations Center (EOC) at 866-300-4374.

# Predicted Area for Potential Fallout Casualties at 12 Dec 2012 13:00 PST

Total external dose from radioactive fallout during first 1 hr of exposure  
 leading to near-term (days to weeks) illness or death



Fallout lethal to most without adequate shelter (exceeds 450 rad). Best action is early shelter followed by informed evacuation to control exposure. Total Exposed Population: 320 Area: 4.8 km<sup>2</sup> Extent: 4.6 km

Dangerous fallout levels can cause death, injury or illness (exceeds 100 rad). Zone of greatest opportunity for life saving and injury reduction. Dose management for first responders essential. Total Exposed Population: 510 Area: 19.5 km<sup>2</sup> Extent: 9.1 km

Notes:

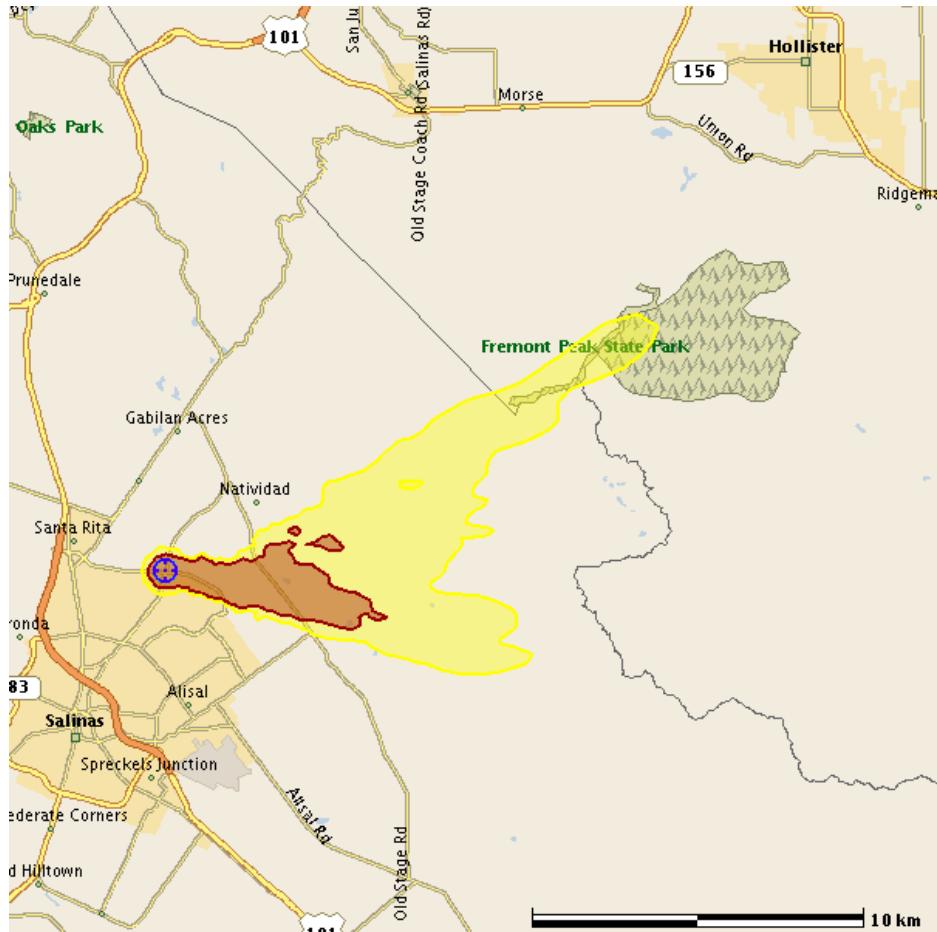
- The best initial action is to seek adequate shelter immediately.
- Sheltering with delayed evacuation is preferred, unless evacuation can be completed before fallout arrival.
- Highest radiation hazard during first hours, then rapidly declines.
- Expect few deaths or serious injuries due to radiation outside the maximum extent of these regions.
- Area size will increase rapidly the first few days, then vary slowly, as they show total dose accumulated since detonation.

Assumptions:

- Assumes 10 kt detonation at 0 ft elevation.
- Areas shown are model predictions based on an estimated source term; confirm with measurements.
- Model assumes that no shelter or other protective actions have been taken to decrease exposure.

# Predicted Area for Potential Fallout Casualties at 13 Dec 2012 00:00 PST

## Total external dose from radioactive fallout during first 12 hr of exposure leading to near-term (days to weeks) illness or death



Fallout lethal to most without adequate shelter (exceeds 450 rad). Best action is early shelter followed by informed evacuation to control exposure. Total Exposed Population: 390 Area: 8.9 km<sup>2</sup> Extent: 6.8 km

Dangerous fallout levels can cause death, injury or illness (exceeds 100 rad). Zone of greatest opportunity for life saving and injury reduction. Dose management for first responders essential. Total Exposed Population: 560 Area: 50.1 km<sup>2</sup> Extent: 16.6 km

### Notes:

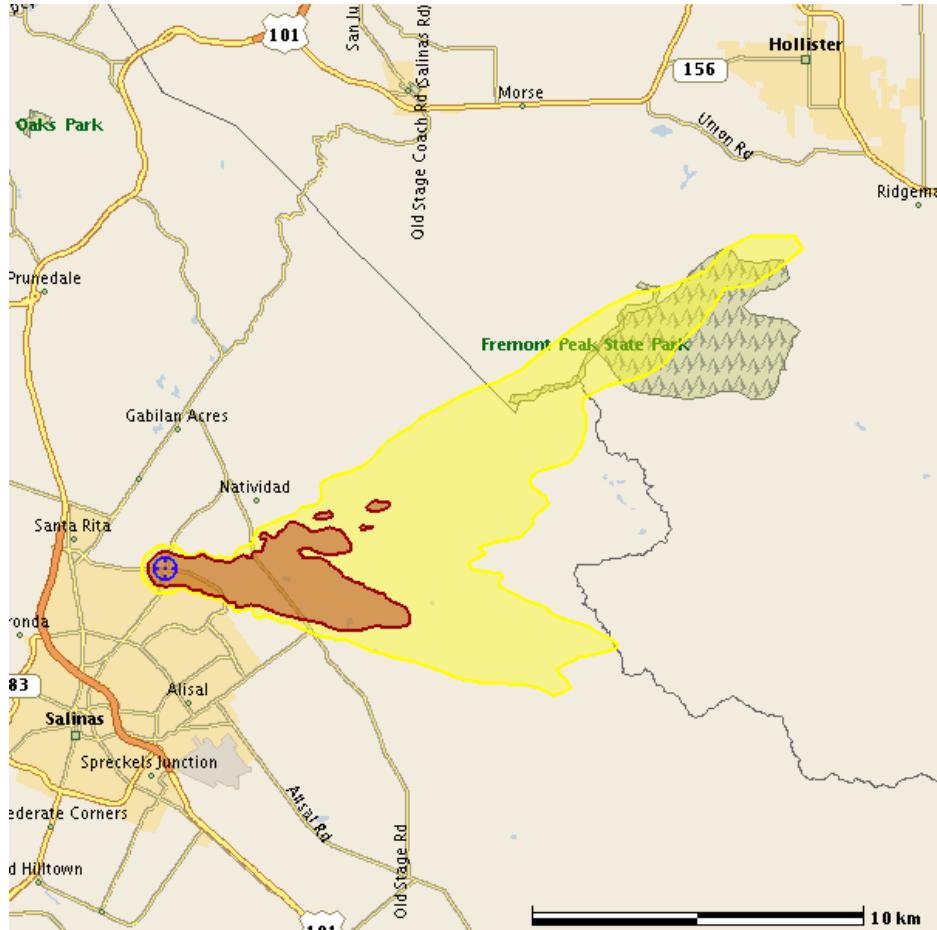
- The best initial action is to seek adequate shelter immediately.
- Sheltering with delayed evacuation is preferred, unless evacuation can be completed before fallout arrival.
- Highest radiation hazard during first hours, then rapidly declines.
- Expect few deaths or serious injuries due to radiation outside the maximum extent of these regions.
- Area size will increase rapidly the first few days, then vary slowly, as they show total dose accumulated since detonation.

### Assumptions:

- Assumes 10 kt detonation at 0 ft elevation.
- Areas shown are model predictions based on an estimated source term; confirm with measurements.
- Model assumes that no shelter or other protective actions have been taken to decrease exposure.

# Predicted Area for Potential Fallout Casualties at 20 Dec 2012 12:00 PST

Total external dose from radioactive fallout during first 192 hr of exposure  
 leading to near-term (days to weeks) illness or death



Fallout lethal to most without adequate shelter (exceeds 450 rad). Best action is early shelter followed by informed evacuation to control exposure. Total Exposed Population: 450 Area: 12.6 km<sup>2</sup> Extent: 7.6 km

Dangerous fallout levels can cause death, injury or illness (exceeds 100 rad). Zone of greatest opportunity for life saving and injury reduction. Dose management for first responders essential. Total Exposed Population: 600 Area: 77.9 km<sup>2</sup> Extent: 21.5 km

Notes:

- The best initial action is to seek adequate shelter immediately.
- Sheltering with delayed evacuation is preferred, unless evacuation can be completed before fallout arrival.
- Highest radiation hazard during first hours, then rapidly declines.
- Expect few deaths or serious injuries due to radiation outside the maximum extent of these regions.
- Area size will increase rapidly the first few days, then vary slowly, as they show total dose accumulated since detonation.

Assumptions:

- Assumes 10 kt detonation at 0 ft elevation.
- Areas shown are model predictions based on an estimated source term; confirm with measurements.
- Model assumes that no shelter or other protective actions have been taken to decrease exposure.



## Predicted Area for Potential Fallout Casualties

Total external dose from radioactive fallout  
leading to near-term (days to weeks) illness or death

### **Key Points**

- Prompt communication of protective action orders to the public is critical.
- Generally, the best initial action is sheltering in the nearest safe building and await instructions. Evacuate after a period for decay to reduce fallout radiation levels.
- Health effects may be greatly reduced for those in the areas shown if sheltered in large multi-story structures or underground areas (basements, parking garages, tunnels, etc.)
- Single-story wood frame houses without basements provide only minimal shelter.
- Decisions to evacuate must be based on event-specific factors such as fallout pattern, radiation intensity, availability of adequate shelter, impending hazards (e.g. fire), etc.
- Early evacuation should be considered for individuals who are threatened by fire or building collapse and for those that lack adequate shelter in the fallout area within 10 miles of the detonation.
- Potential evacuation routes should be established only after the fallout pattern and intensity are well-estimated, and should not obstruct ongoing life-saving missions.
- If possible, when evacuating travel at right angles to the estimated fallout plume and away from the plume centerline.
- Long-term induced cancer rates will be increased in areas beyond those shown here (refer to Predicted EPA/DHS Sheltering/Evacuation Areas product).

# Predicted Area for Potential Fallout Casualties

## Total external dose from radioactive fallout leading to near-term (days to weeks) illness or death

### **Presenter Notes - Additional Information**

- This product estimates radiation effects of the total dose delivered by fallout since detonation for three time periods.
- The two principal actions to protect the public from fallout are: 1) taking shelter and 2) evacuation. No single action will be adequate for all locations and times.
- Generally, the preferred action is to take immediate shelter in the most robust, readily available shelter, then await instructions for an orderly evacuation along the safest routes.
- Duration of shelter primarily depends on adequacy of shelter. Short shelter times (hours) are indicated for those with poor shelter. A day or more may be indicated for those with good shelter and supplies.
- Generally, initial recommendations should be issued as soon as possible after the incident, which will be likely based on little or no incident data.
- Follow-up recommendations should be issued once additional data become available, and may include continued shelter and/or evacuation instructions.
- Adequate shelter significantly reduces radiation dose to occupants during an extended period (e.g. safe underground structures such as basements, parking garages, etc.). Shelter must be structurally stable and otherwise safe to occupy.
- Consider supporting those who are able to spontaneously self-evacuate, by providing information on when to leave and where to go.
- Most of dose is received within the first hours of exposure, 98% in first year.

Time After Detonation	Percent of Total Dose	Time After Detonation	Percent of Total Dose
1 hour	55%	4 hours	68%
12 hours	75%	24 hours	80%

- The highest hazard from fallout occurs within the first few hours and will continue to drop relatively quickly as the radioactive fission products decay.
- Visible fallout (dust and fine particles) is strong evidence for dangerous fallout radiation levels. Fallout may not be visible on rough or dirty surfaces. Lack of visible fallout does not indicate the absence of fallout. Appropriate radiation measurements are required.
- Decontamination of persons is generally not a lifesaving issue. Changing from contaminated to uncontaminated clothes and washing exposed skin is preferred. Simply brushing off outer garments is useful until more thorough decontamination can be accomplished.

**Briefing Product for Public Officials**

**Produced: 13 Dec 2012 13:36 PST**

**Check for updates**

### **Presenter Notes - Technical Background**

- Guidance based on:
  - ◆ "Planning Guidance for Response to a Nuclear Detonation", Second Edition, June, 2010. Developed by the Homeland Security Council Interagency Policy Coordination Subcommittee for Preparedness & Response to Radiological and Nuclear Threats.
  - ◆ "Key Elements of Preparing Emergency Responders for Nuclear and Radiological Terrorism, Commentary No. 19", 2005, National Council on Radiation Protection and Measurements.
  - ◆ "Key Response Planning Factors for the aftermath of Nuclear Terrorism", LLNL-TR-410067, 2009, Lawrence Livermore National Laboratory.
  - ◆ "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents", (EPA 400-R-92-001, May 1992).
- This total dose is estimated by integrating the external exposure over the exposure time (assuming 0.7 rad mid-line body dose per 1 Roentgen exposure). It does not include additional doses due to inhalation, ingestion or skin contamination, which are minor contributors.
- Inner Contour (450 rad) - Expect fatalities exceeding 90% for those lacking shelter inside this zone. Some of these fatalities will be delayed by days or weeks.
- Outer Contour (100 rad) - Expect fatality and radiation injury rate to rapidly decline further out in this zone. Few, if any, fatalities are expected outside this zone. Less than 10% suffer radiation injury at the outer boundary.
- The "Total Exposed Population" is the total estimated population in the zone adjusted for day/night variations due to commuting based on "Landscan" data.
- Briefing Products are intended for presenting a common operating picture to key leaders and decision makers. Other more technical products are available (Standard Products).
- Contact the FRPCC Subcommittee for Environment, Food and Health (Advisory Team) for advice and recommendations by calling FDA Emergency Operations Center (EOC) at 866-300-4374.

**Technical Details: CMHT 702-794-1665**

**Advice & Recommendations: A-Team 866-300-4374**

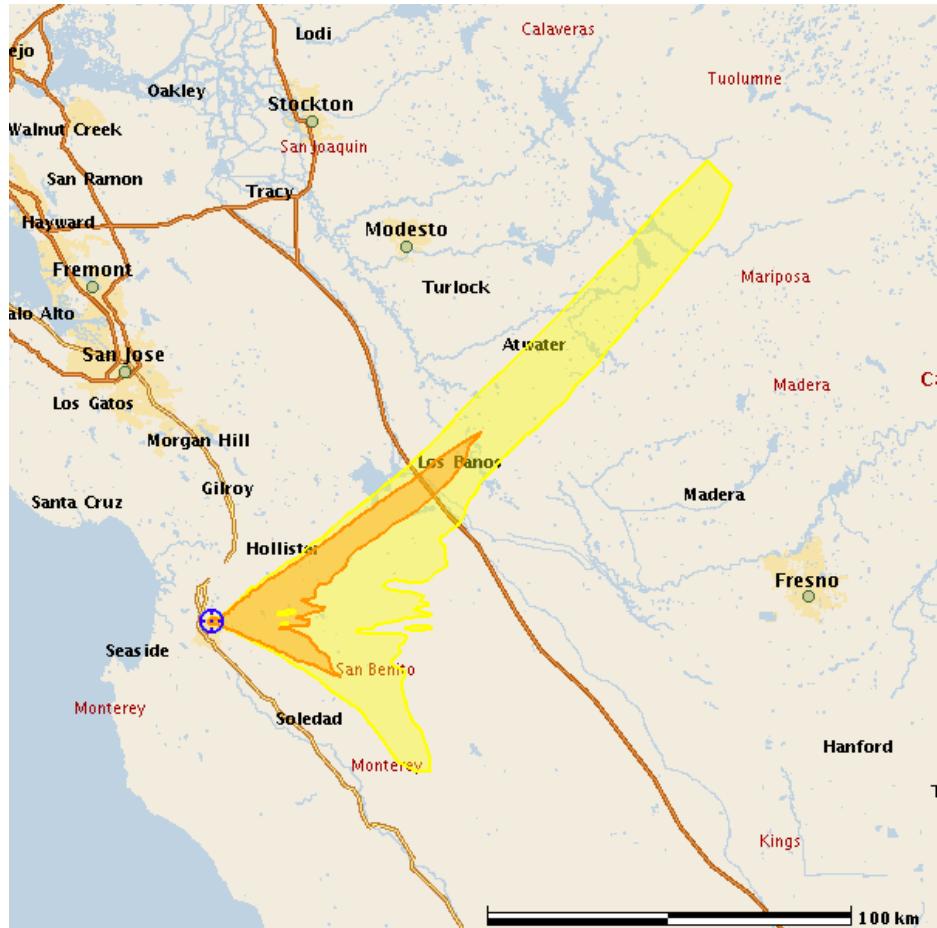
**Example for Demonstration Only**

**page 5 of 5**

## Predicted EPA/DHS Shelter/Evacuation Areas at 13 Dec 2012 00:00 PST

Addresses avoidable additional long-term cancer risk, not acute radiation injury or death

Presented in 6 time steps



**Sheltering or evacuation of entire population generally warranted, unless additional unusually hazardous circumstances exist (exceeds 5 rem).**  
**Total Population: 17800 Area: 869 km<sup>2</sup> Extent: 90.0 km**

**Sheltering or evacuation normally initiated (1 to 5 rem). Total Population: 152000 Area: 4,181 km<sup>2</sup> Extent: 186 km**

### Notes:

- Best initial action is to seek adequate shelter.
- Sheltering followed by delayed evacuation is preferred unless evacuation can be completed before arrival of fallout.
- Relates only to long term risk of cancer. Not relevant to near-term injuries or fatalities due to fallout, which are of immediate concern (see Predicted Potential Fallout Casualties product).
- These protective actions are based only on dose that can be avoided. Predicted dose is calculated for that which is accumulated over the next four days following 13 Dec 2012 00:00 PST. This is the dose that can be avoided by protective action completed by this time.
- Consequences of dose received earlier are not avoidable.

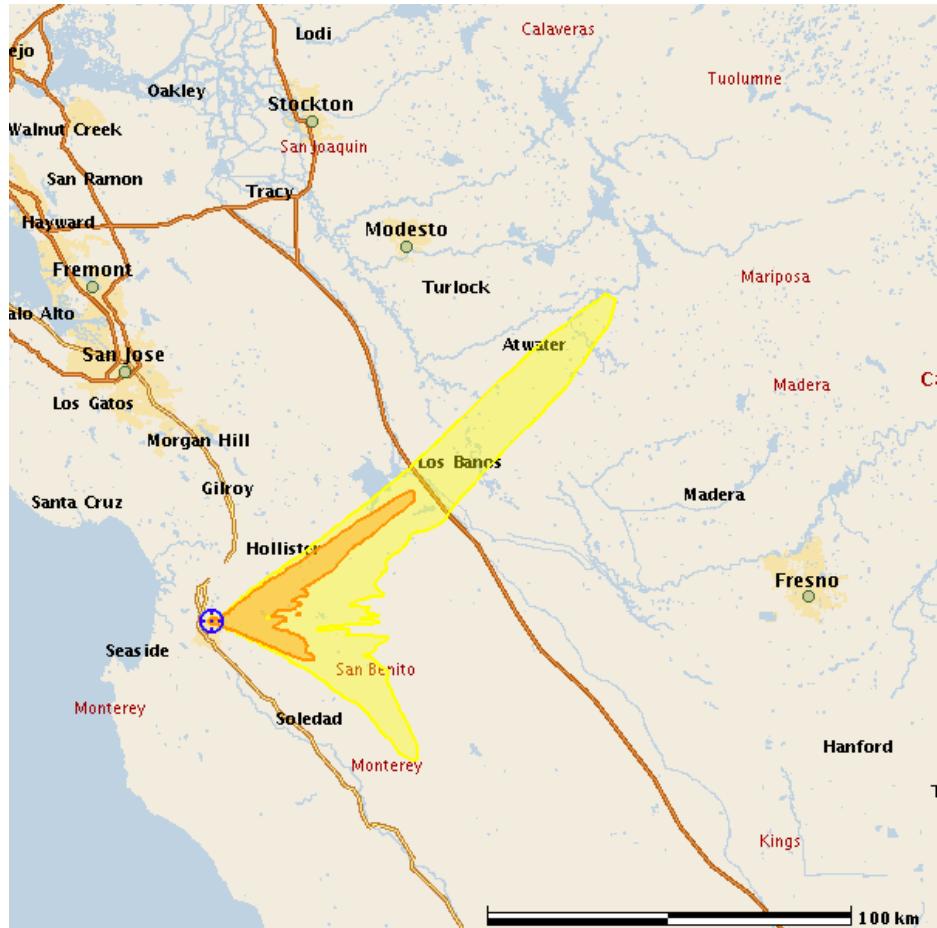
### Assumptions:

- Assumes 10 kt detonation at 0 ft elevation.
- Areas shown are model predictions based on an estimated source term; confirm with measurements.
- Model assumes that no shelter or other protective actions have been taken to decrease exposure.

# Predicted EPA/DHS Shelter/Evacuation Areas at 13 Dec 2012 12:00 PST

Addresses avoidable additional long-term cancer risk, not acute radiation injury or death

Presented in 6 time steps



**Sheltering or evacuation of entire population generally warranted, unless additional unusually hazardous circumstances exist (exceeds 5 rem).**  
**Total Population: 15800 Area: 514 km<sup>2</sup> Extent: 66.0 km**

**Sheltering or evacuation normally initiated (1 to 5 rem). Total Population: 141000 Area: 2,718 km<sup>2</sup> Extent: 141 km**

**Notes:**

- Best initial action is to seek adequate shelter.
- Sheltering followed by delayed evacuation is preferred unless evacuation can be completed before arrival of fallout.
- Relates only to long term risk of cancer. Not relevant to near-term injuries or fatalities due to fallout, which are of immediate concern (see Predicted Potential Fallout Casualties product).
- These protective actions are based only on dose that can be avoided. Predicted dose is calculated for that which is accumulated over the next four days following 13 Dec 2012 12:00 PST. This is the dose that can be avoided by protective action completed by this time.
- Consequences of dose received earlier are not avoidable.

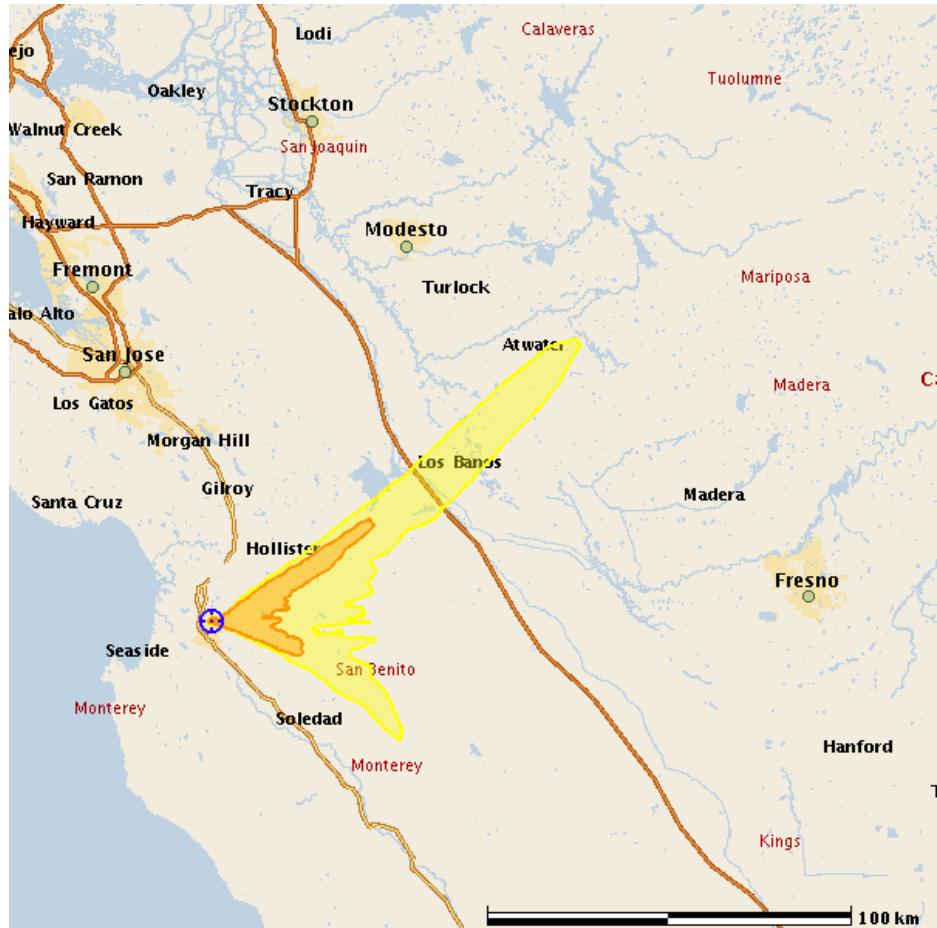
**Assumptions:**

- Assumes 10 kt detonation at 0 ft elevation.
- Areas shown are model predictions based on an estimated source term; confirm with measurements.
- Model assumes that no shelter or other protective actions have been taken to decrease exposure.

## Predicted EPA/DHS Shelter/Evacuation Areas at 14 Dec 2012 00:00 PST

Addresses avoidable additional long-term cancer risk, not acute radiation injury or death

Presented in 6 time steps



**Sheltering or evacuation of entire population generally warranted, unless additional unusually hazardous circumstances exist (exceeds 5 rem).**  
**Total Population: 15600 Area: 370 km<sup>2</sup> Extent: 51.8 km**

**Sheltering or evacuation normally initiated (1 to 5 rem). Total Population: 94500 Area: 2,113 km<sup>2</sup> Extent: 127 km**

### Notes:

- Best initial action is to seek adequate shelter.
- Sheltering followed by delayed evacuation is preferred unless evacuation can be completed before arrival of fallout.
- Relates only to long term risk of cancer. Not relevant to near-term injuries or fatalities due to fallout, which are of immediate concern (see Predicted Potential Fallout Casualties product).
- These protective actions are based only on dose that can be avoided. Predicted dose is calculated for that which is accumulated over the next four days following 14 Dec 2012 00:00 PST. This is the dose that can be avoided by protective action completed by this time.
- Consequences of dose received earlier are not avoidable.

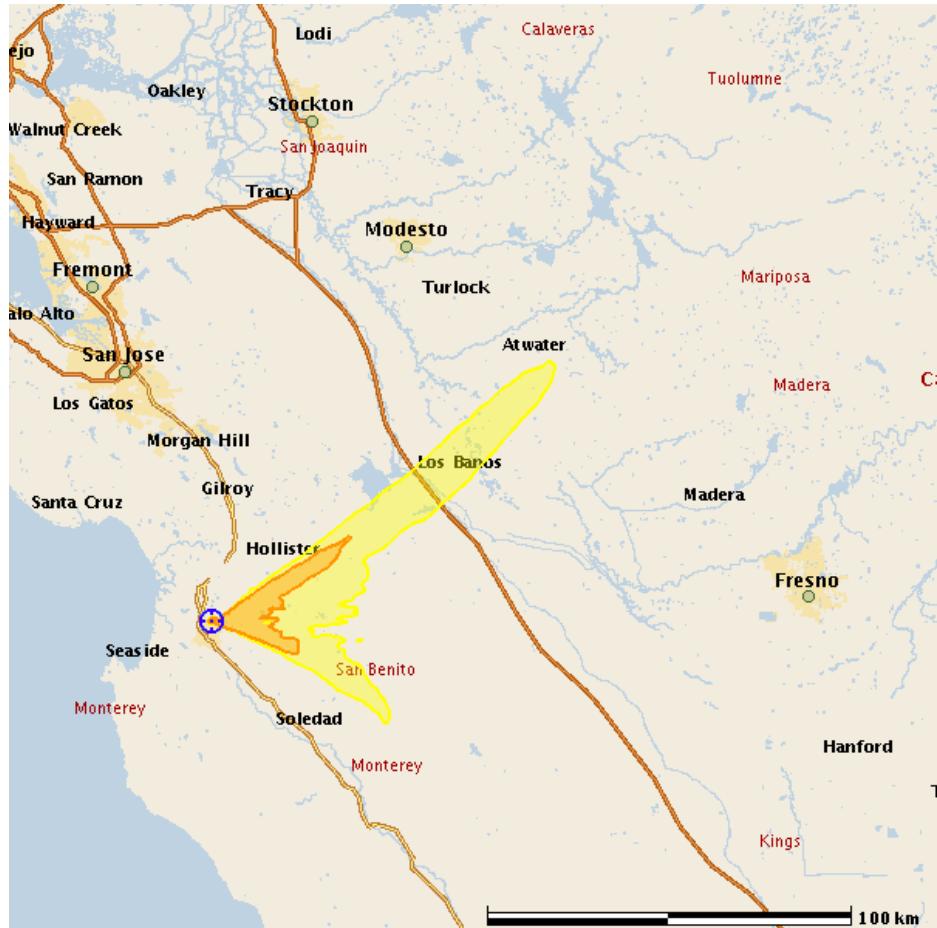
### Assumptions:

- Assumes 10 kt detonation at 0 ft elevation.
- Areas shown are model predictions based on an estimated source term; confirm with measurements.
- Model assumes that no shelter or other protective actions have been taken to decrease exposure.

## Predicted EPA/DHS Shelter/Evacuation Areas at 14 Dec 2012 12:00 PST

Addresses avoidable additional long-term cancer risk, not acute radiation injury or death

Presented in 6 time steps



**Sheltering or evacuation of entire population generally warranted, unless additional unusually hazardous circumstances exist (exceeds 5 rem).**  
**Total Population: 10100 Area: 282 km<sup>2</sup> Extent: 44.2 km**

**Sheltering or evacuation normally initiated (1 to 5 rem). Total Population: 74300 Area: 1,734 km<sup>2</sup> Extent: 117 km**

### Notes:

- Best initial action is to seek adequate shelter.
- Sheltering followed by delayed evacuation is preferred unless evacuation can be completed before arrival of fallout.
- Relates only to long term risk of cancer. Not relevant to near-term injuries or fatalities due to fallout, which are of immediate concern (see Predicted Potential Fallout Casualties product).
- These protective actions are based only on dose that can be avoided. Predicted dose is calculated for that which is accumulated over the next four days following 14 Dec 2012 12:00 PST. This is the dose that can be avoided by protective action completed by this time.
- Consequences of dose received earlier are not avoidable.

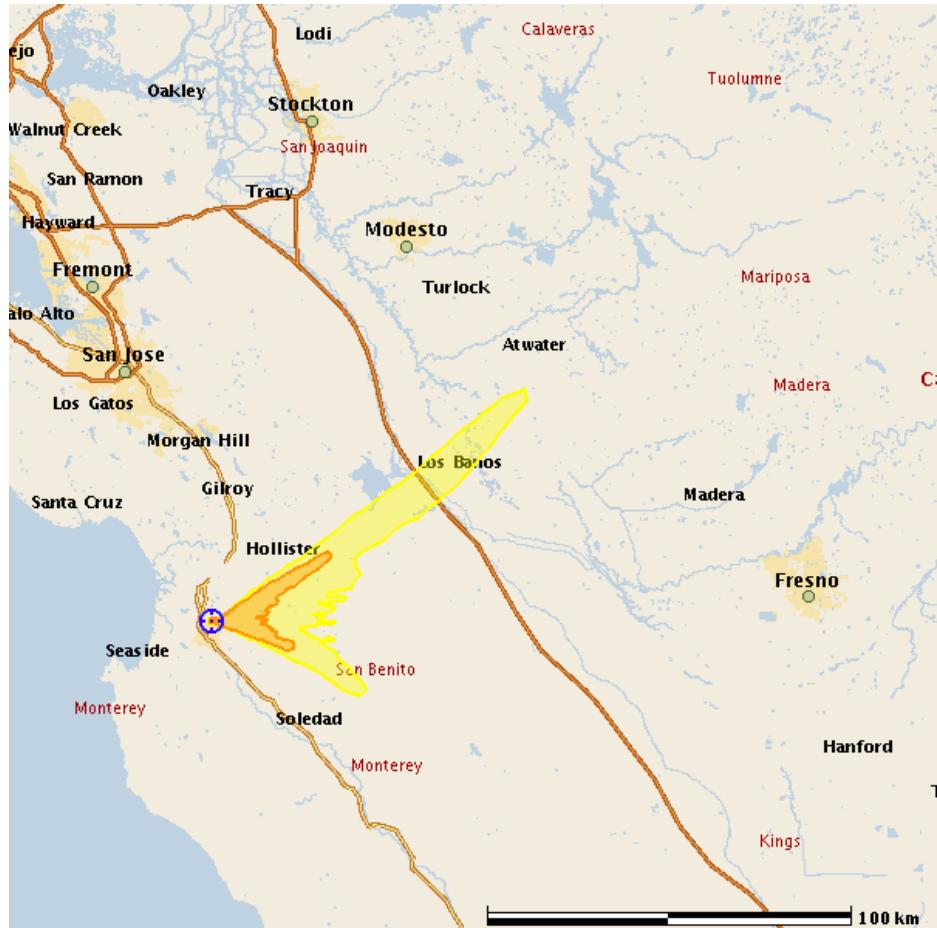
### Assumptions:

- Assumes 10 kt detonation at 0 ft elevation.
- Areas shown are model predictions based on an estimated source term; confirm with measurements.
- Model assumes that no shelter or other protective actions have been taken to decrease exposure.

## Predicted EPA/DHS Shelter/Evacuation Areas at 15 Dec 2012 12:00 PST

Addresses avoidable additional long-term cancer risk, not acute radiation injury or death

Presented in 6 time steps



**Sheltering or evacuation of entire population generally warranted, unless additional unusually hazardous circumstances exist (exceeds 5 rem).**  
**Total Population: 9330 Area: 214 km<sup>2</sup> Extent: 37.3 km**

**Sheltering or evacuation normally initiated (1 to 5 rem). Total Population: 41500 Area: 1,315 km<sup>2</sup> Extent: 107 km**

### Notes:

- Best initial action is to seek adequate shelter.
- Sheltering followed by delayed evacuation is preferred unless evacuation can be completed before arrival of fallout.
- Relates only to long term risk of cancer. Not relevant to near-term injuries or fatalities due to fallout, which are of immediate concern (see Predicted Potential Fallout Casualties product).
- These protective actions are based only on dose that can be avoided. Predicted dose is calculated for that which is accumulated over the next four days following 15 Dec 2012 12:00 PST. This is the dose that can be avoided by protective action completed by this time.
- Consequences of dose received earlier are not avoidable.

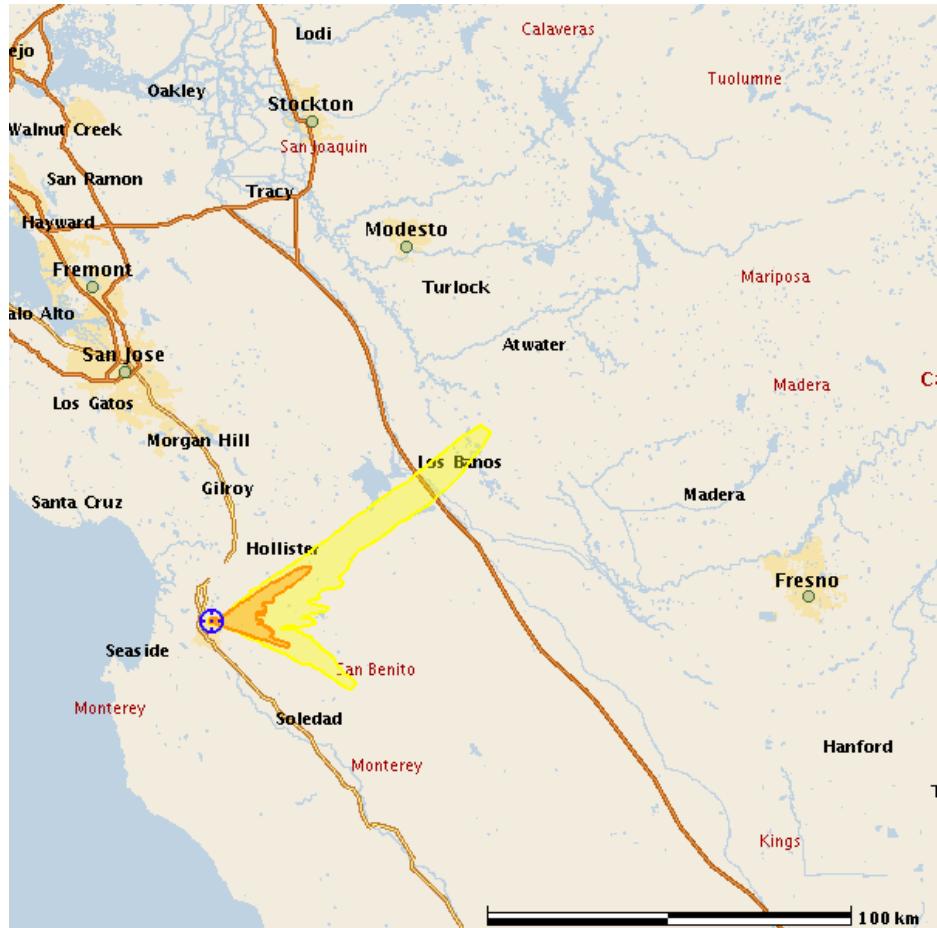
### Assumptions:

- Assumes 10 kt detonation at 0 ft elevation.
- Areas shown are model predictions based on an estimated source term; confirm with measurements.
- Model assumes that no shelter or other protective actions have been taken to decrease exposure.

## Predicted EPA/DHS Shelter/Evacuation Areas at 16 Dec 2012 12:00 PST

Addresses avoidable additional long-term cancer risk, not acute radiation injury or death

Presented in 6 time steps



**Sheltering or evacuation of entire population generally warranted, unless additional unusually hazardous circumstances exist (exceeds 5 rem).**  
**Total Population: 5040 Area: 157 km<sup>2</sup> Extent: 30.9 km**

**Sheltering or evacuation normally initiated (1 to 5 rem).** Total Population: 33100 Area: 1,026 km<sup>2</sup> Extent: 92.1 km

### Notes:

- Best initial action is to seek adequate shelter.
- Sheltering followed by delayed evacuation is preferred unless evacuation can be completed before arrival of fallout.
- Relates only to long term risk of cancer. Not relevant to near-term injuries or fatalities due to fallout, which are of immediate concern (see Predicted Potential Fallout Casualties product).
- These protective actions are based only on dose that can be avoided. Predicted dose is calculated for that which is accumulated over the next four days following 16 Dec 2012 12:00 PST. This is the dose that can be avoided by protective action completed by this time.
- Consequences of dose received earlier are not avoidable.

### Assumptions:

- Assumes 10 kt detonation at 0 ft elevation.
- Areas shown are model predictions based on an estimated source term; confirm with measurements.
- Model assumes that no shelter or other protective actions have been taken to decrease exposure.



APPROVED PRODUCT

## Example for Demonstration Only

Automated Report: Testing  
(36.7158,-121.623)

Nuclear Detonation at 12 Dec 2012 12:00 PST

# Predicted EPA/DHS Shelter/Evacuation Areas

Addresses avoidable additional long-term cancer risk, not acute radiation injury or death

### Key Points

- The best initial action following a nuclear explosion is to seek shelter.
- Sheltering with adequate shielding from radiation, possibly with a delayed evacuation, is the preferred action unless evacuation can be completed before fallout arrival.
- Sheltering alone may be adequate for those in the outermost portion of the yellow zone.
- The size of the Sheltering and Evacuation zones will shrink as radioactive decay causes radiation levels in these areas to decline.
- The cancer risks addressed by these Protective Action Guides (PAGs) are secondary concerns compared to the immediate radiation-induced injuries and deaths.
- The zone of greatest opportunity for life saving and injury reduction (exceeds 100 rad) is indicated on the Potential Fallout Casualties product.
- Cancer risk increases by less than one percent at the outer perimeter of the sheltering/evacuation zones.
- Protective actions are based on dose that can be avoided. Areas shown do not include dose received before the date and time shown on each figure.
- Predicted dose is accumulated for four days after the date/time shown on each figure.
- Predicted dose assumes individuals are unsheltered and unprotected for four full days.

# Predicted EPA/DHS Shelter/Evacuation Areas

## Addresses avoidable additional long-term cancer risk, not acute radiation injury or death

### Presenter Notes - Additional Information

- PAG - Protective Action Guide, defined as the projected dose at which a specific protective action to reduce or avoid that dose is warranted.
- Protective actions are based only on dose that can be avoided, not dose acquired prior to implementation of the protective action.
- Reduce radiation exposure to minimize long-term cancer risk. Evacuation and sheltering reduce radiation exposure.
- Sheltering, possibly followed by a delayed evacuation is strongly preferred, even at long distances downwind, unless shelter is inadequate.
- Preference for sheltering over evacuation is opposite to the norm for nuclear power plant accidents, because a nuclear explosion delivers most of the radiation dose in the first day, while a nuclear power plant accident may have substantial pre-release warning and persist for days.
- Most of dose is received within the first hours of exposure, 98% in first year.

Time After Detonation	Percent of Total Dose	Time After Detonation	Percent of Total Dose
1 hour	55%	4 hours	68%
12 hours	75%	24 hours	80%

- Dose accumulates more slowly as time passes.
- Evacuation and shelter guidance based on EPA/DHS Early Phase Guidelines
  - ♦ "Evacuation (or, for some situations, sheltering) should normally be initiated at 1 rem."
  - ♦ "Sheltering may be the preferred protective action when it will provide protection equal to or greater than evacuation, based on consideration of factors such as source term characteristics, and temporal or other site-specific conditions."
  - ♦ "Because of the higher risk associated with evacuation of some special groups in the population (e.g. those who are not readily mobile), sheltering may be the preferred alternative for such groups as a protective action at projected doses up to 5 rem."
  - ♦ "Under unusually hazardous environmental conditions use of sheltering at projected doses up to 5 rem to the general population (and up to 10 rem to special groups) may become justified."

### Presenter Notes - Technical Background

- Guidance based on EPA and DHS PAGs, as given in:
  - ♦ "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents", (EPA 400-R-92-001, May 1992).
  - ♦ "Planning Guidance for Protection and Recovery Following Radiological Dispersal Device (RDD) and Improvised Nuclear Device (IND) Incidents", (Federal Register, Vol. 73, No. 149, Aug. 1, 2008, pg 45029).
- "The PAG for sheltering or evacuation is expressed in terms of the projected sum of the effective dose equivalent from external radiation and the committed effective dose equivalent incurred from inhalation of radioactive materials from exposure and intake during the early phase." Note that in this case however, committed inhalation dose is not included in the predicted doses.
- Predicted dose is known as Total Effective Dose (TED), which in this case is only due to external irradiation by ground contamination.
- Predicted dose is accumulated over 4 days following date/time shown on each of the figures.
- Predicted dose assumes unsheltered population, but only considers dose that can be avoided by protective actions. Doses received prior to this point in time are not considered.
- Radioactive contamination is expected outside the contoured areas, but not at levels expected to exceed federal guidelines for evacuation and sheltering based on current information.
- The "Total Population" is the total estimated population in the zone adjusted for day/night variations due to commuting based on "Landscan" data.
- Briefing Products are intended for presenting a common operating picture to key leaders and decision makers. Other more technical products are available (Standard Products).
- Contact the FRPCC Subcommittee for Environment, Food and Health (Advisory Team) for advice and recommendations by calling the FDA Emergency Operations Center (EOC) at 866-300-4374.

# Predicted EPA/DHS Relocation Areas

Addresses avoidable additional long-term cancer risk, not acute radiation injury or death



Relocation warranted due to dose expected to be received during the 2nd year (begins 12 Dec 2013 12:00 PST). Exceeds 0.5 rem. Total Population: 5600 Area: 176 km<sup>2</sup> Extent: 34.5 km

Relocation warranted due to dose expected to be received during the 1st year after 13 Dec 2012 12:00 PST. Exceeds 2 rem. Total Population: 145000 Area: 3,339 km<sup>2</sup> Extent: 181 km

#### Notes:

- Relocation addresses only increased cancer risk due to long term exposures.
- Predicted dose assumes unsheltered individual with no protective actions or mitigation.
- First-Year zone decreases in size with time, because dose received in the past and before the relocation is not included. Protective actions are based only on dose that can be avoided.
- Individuals may have received a much higher total dose if present since detonation time.

#### Assumptions:

- Assumes 10 kt detonation at 0 ft elevation.
- Areas shown are model predictions based on an estimated source term; confirm with measurements.
- Model assumes that no shelter or other protective actions have been taken to decrease exposure.



## Predicted EPA/DHS Relocation Areas

Addresses avoidable additional long-term cancer risk, not acute radiation injury or death

### ***Key Points***

- Relocation is not urgent. Protective Action Guidelines (PAGs) are based on long term exposure and cancer risk.
- Areas shown do not include dose received before 13 Dec 2012 12:00 PST.
- Size of First-Year Relocation area decreases as time passes because the dose received before the Relocation is ignored.
- Some groups not previously evacuated may require relocation.
- Re-entry into relocated areas may be permitted with appropriate controls.
- Separate guidelines for:
  - ◆ Dose during first year,
  - ◆ Dose during any subsequent year (second year dose will be the highest and is shown on plot).
- Only ground contamination contributes to dose.
- Dose rate tends to naturally diminish with time as fallout decays.
- Dose reduction measures can be considered in lieu of relocation.

# Predicted EPA/DHS Relocation Areas

Addresses avoidable additional long-term cancer risk, not acute radiation injury or death

## Presenter Notes - Additional Information

- PAG - Protective Action Guide, defined as projected dose at which a specific protective action to reduce or avoid that dose is warranted.
- Relocation PAG applies only to dose that can be avoided.
- Following the sheltering/evacuation (early phase) it may be necessary to temporarily relocate the public from areas until decontamination has taken place.
- Contrary to the situation during sheltering/evacuation, when decisions usually must be made and implemented quickly, many decisions and actions like relocation can be delayed until adequate resources are in place (intermediate phase).
- PAGs should be considered as guidance only. During an incident, due to unanticipated local conditions and constraints, professional judgment will be required. Situations can be envisaged in which relocation of the public, based on the recommended PAGs, would be impracticable. Conversely, under some conditions relocation may be practicable at doses below the PAGs.
- Some groups not previously evacuated may require relocation.
- Informed judgment must be exercised to assure relocation priority for individuals in areas having the highest exposure rates.
- Contamination below PAG levels extends beyond the relocation area. Monitoring and simple dose reduction efforts are recommended in this area to reduce doses to the extent practical.
- Re-entry into relocated areas may be permitted with appropriate controls.

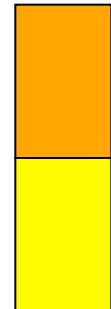
## Presenter Notes - Technical Background

- Guidance based on EPA and DHS PAGs, as given in:
  - ◆ "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents", (EPA 400-R-92-001, May 1992).
  - ◆ "Planning Guidance for Protection and Recovery Following Radiological Dispersal Device (RDD) and Improvised Nuclear Device (IND) Incidents", (Federal Register, Vol. 73, No. 149, Aug. 1, 2008, pg 45029).
- Predicted dose is the projected Total Effective Dose (TED) which in this case includes only external irradiation, accounting for weathering of material and radioactive decay. Only ground contamination contributes to the dose. There is no plume contribution.
- Two separate dose criteria are used: 1) Dose during the first year (2 rem), 2) Dose during the second or any subsequent year (0.5 rem).
- Projected dose assumes individuals are unsheltered and unprotected, and no mitigation or remediation actions are taken.
- Dose reduction factors associated with simple, rapid decontamination techniques are not included in calculating projected dose for decisions on relocation, as prescribed by EPA PAGs.
- Dose reducing actions may reduce the size of the relocation area and the size of the affected population.
- Dose rate naturally diminishes with time due to radioactive decay and weathering of contamination into the soil.
- Radioactive contamination is expected outside the contoured areas, but at levels below the federal guidelines for relocation based on current information.
- The "Total Population" is the total estimated population in the zone adjusted for day/night variations due to commuting based on "Landscan" data.
- Briefing Products are intended for presenting a common operating picture to key leaders and decision makers. Other more technical products are available (Standard Products).
- Contact the FRPCC Subcommittee for Environment, Food and Health (Advisory Team) for advice and recommendations by calling FDA Emergency Operations Center (EOC) at 866-300-4374.

## Predicted Areas of Concern for Agricultural Products

Areas where crops and milk may exceed FDA's default food safety guidelines

Based on fallout deposition predicted for 17 Dec 2012 20:00 UTC (120 hr after detonation)



Produce ready for harvest in this area may exceed FDA's default food safety guidelines [exceeds 10000 pCi/m<sup>2</sup> of I-131]. Area: 1.37E6 km<sup>2</sup> Extent: 2,877 km

Milk from cows pastured in this area may exceed FDA's default food safety guidelines [exceeds 8500 pCi/m<sup>2</sup> of I-131]. Area: 1.42E6 km<sup>2</sup> Extent: 2,883 km

### Notes:

- Based on predicted fallout deposition. Food not yet analyzed.
- Simple precautionary actions warranted to avoid or reduce potential contamination of food/feed.
- Temporary food embargo may be warranted pending food analysis.

### Assumptions:

- Assumes 10 kt detonation at 0 ft elevation.
- Assumes deposition of fallout complete and at maximum geographic extent on 17 Dec 2012 20:00 UTC.
- Areas shown are model predictions based on an estimated source term; confirm with measurements.

Food Ingestion: Testing  
(36.7158,-121.623)

Nuclear Detonation at 12 Dec 2012 20:00 UTC

## Predicted Areas of Concern for Agricultural Products

Areas where crops and milk may exceed FDA's default food safety guidelines

Based on fallout deposition predicted for 17 Dec 2012 20:00 UTC (120 hr after detonation)

### *Key Points*

- FDA guidance applies to concentration of radioactivity in foods as prepared for eating. This product is based on projection of food concentration from expected and/or measured environmental deposition, not measured food concentration.
- Extensive, time consuming sampling and analysis required to properly assess food contamination.
- FDA recommends simple precautions to avoid/reduce contamination of food/feed, including use of temporary food embargoes to prevent introduction of contaminated food into commerce.
  - ◆ Simple precautions include covering exposed products, moving animals to shelter, corralling livestock and providing protected feed and water.
  - ◆ Temporary embargo permits adequate monitoring and sampling to be performed as the basis of future protective actions.
- Food products not yet ready for harvest should be analyzed at a later time.
- Pre-packaged food and beverages are generally not affected.
- Drinking water is controlled by separate EPA guidelines.
- FDA DILs are very conservative and generic. New DILs may be developed when more information becomes available.

Briefing Product for Public Officials

Current: 21 Dec 2012 20:22 UTC

Check for updates

Technical Details: CMHT 702-794-1665  
Advice & Recommendations: A-Team 866-300-4374

Food Ingestion: Testing  
(36.7158,-121.623)

Nuclear Detonation at 12 Dec 2012 20:00 UTC

# Predicted Areas of Concern for Agricultural Products

## Areas where crops and milk may exceed FDA's default food safety guidelines

### Based on fallout deposition predicted for 17 Dec 2012 20:00 UTC (120 hr after detonation)

#### **Presenter Notes - Additional Information**

- This is a preliminary assessment based on predicted radioactivity levels in the environment, not concentration of radioactivity in foods. FDA food safety guidance is based on concentration in foods as prepared for consumption.
  - This preliminary assessment pertains only to food products that are ready for immediate consumption, not foods to be harvested at a future date or foods grown underground or indoors.
  - No food sampling has taken place. Confidence and accuracy will be improved once results of food sampling are obtained.
  - "Protective actions can be taken before the release or arrival of contamination if there is advance knowledge that radionuclides may accidentally contaminate the environment."\*
  - "Protective actions which can be taken within the area likely to be affected and prior to confirmation of contamination consist of:
    - ◆ simple precautionary actions to avoid or reduce the potential for contamination of food and animal feeds, and
    - ◆ temporary embargoes to prevent the introduction into commerce of food which is likely to be contaminated."\*
  - "Protective actions which should be implemented when the contamination in food equals or exceeds the DILs consist of:
    - ◆ temporary embargoes to prevent the contaminated food from being introduced into commerce,
    - ◆ normal food production and processing actions that reduce the amount of contamination in or on food to below the DILs."\*
  - "Normal food production and processing procedures that could reduce the amount of radioactive contamination in or on the food could be simple, (such as holding to allow for radioactive decay, or removal of surface contamination by brushing, washing, or peeling)...".\*
  - Food products that are not yet ready for harvest should be analyzed at a later time before consumption to determine if they are suitable for consumption.
  - Pre-packaged food and beverages in these areas are generally not affected.
  - This map is valid for only this growing season.
- \*\*"Guidance on Accidental Radioactive Contamination of Human Food and Animal Feeds: Recommendations for State and Local Agencies", (Federal Register, Vol. 71, No. 1, Jan. 3, 2006, pg 174).

**Briefing Product for Public Officials****Current: 21 Dec 2012 20:22 UTC****Check for updates**

Example for Demonstration Only

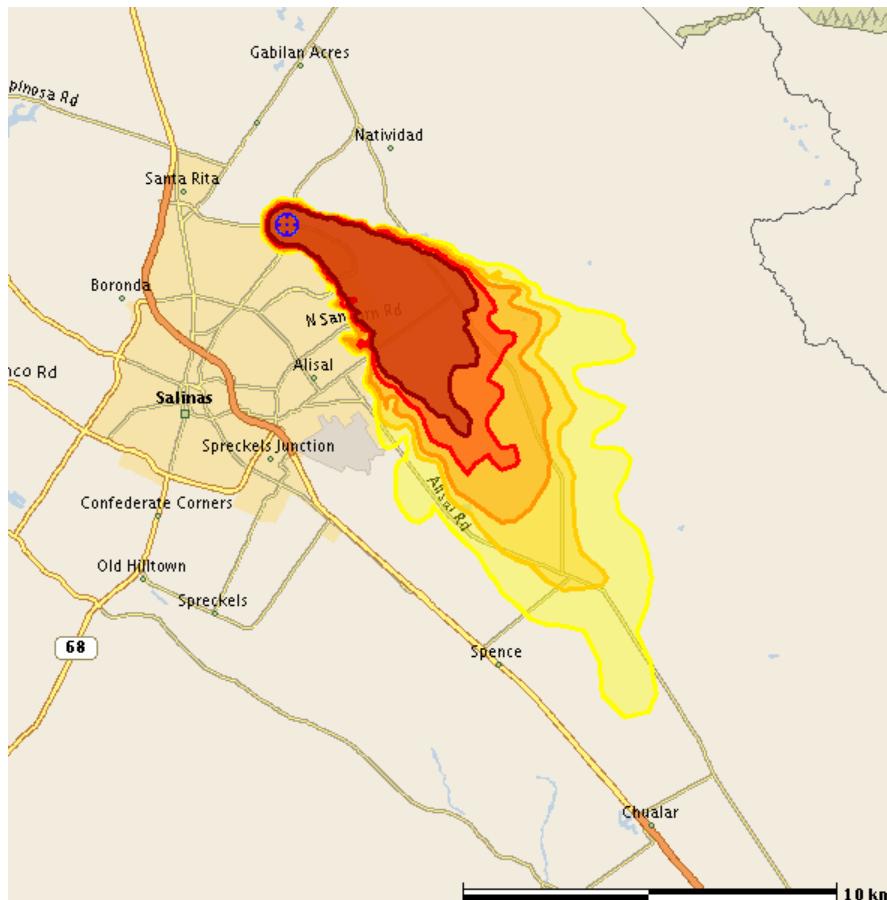
**Technical Details: CMHT 702-794-1665**  
**Advice & Recommendations: A-Team 866-300-4374**
**page 3 of 3**

# **EXAMPLE COMPARISON OF A NUCLEAR DETONATION TECHNICAL AND BRIEFING PRODUCTS**

## Example for Demonstration Only

### Early Fallout Casualties (1-Day Groundshine Dose)

### Sample Nuc Det (LODI) Automated Report - Testing



**Map Size:** 24.1 km by 24.1 km **Id:** Production3.rcE16742.rcC1  
**NARAC Operations:** ( NARAC Staff ); narac@llnl.gov; 925-424-6465

**Requested by:** {}  
**Approved by:** {NARAC Operations; NARAC}

#### Acute (Short-Term) Effects

	Description	(rad) Extent Area	Population Fatalities Casualties
█	Fatalities in over 90% of Population.	>450 7.4km 14.0 km2	6,050 5,980 6,050
█	Fatalities in over 50% of Population.	>300 8.8km 20.0 km2	7,230 6,850 7,230
█	Fatalities in over 10% of Population.	>200 10.0km 29.7 km2	8,990 7,320 8,860
█	Non-Fatal Injuries/Effects in over 50% of Surviving Population.	>150 12.8km 38.9 km2	9,970 7,360 9,520
█	Non-Fatal Injuries/Effects in over 10% of Surviving Population.	>100 16.2km 61.9 km2	12,000 7,370 10,100

Areas and counts in the table are cumulative. Casualties include both Fatal and Non-Fatal effects. Population Source = LandScan2010.

Effects or contamination from November 02, 2013 17:00 UTC to November 03, 2013 17:00 UTC

**Release Location:** 36.715775 N, 121.623420 W

**Material:** Nuclear Detonation Radioactive Debris

**Generated On:** November 13, 2013 22:51 UTC

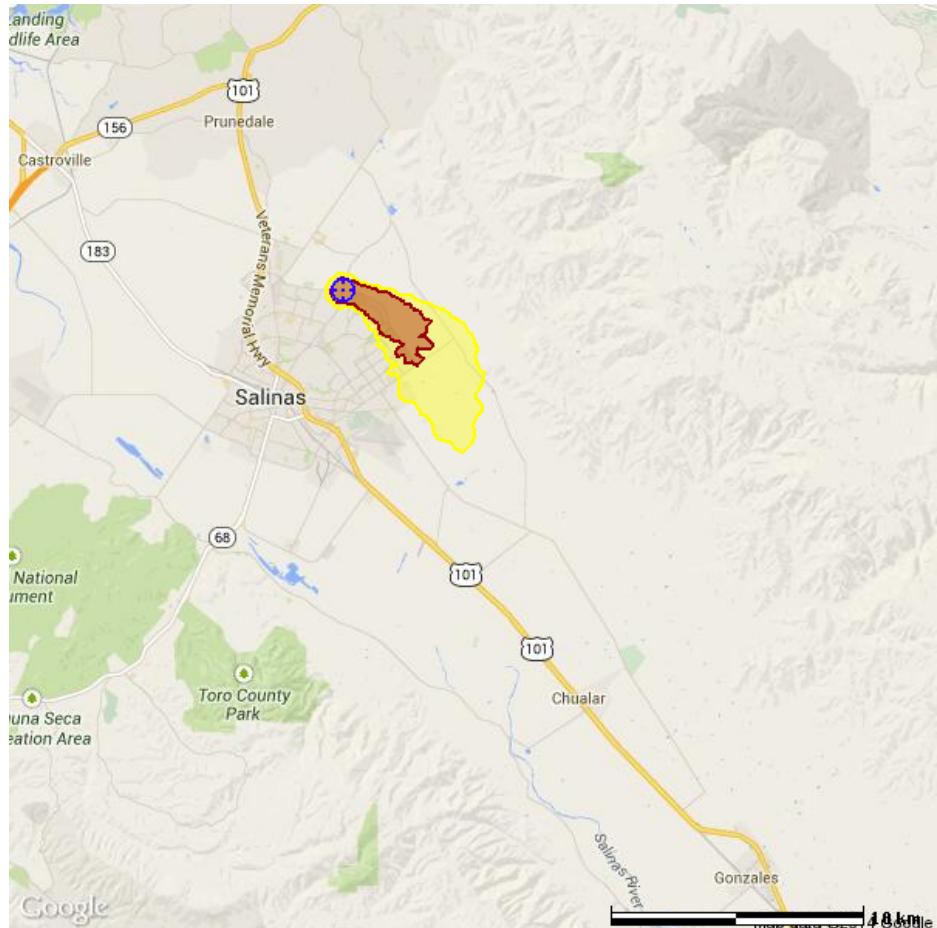
**Model:** ADAPT/LODI

**Comments:** Population counts have been reduced by Prompt Effect Fatalities

Hypothetical release starting at 11/02/2013 17:00:00 UTC for unknown  
canned met at 11/02/2013 17:00:00 UTC

# Predicted Area for Potential Fallout Casualties at 02 Nov 2013 18:00 UTC

Total external dose from radioactive fallout during first 1 hr of exposure  
leading to near-term (days to weeks) illness or death



**Red:** Fallout lethal to most without adequate shelter (exceeds 450 rad). Best action is early shelter followed by informed evacuation to control exposure. Total Exposed Population: 2610 Area: 5.4 km<sup>2</sup> Extent: 4.2 km

**Yellow:** Dangerous fallout levels can cause death, injury or illness (exceeds 100 rad). Zone of greatest opportunity for life saving and injury reduction. Dose management for first responders essential. Total Exposed Population: 8250 Area: 19.1 km<sup>2</sup> Extent: 7.9 km

#### Notes:

- The best initial action is to seek adequate shelter immediately.
- Sheltering with delayed evacuation is preferred, unless evacuation can be completed before fallout arrival.
- Highest radiation hazard during first hours, then rapidly declines.
- Expect few deaths or serious injuries due to radiation outside the maximum extent of these regions.
- Area size will increase rapidly the first few days, then vary slowly, as they show total dose accumulated since detonation.

#### Assumptions:

- Assumes 10 kt detonation at 0 ft elevation.
- Areas shown are model predictions based on an estimated source term; confirm with measurements.
- Model assumes that no shelter or other protective actions have been taken to decrease exposure.

## Predicted Area for Potential Fallout Casualties

Total external dose from radioactive fallout  
leading to near-term (days to weeks) illness or death

### **Key Points**

- Prompt communication of protective action orders to the public is critical.
- Generally, the best initial action is sheltering in the nearest safe building and await instructions. Evacuate after a period for decay to reduce fallout radiation levels.
- Health effects may be greatly reduced for those in the areas shown if sheltered in large multi-story structures or underground areas (basements, parking garages, tunnels, etc.)
- Single-story wood frame houses without basements provide only minimal shelter.
- Decisions to evacuate must be based on event-specific factors such as fallout pattern, radiation intensity, availability of adequate shelter, impending hazards (e.g. fire), etc.
- Early evacuation should be considered for individuals who are threatened by fire or building collapse and for those that lack adequate shelter in the fallout area within 10 miles of the detonation.
- Potential evacuation routes should be established only after the fallout pattern and intensity are well-estimated, and should not obstruct ongoing life-saving missions.
- If possible, when evacuating travel at right angles to the estimated fallout plume and away from the plume centerline.
- Long-term induced cancer rates will be increased in areas beyond those shown here (refer to Predicted EPA/DHS Sheltering/Evacuation Areas product).

# Predicted Area for Potential Fallout Casualties

## Total external dose from radioactive fallout leading to near-term (days to weeks) illness or death

### **Presenter Notes - Additional Information**

- This product estimates radiation effects of the total dose delivered by fallout since detonation for three time periods.
- The two principal actions to protect the public from fallout are: 1) taking shelter and 2) evacuation. No single action will be adequate for all locations and times.
- Generally, the preferred action is to take immediate shelter in the most robust, readily available shelter, then await instructions for an orderly evacuation along the safest routes.
- Duration of shelter primarily depends on adequacy of shelter. Short shelter times (hours) are indicated for those with poor shelter. A day or more may be indicated for those with good shelter and supplies.
- Generally, initial recommendations should be issued as soon as possible after the incident, which will be likely based on little or no incident data.
- Follow-up recommendations should be issued once additional data become available, and may include continued shelter and/or evacuation instructions.
- Adequate shelter significantly reduces radiation dose to occupants during an extended period (e.g. safe underground structures such as basements, parking garages, etc.). Shelter must be structurally stable and otherwise safe to occupy.
- Consider supporting those who are able to spontaneously self-evacuate, by providing information on when to leave and where to go.
- Most of dose is received within the first hours of exposure, 98% in first year.

Time After Detonation	Percent of Total Dose	Time After Detonation	Percent of Total Dose
1 hour	55%	4 hours	68%
12 hours	75%	24 hours	80%

- The highest hazard from fallout occurs within the first few hours and will continue to drop relatively quickly as the radioactive fission products decay.
- Visible fallout (dust and fine particles) is strong evidence for dangerous fallout radiation levels. Fallout may not be visible on rough or dirty surfaces. Lack of visible fallout does not indicate the absence of fallout. Appropriate radiation measurements are required.
- Decontamination of persons is generally not a lifesaving issue. Changing from contaminated to uncontaminated clothes and washing exposed skin is preferred. Simply brushing off outer garments is useful until more thorough decontamination can be accomplished.

Briefing Product for Public Officials

Produced: 13 Nov 2013 22:50 UTC

Check for updates

Example for Demonstration Only

### **Presenter Notes - Technical Background**

- Guidance based on:
  - ♦ "Planning Guidance for Response to a Nuclear Detonation", Second Edition, June, 2010. Developed by the Homeland Security Council Interagency Policy Coordination Subcommittee for Preparedness & Response to Radiological and Nuclear Threats.
  - ♦ "Key Elements of Preparing Emergency Responders for Nuclear and Radiological Terrorism, Commentary No. 19", 2005, National Council on Radiation Protection and Measurements.
  - ♦ "Key Response Planning Factors for the aftermath of Nuclear Terrorism", LLNL-TR-410067, 2009, Lawrence Livermore National Laboratory.
  - ♦ "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents", (EPA 400-R-92-001, May 1992).
- This total dose is estimated by integrating the external exposure over the exposure time (assuming 0.7 rad mid-line body dose per 1 Roentgen exposure). It does not include additional doses due to inhalation, ingestion or skin contamination, which are minor contributors.
- Inner Contour (450 rad) - Expect fatalities exceeding 90% for those lacking shelter inside this zone. Some of these fatalities will be delayed by days or weeks.
- Outer Contour (100 rad) - Expect fatality and radiation injury rate to rapidly decline further out in this zone. Few, if any, fatalities are expected outside this zone. Less than 10% suffer radiation injury at the outer boundary.
- The "Total Exposed Population" is the total estimated population in the zone adjusted for day/night variations due to commuting based on "Landscan" data.
- Briefing Products are intended for presenting a common operating picture to key leaders and decision makers. Other more technical products are available (Standard Products).
- Contact the FRPCC Subcommittee for Environment, Food and Health (Advisory Team) for advice and recommendations by calling FDA Emergency Operations Center (EOC) at 866-300-4374.

Technical Details: CMHT 702-794-1665

Advice & Recommendations: A-Team 866-300-4374

page 5 of 5

# **NARAC/IMAAC Briefing Products for a Radiological Material Dispersal**

*Updated Version (December 2014)*

Kristen Yu (LLNL), Kevin Foster (LLNL),  
and Harvey Clark (RSL)



LLNL-PRES-609133 (IND +CB)

LLNL-PRES-659598 (NPP)

LLNL-PRES- 665558 (RDD)

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344. The Department of Homeland Security sponsored part of the production of this material.



# Radiological Dispersal Device (RDD) Briefing Product Set

RDD Briefing Product Set contains six products for three phases of an incident:

## Early Phase:

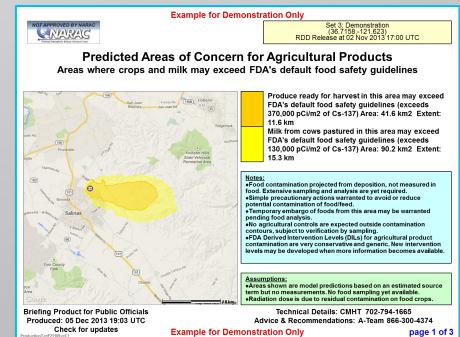
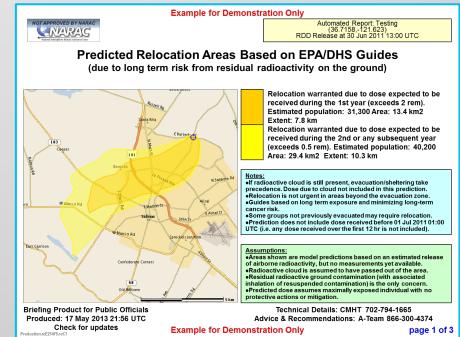
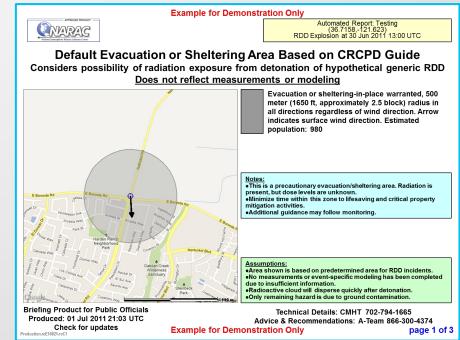
1. Default Evacuation or Sheltering Area Based on CRCPD Guide
2. Evacuation/Sheltering Areas Based on EPA/DHS Guides (cloud present/passed)
3. Worker Protection Areas
4. Potassium Iodide Administration Areas (for releases involving radioactive iodine)

## Intermediate Phase:

5. Relocation areas based on EPA/DHS Guide

## Late Phase:

6. Areas of Concern for Agricultural Products

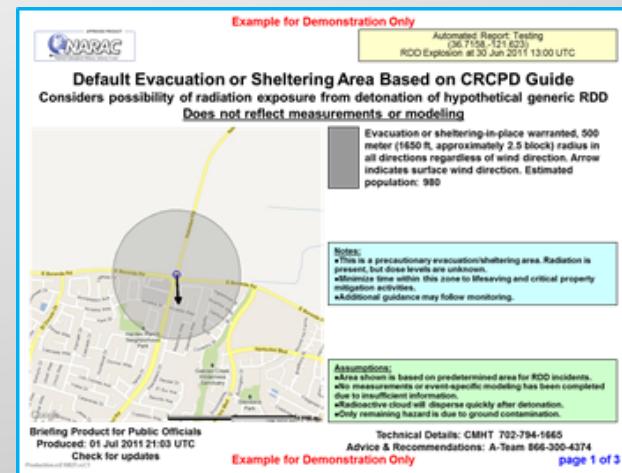


RDD Briefing Product sponsorship: DOE funded format/content design of briefing products (in collaboration with RSL) and implementation in FY08-FY09. DHS-hosted review by IMAAC Interagency Working Group and representatives of the National Emergency Management Association (NEMA).

# EARLY PHASE

# Default Evacuation or Sheltering Area Based on CRCPD Guide

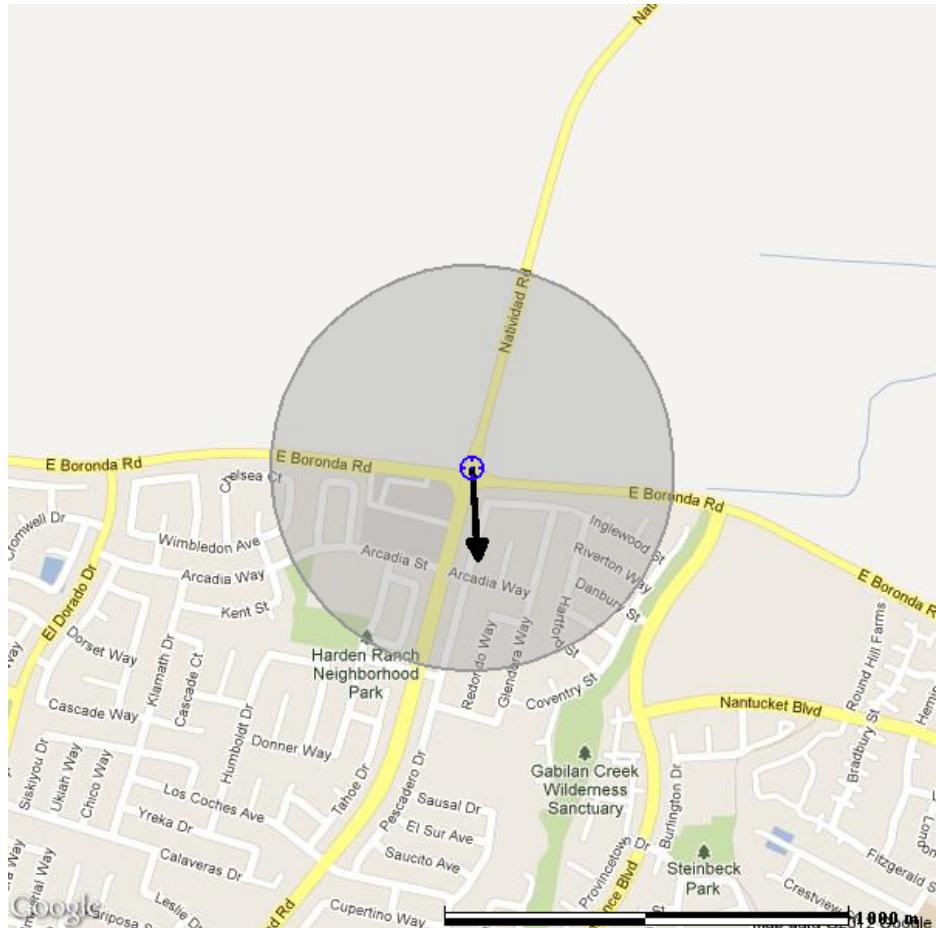
- This is a precautionary evacuation/sheltering area (radiation is present, but dose levels are unknown)
- Default Evacuation or Sheltering Area based on “Handbook for Responding to a Radiological Dispersal Device”, CRCPD Pub. 06-6
- Does not reflect measurements or modeling
- Single arrow at the center indicates surface wind direction (as part of the technical product set, NARAC produces relative air and ground contamination plots that more completely illustrates the meteorological situation)



# Default Evacuation or Sheltering Area Based on CRCPD Guide

Considers possibility of radiation exposure from detonation of hypothetical generic RDD

Does not reflect measurements or modeling



Evacuation or sheltering-in-place warranted, 500 meter (1650 ft, approximately 2.5 block) radius in all directions regardless of wind direction. Arrow indicates surface wind direction. Estimated population: 980

**Notes:**

- This is a precautionary evacuation/sheltering area. Radiation is present, but dose levels are unknown.
- Minimize time within this zone to lifesaving and critical property mitigation activities.
- Additional guidance may follow monitoring.

**Assumptions:**

- Area shown is based on predetermined area for RDD incidents.
- No measurements or event-specific modeling has been completed due to insufficient information.
- Radioactive cloud will disperse quickly after detonation.
- Only remaining hazard is due to ground contamination.



## Default Evacuation or Sheltering Area Based on CRCPD Guide

Considers possibility of radiation exposure from detonation of hypothetical generic RDD  
Does not reflect measurements or modeling

### Key Points

- Treat life-threatening injuries immediately, victim's contamination is secondary.
- Rescue all injured persons, move upwind of the immediate blast area.
- Evacuation/sheltering warranted to minimize potential acute effects and long-term cancer risk.
- Default protocol recommended by CRCPD is as follows:
  - Evacuate all non-essential personnel within a 500 m (1650 ft) radius.
  - Monitor evacuees for contamination and collect information to evaluate exposure.
  - Stage response assets upwind, if possible. Place assets where radiation levels are less than 2 mR/h or less than 1,000 cpm as measured by "pancake probe".
  - Set-up access control perimeter based on measurements.
- Sheltering-in-place may be preferable to evacuation in some situations
  - Certain populations may need special consideration (hospitals, nursing homes...),
  - Severe weather, competing disasters, impediments to evacuation.
- Radiological monitoring urgently needed to determine magnitude and extent of ground contamination.
- Extreme caution necessary where radiation exceeds 10,000 mR/h.
- Consult "Smoke Plot" in Standard Product set for more detail.



# Default Evacuation or Sheltering Area Based on CRCPD Guide

## Considers possibility of radiation exposure from detonation of hypothetical generic RDD

### Does not reflect measurements or modeling

#### **Presenter Notes - Additional Information**

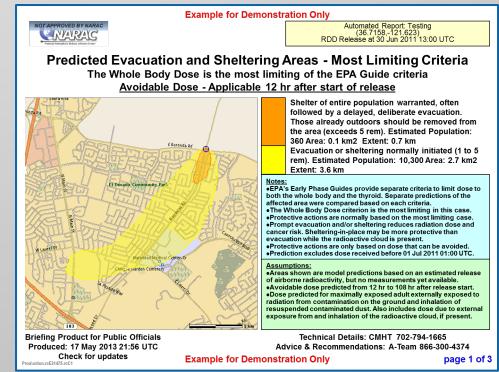
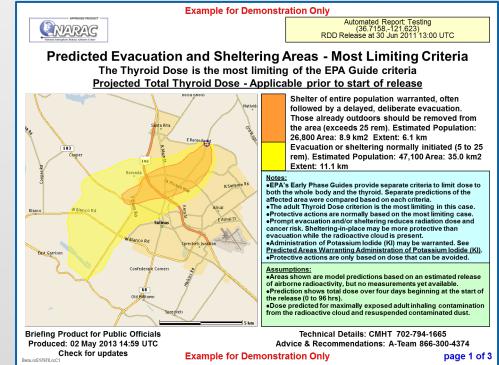
- Contamination of victims is a secondary concern compared to medical care for life threatening injuries. Transport and care should not be delayed to decontaminate those severely injured.
- Area shown is based on a default radius for a generic RDD, determined through experiments and modeling. Area does not reflect measurements or event-specific modeling, because information about the RDD is insufficient.
- Arrow shows direction surface winds will carry contamination. Some contamination may be carried by winds in other directions that are well above the surface.
- The radioactive cloud disperses quickly, leaving only ground contamination as the primary radiological hazard.
- In the absence of device-specific or measurement information, default protocol recommended by the Conference of Radiation Control Program Directors (CRCPD) is as follows:
  - ◆ Rescue all injured persons, moving personnel, as feasible, upwind of the immediate blast area (or away from movement of the dust and debris cloud, if visible).
  - ◆ Evacuate all other non-essential personnel within a 500 m (1650 ft or about 2.5 city blocks) radius.
  - ◆ Monitor evacuees for contamination and collect information needed to evaluate exposure.
  - ◆ Stage response assets upwind, if possible. Place assets where radiation levels are less than 2 mR/h or less than 1,000 cpm as measured by "pancake probe".
- Sheltering-in-place may be preferable to evacuation in some situations
  - ◆ Certain populations may need special consideration (hospitals, nursing homes, prisoners, etc.)
  - ◆ Severe weather, competing disasters, impediments to evacuation
- Updated calculations will be performed whenever, and as soon as, additional information becomes available.
- Conduct radiation monitoring to determine magnitude and extent of ground contamination.
- Exercise extreme caution where radiation exceeds 10,000 mR/h.

#### **Presenter Notes - Technical Background**

- Guidance based on a technical analysis of the consequences of hypothetical RDDs, as given in:
  - ◆ "Handbook for Responding to a Radiological Dispersal Device", CRCPD Pub. 06-6, [www.crcpd.org/RDD.htm](http://www.crcpd.org/RDD.htm)
  - ◆ "Realistic radiological dispersal device hazard boundaries and ramifications for early consequence management decisions", Harper, Musolini, Wente. *Health Phys.* July 2007
- The precautionary evacuation or sheltering area is based on potential exposure to ionizing radiation and seeks to minimize possible acute health effects and long term cancer risks.
- Predetermined area is defined as the area of highest concern for the more probable scenarios, and is the area in which acute effects, a lifetime inhalation dose of 100 rem, or a 5 rem groundshine (5-hour exposure) dose might occur.
- Knowledge of the type and quantity of radiological material is required to model radiological dispersal and potential impact to the environment. Therefore, measurements are required.
- Once the source term has been better defined, expect updated guidance regarding evacuation, sheltering, relocation and agricultural intervention.
- Contact the FRPCC Subcommittee for Environment, Food and Health (Advisory Team) for advice and recommendations. Available by calling FDA Emergency Operations Center (EOC) at 866-300-4374.
- Consult "Smoke Plot" in Standard Product set for qualitative visualization of plume footprint.

# Predicted Evacuation and Sheltering Areas Based on EPA/DHS Guides

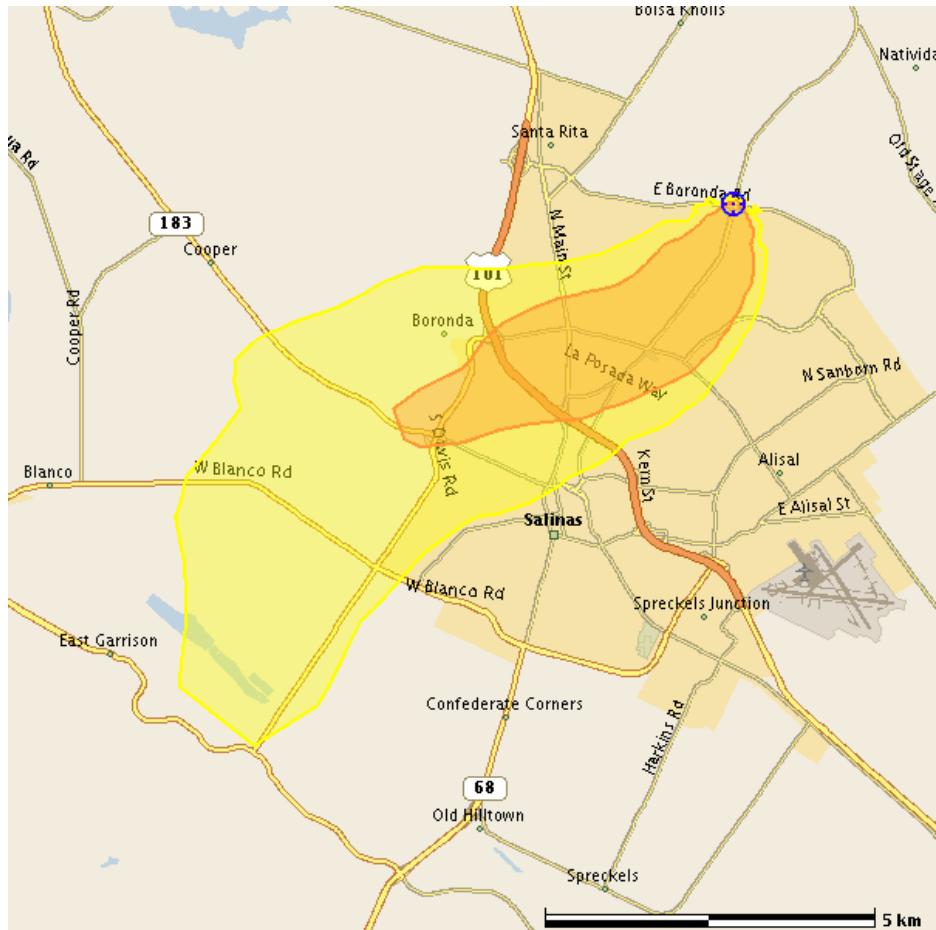
- This product may be used to refine initial default Evacuation and Sheltering decisions
- Contours area displayed are the EPA or DHS PAGs (Protective Action Guidelines)
- Contours depict areas of dose that may be avoided by evacuation and/or sheltering
- Plume footprint may change with each update, indicating an updated prediction of avoidable dose
- Product indicates whether the radioactive cloud is still present or has passed
  - May include all plume passage 4-day dose (0-96 hours) or only avoidable dose (default avoidable dose period is 12-108 hours)
  - Only dose from ground contamination is considered if the plume has passed
  - May reflect measurements (if indicated in the green box)



# Predicted Evacuation and Sheltering Areas - Most Limiting Criteria

The Thyroid Dose is the most limiting of the EPA Guide criteria

Projected Total Thyroid Dose - Applicable prior to start of release



**Orange Area:** Shelter of entire population warranted, often followed by a delayed, deliberate evacuation. Those already outdoors should be removed from the area (exceeds 25 rem). Estimated Population: 26,800 Area: 8.9 km<sup>2</sup> Extent: 6.1 km

**Yellow Area:** Evacuation or sheltering normally initiated (5 to 25 rem). Estimated Population: 47,100 Area: 35.0 km<sup>2</sup> Extent: 11.1 km

#### Notes:

- EPA's Early Phase Guides provide separate criteria to limit dose to both the whole body and the thyroid. Separate predictions of the affected area were compared based on each criteria.
- The adult Thyroid Dose criterion is the most limiting in this case.
- Protective actions are normally based on the most limiting case.
- Prompt evacuation and/or sheltering reduces radiation dose and cancer risk. Sheltering-in-place may be more protective than evacuation while the radioactive cloud is present.
- Administration of Potassium Iodide (KI) may be warranted. See [Predicted Areas Warranting Administration of Potassium Iodide \(KI\)](#).
- Protective actions are only based on dose that can be avoided.

#### Assumptions:

- Areas shown are model predictions based on an estimated release of airborne radioactivity, but no measurements yet available.
- Prediction shows total dose over four days beginning at the start of the release (0 to 96 hrs).
- Dose predicted for maximally exposed adult inhaling contamination from the radioactive cloud and resuspended contaminated dust.

## Predicted Evacuation and Sheltering Areas - Most Limiting Criteria

The Thyroid Dose is the most limiting of the EPA Guide criteria

Projected Total Thyroid Dose - Applicable prior to start of release

### *Key Points*

- Both the Whole Body Dose and Thyroid Dose predictions were considered.
- The Thyroid Dose was found to affect the greatest area and is therefore the most limiting case. Normally, decisions are based on the most limiting case.
- When large amounts of radioiodine are present, then the dose of radiation to the thyroid may be most limiting due to inhalation of that radioiodine.
- Sheltering-in-place may be preferable to evacuation in some cases, such as for limited mobility populations or if unusually hazardous environmental conditions exist.
- EPA estimates sheltering may reduce dose due to infiltration by a factor of 1.3 to 539.
- Greatest hazard is due to exposure to the radioactive cloud. Sheltering followed by delayed evacuation after cloud passage may be preferable. Evacuation before radioactive cloud arrival is best, but avoid evacuation in the radioactive cloud.
- Predicted dose is accumulated from the start of the release for a period of 96 hours (4 days), specifically 30 Jun 2011 13:00 UTC to 04 Jul 2011 13:00 UTC.
- Refer to the separate Briefing Product Predicted Areas Warranting Administration of Potassium Iodide (KI), because administration of KI can reduce thyroid dose.

# Predicted Evacuation and Sheltering Areas - Most Limiting Criteria

## The Thyroid Dose is the most limiting of the EPA Guide criteria

### Projected Total Thyroid Dose - Applicable prior to start of release

#### **Presenter Notes - Additional Information**

- PAG - Protective Action Guide is a projected dose at which a specific protective action to reduce or avoid that dose is warranted.
- The EPA Early Phase PAG has a primary guideline for the dose to the whole body and a supplementary guideline for dose to the thyroid and skin.
- Protective actions are based only on dose that can be avoided, not dose acquired prior to implementation of the protective action.
- Reduce radiation dose to minimize long-term cancer risk.
- Evacuation and/or sheltering-in-place is an effective protective action to avoid or reduce both dose to the whole body and dose to the thyroid.
- Sheltering may be the preferred protective action when it will provide protection equal to or greater than evacuation.
- No specific minimum level is established for initiation of sheltering.
- Completion of evacuation before plume arrival is best. Evacuation in radioactive cloud may result in more dose than sheltering until cloud passage. Evacuees in cloud should cover mouth & nose with available filter materials (handkerchief).
- Sheltering followed by delayed evacuation may be best if radioactive decay is very rapid (e.g. dominated by radioiodine).
- Thyroid Dose criteria (Committed Dose Equivalent) for evacuation and sheltering are obtained by a modification of the Early Phase PAG's Whole Body Dose (i.e., Total Effective Dose) criterion.
  - ◆ Evacuation (or, for some situations, sheltering) should normally be initiated at 5 rem dose to the thyroid.
  - ◆ Because of the higher risk associated with evacuation of some special groups in the population (e.g. those who are not readily mobile), sheltering may be the preferred alternative for such groups as a protective action at projected doses up to 25 rem dose to the thyroid.
  - ◆ Under unusually hazardous environmental conditions use of sheltering at projected doses up to 25 rem dose to the thyroid for the general population (and up to 50 rem dose to the thyroid for special groups) may become justified.
- Thyroid Dose can be reduced by timely administration of stable iodine (KI).
- Protective actions may be initiated over larger areas and at lower contamination/dose levels if advantageous (e.g., in order to account for uncertainties in the predicted dose and mapped areas, and/or to use boundaries, such as roads, that are convenient).

**Briefing Product for Public Officials**

**Produced: 02 May 2013 14:59 UTC**

**Check for updates**

#### **Presenter Notes - Technical Background**

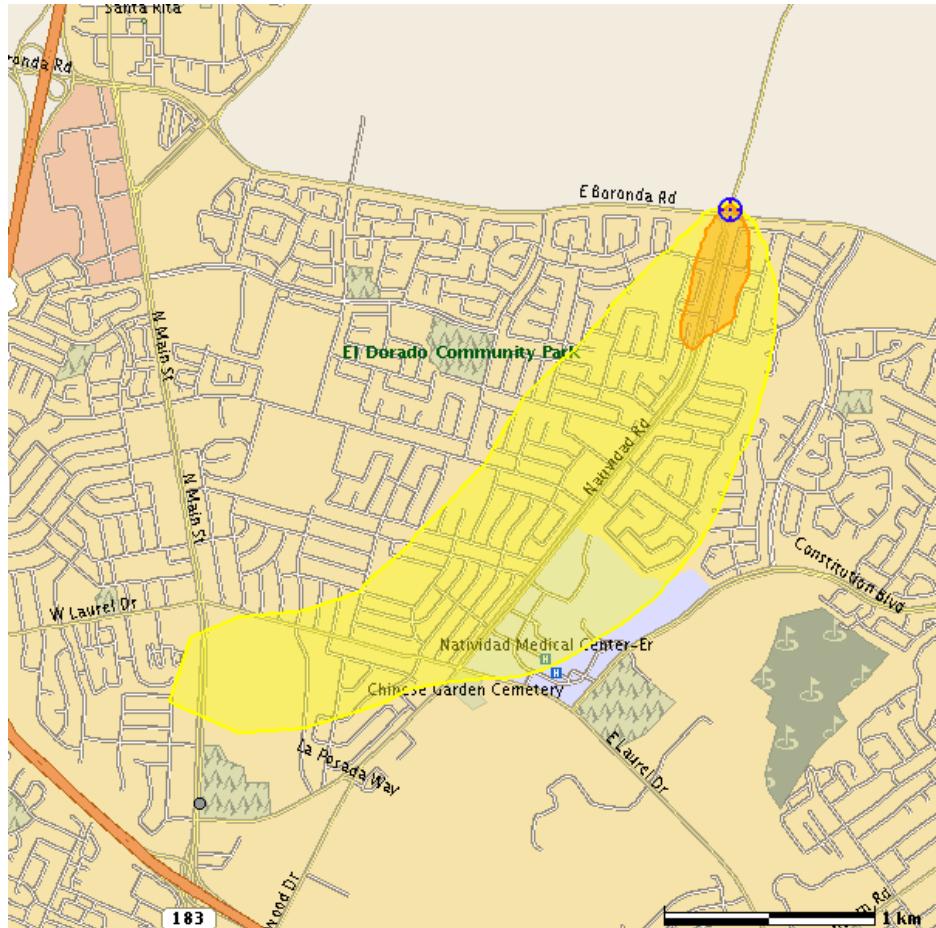
- Guidance based on EPA and DHS PAGs, as given in:
  - ◆ "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents", (EPA 400-R-92-001, May 1992).
  - ◆ "Planning Guidance for Protection and Recovery Following Radiological Dispersal Device (RDD) and Improvised Nuclear Device (IND) Incidents", (Federal Register, Vol. 73, No. 149, Aug. 1, 2008, pg 45029).
  - ◆ Jetter, J. J. and C. Whitfield. "Effectiveness of Expedient Sheltering in Place in a Residence", Journal of Hazardous Materials. Elsevier, Amsterdam, Holland, 119(1-3):31-40, (2005).
- The PAG for evacuation and/or sheltering is expressed in terms of the committed effective dose to the thyroid due to inhalation of radioactive iodine from 1) Inhalation of the contaminated air as the cloud passes and 2) Inhalation of resuspended contaminated dust.
- Hazard is greatest while the radioactive cloud is present, because both pathways above contribute. After the radioactive cloud passes only inhalation of resuspended contaminated dust will continue to contribute significantly.
- Although Table 2-1 "PAGs for the Early Phase of a Nuclear Incident" of the EPA PAG Manual is the whole body dose criteria, footnote "b" guides how the Early Phase PAGs can be expressed in terms of thyroid dose. "Committed dose equivalents to the thyroid and skin may be 5 and 50 times larger, respectively." Therefore, the dose guidelines for thyroid dose are five times (5X) that for the whole body dose.
- Radioactive contamination is expected outside the contoured areas, but not at levels expected to exceed federal guidelines for evacuation and sheltering based on current information.
- Additional technical and background information is provided in the Consequence Report containing the detailed, technical version of this calculation.
- Briefing Products are intended for presenting a common operating picture to key leaders and decision makers. Other more technical products are available (Standard Products and associated Consequence Reports).
- Contact the FRPCC Subcommittee for Environment, Food and Health (Advisory Team) for advice and recommendations. Available by calling the FDA Emergency Operations Center (EOC) at 866-300-4374.

**Technical Details: CMHT 702-794-1665**

**Advice & Recommendations: A-Team 866-300-4374**

# Predicted Evacuation and Sheltering Areas - Most Limiting Criteria

The Whole Body Dose is the most limiting of the EPA Guide criteria  
Avoidable Dose - Applicable 12 hr after start of release



**Orange Area:** Shelter of entire population warranted, often followed by a delayed, deliberate evacuation. Those already outdoors should be removed from the area (exceeds 5 rem). Estimated Population: 360 Area: 0.1 km<sup>2</sup> Extent: 0.7 km

**Yellow Area:** Evacuation or sheltering normally initiated (1 to 5 rem). Estimated Population: 10,300 Area: 2.7 km<sup>2</sup> Extent: 3.6 km

#### Notes:

- EPA's Early Phase Guides provide separate criteria to limit dose to both the whole body and the thyroid. Separate predictions of the affected area were compared based on each criteria.
- The Whole Body Dose criterion is the most limiting in this case.
- Protective actions are normally based on the most limiting case.
- Prompt evacuation and/or sheltering reduces radiation dose and cancer risk. Sheltering-in-place may be more protective than evacuation while the radioactive cloud is present.
- Protective actions are only based on dose that can be avoided.
- Prediction excludes dose received before 01 Jul 2011 01:00 UTC.

#### Assumptions:

- Areas shown are model predictions based on an estimated release of airborne radioactivity, but no measurements yet available.
- Avoidable dose predicted from 12 hr to 108 hr after release start.
- Dose predicted for maximally exposed adult externally exposed to radiation from contamination on the ground and inhalation of resuspended contaminated dust. Also includes dose due to external exposure from and inhalation of the radioactive cloud, if present.

## Predicted Evacuation and Sheltering Areas - Most Limiting Criteria

The Whole Body Dose is the most limiting of the EPA Guide criteria  
Avoidable Dose - Applicable 12 hr after start of release

### **Key Points**

- Both the Whole Body Dose and Thyroid Dose predictions were considered.
- The Whole Body Dose was found to affect the greatest area and is therefore the most limiting case. Normally, decisions are based on the most limiting case.
- Generally, the dose of radiation to the whole body is most limiting, unless large amounts of radioiodine are present.
- Sheltering-in-place may be preferable to evacuation in some cases, such as for limited mobility populations or if unusually hazardous environmental conditions exist.
- As time passes, the protective value of sheltering-in-place may diminish.
- The area still technically warranting evacuation and/or sheltering is smaller following passage of the radioactive cloud, than predicted while the plume was present.
- Predicted dose is accumulated from 12 hr after the start of the release for a period of 96 hours (4 days), specifically 01 Jul 2011 01:00 UTC to 05 Jul 2011 01:00 UTC.

# Predicted Evacuation and Sheltering Areas - Most Limiting Criteria

## The Whole Body Dose is the most limiting of the EPA Guide criteria

### Avoidable Dose - Applicable 12 hr after start of release

#### **Presenter Notes - Additional Information**

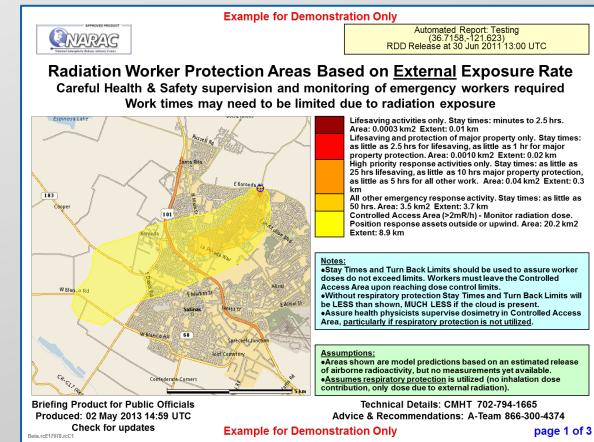
- PAG - Protective Action Guide is a projected dose at which a specific protective action to reduce or avoid that dose is warranted.
- The EPA Early Phase PAG has a primary guideline for the dose to the whole body and a supplementary guideline for dose to the thyroid and skin.
- Protective actions are based only on dose that can be avoided, not dose acquired prior to implementation of the protective action.
- Reduce radiation dose to minimize long-term cancer risk.
- Evacuation and/or sheltering-in-place is an effective protective action to avoid or reduce both dose to the whole body and dose to the thyroid.
- Sheltering may be the preferred protective action when it will provide protection equal to or greater than evacuation.
- No specific minimum level is established for initiation of sheltering.
- Sheltering followed by delayed evacuation may be best if radioactive decay is very rapid (e.g. dominated by radioiodine).
- Whole Body Dose (i.e. Total Effective Dose) criteria for evacuation and sheltering based on EPA Early Phase PAGs:
  - ♦"Evacuation (or, for some situations, sheltering) should normally be initiated at 1 rem."
  - ♦"Because of the higher risk associated with evacuation of some special groups in the population (e.g. those who are not readily mobile), sheltering may be the preferred alternative for such groups as a protective action at projected doses up to 5 rem."
  - ♦"Under unusually hazardous environmental conditions use of sheltering at projected doses up to 5 rem to the general population (and up to 10 rem to special groups) may become justified."
- Protective actions may be initiated over larger areas and at lower contamination/dose levels if advantageous (e.g., in order to account for uncertainties in the predicted dose and mapped areas, and/or to use boundaries, such as roads, that are convenient).

#### **Presenter Notes - Technical Background**

- Guidance based on EPA and DHS Protective Action Guides (PAGs), as given in:
  - ♦"Manual of Protective Action Guides and Protective Actions for Nuclear Incidents", (EPA 400-R-92-001, May 1992).
  - ♦"Planning Guidance for Protection and Recovery Following Radiological Dispersal Device (RDD) and Improvised Nuclear Device (IND) Incidents", (Federal Register, Vol. 73, No. 149, Aug. 1, 2008, pg 45029).
- "The PAG for evacuation (or, as an alternative in certain cases, sheltering) is expressed in terms of the projected sum of the effective dose from external radiation and the committed effective dose incurred from inhalation of radioactive materials from exposure and intake during the early phase." These include: 1) External irradiation by the radioactive cloud, 2) Inhalation of the contaminated air as it passes, 3) External irradiation by ground contamination, 4) Inhalation of contaminated dust, and is the Total Effective Dose (TED).
- Hazard is greatest while the radioactive cloud is present because all four pathways above contribute. After the radioactive cloud passes only 3) Irradiation by ground contamination and 4) Inhalation of resuspended contaminated dust will continue to contribute.
- Radioactive contamination is expected outside the contoured areas, but not at levels expected to exceed federal guidelines for evacuation and sheltering based on current information.
- Additional technical and background information is provided in the Consequence Report containing the detailed, technical version of this calculation.
- Briefing Products are intended for presenting a common operating picture to key leaders and decision makers. Other more technical products are available (Standard Products and associated Consequence Reports).
- Contact the FRPCC Subcommittee for Environment, Food and Health (Advisory Team) for advice and recommendations. Available by calling the FDA Emergency Operations Center (EOC) at 866-300-4374.

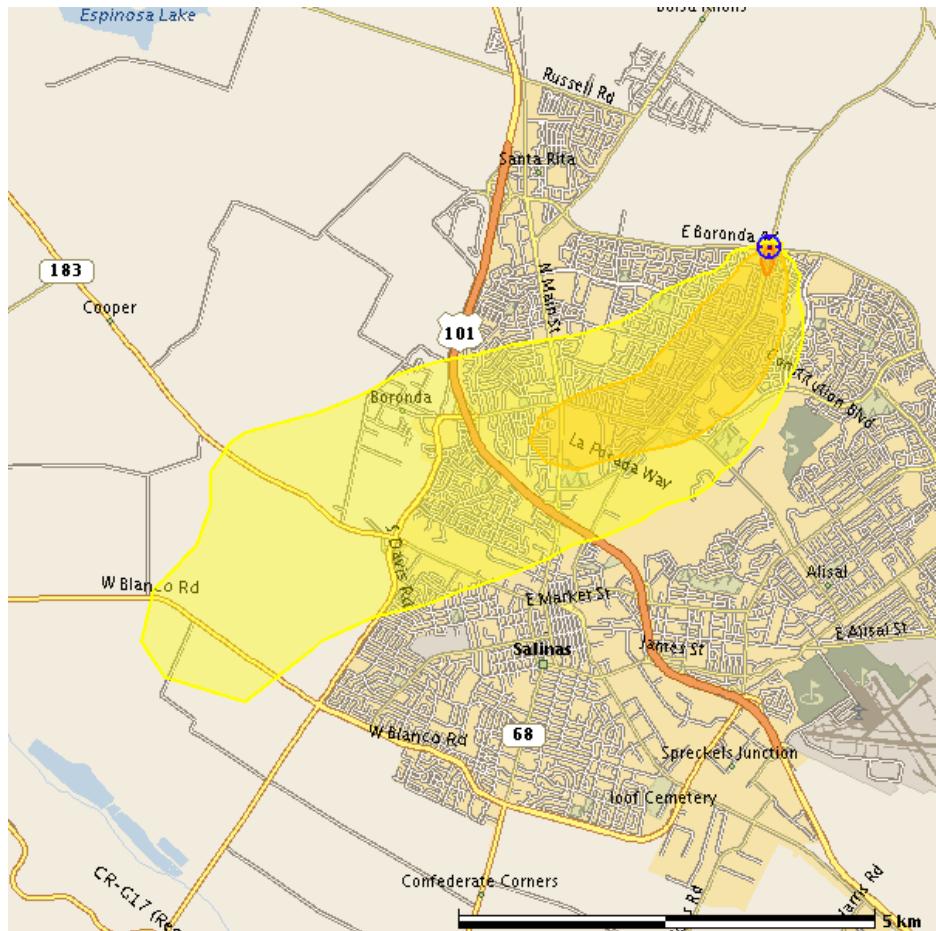
# Worker Protection Areas Determined From Exposure Rates

- This product is used by dose assessment personnel to plan the tasks of Emergency Workers
  - Product displays an exposure rate at a specific time
  - Emergency Worker Stay Times are predicted based on that exposure rate
  - Note: if the radiation involved is decaying rapidly, this product will change significantly over time
- Contours displayed are the EPA or DHS worker guidelines and CRCPD guidance
- Product also may be used to estimate the ongoing dose received by the unsheltered general population
- May reflect measurements (indicated in the green box)



# Radiation Worker Protection Areas Based on External Exposure Rate

Careful Health & Safety supervision and monitoring of emergency workers required  
 Work times may need to be limited due to radiation exposure



	Lifesaving activities only. Stay times: minutes to 2.5 hrs. Area: 0.0003 km <sup>2</sup> Extent: 0.01 km
	Lifesaving and protection of major property only. Stay times: as little as 2.5 hrs for lifesaving, as little as 1 hr for major property protection. Area: 0.0010 km <sup>2</sup> Extent: 0.02 km
	High priority response activities only. Stay times: as little as 25 hrs lifesaving, as little as 10 hrs major property protection, as little as 5 hrs for all other work. Area: 0.04 km <sup>2</sup> Extent: 0.3 km
	All other emergency response activity. Stay times: as little as 50 hrs. Area: 3.5 km <sup>2</sup> Extent: 3.7 km
	Controlled Access Area (>2mR/h) - Monitor radiation dose. Position response assets outside or upwind. Area: 20.2 km <sup>2</sup> Extent: 8.9 km

**Notes:**

- Stay Times and Turn Back Limits should be used to assure worker doses do not exceed limits. Workers must leave the Controlled Access Area upon reaching dose control limits.
- Without respiratory protection Stay Times and Turn Back Limits will be LESS than shown, MUCH LESS if the cloud is present.
- Assure health physicists supervise dosimetry in Controlled Access Area, particularly if respiratory protection is not utilized.

**Assumptions:**

- Areas shown are model predictions based on an estimated release of airborne radioactivity, but no measurements yet available.
- Assumes respiratory protection is utilized (no inhalation dose contribution, only dose due to external radiation).



# Radiation Worker Protection Areas Based on External Exposure Rate

Careful Health & Safety supervision and monitoring of emergency workers required

Work times may need to be limited due to radiation exposure

## *Key Points*

- This map product is valid at 01 Jul 2011 01:00 UTC .
- Map portrays only dose rate due to external exposure.
- Dose from inhalation of contaminated dust or from the radioactive cloud is not included.
- This product assumes respiratory protection is utilized until shown as unnecessary.
- If respiratory protection is NOT used, then indicated exposures must be multiplied by potentially large correction factors (as much as a few hundred), particularly if a cloud of radioactive iodine is present. The CMHT cited below can provide this correction factor.
- Stay Times and Turn Back Limits will be reduced by the same correction factor.
- Exposures exceeding routine occupational limits require informed consent.
- For purposes of limiting worker radiation dose, exposures are cumulative day-by-day.
- Strive to keep exposures As-Low-As-Reasonably-Achievable (ALARA).
  - Plan work to minimize exposure time
  - Avoid lingering in areas with elevated radiation levels
  - Take advantage of available shielding (trucks, walls...)
  - Position assets outside of radiation area, if possible.
- Avoid, or minimize, eating or drinking in radiation areas to extent practical.
- Engage assistance of health physics professionals for shift specific guidance ASAP.

Automated Report: Testing  
(36.7158,-121.623)

RDD Release at 30 Jun 2011 13:00 UTC

# Radiation Worker Protection Areas Based on External Exposure Rate

## Careful Health & Safety supervision and monitoring of emergency workers required

### Work times may need to be limited due to radiation exposure

#### Presenter Notes - Additional Information

- This is a map of external exposure rate due to radioactive contamination on the ground.
- Only the external exposure rate is considered. Inhalation of radioactive material can be another large source of dose. However, respiratory protection will prevent the dose due to inhalation.
- If radioiodine is present in the radioactive cloud, then the use of Potassium Iodide (KI) may be indicated. Seek advice of health physics professionals.
- The total dose may be up to 100 times greater than the external exposure indicated on a dosimeter, if respiratory protection is not used while the radioactive cloud is present. Even if the cloud has passed the multiplier can still be significant due to resuspended material/contamination.
- Emergency dose limits attempt to balance risk from radiation against benefit of an activity. Dose limits vary depending on activity (lifesaving, protection of major property, general response work).
- Emergency responders are prohibited from performing work in a radiation area after their dose limit has been reached. This may place them out of service for up to a year.
- All exposures exceeding routine occupational limits (5,000 mrem) require informed consent of the worker (for lifesaving or protection of valuable property activities).
- An individual's radiation dose is a cumulative total of their dose received each day.
- Plan activities to make exposures As-Low-As-Reasonably-Achievable (ALARA).
  - ◆ Plan work to minimize exposure time
  - ◆ Avoid lingering in areas with radiation levels over 2 mR/h
  - ◆ Take advantage of available shielding (trucks, walls...)
  - ◆ Position assets outside the Controlled Access Area boundary and upwind if possible
  - ◆ Use respiratory protection, until demonstrated as unnecessary
  - ◆ Avoid, or minimize, eating or drinking in radiation areas to the extent practical.
- Assure health physics professionals are involved in worker safety oversight.

#### Presenter Notes - Technical Background

- Guidance based on EPA/DHS PAGs as given in:
  - ◆ "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents", (EPA 400-R-92-001, May 1992).
  - ◆ "Planning Guidance for Protection and Recovery Following Radiological Dispersal Device (RDD) and Improvised Nuclear Device (IND) Incidents", (Federal Register, Vol. 73, No. 149, Aug. 1, 2008, pg 45029).
  - ◆ "Handbook for Responding to a Radiological Dispersal Device", CRCPD Pub. 06-6, [www.crcpd.org/RDD.htm](http://www.crcpd.org/RDD.htm)
- Lifesaving dose limit is 25,000 mrem for the event, which assures exposures will not produce acute health effects.
- Protection of valuable property dose limit is 10,000 mrem for an event.
- Occupational dose limit of 5,000 mrem per year applies to all other emergency response work.
- Emergency responders without radiological worker training or monitoring should remain outside the 2 mR/h boundary, if possible.
- Contour levels correspond to exposure rate thresholds of 10,000 mR/h, 1,000 mR/h, 100 mR/h, 10 mR/h and 2 mR/h (Controlled Access Area). Fewer than five contours may be shown if some of these higher thresholds are not reached.
- Emergency dose limits apply to emergency response workers. Lower dose limits apply to the general public.
- Consult a health physics professional to evaluate the benefit and added risk of various types of PPE.
- Radioactive contamination is expected outside the contoured areas, but not at levels expected to exceed federal guidelines for worker protection based on current information.
- Additional technical and background information is provided in the Consequence Report containing the detailed, technical version of this calculation.
- Briefing Products are intended for presenting a common operating picture to key leaders and decision makers. Other more technical products are available (Standard Products and associated Consequence Reports).
- Contact the FRPCC Subcommittee for Environment, Food and Health (Advisory Team) for advice and recommendations. Available by calling FDA Emergency Operations Center (EOC) at 866-300-4374.

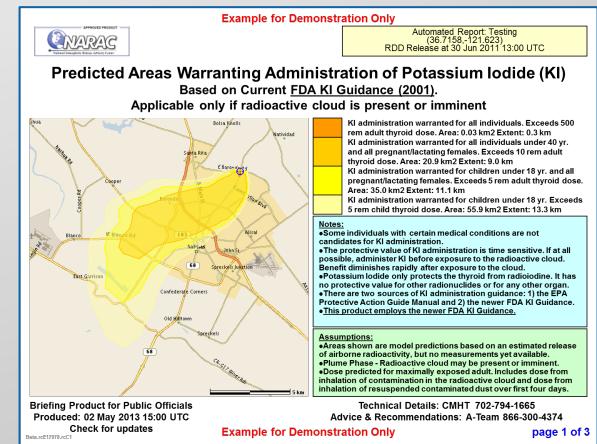
Technical Details: CMHT 702-794-1665

Advice &amp; Recommendations: A-Team 866-300-4374

page 3 of 3

# Predicted Areas Warranting Administration of Potassium Iodide (KI)

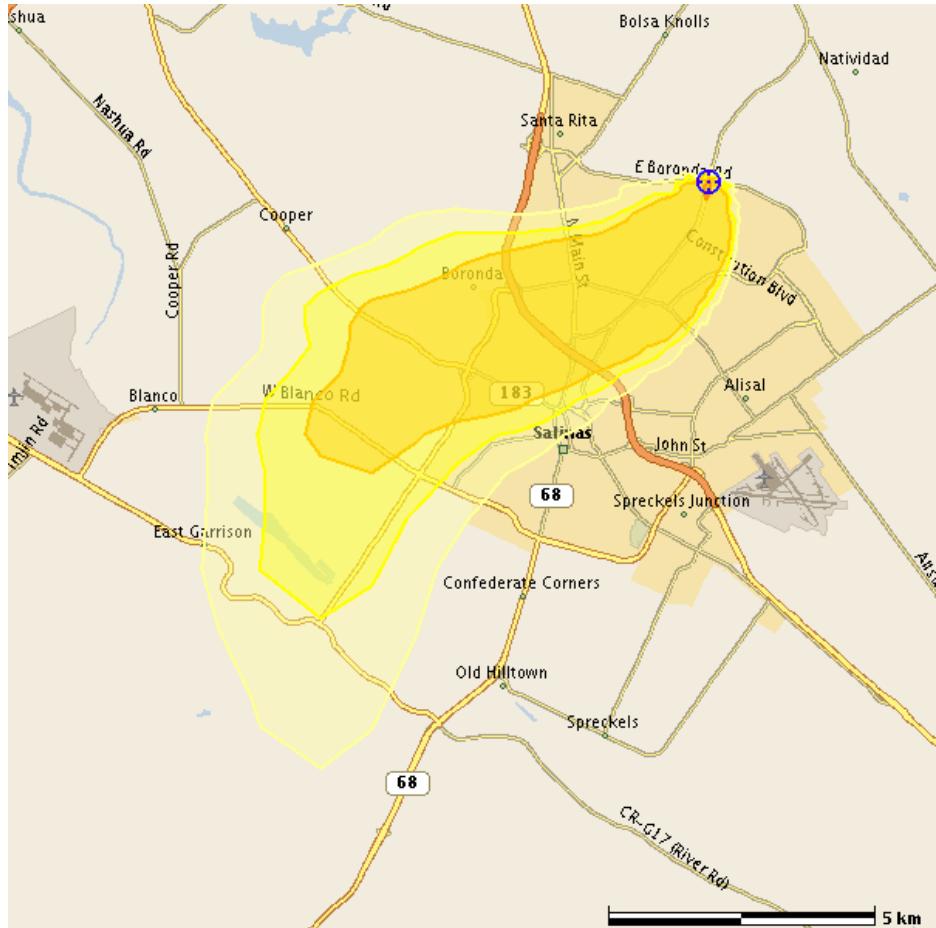
- This product is provided for cases in which radioactive iodine is released
- Product is used to determine whether administration of potassium iodide (KI) may be warranted to protect against the risk of thyroid cancer
- Product is based on predicted dose from inhalation of the radioactive cloud during plume passage and resuspended dust from ground contamination over the first four days
- Contours displayed are based on the 2001 Food and Drug Administration Protective Action Guide, which considers the thyroid dose for different age groups and special cases
- Use of KI may be an effective alternative to evacuation for cases involving radioiodine releases



# Predicted Areas Warranting Administration of Potassium Iodide (KI)

## Based on Current FDA KI Guidance (2001).

### Applicable only if radioactive cloud is present or imminent



	KI administration warranted for all individuals. Exceeds 500 rem adult thyroid dose. Area: 0.03 km <sup>2</sup> Extent: 0.3 km
	KI administration warranted for all individuals under 40 yr. and all pregnant/lactating females. Exceeds 10 rem adult thyroid dose. Area: 20.9 km <sup>2</sup> Extent: 9.0 km
	KI administration warranted for children under 18 yr. and all pregnant/lactating females. Exceeds 5 rem adult thyroid dose. Area: 35.0 km <sup>2</sup> Extent: 11.1 km
	KI administration warranted for children under 18 yr. Exceeds 5 rem child thyroid dose. Area: 55.9 km <sup>2</sup> Extent: 13.3 km

#### Notes:

- Some individuals with certain medical conditions are not candidates for KI administration.
- The protective value of KI administration is time sensitive. If at all possible, administer KI before exposure to the radioactive cloud. Benefit diminishes rapidly after exposure to the cloud.
- Potassium Iodide only protects the thyroid from radioiodine. It has no protective value for other radionuclides or for any other organ.
- There are two sources of KI administration guidance: 1) the EPA Protective Action Guide Manual and 2) the newer FDA KI Guidance.
- This product employs the newer FDA KI Guidance.

#### Assumptions:

- Areas shown are model predictions based on an estimated release of airborne radioactivity, but no measurements yet available.
- Plume Phase - Radioactive cloud may be present or imminent.
- Dose predicted for maximally exposed adult. Includes dose from inhalation of contamination in the radioactive cloud and dose from inhalation of resuspended contaminated dust over first four days.



# Predicted Areas Warranting Administration of Potassium Iodide (KI)

Based on Current FDA KI Guidance (2001).

Applicable only if radioactive cloud is present or imminent

## Key Points

- Decision makers must choose which of the two available guidelines to employ.
- The older KI guideline cited by EPA (1992) is recognized as prevailing, but the newer FDA KI Guidance, combined with updated dose estimation methods, is better practice and science.
- This prediction utilizes the 2001 FDA KI guidance and updated dose estimation method which considers thyroid dose for several age groups and special cases.
- Radiation dose to the thyroid increases the risk of thyroid cancer.
- Potassium Iodide (KI) is used to protect against radioiodine dose to the thyroid.
- Use of KI may be an effective alternative to evacuation in cases involving radioiodine releases, if evacuation cannot be implemented or exposure occurs during evacuation. See Predicted Evacuation and Sheltering Areas products for evacuation/shelter guidance.
- KI is most effective when administered immediately prior to exposure to the plume, but significant protection can be provided even if administration is delayed 3 or 4 hours after initial exposure.
- Repeat administration of KI every 24 hours, if radioiodine exposure is prolonged.
- Age specific dosages are established. Contact medical and radiation health professionals for additional guidance.

Automated Report: Testing  
(36.7158,-121.623)

RDD Release at 30 Jun 2011 13:00 UTC

# Predicted Areas Warranting Administration of Potassium Iodide (KI)

## Based on Current FDA KI Guidance (2001).

### Applicable only if radioactive cloud is present or imminent

#### **Presenter Notes - Additional Information**

- The KI administration guidance found in the EPA PAG Manual (1992) continues to be widely used by NRC licensees, FEMA and other organizations. It is recognized as the prevailing guideline, in spite of the release of updated KI administration guidance by FDA (2001). The guidance found in the EPA PAG Manual is based on the FDA's 1982 guidelines for use of KI in radiation emergencies and reflects the best practice and science of the 1980s.
- The FDA KI guidance (2001) cannot be used with the old dose estimation science, because the new guidance is age dependent but the old dose estimation science does not support age dependence.
- A prediction using the EPA KI guidance (1992) and older dose estimation science is available. See the companion prediction Predicted Areas Warranting Administration of Potassium Iodide (KI) sub-titled Based on Current EPA Guidance (1992).
- Radiation dose to the thyroid increases the risk of thyroid cancer.
- Radioiodine inhalation is the strongest contributor to thyroid dose.
- Potassium Iodide blocks most of the absorption of radioiodine by the thyroid.
- The area on the graphic describing KI administration to children under 18 is actually for the most limiting child age group (1 year-old infant).
- The newer FDA guide reports:
  - ◆ "The protective effects of KI last approximately 24 hours. For optimal prophylaxis, KI should therefore be dosed daily, until a risk of significant exposure to radioiodines by either inhalation or ingestion no longer exists."
  - ◆ "The overall benefits of KI far exceed the risks of overdosing, especially in children, though we continue to emphasize particular attention to dose in infants."
  - ◆ "KI may still have a substantial protective effect even if taken 3 or 4 hours after exposure" (the older EPA guide says 1 or 2 hours).
- Repeat dosing should be avoided for newborns, pregnant and lactating women.

#### **Presenter Notes - Technical Background**

- Guidance based on the new FDA KI PAG as given in:
  - ◆ "Guidance: Potassium Iodide as a Thyroid Blocking Agent in Radiation Emergencies", (U.S. Department of Health and Human Services Food and Drug Administration, Center for Drug Evaluation and Research (CDER), December 2001, Procedural)
- This prediction employs the updated ICRP 60+ dosimetry model and dose factors. Although in use by many agencies, some still utilize the old FGR 11 dose factors and ICRP 23/26/30 dosimetry model to calculate doses from exposure and intake. This may lead to different dose predictions.
- Potassium Iodide (KI) preferentially deposits in the thyroid whether inhaled or ingested. Inhalation of contaminated air is the concern while the cloud is present. Inhalation of radioiodine is a particularly large contributor to thyroid dose.
- The FDA KI guide recommends these KI doses if the following potential thyroid doses are exceeded:

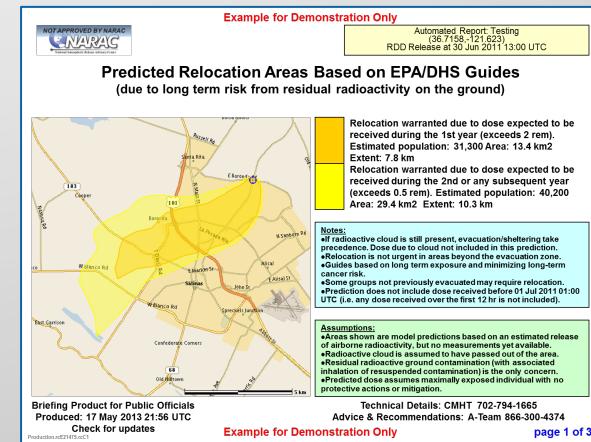
Group	Thyroid Dose	KI Dose
• Adults over 40	> or = 500 rem	130 mg
• Adults 18 to 40	> or = 10 rem	130 mg
• Pregnant/lactating women	> or = 5 rem	130 mg
• Adolescents 12 to 18	> or = 5 rem	65 mg
• Children 3 to 12	> or = 5 rem	65 mg
• Infant 1 mo to 3 yr	> or = 5 rem	32 mg
• Infant birth to 1 mo	> or = 5 rem	16 mg

- Contaminated air will be found outside contoured areas, but not at levels expected to exceed FDA guidelines for KI administration.
- Additional technical and background information is provided in the Consequence Report containing the detailed, technical version of this calculation.
- Briefing Products are intended for presenting a common operating picture to key leaders and decision makers. Other more technical products are available (Standard Products and associated Consequence Reports).
- Contact the FRPCC Subcommittee for Environment, Food and Health (Advisory Team) for advice and recommendations. Available by calling the FDA Emergency Operations Center (EOC) at 866-300-4374.

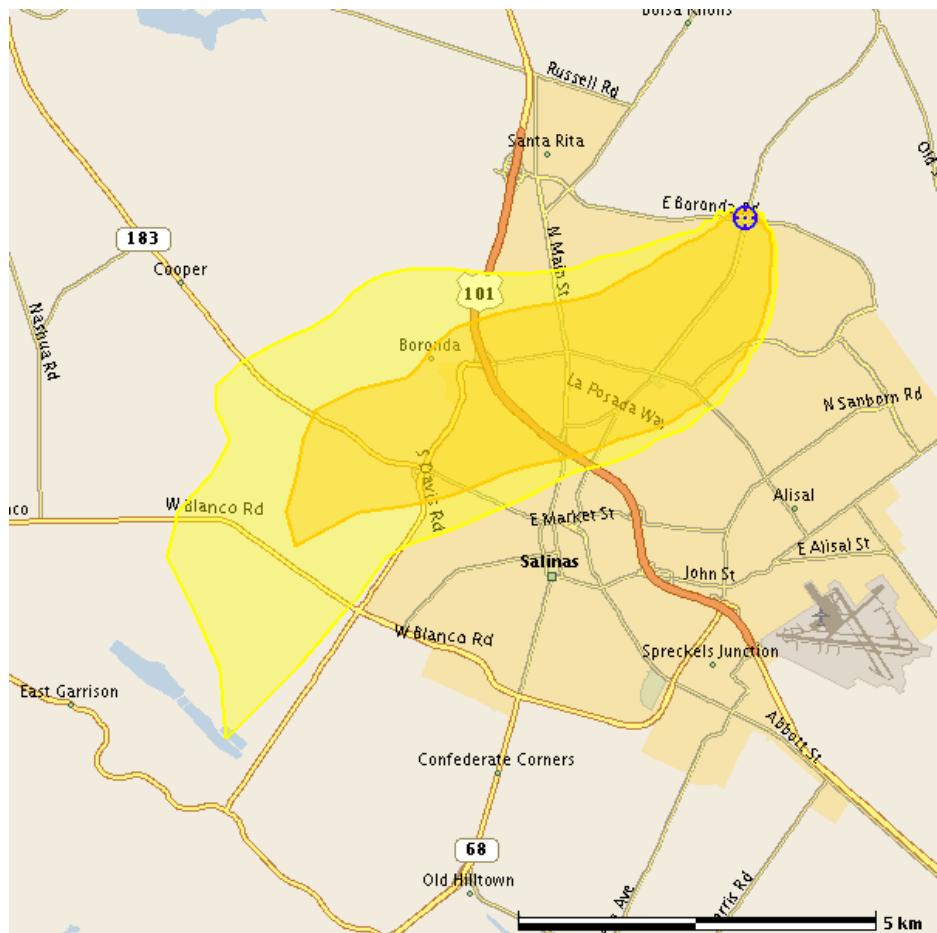
# INTERMEDIATE PHASE

# Predicted Relocation Areas Based on EPA/DHS Guides

- This product is used to determine the dose that may be avoided in the long term (1 to 2 years or 50 years) if the population is relocated
- Contours displayed are the EPA or DHS PAGs (Protective Action Guides)
- By this time, the plume will most likely have passed and the dose received will be from ground contamination, either by direct exposure or via inhalation of resuspended material
- May reflect measurements (as indicated in the green box)



## Predicted Relocation Areas Based on EPA/DHS Guides (due to long term risk from residual radioactivity on the ground)



**Relocation warranted due to dose expected to be received during the 1st year (exceeds 2 rem).  
Estimated population: 31,300 Area: 13.4 km<sup>2</sup>  
Extent: 7.8 km**

**Relocation warranted due to dose expected to be received during the 2nd or any subsequent year (exceeds 0.5 rem). Estimated population: 40,200  
Area: 29.4 km<sup>2</sup> Extent: 10.3 km**

### Notes:

- If radioactive cloud is still present, evacuation/sheltering take precedence. Dose due to cloud not included in this prediction.
- Relocation is not urgent in areas beyond the evacuation zone.
- Guides based on long term exposure and minimizing long-term cancer risk.
- Some groups not previously evacuated may require relocation.
- Prediction does not include dose received before 01 Jul 2011 01:00 UTC (i.e. any dose received over the first 12 hr is not included).

### Assumptions:

- Areas shown are model predictions based on an estimated release of airborne radioactivity, but no measurements yet available.
- Radioactive cloud is assumed to have passed out of the area.
- Residual radioactive ground contamination (with associated inhalation of resuspended contamination) is the only concern.
- Predicted dose assumes maximally exposed individual with no protective actions or mitigation.

## Predicted Relocation Areas Based on EPA/DHS Guides (due to long term risk from residual radioactivity on the ground)

### **Key Points**

- Protective actions are based only on dose that can be avoided.
- Relocation based on whole body dose. Thyroid dose is no longer a concern because any radioiodine originally present has decayed to levels below concern.
- Re-entry into relocated areas permitted with appropriate controls.
- Separate relocation guides are used for the following:
  - Dose during first year,
  - Dose during any subsequent year.
- Assumes maximally exposed individual, no protective actions considered.
- Only ground contamination contributes to dose (including inhalation of resuspended material).
- Dose rate tends to naturally diminish with time.
- Dose reduction measures can be considered, contact Advisory Team (A-Team).

# Predicted Relocation Areas Based on EPA/DHS Guides

## (due to long term risk from residual radioactivity on the ground)

### **Presenter Notes - Additional Information**

- PAG - Protective Action Guideline, projected dose at which a specific protective action to reduce or avoid that dose is warranted.
- Relocation PAG applies only to dose that can be avoided during the first year.
- Following early phase response it may be necessary to temporarily relocate the public from areas until decontamination has taken place.
- Areas shown do not include dose received before 01 Jul 2011 01:00 UTC.
- In contrast to the situation during the early phase, when decisions usually must be made and implemented quickly, many relocation decisions and actions during the intermediate phase can be delayed until adequate resources are in place.
- Some groups not previously evacuated may require relocation.
- It may also be necessary to consider the EPA's Long Term Objective criteria which limit dose:
  - accrued during the second and each subsequent year,
  - accrued over a 50-year period (available as a separate product).
- PAGs should be considered as guidance only. During an incident, due to unanticipated local conditions and constraints, professional judgment will be required. Situations can be envisaged in which relocation of the public, based on the recommended PAGs, would be impractical. Conversely, under some conditions relocation may be practical at doses below the PAGs.
- Informed judgment must be exercised to prioritize protection for individuals in areas having the highest exposure rates.
- Simple dose reduction efforts are recommended for areas outside the relocation area to reduce doses to the extent practical.
- Re-entry into relocated areas may be permitted with appropriate controls.
- Dose rate tends to naturally diminish with time due to radioactive decay and weathering of contamination into the soil.
- Radioactive decay may be rapid for the first weeks then slow in subsequent months to years, because radioactive iodine and other short-live radionuclides will nearly vanish but longer-lived radionuclides will persist.
- Protective actions may be initiated over larger areas and at lower contamination/dose levels if advantageous (e.g., in order to account for uncertainties in the predicted dose and mapped areas, and/or to use boundaries, such as roads, that are convenient).

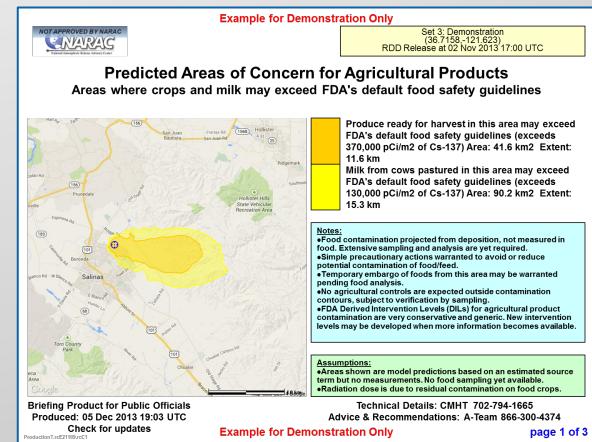
### **Presenter Notes - Technical Background**

- Guidance based on EPA and DHS PAGs, as given in:
  - ◆ "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents", (EPA 400-R-92-001, May 1992).
  - ◆ "Planning Guidance for Protection and Recovery Following Radiological Dispersal Device (RDD) and Improvised Nuclear Device (IND) Incidents", (Federal Register, 73:149, Aug. 1, 2008, pg 45029).
- Dose considered is the projected Total Effective Dose Equivalent (TEDE) which includes external irradiation and inhalation of re-suspended material, accounting for weathering of material and radioactive decay. Only ground contamination contributes to the dose. There is no plume contribution.
- Two separate dose criteria are used: 1) Dose during first year (2 rem), 2) Dose during second or any subsequent year (0.5 rem).
- First year dose accumulated from 12 hrs to 1 year + 12 hrs (12 to 8,772 hrs).
- Second and subsequent dose accumulated from beginning to end of year two (i.e. 8,760 hrs to 17,520 hrs).
- Projected dose assumes individuals are unsheltered and unprotected, and no mitigation or remediation actions are taken (maximally exposed individual).
- Dose reduction factors associated with simple, rapid decontamination techniques are not included in calculating projected dose for decisions on relocation, as prescribed by EPA PAGs.
- Some special cases may also require consideration of beta radiation from surface contamination and direct ingestion of contaminated soil.
- The sizes of the relocation and affected population areas can be reduced by reducing dose in the area by removal/shielding of radioactive material.
- Radioactive contamination is expected outside the contoured areas, but not at levels expected to exceed federal relocation guidelines based on current information.
- Additional technical and background information is provided in the Consequence Report containing the detailed, technical version of this calculation.
- Briefing Products are intended for presenting a common operating picture to key leaders and decision makers. Other more technical products are available (Standard Products and associated Consequence Reports).
- Contact the FRPCC Subcommittee for Environment, Food and Health (Advisory Team) for advice and recommendations. Available by calling FDA Emergency Operations Center (EOC) at 866-300-4374.

# LATE PHASE

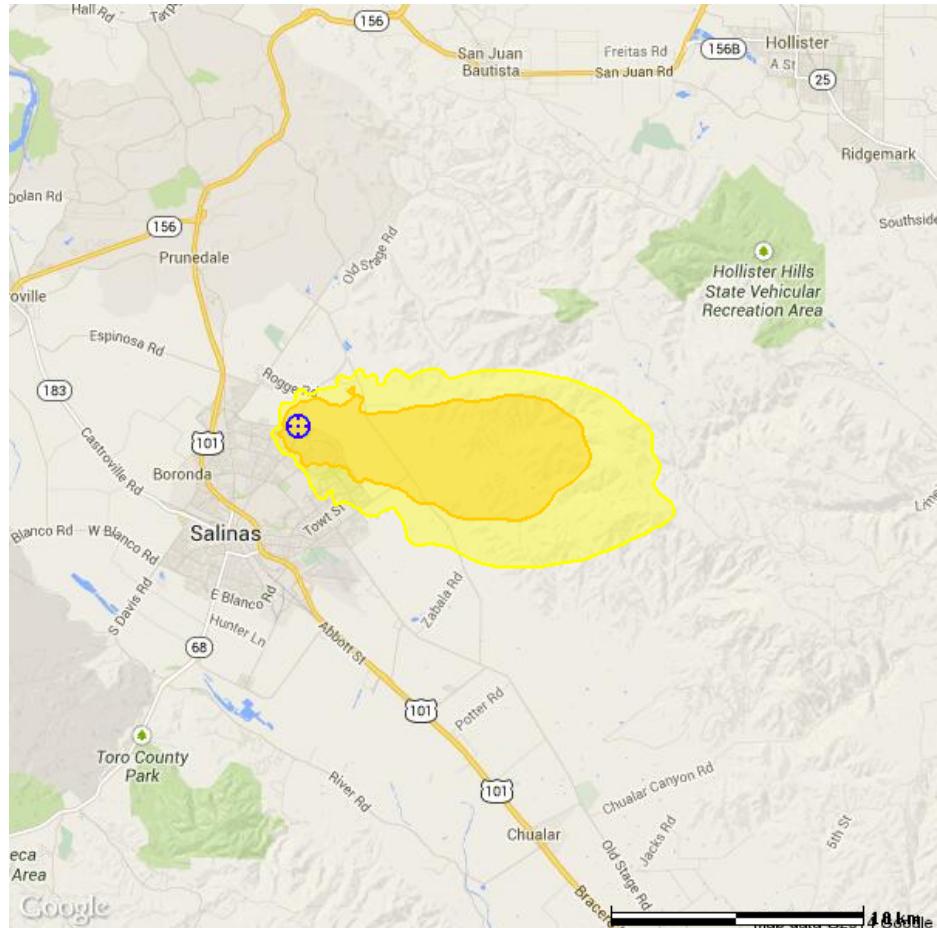
# Predicted Areas of Concern for Agricultural Products

- This product is used to determine where there is the potential to exceed food safety guidelines and may be used to guide crop sampling efforts
- Contours displayed are DRLs (Derived Response Levels) corresponding to FDA DILs (Derived Intervention Levels)
- Levels displayed on this product are very low and are difficult to measure directly
- May reflect measurements (indicated in the green box)



# Predicted Areas of Concern for Agricultural Products

## Areas where crops and milk may exceed FDA's default food safety guidelines



Produce ready for harvest in this area may exceed FDA's default food safety guidelines (exceeds 370,000 pCi/m<sup>2</sup> of Cs-137) Area: 41.6 km<sup>2</sup> Extent: 11.6 km

Milk from cows pastured in this area may exceed FDA's default food safety guidelines (exceeds 130,000 pCi/m<sup>2</sup> of Cs-137) Area: 90.2 km<sup>2</sup> Extent: 15.3 km

### Notes:

- Food contamination projected from deposition, not measured in food. Extensive sampling and analysis are yet required.
- Simple precautionary actions warranted to avoid or reduce potential contamination of food/feed.
- Temporary embargo of foods from this area may be warranted pending food analysis.
- No agricultural controls are expected outside contamination contours, subject to verification by sampling.
- FDA Derived Intervention Levels (DILs) for agricultural product contamination are very conservative and generic. New intervention levels may be developed when more information becomes available.

### Assumptions:

- Areas shown are model predictions based on an estimated source term but no measurements. No food sampling yet available.
- Radiation dose is due to residual contamination on food crops.

## Predicted Areas of Concern for Agricultural Products

Areas where crops and milk may exceed FDA's default food safety guidelines

### *Key Points*

- FDA guidance applies to concentration of radioactivity in foods as prepared for eating. This product is based on projection of food concentration from expected and/or measured environmental deposition, not measured food concentration. Assumes no reduction of contamination by washing, peeling, cooking or other processing.
- FDA recommends consultation with the FDA on: 1) simple precautions to avoid/reduce contamination of food/feed and 2) use of temporary food embargoes to prevent introduction of contaminated food into commerce.
  - Simple precautions include covering exposed products, moving animals to shelter, corralling livestock and providing protected feed and water.
  - The temporary embargo permits adequate monitoring and sampling to be performed as the basis of future protective actions.
- Food products not yet ready for harvest should be analyzed at a later time.
- Pre-packaged food and beverages are generally not affected.
- FDA guidance assumes 30% of all food eaten is contaminated (very conservative).
- Drinking water is controlled by separate EPA guidelines.
- Extensive, time consuming sampling and analysis will be required to properly assess food contamination.

# Predicted Areas of Concern for Agricultural Products

## Areas where crops and milk may exceed FDA's default food safety guidelines

### **Presenter Notes - Additional Information**

- This is a preliminary assessment based on predicted radioactivity levels in the environment, not concentration of radioactivity in foods. FDA food safety guidance is based on concentration in foods as prepared for consumption.
- This preliminary assessment pertains only to food products that are ready for immediate consumption, not foods to be harvested at a future date, or to foods grown underground or indoors.
- No food sampling has taken place. Confidence and accuracy will be improved once results of food sampling are obtained.
- "Protective actions can be taken before the release or arrival of contamination if there is advance knowledge that radionuclides may accidentally contaminate the environment."
- "Protective actions which can be taken within the area likely to be affected and prior to confirmation of contamination consist of:
  - ◆ simple precautionary actions to avoid or reduce the potential for contamination of food and animal feeds, and
  - ◆ temporary embargoes to prevent the introduction into commerce of food which is likely to be contaminated."
- "Protective actions which should be implemented when the contamination in food equals or exceeds the DILs consist of:
  - ◆ temporary embargoes to prevent the contaminated food from being introduced into commerce,
  - ◆ normal food production and processing actions that reduce the amount of contamination in or on food to below the DILs."
- "Normal food production and processing procedures that could reduce the amount of radioactive contamination in or on the food could be simple, (such as holding to allow for radioactive decay, or removal of surface contamination by brushing, washing, or peeling)..."
- Food products that are not yet ready for harvest should be analyzed at a later time before consumption to determine if they are suitable for consumption.
- Pre-packaged food and beverages in these areas are not affected.
- This map is valid for only this growing season.
- Protective actions may be initiated over larger areas and at lower contamination/dose levels if advantageous (e.g., in order to account for uncertainties in the predicted dose and mapped areas, and/or to use boundaries, such as roads, that are convenient).

**Briefing Product for Public Officials**

**Produced: 05 Dec 2013 19:03 UTC**

**Check for updates**

Example for Demonstration Only

**Technical Details: CMHT 702-794-1665**  
**Advice & Recommendations: A-Team 866-300-4374**

**page 3 of 3**

# EXAMPLE COMPARISON OF RDD TECHNICAL AND BRIEFING PRODUCT

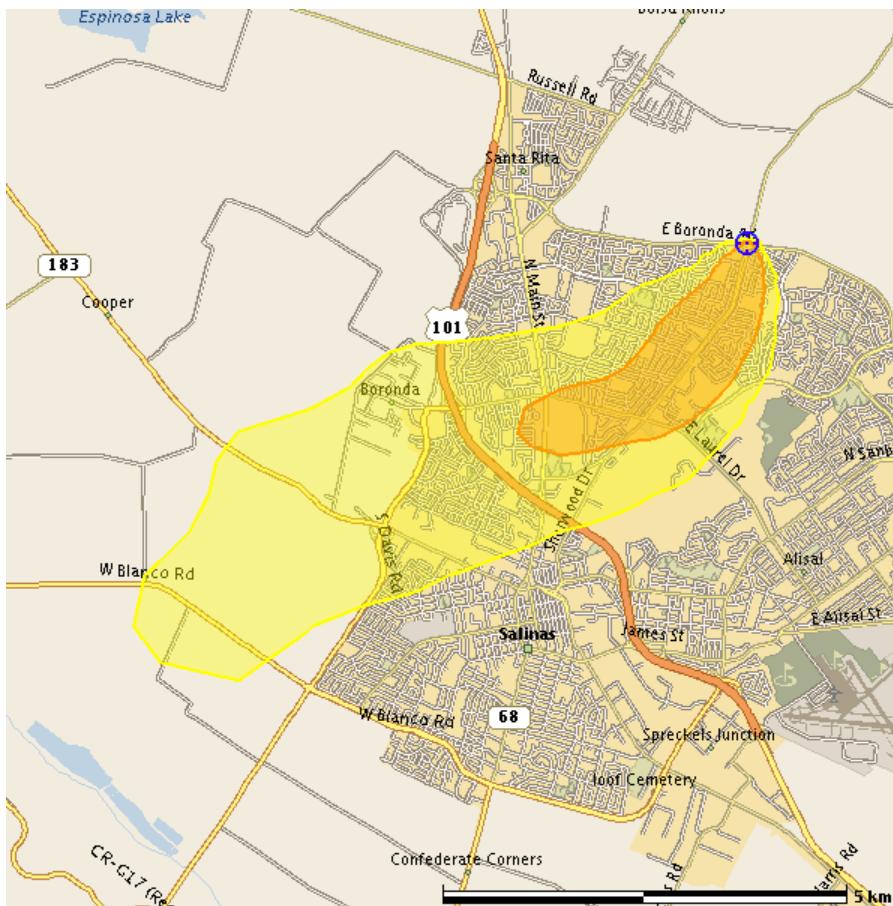
TECHNICAL PRODUCTS INCLUDE BOTH TED AND CDE  
CALCULATION

BRIEFING PRODUCT IS BASED ON THE CDE AS THE LIMITING  
CASE

## Example for Demonstration Only

### Early Phase TED (0-96 hrs) (Total Effective Dose Including Plume Passage)

### Sample Explosion Rad Automated Report - Testing



**Map Size:** 11.2 km by 11.2 km   **Id:** Production.rcE20457.rcC1  
**NARAC Operations:** ( onDuty Assessor ); narac@llnl.gov; 925-424-6465  
**Requested by:** {}  
**Approved by:** {NARAC Operations; NARAC}

Early Phase Dose			
	Description	(rem) Extent Area	Population
>5	Exceeds 5 rem total effective dose.	3.7km 3.4 km <sup>2</sup>	12,700
>1	Exceeds 1 rem total effective dose.	9.0km 20.2 km <sup>2</sup>	36,600

Areas and counts in the table are cumulative. Population Source = LandScanUSA10.

Effects or contamination from June 30, 2011 06:00 PDT to July 04, 2011 06:00 PDT

**Release Location:** 36.715775 N, 121.623420 W

**Material:** CS-137 + I-131 + XE-133

**Generated On:** December 18, 2012 11:47 PST

**Model:** ADAPT/LODI

**Comments:** Doses shown are total accumulated from the beginning of release.

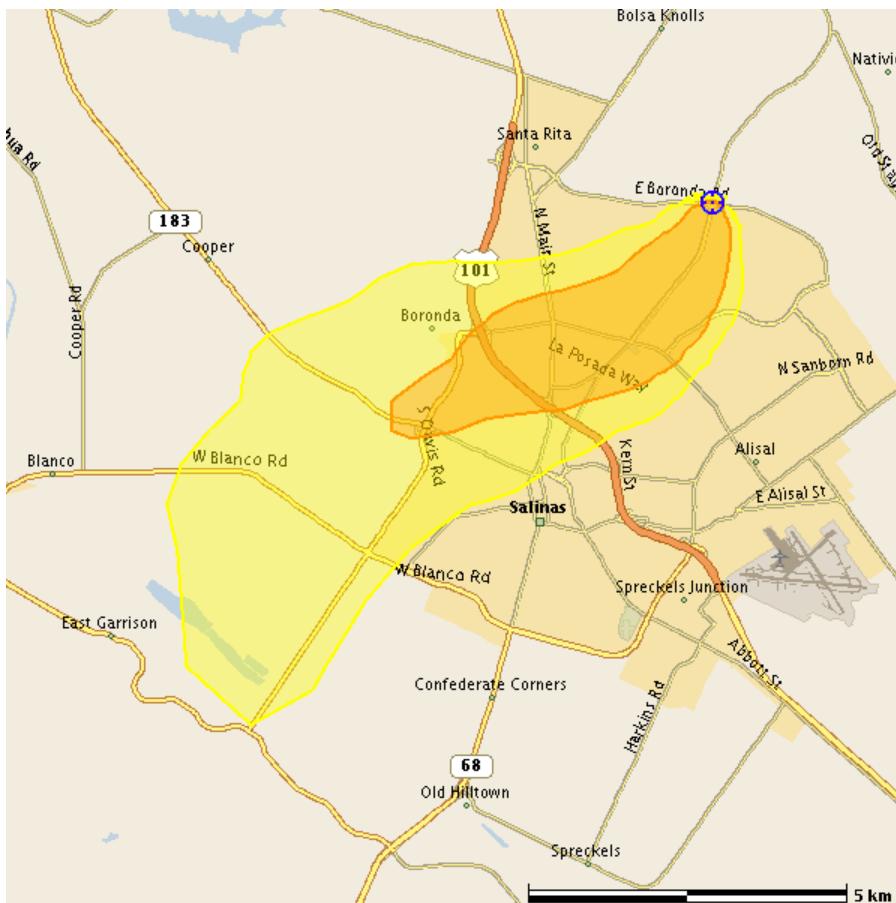
Release starting at 06/30/2011 13:00:00 UTC for 1 sec

met obs at 1 hr intervals from 06/30/2011 13:00:00 UTC to 07/01/2011 12:00:00 UTC

## Example for Demonstration Only

### Early Phase Thyroid CDE (0-96 hrs) (Thyroid Committed Dose Equivalent Including Plume Passage)

### Sample Explosion Rad Automated Report - Testing



Early Phase Dose			
	Description	(rem) Extent Area	Population
	Exceeds 25 rem thyroid dose.	>25 6.2km 8.9 km <sup>2</sup>	26,800
	Exceeds 5 rem thyroid dose.	>5 11.0km 34.5 km <sup>2</sup>	47,400

Areas and counts in the table are cumulative. Population Source = LandScanUSA10.

Effects or contamination from June 30, 2011 06:00 PDT to July 04, 2011 06:00 PDT

**Release Location:** 36.715775 N, 121.623420 W

**Material:** CS-137 + I-131

**Generated On:** December 18, 2012 11:47 PST

**Model:** ADAPT/PUFF/LODI

**Comments:** Doses shown are total accumulated from the beginning of release.

Release starting at 06/30/2011 13:00:00 UTC for 1 sec

met obs at 1 hr intervals from 06/30/2011 13:00:00 UTC to 07/01/2011 12:00:00 UTC

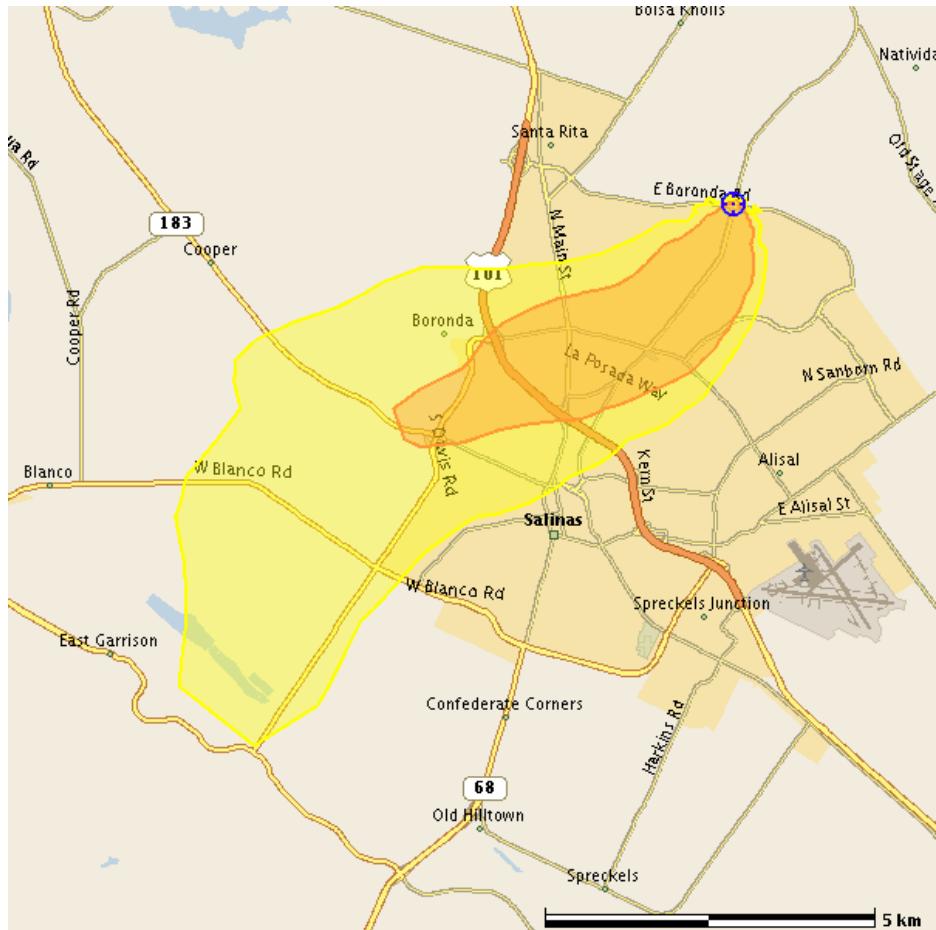
**Map Size:** 14.2 km by 14.2 km **Id:** Production.rcE20457.rcC1  
 NARAC Operations: ( onDuty Assessor ); narac@llnl.gov; 925-424-6465

Requested by: {}  
 Approved by: {NARAC Operations; NARAC}

# Predicted Evacuation and Sheltering Areas - Most Limiting Criteria

The Thyroid Dose is the most limiting of the EPA Guide criteria

Projected Total Thyroid Dose - Applicable prior to start of release



**Orange Area:** Shelter of entire population warranted, often followed by a delayed, deliberate evacuation. Those already outdoors should be removed from the area (exceeds 25 rem). Estimated Population: 26,800 Area: 8.9 km<sup>2</sup> Extent: 6.1 km

**Yellow Area:** Evacuation or sheltering normally initiated (5 to 25 rem). Estimated Population: 47,100 Area: 35.0 km<sup>2</sup> Extent: 11.1 km

#### Notes:

- EPA's Early Phase Guides provide separate criteria to limit dose to both the whole body and the thyroid. Separate predictions of the affected area were compared based on each criteria.
- The adult Thyroid Dose criterion is the most limiting in this case.
- Protective actions are normally based on the most limiting case.
- Prompt evacuation and/or sheltering reduces radiation dose and cancer risk. Sheltering-in-place may be more protective than evacuation while the radioactive cloud is present.
- Administration of Potassium Iodide (KI) may be warranted. See [Predicted Areas Warranting Administration of Potassium Iodide \(KI\)](#).
- Protective actions are only based on dose that can be avoided.

#### Assumptions:

- Areas shown are model predictions based on an estimated release of airborne radioactivity, but no measurements yet available.
- Prediction shows total dose over four days beginning at the start of the release (0 to 96 hrs).
- Dose predicted for maximally exposed adult inhaling contamination from the radioactive cloud and resuspended contaminated dust.

Automated Report: Testing  
(36.7158,-121.623)

RDD Release at 30 Jun 2011 13:00 UTC

## Predicted Evacuation and Sheltering Areas - Most Limiting Criteria

The Thyroid Dose is the most limiting of the EPA Guide criteria

Projected Total Thyroid Dose - Applicable prior to start of release

### *Key Points*

- Both the Whole Body Dose and Thyroid Dose predictions were considered.
- The Thyroid Dose was found to affect the greatest area and is therefore the most limiting case. Normally, decisions are based on the most limiting case.
- When large amounts of radioiodine are present, then the dose of radiation to the thyroid may be most limiting due to inhalation of that radioiodine.
- Sheltering-in-place may be preferable to evacuation in some cases, such as for limited mobility populations or if unusually hazardous environmental conditions exist.
- EPA estimates sheltering may reduce dose due to infiltration by a factor of 1.3 to 539.
- Greatest hazard is due to exposure to the radioactive cloud. Sheltering followed by delayed evacuation after cloud passage may be preferable. Evacuation before radioactive cloud arrival is best, but avoid evacuation in the radioactive cloud.
- Predicted dose is accumulated from the start of the release for a period of 96 hours (4 days), specifically 30 Jun 2011 13:00 UTC to 04 Jul 2011 13:00 UTC.
- Refer to the separate Briefing Product Predicted Areas Warranting Administration of Potassium Iodide (KI), because administration of KI can reduce thyroid dose.

# Predicted Evacuation and Sheltering Areas - Most Limiting Criteria

## The Thyroid Dose is the most limiting of the EPA Guide criteria

### Projected Total Thyroid Dose - Applicable prior to start of release

#### **Presenter Notes - Additional Information**

- PAG - Protective Action Guide is a projected dose at which a specific protective action to reduce or avoid that dose is warranted.
- The EPA Early Phase PAG has a primary guideline for the dose to the whole body and a supplementary guideline for dose to the thyroid and skin.
- Protective actions are based only on dose that can be avoided, not dose acquired prior to implementation of the protective action.
- Reduce radiation dose to minimize long-term cancer risk.
- Evacuation and/or sheltering-in-place is an effective protective action to avoid or reduce both dose to the whole body and dose to the thyroid.
- Sheltering may be the preferred protective action when it will provide protection equal to or greater than evacuation.
- No specific minimum level is established for initiation of sheltering.
- Completion of evacuation before plume arrival is best. Evacuation in radioactive cloud may result in more dose than sheltering until cloud passage. Evacuees in cloud should cover mouth & nose with available filter materials (handkerchief).
- Sheltering followed by delayed evacuation may be best if radioactive decay is very rapid (e.g. dominated by radioiodine).
- Thyroid Dose criteria (Committed Dose Equivalent) for evacuation and sheltering are obtained by a modification of the Early Phase PAG's Whole Body Dose (i.e., Total Effective Dose) criterion.
  - ◆ Evacuation (or, for some situations, sheltering) should normally be initiated at 5 rem dose to the thyroid.
  - ◆ Because of the higher risk associated with evacuation of some special groups in the population (e.g. those who are not readily mobile), sheltering may be the preferred alternative for such groups as a protective action at projected doses up to 25 rem dose to the thyroid.
  - ◆ Under unusually hazardous environmental conditions use of sheltering at projected doses up to 25 rem dose to the thyroid for the general population (and up to 50 rem dose to the thyroid for special groups) may become justified.
- Thyroid Dose can be reduced by timely administration of stable iodine (KI).
- Protective actions may be initiated over larger areas and at lower contamination/dose levels if advantageous (e.g., in order to account for uncertainties in the predicted dose and mapped areas, and/or to use boundaries, such as roads, that are convenient).

**Briefing Product for Public Officials**

**Produced: 02 May 2013 14:59 UTC**

**Check for updates**

#### **Presenter Notes - Technical Background**

- Guidance based on EPA and DHS PAGs, as given in:
  - ◆ "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents", (EPA 400-R-92-001, May 1992).
  - ◆ "Planning Guidance for Protection and Recovery Following Radiological Dispersal Device (RDD) and Improvised Nuclear Device (IND) Incidents", (Federal Register, Vol. 73, No. 149, Aug. 1, 2008, pg 45029).
  - ◆ Jetter, J. J. and C. Whitfield. "Effectiveness of Expedient Sheltering in Place in a Residence", Journal of Hazardous Materials. Elsevier, Amsterdam, Holland, 119(1-3):31-40, (2005).
- The PAG for evacuation and/or sheltering is expressed in terms of the committed effective dose to the thyroid due to inhalation of radioactive iodine from 1) Inhalation of the contaminated air as the cloud passes and 2) Inhalation of resuspended contaminated dust.
- Hazard is greatest while the radioactive cloud is present, because both pathways above contribute. After the radioactive cloud passes only inhalation of resuspended contaminated dust will continue to contribute significantly.
- Although Table 2-1 "PAGs for the Early Phase of a Nuclear Incident" of the EPA PAG Manual is the whole body dose criteria, footnote "b" guides how the Early Phase PAGs can be expressed in terms of thyroid dose. "Committed dose equivalents to the thyroid and skin may be 5 and 50 times larger, respectively." Therefore, the dose guidelines for thyroid dose are five times (5X) that for the whole body dose.
- Radioactive contamination is expected outside the contoured areas, but not at levels expected to exceed federal guidelines for evacuation and sheltering based on current information.
- Additional technical and background information is provided in the Consequence Report containing the detailed, technical version of this calculation.
- Briefing Products are intended for presenting a common operating picture to key leaders and decision makers. Other more technical products are available (Standard Products and associated Consequence Reports).
- Contact the FRPCC Subcommittee for Environment, Food and Health (Advisory Team) for advice and recommendations. Available by calling the FDA Emergency Operations Center (EOC) at 866-300-4374.

**Technical Details: CMHT 702-794-1665**

**Advice & Recommendations: A-Team 866-300-4374**

# **NARAC/IMAAC Briefing Products for Nuclear Power Plant Accidents**

Kristen Yu (LLNL) and Harvey Clark (RSL)



LLNL-PRES-609133 (IND +CB)

LLNL-PRES-659598 (NPP)

LLNL-PRES- 665558 (RDD)

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344. The Department of Homeland Security sponsored part of the production of this material.



# Nuclear Power Plant (NPP) Accident Briefing Product Set

NPP Briefing Product Set contains six products for three phases of an incident:

## Early Phase:

1. Evacuation/Sheltering Areas Based on EPA/DHS Guides (cloud present/ passed)
2. Worker Protection Areas
3. Potassium Iodide Administration Areas (for releases involving radioactive iodine)

## Intermediate Phase:

4. Relocation areas based on EPA/DHS Guide
5. Recovery areas based on EPA/DHS Guide

## Late Phase:

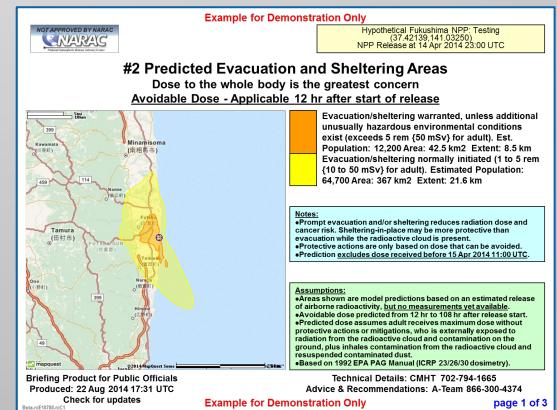
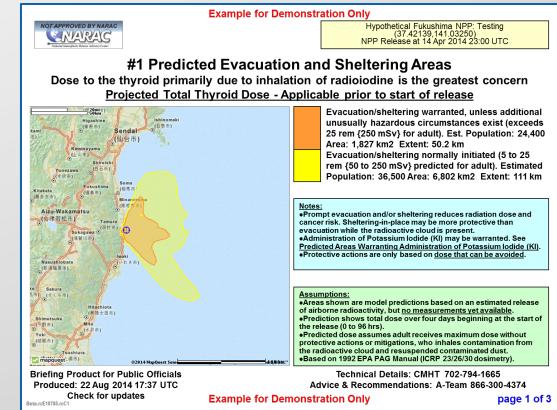
6. Areas of Concern for Agricultural Products

NPP Briefing Product sponsorship: DOE funded format/content design of briefing products and implementation in FY08-FY09; FEMA supported FY14 revision in collaboration with RSL.

# EARLY PHASE

# Predicted Evacuation and Sheltering Areas Based on EPA/DHS Guides

- This product may be used to refine initial default Evacuation and Sheltering decisions
- Contours area displayed are the EPA or DHS PAGs (Protective Action Guidelines)
- Contours depict areas of dose that may be avoided by evacuation and/or sheltering
- Plume footprint may shrink with each update, indicating an updated prediction of avoidable dose
- Product indicates whether the radioactive cloud is still present or has passed
  - May include all plume passage 4-day dose (0-96 hours) or only avoidable dose (default avoidable dose period is 12-108 hours)
  - Considers only dose from ground contamination if the plume has passed
  - May reflect measurements (if indicated in the green box)

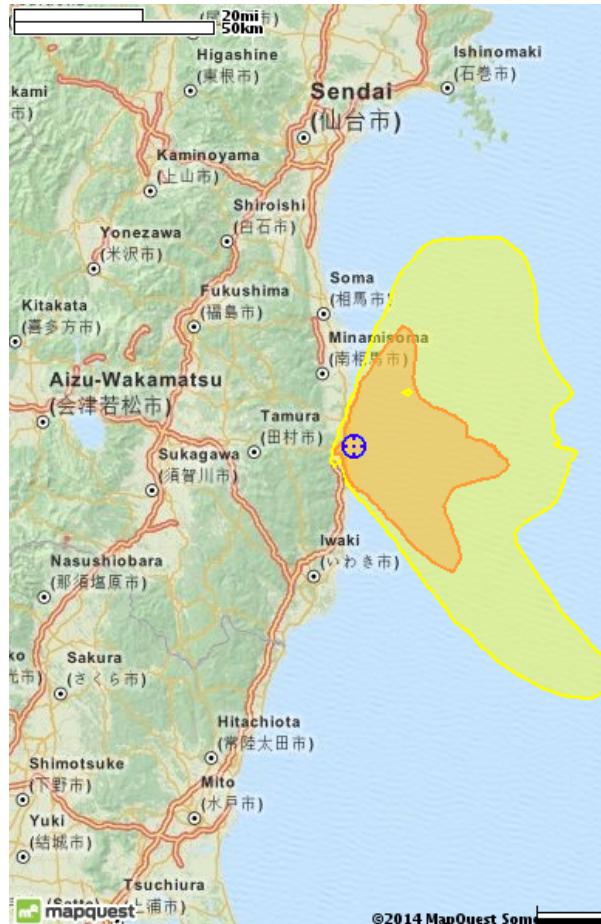


Hypothetical Fukushima NPP: Testing  
 (37.42139,141.03250)  
 NPP Release at 14 Apr 2014 23:00 UTC

# #1 Predicted Evacuation and Sheltering Areas

Dose to the thyroid primarily due to inhalation of radioiodine is the greatest concern

Projected Total Thyroid Dose - Applicable prior to start of release



Evacuation/sheltering warranted, unless additional unusually hazardous circumstances exist (exceeds 25 rem {250 mSv} for adult). Est. Population: 24,400 Area: 1,827 km<sup>2</sup> Extent: 50.2 km

Evacuation/sheltering normally initiated (5 to 25 rem {50 to 250 mSv} predicted for adult). Estimated Population: 36,500 Area: 6,802 km<sup>2</sup> Extent: 111 km

Notes:

- Prompt evacuation and/or sheltering reduces radiation dose and cancer risk. Sheltering-in-place may be more protective than evacuation while the radioactive cloud is present.
- Administration of Potassium Iodide (KI) may be warranted. See Predicted Areas Warranting Administration of Potassium Iodide (KI).
- Protective actions are only based on dose that can be avoided.

Assumptions:

- Areas shown are model predictions based on an estimated release of airborne radioactivity, but no measurements yet available.
- Prediction shows total dose over four days beginning at the start of the release (0 to 96 hrs).
- Predicted dose assumes adult receives maximum dose without protective actions or mitigations, who inhales contamination from the radioactive cloud and resuspended contaminated dust.
- Based on 1992 EPA PAG Manual (ICRP 23/26/30 dosimetry).

## #1 Predicted Evacuation and Sheltering Areas

Dose to the thyroid primarily due to inhalation of radioiodine is the greatest concern  
Projected Total Thyroid Dose - Applicable prior to start of release

### **Key Points**

- EPA's Early Phase Guides provide separate criteria to limit dose to both the whole body and the thyroid. Separate predictions were considered. The Thyroid Dose was found to be the greatest concern and affects the largest area.
- Dose to the thyroid is caused by inhalation of radioiodine.
- Those already outdoors should seek shelter or evacuate per issued recommendation(s).
- Sheltering-in-place may be preferable to evacuation in some cases, such as for limited mobility populations or if unusually hazardous environmental conditions exist.
- Greatest hazard is due to exposure to the radioactive cloud. Sheltering followed by delayed evacuation after cloud passage may be preferable. Evacuation before radioactive cloud arrival is best, but avoid evacuation in the radioactive cloud.
- Predicted dose is accumulated from the start of the release for a period of 96 hours (4 days), specifically 14 Apr 2014 23:00 UTC to 18 Apr 2014 23:00 UTC.
- The airborne radioactive cloud was present until only 17 Apr 2014 05:00 UTC.
- Refer to the separate Briefing Product Predicted Areas Warranting Administration of Potassium Iodide (KI), because administration of KI can reduce thyroid dose.

# #1 Predicted Evacuation and Sheltering Areas

Dose to the thyroid primarily due to inhalation of radioiodine is the greatest concern  
Projected Total Thyroid Dose - Applicable prior to start of release

## Presenter Notes - Additional Information

- PAG - Protective Action Guide is a projected dose at which a specific protective action to reduce or avoid that dose is warranted.
- The EPA Early Phase PAG has a primary guideline for the dose to the whole body and a supplementary guideline for dose to the thyroid and skin.
- Protective actions are based only on dose that can be avoided, not dose acquired prior to implementation of the protective action.
- Reduce radiation dose to minimize long-term cancer risk.
- Evacuation and/or sheltering-in-place is an effective protective action to avoid or reduce both dose to the whole body and dose to the thyroid.
- Sheltering may be the preferred protective action when it will provide protection equal to or greater than evacuation (example: evacuation through a plume).
- No specific minimum level is established for initiation of sheltering.
- Completion of evacuation before plume arrival is best. Evacuation in radioactive cloud may result in more dose than sheltering until cloud passage. Evacuees in cloud should cover mouth & nose with available filter materials (handkerchief).
- Sheltering followed by delayed evacuation may be best if radioactive decay is very rapid (e.g. dominated by radioiodine).
- Thyroid Dose criteria (Committed Dose Equivalent) for evacuation and sheltering are obtained by a modification of the Early Phase PAG's Whole Body Dose (i.e., Total Effective Dose Equivalent) criterion.
  - ◆ Evacuation (or, for some situations, sheltering) should normally be initiated at 5 rem dose to the thyroid.
  - ◆ Because of the higher risk associated with evacuation of some special groups in the population (e.g. those who are not readily mobile), sheltering may be the preferred alternative for such groups as a protective action at projected doses up to 25 rem dose to the thyroid.
  - ◆ Under unusually hazardous environmental conditions use of sheltering at projected doses up to 25 rem dose to the thyroid for the general population (and up to 50 rem dose to the thyroid for special groups) may become justified.
- Thyroid Dose can be reduced by timely administration of stable iodine (KI).
- Protective actions may be initiated over larger areas and at lower contamination/dose levels if advantageous (e.g., in order to account for uncertainties in the predicted dose and mapped areas, and/or to use boundaries, such as roads, that are convenient).

Briefing Product for Public Officials

Produced: 22 Aug 2014 17:37 UTC

Check for updates

## Presenter Notes - Technical Background

- Guidance based on EPA Protective Action Guides (PAGs), as given in:
  - ◆ "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents", (EPA 400-R-92-001, May 1992).
  - ◆ Jetter, J. J. and C. Whitfield. "Effectiveness of Expedient Sheltering in Place in a Residence", Journal of Hazardous Materials. Elsevier, Amsterdam, Holland, 119(1-3):31-40, (2005).
- The PAG for evacuation and/or sheltering is expressed in terms of the committed effective dose to the thyroid due to inhalation of radioactive iodine from 1) Inhalation of the contaminated air as the cloud passes and 2) Inhalation of resuspended contaminated dust.
- Hazard is greatest while the radioactive cloud is present, because both pathways above contribute. After the radioactive cloud passes only inhalation of resuspended contaminated dust will continue to contribute significantly.
- Although Table 2-1 "PAGs for the Early Phase of a Nuclear Incident" of the EPA PAG Manual is the whole body dose criteria, footnote "b" guides how the Early Phase PAGs can be expressed in terms of thyroid dose. "Committed dose equivalents to the thyroid and skin may be 5 and 50 times larger, respectively." Therefore, the dose guidelines for thyroid dose are five times (5X) that for the whole body dose.
- This assessment is based on the ICRP 23/26/30 dosimetry model (1992 EPA PAG Manual). Assessment based on the more recent ICRP 60+ dosimetry model is also available (2013 EPA PAG Manual).
- Prolonged infiltration of contaminated air may diminish the protective value of sheltering-in-place.
- Radioactive contamination is expected outside the contoured areas, but not at levels expected to exceed federal guidelines for evacuation and sheltering based on current information.
- Additional technical and background information is provided in the Consequence Report containing the detailed, technical version of this calculation.
- Briefing Products are intended for presenting a common operating picture to key leaders and decision makers. Other more technical products are available (Standard Products and associated Consequence Reports).
- Contact the FRPCC Subcommittee for Environment, Food and Health (Advisory Team) for advice and recommendations. Available by calling the FDA Emergency Operations Center (EOC) at 866-300-4374.

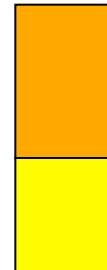
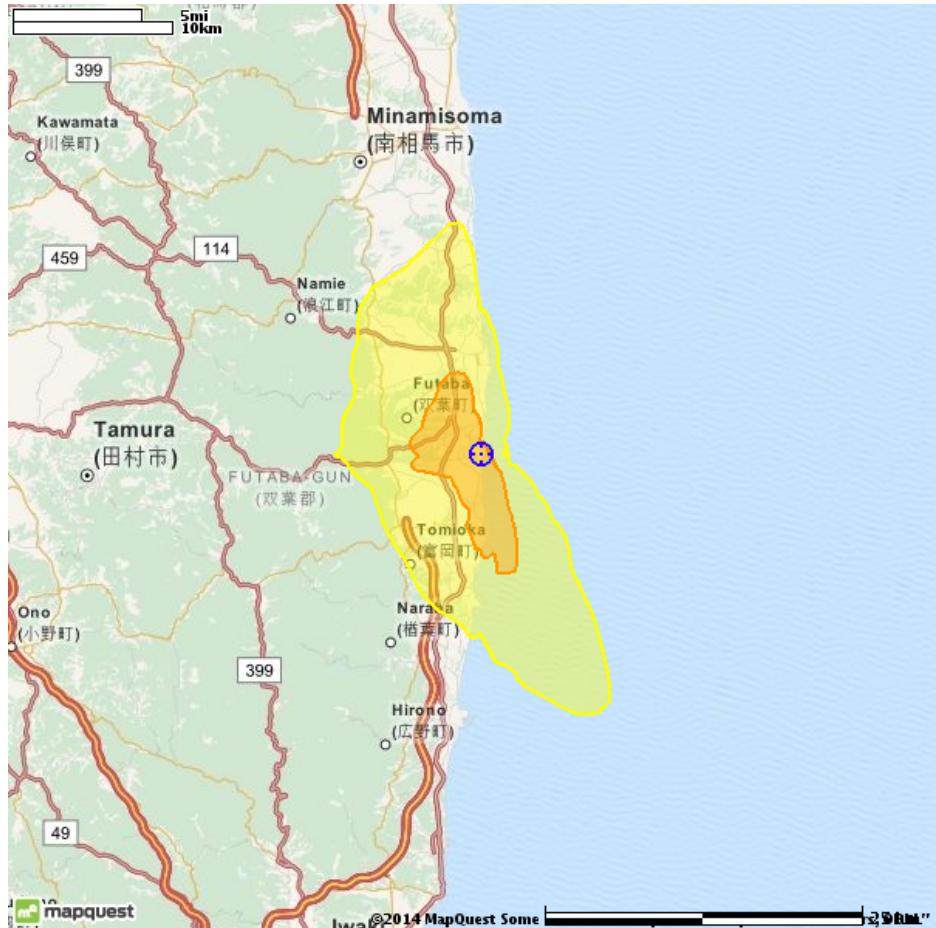
Technical Details: CMHT 702-794-1665

Advice & Recommendations: A-Team 866-300-4374

# #1 Predicted Evacuation and Sheltering Areas

Dose to the whole body is the greatest concern

Projected Total Whole Body Dose - Applicable prior to start of release



Evacuation/sheltering warranted, unless additional unusually hazardous circumstances exist (exceeds 5 rem {50 mSv} predicted for adult). Est.  
Population: 13,700 Area: 59.2 km<sup>2</sup> Extent: 9.5 km  
Evacuation/sheltering normally initiated (1 to 5 rem {10 to 50 mSv} predicted for adult). Estimated  
Population: 64,700 Area: 386 km<sup>2</sup> Extent: 22.2 km

#### Notes:

- Prompt evacuation and/or sheltering reduces radiation dose and cancer risk. Sheltering-in-place may be more protective than evacuation while the radioactive cloud is present.
- Protective actions are only based on dose that can be avoided.

#### Assumptions:

- Areas shown are model predictions based on an estimated release of airborne radioactivity, but no measurements yet available.
- Prediction shows total dose over four days beginning at the start of the release (0 to 96 hrs).
- Predicted dose assumes adult receives maximum dose without protective actions or mitigations, who is externally exposed to radiation from the radioactive cloud and contamination on the ground, plus inhales contamination from the radioactive cloud and resuspended contaminated dust.
- Based on 1992 EPA PAG Manual (ICRP 23/26/30 dosimetry).

## #1 Predicted Evacuation and Sheltering Areas

Dose to the whole body is the greatest concern

Projected Total Whole Body Dose - Applicable prior to start of release

### *Key Points*

- EPA's Early Phase Guides provide separate criteria to limit dose to both the whole body and the thyroid. Separate predictions were considered. The Whole Body Dose was found to be the greatest concern and affects the largest area.
- Generally, the radiation dose to the whole body is most limiting, unless large amounts of radioiodine are present or expected.
- Those already outdoors should seek shelter or evacuate per issued recommendation(s).
- Sheltering-in-place may be preferable to evacuation in some cases, such as for limited mobility populations or if unusually hazardous environmental conditions exist.
- Greatest hazard is due to exposure to the radioactive cloud. Sheltering followed by delayed evacuation after cloud passage may be preferable. Evacuation before radioactive cloud arrival is best, but avoid evacuation in the radioactive cloud.
- Predicted dose is accumulated from the start of the release for a period of 96 hours (4 days), specifically 14 Apr 2014 23:00 UTC to 18 Apr 2014 23:00 UTC.
- The airborne radioactive cloud was present until only 18 Apr 2014 11:15 UTC.

# #1 Predicted Evacuation and Sheltering Areas

Dose to the whole body is the greatest concern

## Projected Total Whole Body Dose - Applicable prior to start of release

### Presenter Notes - Additional Information

- PAG - Protective Action Guide is a projected dose at which a specific protective action to reduce or avoid that dose is warranted.
- The EPA Early Phase PAG has a primary guideline for the dose to the whole body and a supplementary guideline for dose to the thyroid and skin.
- Protective actions are based only on dose that can be avoided, not dose acquired prior to implementation of the protective action.
- Reduce radiation dose to minimize long-term cancer risk.
- Evacuation and/or sheltering-in-place is an effective protective action to avoid or reduce both dose to the whole body and dose to the thyroid.
- Sheltering may be the preferred protective action when it will provide protection equal to or greater than evacuation (example: evacuation through a plume).
- No specific minimum level is established for initiation of sheltering.
- Completion of evacuation before plume arrival is best. Evacuation in radioactive cloud may result in more dose than sheltering until cloud passage. Evacuees in cloud should cover mouth & nose with available filter materials (handkerchief).
- Sheltering followed by delayed evacuation may be best if radioactive decay is very rapid (e.g. dominated by radioiodine).
- Whole Body Dose (i.e. Total Effective Dose Equivalent) criteria for evacuation and sheltering based on EPA Early Phase PAGs:
  - ♦ "Evacuation (or, for some situations, sheltering) should normally be initiated at 1 rem."
  - ♦ "Because of the higher risk associated with evacuation of some special groups in the population (e.g. those who are not readily mobile), sheltering may be the preferred alternative for such groups as a protective action at projected doses up to 5 rem."
  - ♦ "Under unusually hazardous environmental conditions use of sheltering at projected doses up to 5 rem to the general population (and up to 10 rem to special groups) may become justified."
- Protective actions may be initiated over larger areas and at lower contamination/dose levels if advantageous (e.g., in order to account for uncertainties in the predicted dose and mapped areas, and/or to use boundaries, such as roads, that are convenient).

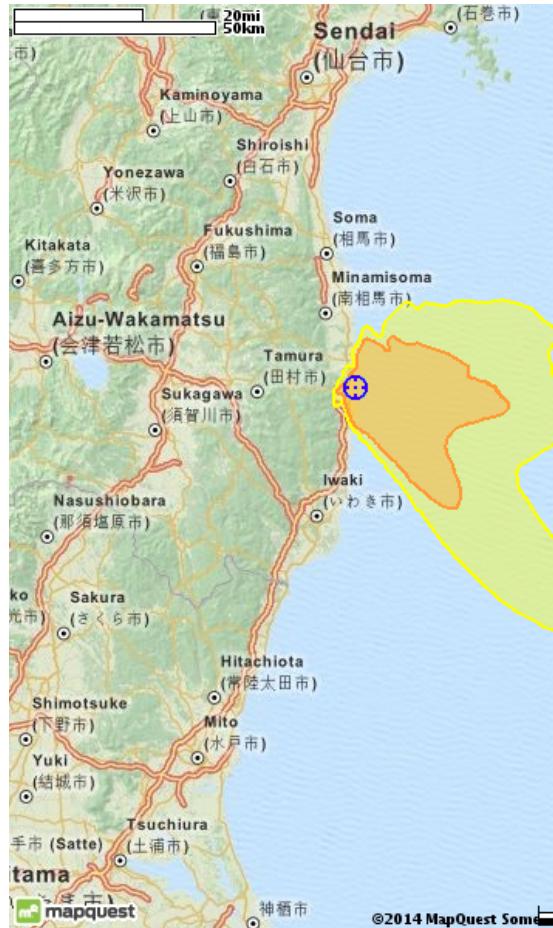
### Presenter Notes - Technical Background

- Guidance based on EPA Protective Action Guides (PAGs), as given in:
  - ♦ "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents", (EPA 400-R-92-001, May 1992).
  - ♦ Jetter, J. J. and C. Whitfield. "Effectiveness of Expedient Sheltering in Place in a Residence", Journal of Hazardous Materials. Elsevier, Amsterdam, Holland, 119(1-3):31-40, (2005).
- "The PAG for evacuation (or, as an alternative in certain cases, sheltering) is expressed in terms of the projected sum of the effective dose from external radiation and the committed effective dose incurred from inhalation of radioactive materials from exposure and intake during the early phase." These include contributions from: 1) External irradiation by the radioactive cloud, 2) Inhalation of the contaminated air as it passes, 3) External irradiation by ground contamination, 4) Inhalation of resuspended contaminated dust, and is the Total Effective Dose Equivalent (TEDE).
- Hazard is greatest while the radioactive cloud is present because all four pathways above contribute. After the radioactive cloud passes only 3) Irradiation by ground contamination and 4) Inhalation of resuspended contaminated dust will continue to contribute significantly.
- This assessment is based on the ICRP 23/26/30 dosimetry model (1992 EPA PAG Manual). Assessment based on the more recent ICRP 60+ dosimetry model is also available (2013 EPA PAG Manual).
- Radioactive contamination is expected outside the contoured areas, but not at levels expected to exceed federal guidelines for evacuation and sheltering based on current information.
- Additional technical and background information is provided in the Consequence Report containing the detailed, technical version of this calculation.
- Briefing Products are intended for presenting a common operating picture to key leaders and decision makers. Other more technical products are available (Standard Products and associated Consequence Reports).
- Contact the FRPCC Subcommittee for Environment, Food and Health (Advisory Team) for advice and recommendations. Available by calling the FDA Emergency Operations Center (EOC) at 866-300-4374.

## #2 Predicted Evacuation and Sheltering Areas

Dose to the thyroid due to inhalation or radioiodine is the greatest concern

Avoidable Dose - Applicable 12 hr after start of release



Evacuation/sheltering warranted, unless unusually hazardous environmental conditions exist (exceeds 25 rem {250 mSv} predicted for adult).  
 Est. Population: 17,100 Area: 1,477 km<sup>2</sup> Extent: 49.5 km

Evacuation/sheltering normally initiated (5 to 25 rem {50 to 250 mSv} predicted for adult). Estimated Population: 29,300 Area: 4,944 km<sup>2</sup> Extent: 110 km

**Notes:**

- Prompt evacuation and/or sheltering reduces radiation dose and cancer risk. Sheltering-in-place may be more protective than evacuation while the radioactive cloud is present.
- Administration of Potassium Iodide (KI) may be warranted. See Predicted Areas Warranting Administration of Potassium Iodide (KI).
- Protective actions are only based on dose that can be avoided.
- Prediction excludes dose received before 15 Apr 2014 11:00 UTC.

**Assumptions:**

- Areas shown are model predictions based on an estimated release of airborne radioactivity, but no measurements yet available.
- Avoidable dose predicted from 12 hr to 108 hr after release start.
- Predicted dose assumes adult receives maximum dose without protective actions or mitigations, who inhales contamination from the radioactive cloud and resuspended contaminated dust.
- Based on 1992 EPA PAG Manual (ICRP 23/26/30 dosimetry).

## #2 Predicted Evacuation and Sheltering Areas

Dose to the thyroid due to inhalation or radioiodine is the greatest concern  
Avoidable Dose - Applicable 12 hr after start of release

### **Key Points**

- T+12 hr period predicts the remaining future dose because it may not be practical to implement or complete protective actions by that time.
- The EPA's Early Phase Guides provide separate criteria to limit dose to both the whole body and the thyroid. Separate predictions were considered. The Thyroid Dose was found to be the greatest concern and affects the largest area.
- Dose to the thyroid is caused by inhalation of radioiodine.
- Sheltering-in-place may be preferable to evacuation in some cases, such as for limited mobility populations or if unusually hazardous environmental conditions exist.
- Prolonged infiltration of contaminated air may diminish the value of sheltering-in-place.
- The area still technically warranting evacuation and/or sheltering may be smaller following passage of the radioactive cloud, because it no longer contributes to dose.
- Predicted dose is accumulated from 12 hr after the start of the release for a period of 96 hours (4 days), specifically 15 Apr 2014 11:00 UTC to 19 Apr 2014 11:00 UTC.
- The airborne radioactive cloud was present until only 17 Apr 2014 05:00 UTC.
- Refer to the separate Briefing Product Predicted Areas Warranting Administration of Potassium Iodide (KI), because administration of KI can reduce thyroid dose.

## #2 Predicted Evacuation and Sheltering Areas

Dose to the thyroid due to inhalation or radioiodine is the greatest concern  
Avoidable Dose - Applicable 12 hr after start of release

### Presenter Notes - Additional Information

- PAG - Protective Action Guide is a projected dose at which a specific protective action to reduce or avoid that dose is warranted.
- The EPA Early Phase PAG has a primary guideline for the dose to the whole body and a supplementary guideline for dose to the thyroid and skin.
- Protective actions are based only on dose that can be avoided, not dose acquired prior to implementation of the protective action.
- Reduce radiation dose to minimize long-term cancer risk.
- Evacuation and/or sheltering-in-place is an effective protective action to avoid or reduce both dose to the whole body and dose to the thyroid.
- Sheltering may be the preferred protective action when it will provide protection equal to or greater than evacuation (example: evacuation through a plume).
- No specific minimum level is established for initiation of sheltering.
- Sheltering followed by delayed evacuation may be best if radioactive decay is very rapid (e.g. dominated by radioiodine).
- Computed using source term and meteorology predicted at T+12 hr, excludes contribution from 1st 12 hr.
- Thyroid Dose criteria (Committed Dose Equivalent) for evacuation and sheltering are obtained by a modification of the Early Phase PAG's Whole Body Dose (i.e., Total Effective Dose Equivalent) criterion.
  - ♦ Evacuation (or, for some situations, sheltering) should normally be initiated at 5 rem {50 mSv} dose to the thyroid.
  - ♦ Because of the higher risk associated with evacuation of some special groups in the population (e.g. those who are not readily mobile), sheltering may be the preferred alternative as a protective action at projected doses up to 25 rem {250 mSv} to the thyroid.
  - ♦ Under unusually hazardous environmental conditions use of sheltering at projected doses up to 25 rem {250 mSv} to the thyroid for the general population (and up to 50 rem {500 mSv} dose to the thyroid for special groups) may become justified.
- Thyroid Dose can be reduced by timely administration of stable iodine (KI).
- Protective actions may be initiated over larger areas and at lower contamination/dose levels if advantageous (e.g., in order to account for uncertainties in the predicted dose and mapped areas, and/or to use boundaries, such as roads, that are convenient).

Briefing Product for Public Officials  
Produced: 22 Aug 2014 17:37 UTC  
Check for updates

Example for Demonstration Only

Technical Details: CMHT 702-794-1665

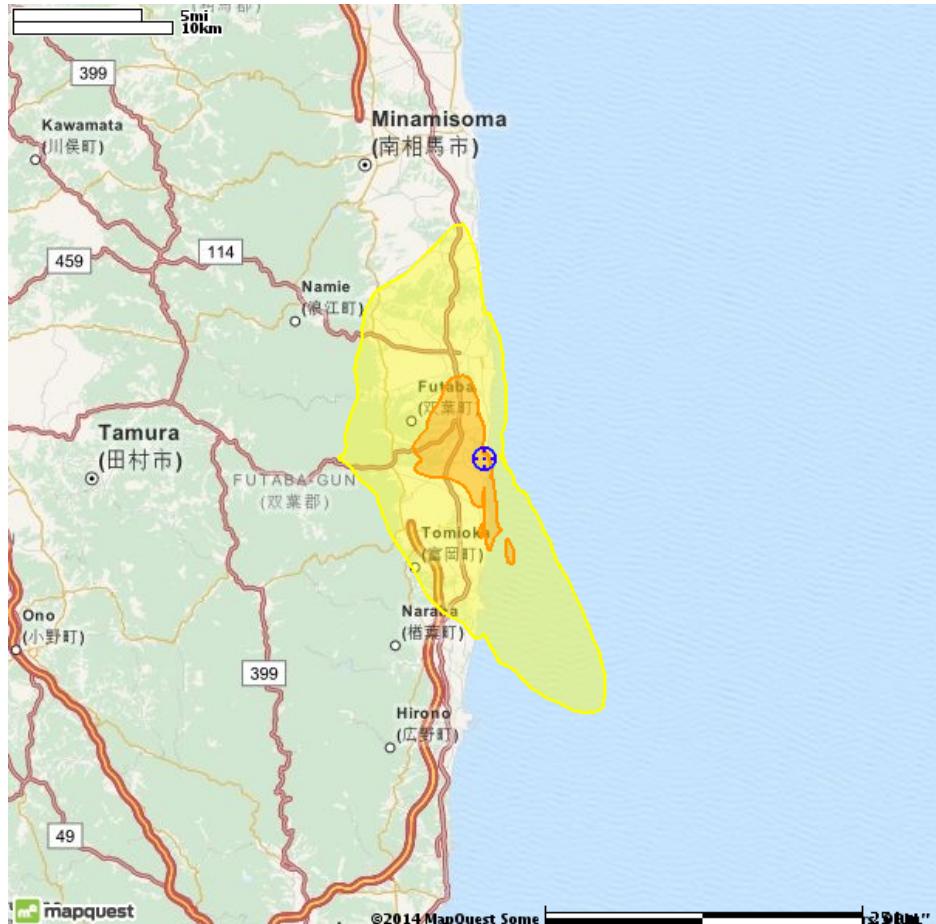
Advice & Recommendations: A-Team 866-300-4374

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## #2 Predicted Evacuation and Sheltering Areas

Dose to the whole body is the greatest concern

Avoidable Dose - Applicable 12 hr after start of release



**Evacuation/sheltering warranted, unless additional unusually hazardous environmental conditions exist (exceeds 5 rem {50 mSv} for adult). Est. Population: 12,200 Area: 42.5 km<sup>2</sup> Extent: 8.5 km**  
**Evacuation/sheltering normally initiated (1 to 5 rem {10 to 50 mSv} for adult). Estimated Population: 64,700 Area: 367 km<sup>2</sup> Extent: 21.6 km**

### Notes:

- Prompt evacuation and/or sheltering reduces radiation dose and cancer risk. Sheltering-in-place may be more protective than evacuation while the radioactive cloud is present.
- Protective actions are only based on dose that can be avoided.
- Prediction excludes dose received before 15 Apr 2014 11:00 UTC.

### Assumptions:

- Areas shown are model predictions based on an estimated release of airborne radioactivity, but no measurements yet available.
- Avoidable dose predicted from 12 hr to 108 hr after release start.
- Predicted dose assumes adult receives maximum dose without protective actions or mitigations, who is externally exposed to radiation from the radioactive cloud and contamination on the ground, plus inhales contamination from the radioactive cloud and resuspended contaminated dust.
- Based on 1992 EPA PAG Manual (ICRP 23/26/30 dosimetry).

## #2 Predicted Evacuation and Sheltering Areas

Dose to the whole body is the greatest concern

Avoidable Dose - Applicable 12 hr after start of release

### **Key Points**

- T+12 hr period predicts the remaining future dose because it may not be practical to implement or complete protective actions by that time.
- The EPA's Early Phase Guides provide separate criteria to limit dose to both the whole body and the thyroid. Separate predictions were considered. The Whole Body Dose was found to be the greatest concern and affects the largest area.
- Generally, the radiation dose to the whole body is most limiting, unless large amounts of radioiodine are present or expected.
- Sheltering-in-place may be preferable to evacuation in some cases, such as for limited mobility populations or if unusually hazardous environmental conditions exist.
- Prolonged infiltration of contaminated air may diminish the value of sheltering-in-place.
- The area still technically warranting evacuation and/or sheltering may be smaller following passage of the radioactive cloud, because it no longer contributes to dose.
- Predicted dose is accumulated from 12 hr after the start of the release for a period of 96 hours (4 days), specifically 15 Apr 2014 11:00 UTC to 19 Apr 2014 11:00 UTC.
- The airborne radioactive cloud was present until only 18 Apr 2014 11:15 UTC.

## #2 Predicted Evacuation and Sheltering Areas

Dose to the whole body is the greatest concern

Avoidable Dose - Applicable 12 hr after start of release

### Presenter Notes - Additional Information

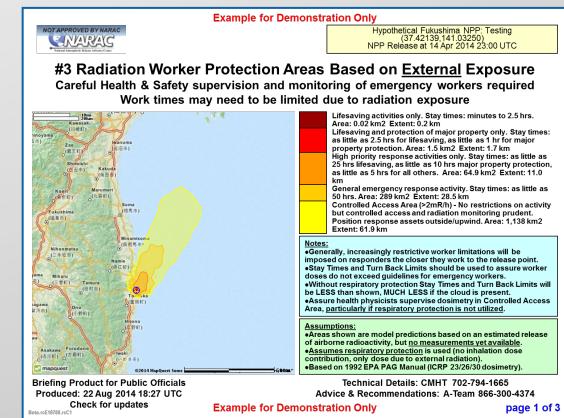
- PAG - Protective Action Guide is a projected dose at which a specific protective action to reduce or avoid that dose is warranted.
- The EPA Early Phase PAG has a primary guideline for the dose to the whole body and a supplementary guideline for dose to the thyroid and skin.
- Protective actions are based only on dose that can be avoided, not dose acquired prior to implementation of the protective action.
- Reduce radiation dose to minimize long-term cancer risk.
- Evacuation and/or sheltering-in-place is an effective protective action to avoid or reduce both dose to the whole body and dose to the thyroid.
- Sheltering may be the preferred protective action when it will provide protection equal to or greater than evacuation (example: evacuation through a plume).
- No specific minimum level is established for initiation of sheltering.
- Sheltering followed by delayed evacuation may be best if radioactive decay is very rapid (e.g. dominated by radioiodine).
- Computed using source term and meteorology predicted at T+12 hr, excludes contribution from 1st 12 hr.
- Whole Body Dose (i.e. Total Effective Dose Equivalent) criteria for evacuation and sheltering based on EPA Early Phase PAGs:
  - ♦ "Evacuation (or, for some situations, sheltering) should normally be initiated at 1 rem."
  - ♦ "Because of the higher risk associated with evacuation of some special groups in the population (e.g. those who are not readily mobile), sheltering may be the preferred alternative for such groups as a protective action at projected doses up to 5 rem."
  - ♦ "Under unusually hazardous environmental conditions use of sheltering at projected doses up to 5 rem to the general population (and up to 10 rem to special groups) may become justified."
- Protective actions may be initiated over larger areas and at lower contamination/dose levels if advantageous (e.g., in order to account for uncertainties in the predicted dose and mapped areas, and/or to use boundaries, such as roads, that are convenient).

### Presenter Notes - Technical Background

- Guidance based on EPA Protective Action Guides (PAGs), as given in:
  - ♦ "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents", (EPA 400-R-92-001, May 1992).
  - ♦ Jetter, J.J. and C. Whitfield. "Effectiveness of Expedient Sheltering in Place in a Residence", Journal of Hazardous Materials. Elsevier, Amsterdam, Holland, 119(1-3):31-40, (2005).
- "The PAG for evacuation (or, as an alternative in certain cases, sheltering) is expressed in terms of the projected sum of the effective dose from external radiation and the committed effective dose incurred from inhalation of radioactive materials from exposure and intake during the early phase." These include: 1) External irradiation by the radioactive cloud, 2) Inhalation of the contaminated air as it passes, 3) External irradiation by ground contamination, 4) Inhalation of contaminated dust, and is the Total Effective Dose Equivalent (TEDE).
- Hazard is greatest while the radioactive cloud is present because all four pathways above contribute. After the radioactive cloud passes only 3) Irradiation by ground contamination and 4) Inhalation of resuspended contaminated dust will continue to contribute.
- This assessment is based on the ICRP 23/26/30 dosimetry model (1992 EPA PAG Manual). Assessment based on the more recent ICRP 60+ dosimetry model is also available (2013 EPA PAG Manual).
- Radioactive contamination is expected outside the contoured areas, but not at levels expected to exceed federal guidelines for evacuation and sheltering based on current information.
- Additional technical and background information is provided in the Consequence Report containing the detailed, technical version of this calculation.
- Briefing Products are intended for presenting a common operating picture to key leaders and decision makers. Other more technical products are available (Standard Products and associated Consequence Reports).
- Contact the FRPCC Subcommittee for Environment, Food and Health (Advisory Team) for advice and recommendations. Available by calling the FDA Emergency Operations Center (EOC) at 866-300-4374.

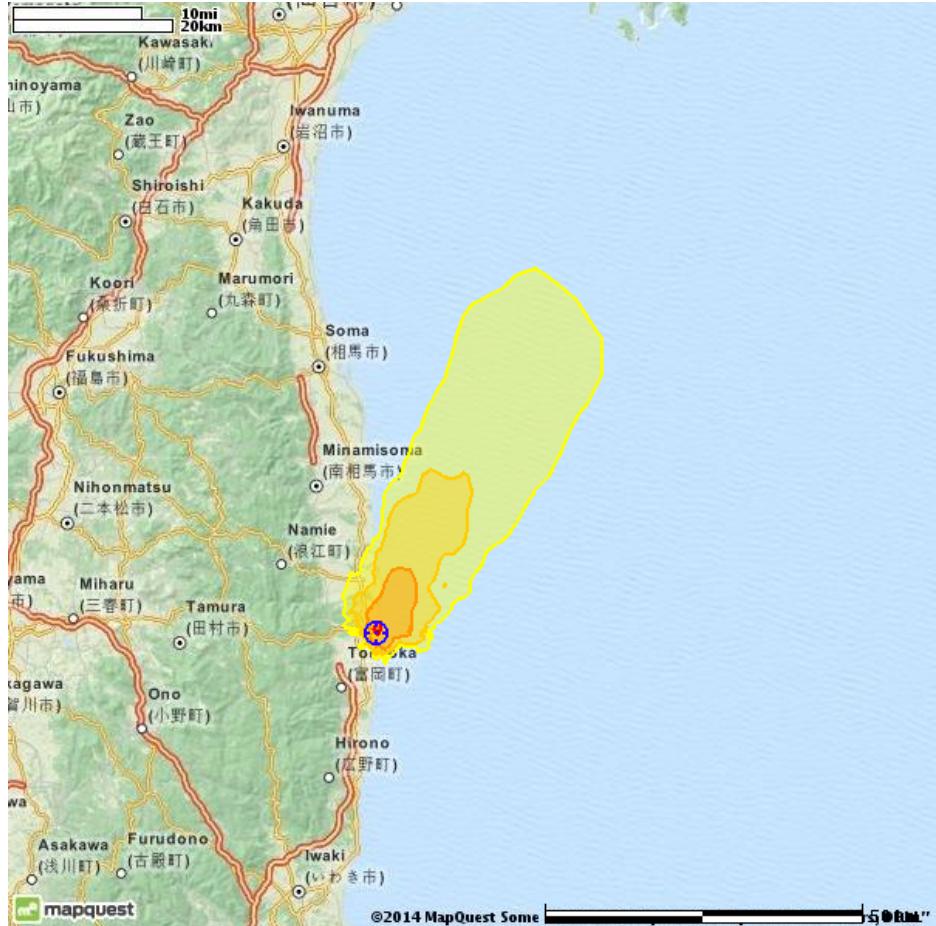
# Worker Protection Areas Determined From Exposure Rates

- This product is used by dose assessment personnel to plan the tasks of Emergency Workers
  - Product displays an exposure rate at a specific time
  - Emergency Worker Stay Times are predicted based on that exposure rate
  - Note: if the radiation involved is decaying rapidly, this product will change significantly over time
- Contours displayed are the EPA or DHS worker guidelines and CRCPD guidance
- Product also may be used to estimate the ongoing dose received by the unsheltered general population
- May reflect measurements (indicated in the green box)



## #3 Radiation Worker Protection Areas Based on External Exposure

Careful Health & Safety supervision and monitoring of emergency workers required  
 Work times may need to be limited due to radiation exposure



	Lifesaving activities only. Stay times: minutes to 2.5 hrs. Area: 0.02 km <sup>2</sup> Extent: 0.2 km
	Lifesaving and protection of major property only. Stay times: as little as 2.5 hrs for lifesaving, as little as 1 hr for major property protection. Area: 1.5 km <sup>2</sup> Extent: 1.7 km
	High priority response activities only. Stay times: as little as 25 hrs lifesaving, as little as 10 hrs major property protection, as little as 5 hrs for all others. Area: 64.9 km <sup>2</sup> Extent: 11.0 km
	General emergency response activity. Stay times: as little as 50 hrs. Area: 289 km <sup>2</sup> Extent: 28.5 km
	Controlled Access Area (>2mR/h) - No restrictions on activity but controlled access and radiation monitoring prudent. Position response assets outside/upwind. Area: 1,138 km <sup>2</sup> Extent: 61.9 km

### Notes:

- Generally, increasingly restrictive worker limitations will be imposed on responders the closer they work to the release point.
- Stay Times and Turn Back Limits should be used to assure worker doses do not exceed guidelines for emergency workers.
- Without respiratory protection Stay Times and Turn Back Limits will be LESS than shown, MUCH LESS if the cloud is present.
- Assure health physicists supervise dosimetry in Controlled Access Area, particularly if respiratory protection is not utilized.

### Assumptions:

- Areas shown are model predictions based on an estimated release of airborne radioactivity, but no measurements yet available.
- Assumes respiratory protection is used (no inhalation dose contribution, only dose due to external radiation).
- Based on 1992 EPA PAG Manual (ICRP 23/26/30 dosimetry).

## #3 Radiation Worker Protection Areas Based on External Exposure

Careful Health & Safety supervision and monitoring of emergency workers required

Work times may need to be limited due to radiation exposure

### **Key Points**

- Product portrays areas where responder work times may be limited to protect workers.
- Occupational limits do not apply to emergencies. Instead, dose guidelines are provided for emergency response. Different guidelines apply to 1) lifesaving, 2) protection of major property and 3) any other emergency response work. Avoid exceeding guidelines.
- Radiation doses to emergency workers are voluntary and require informed consent.
- Emergency workers do not "burn out" if the guideline is exceeded, but must consent to additional radiation exposure/dose to continue work in a radiation area.
- Response activities must be prioritized and carefully planned to obtain the maximum benefit from the least amount of worker exposure.
- Work controls may limit time in radiation area (Stay Time) and require stop work and retreat in high radiation areas (Turn Back Limits).
- Map assumes respiratory protection is used to prevent dose due to inhalation of radioactivity in the radioactive cloud or in contaminated dust.
- For purposes of limiting worker radiation dose, doses accumulate day-by-day.
- Strive to keep exposures As-Low-As-Reasonably-Achievable (ALARA).
- Engage assistance of health physics professionals for specific guidance ASAP.
- This map product is valid at 15 Apr 2014 11:00 UTC .

## #3 Radiation Worker Protection Areas Based on External Exposure

### Careful Health & Safety supervision and monitoring of emergency workers required

### Work times may need to be limited due to radiation exposure

#### Presenter Notes - Additional Information

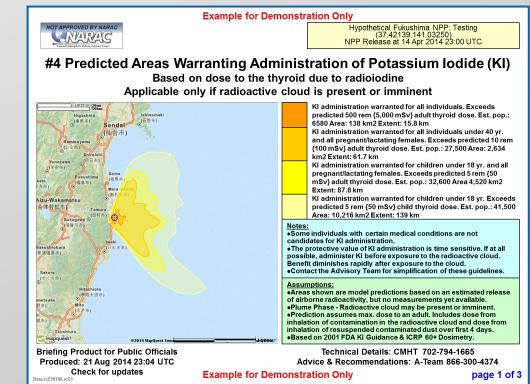
- Map assumes external exposure rate is essentially equivalent to total dose rate (1 mrem/h = 1 mR/h = 0.01mSv/h), because utilization of respiratory protection is assumed.
- The total dose may be up to 100 times greater than the external exposure indicated on a personal dosimeter, if respiratory protection is not used while the radioactive cloud is present.
- Even if the cloud has passed the multiplier can still be significant due to resuspended material/contamination.
- CMHT can provide this exposure rate to total dose multiplier (conversion factor).
- If radioiodine is present in the radioactive cloud, then the use of Potassium Iodide (KI) may be indicated. Seek advice of health physics professionals.
- All radiation exposures require informed consent, particularly those exceeding routine occupational limits (5 rem {50mSv}), such as for lifesaving or protection of valuable property activities.
- An individual's radiation dose is a cumulative total of their dose received each day or work period.
- Plan activities to make exposures As-Low-As-Reasonably-Achievable (ALARA).
  - ◆ Plan work to minimize exposure time
  - ◆ Avoid lingering in areas with radiation levels over 2 mR/h (0.02 mSv/h)
  - ◆ Take advantage of available shielding (trucks, walls...)
  - ◆ Position assets outside the Controlled Access Area boundary and upwind if possible
  - ◆ Use respiratory protection, until demonstrated as unnecessary
  - ◆ Avoid, or minimize, eating or drinking in radiation areas to the extent practical.
- Assure health physics professionals are involved in worker safety oversight.
- The CMHT can provide predictions of total dose rate for those without respiratory protection. This includes guidance for use of Electronic Personal Dosimeters (EPDs).

#### Presenter Notes - Technical Background

- Guidance based on EPA/DHS PAGs as given in:
  - ◆ "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents", (EPA 400-R-92-001, May 1992).
- This assessment is based on the ICRP 23/26/30 dosimetry model (1992 EPA PAG Manual). Assessment based on the more recent ICRP 60+ dosimetry model is also available (2013 EPA PAG Manual).
- Lifesaving dose guideline is 25 rem (250 mSv) for the event, which assures exposures will not produce acute health effects.
- Protection of valuable property dose guideline is 10 rem for an event.
- A dose guideline applies to all other general emergency response work
- Emergency responders without radiological worker training or monitoring should remain outside the 2 mR/h (0.02 mSv/h) boundary, if possible.
- Contour levels correspond to predicted exposure rate levels of:
  - 10,000 mR/h, 1,000 mR/h, 100 mR/h, 10 mR/h, 2mR/h
  - {100 mSv/h, 10 mSv/h, 1 mSv/h, 0.1 mSv/h, 0.02 mSv/h}
- Fewer than five contours may be shown if some of these higher thresholds are not reached.
- EPA's emergency dose guidelines apply to emergency response workers. However, not all organizations use these EPA limits.
- Lower dose guidelines apply to the general public.
- Consult a health physics professional to evaluate the benefit and added risk of various types of PPE.
- Radioactive contamination is expected outside the contoured areas, but not at levels currently expected to exceed federal guidelines.
- Additional technical and background information is provided in the Consequence Report containing the detailed, technical version of this calculation.
- Briefing Products are intended for presenting a common operating picture to key leaders and decision makers. Other more technical products are available (Standard Products and associated Consequence Reports).
- Contact the FRPCC Subcommittee for Environment, Food and Health (Advisory Team) for advice and recommendations. Available by calling FDA Emergency Operations Center (EOC) at 866-300-4374.

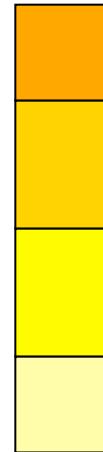
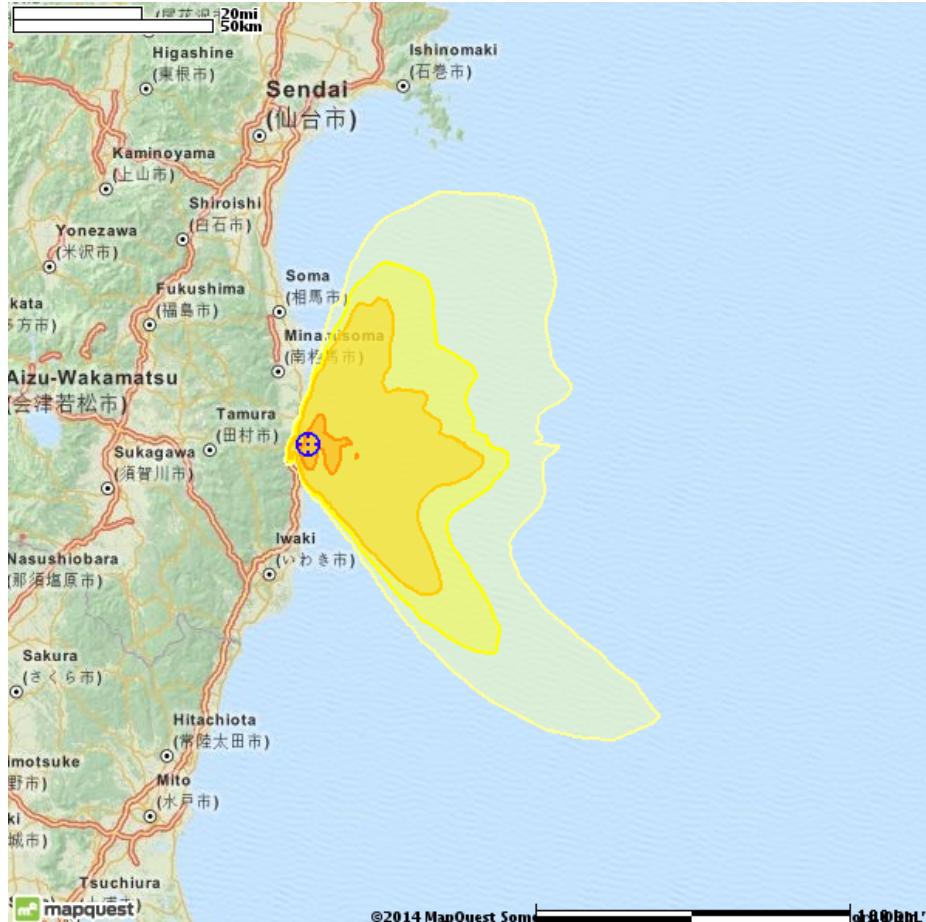
# Predicted Areas Warranting Administration of Potassium Iodide (KI)

- This product is provided for cases in which radioactive iodine is released
- Product is used to determine whether administration of potassium iodide (KI) may be warranted to protect against the risk of thyroid cancer
- Product is based on predicted dose from inhalation of the radioactive cloud during plume passage and resuspended dust from ground contamination over the first four days
- Contours displayed are based on the 2001 Food and Drug Administration Protective Action Guide, which considers the thyroid dose for different age groups and special cases
- Use of KI may be an effective alternative to evacuation for cases involving radioiodine releases



## #4 Predicted Areas Warranting Administration of Potassium Iodide (KI)

Based on dose to the thyroid due to radioiodine  
 Applicable only if radioactive cloud is present or imminent



KI administration warranted for all individuals. Exceeds predicted 500 rem {5,000 mSv} adult thyroid dose. Est. pop.: 6580 Area: 138 km<sup>2</sup> Extent: 15.8 km  
 KI administration warranted for all individuals under 40 yr. and all pregnant/lactating females. Exceeds predicted 10 rem {100 mSv} adult thyroid dose. Est. pop.: 27,500 Area: 2,634 km<sup>2</sup> Extent: 61.7 km  
 KI administration warranted for children under 18 yr. and all pregnant/lactating females. Exceeds predicted 5 rem {50 mSv} adult thyroid dose. Est. pop.: 32,600 Area 4,520 km<sup>2</sup> Extent: 87.8 km  
 KI administration warranted for children under 18 yr. Exceeds predicted 5 rem {50 mSv} child thyroid dose. Est. pop.: 41,500 Area: 10,216 km<sup>2</sup> Extent: 139 km

### Notes:

- Some individuals with certain medical conditions are not candidates for KI administration.
- The protective value of KI administration is time sensitive. If at all possible, administer KI before exposure to the radioactive cloud. Benefit diminishes rapidly after exposure to the cloud.
- Contact the Advisory Team for simplification of these guidelines.

### Assumptions:

- Areas shown are model predictions based on an estimated release of airborne radioactivity, but no measurements yet available.
- Plume Phase - Radioactive cloud may be present or imminent.
- Prediction assumes max. dose to an adult. Includes dose from inhalation of contamination in the radioactive cloud and dose from inhalation of resuspended contaminated dust over first 4 days.
- Based on 2001 FDA KI Guidance & ICRP 60+ Dosimetry.

## #4 Predicted Areas Warranting Administration of Potassium Iodide (KI)

Based on dose to the thyroid due to radioiodine

Applicable only if radioactive cloud is present or imminent

### ***Key Points***

- Utilization of KI is a supplemental action. Evacuation is the primary protective action.
- Use of KI may be an effective alternative to evacuation in cases involving radioiodine releases, if evacuation cannot be implemented or exposure occurs during evacuation. See Predicted Evacuation and Sheltering Areas products for evacuation/shelter guidance.
- Leaving shelter to seek KI may result in increased radiation dose.
- The simplified approach under consideration would suggest KI administration for all members of the entire public at a single dose level, rather than four tiered dose levels.
- Potassium Iodide only protects the thyroid from radioiodine. It has not protective value for other radionuclides or for any other organ.
- Radiation dose to the thyroid increases the risk of thyroid cancer.
- KI is most effective when administered immediately prior to exposure to the plume, but significant protection can be provided even if administration is delayed 3 or 4 hours after initial exposure.
- Predicted thyroid dose is accumulated from the start of the release for a period of 96 hours (4 days), specifically 14 Apr 2014 23:00 UTC to 0 hr.

## #4 Predicted Areas Warranting Administration of Potassium Iodide (KI)

Based on dose to the thyroid due to radioiodine  
 Applicable only if radioactive cloud is present or imminent

### Presenter Notes - Additional Information

- This product is based on the 2001 FDA KI administration guidance.
- Radiation dose to the thyroid increases the risk of thyroid cancer.
- Radioiodine inhalation is the strongest contributor to thyroid dose.
- Potassium Iodide blocks most of the absorption of radioiodine by the thyroid.
- The area on the graphic describing KI administration to children under 18 is actually for the most limiting child age group (1 year-old infant).
- The FDA guide reports:
  - ♦ "The protective effects of KI last approximately 24 hours. For optimal prophylaxis, KI should therefore be dosed daily, until a risk of significant exposure to radioiodines by either inhalation or ingestion no longer exists."
  - ♦ "The overall benefits of KI far exceed the risks of overdosing, especially in children, though we continue to emphasize particular attention to dose in infants."
  - ♦ "KI may still have a substantial protective effect even if taken 3 or 4 hours after exposure" (the older EPA guide says 1 or 2 hours).
- Age specific dosages are established. Contact medical and radiation health professionals for radiation guidance.
- Prolonged radioiodine exposure may require subsequent administration of KI. Repeat dosing should be avoided for newborns, pregnant and lactating women. Consult medical professionals.

### Presenter Notes - Technical Background

- Guidance based on the new FDA KI PAG as given in:
  - ♦ "Guidance: Potassium Iodide as a Thyroid Blocking Agent in Radiation Emergencies", (U.S. Department of Health and Human Services Food and Drug Administration, Center for Drug Evaluation and Research (CDER), December 2001, Procedural)
- This prediction employs the updated ICRP 60+ dosimetry model and dose factors.
- A simplified approach to KI administration is under consideration, which would provide KI to the entire public if the projected child thyroid dose exceeds 5 rem (50 mSv).
- Potassium Iodide (KI) preferentially deposits in the thyroid whether inhaled or ingested. Inhalation of contaminated air is the concern while the cloud is present. Inhalation of radioiodine is a particularly large contributor to thyroid dose.
- The FDA KI guide recommends these KI dosages if the following potential thyroid doses are exceeded:

Group	Potential Thyroid Dose	KIDosage
♦ Adults over 40	> or = 500 rem {5,000 mSv}	130 mg
♦ Adults 18 to 40	> or = 10 rem {100 mSv}	130 mg
♦ Pregnant/lactating women	> or = 5 rem {50mSv}	130 mg
♦ Adolescents 12 to 18	> or = 5 rem {50mSv}	65 mg
♦ Children 3 to 12	> or = 5 rem {50mSv}	65 mg
♦ Infant 1 mo to 3 yr	> or = 5 rem {50 mSv}	32 mg
♦ Infant birth to 1 mo	> or = 5 rem {50 mSv}	16 mg

- Contaminated air will be found outside contoured areas, but not at levels expected to exceed FDA guidelines for KI administration.
- Additional technical and background information is provided in the Consequence Report containing the detailed, technical version of this calculation.
- Briefing Products are intended for presenting a common operating picture to key leaders and decision makers. Other more technical products are available (Standard Products and associated Consequence Reports).
- Contact the FRPCC Subcommittee for Environment, Food and Health (Advisory Team) for advice and recommendations. Available by calling the FDA Emergency Operations Center (EOC) at 866-300-4374.

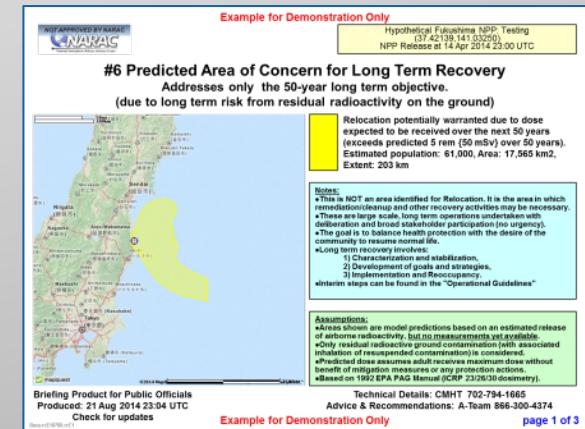
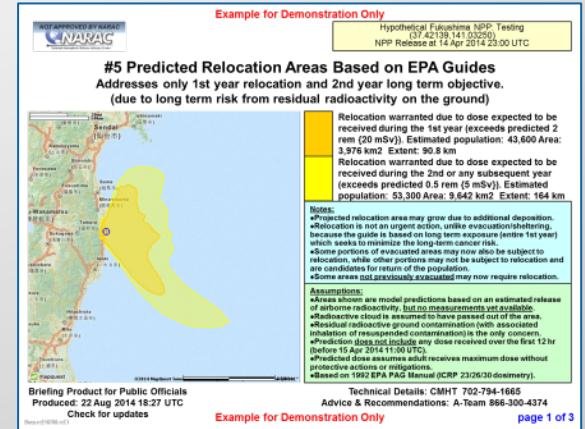
Technical Details: CMHT 702-794-1665

Advice & Recommendations: A-Team 866-300-4374

# INTERMEDIATE PHASE

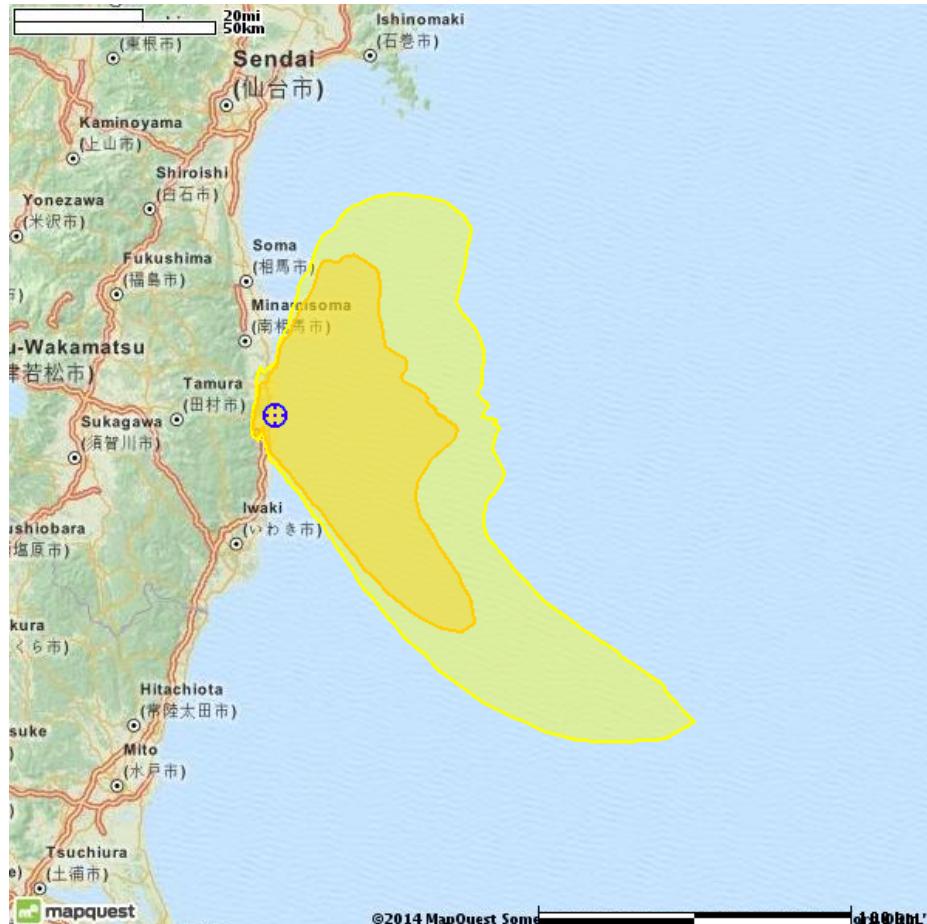
# Predicted Relocation Areas Based on EPA/DHS Guides

- These products are used to determine the dose that may be avoided in the long term (1 to 2 years or 50 years) if the population is relocated
- Contours displayed are the EPA or DHS PAGs (Protective Action Guides)
- By this time, the plume will most likely have passed and the dose received will be from ground contamination, either by direct exposure or via inhalation of resuspended material
- May reflect measurements (as indicated in the green box)



## #5 Predicted Relocation Areas Based on EPA Guides

Addresses only 1st year relocation and 2nd year long term objective.  
 (due to long term risk from residual radioactivity on the ground)



Relocation warranted due to dose expected to be received during the 1st year (exceeds predicted 2 rem {20 mSv}). Estimated population: 43,600 Area: 3,976 km<sup>2</sup> Extent: 90.8 km

Relocation warranted due to dose expected to be received during the 2nd or any subsequent year (exceeds predicted 0.5 rem {5 mSv}). Estimated population: 53,300 Area: 9,642 km<sup>2</sup> Extent: 164 km

### Notes:

- Projected relocation area may grow due to additional deposition.
- Relocation is not an urgent action, unlike evacuation/sheltering, because the guide is based on long term exposure (entire 1st year) which seeks to minimize the long-term cancer risk.
- Some portions of evacuated areas may now also be subject to relocation, while other portions may not be subject to relocation and are candidates for return of the population.
- Some areas not previously evacuated may now require relocation.

### Assumptions:

- Areas shown are model predictions based on an estimated release of airborne radioactivity, but no measurements yet available.
- Radioactive cloud is assumed to have passed out of the area.
- Residual radioactive ground contamination (with associated inhalation of resuspended contamination) is the only concern.
- Prediction does not include any dose received over the first 12 hr (before 15 Apr 2014 11:00 UTC).
- Predicted dose assumes adult receives maximum dose without protective actions or mitigations.
- Based on 1992 EPA PAG Manual (ICRP 23/26/30 dosimetry).

## #5 Predicted Relocation Areas Based on EPA Guides

Addresses only 1st year relocation and 2nd year long term objective.  
(due to long term risk from residual radioactivity on the ground)

### ***Key Points***

- Protective actions are based only on dose that can be avoided.
- Relocation recommendation is based on whole body dose. Thyroid dose is no longer be a concern because any radioiodine originally present has decayed to levels below concern.
- Re-entry into relocated areas is permitted with appropriate controls.
- Separate guidelines are used for the following:
  - ◆ Dose during 1st year (relocation),
  - ◆ Dose during 2nd year or any subsequent year (2nd-year long term objective),
  - ◆ Dose during the next 50 years (50-year long term objective).
- Re-entry into portions of restricted areas (evacuation & relocation) may be permitted for justified reasons with appropriate radiological controls and dose monitoring/tracking.
- Re-entry is temporary, not to be confused with return or reoccupation.
- Predicted dose assumes adult receives maximum dose without benefit of protective actions or mitigations.
- Dose rate will naturally diminish with time due to radioactive decay and weathering.
- Dose reduction measures can be considered, contact Advisory Team (A-Team).

## #5 Predicted Relocation Areas Based on EPA Guides

Addresses only 1st year relocation and 2nd year long term objective.  
 (due to long term risk from residual radioactivity on the ground)

### Presenter Notes - Additional Information

- PAG - Protective Action Guideline, projected dose at which a specific protective action to reduce or avoid that dose is warranted.
- Relocation PAG applies only to dose that can be avoided during the first year and any subsequent year.
- Following early phase response it may be necessary to temporarily relocate the public from areas until decontamination has taken place.
- Areas shown do not include dose received before 15 Apr 2014 11:00 UTC.
- In contrast to the situation during the early phase, when decisions usually must be made and implemented quickly, many relocation decisions and actions during the intermediate phase can be delayed until adequate resources are in place.
- Some groups not previously evacuated may require relocation.
- PAGs are guidance only. During an incident, due to unanticipated local conditions and constraints, professional judgment will be required. Situations can be envisaged in which relocation of the public, based on the recommended PAGs, would be impractical. Conversely, under some conditions relocation may be quite practical at doses below the PAGs.
- Informed judgment must be exercised to prioritize protection for individuals in areas having the highest exposure rates.
- Simple dose reduction efforts are recommended for areas outside the relocation area to reduce doses to the extent practical.
- Re-entry is temporary access to the restricted area under controlled conditions for the purpose of performing activities essential to stabilization, relocation and recovery. Residence is not permitted.
- Dose rate tends to naturally diminish with time due to radioactive decay and weathering of contamination into the soil.
- Dose rate may decline rapidly for the first weeks then slow in subsequent months to years, because radioactive iodine and other short-live radionuclides will nearly vanish but longer-lived radionuclides will persist.
- Protective actions may be initiated over larger areas and at lower contamination/dose levels if advantageous (e.g., in order to account for uncertainties in the predicted dose and mapped areas, and/or to use boundaries, such as roads, that are convenient).

### Presenter Notes - Technical Background

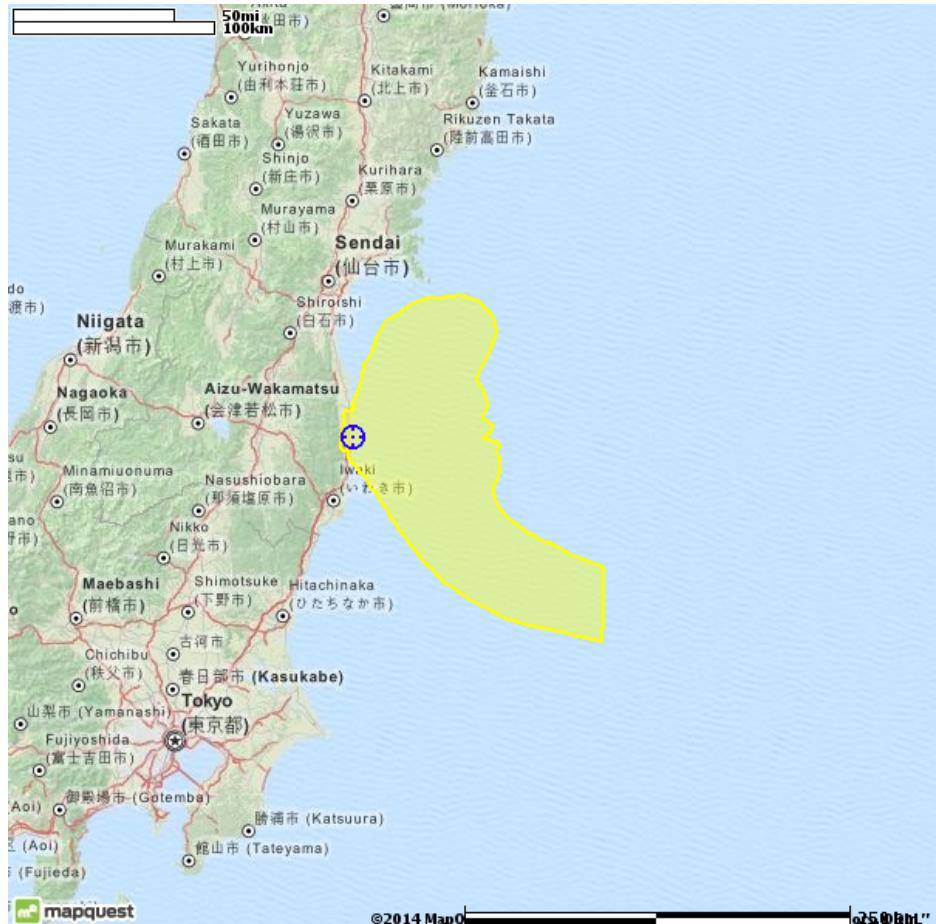
- Guidance based on EPA and DHS PAGs, as given in:  
 ◆ "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents", (EPA 400-R-92-001, May 1992).
- This assessment is based on the ICRP 23/26/30 dosimetry model (1992 EPA PAG Manual). Assessment based on the more recent ICRP 60+ dosimetry model is also available (2013 EPA PAG Manual).
- Dose considered is the projected Total Effective Dose Equivalent (TEDE) which includes external irradiation and inhalation of re-suspended material, accounting for weathering of material and radioactive decay. Only ground contamination contributes to the dose. There is no plume contribution.
- Three separate dose criteria are used: 1) Dose during first year (2 rem) {20 mSv}, 2) Dose during second or any subsequent year (0.5 rem) {5 mSv} 3) Dose over 50 years (5 rem) {50 mSv}.
  - First year dose accumulated from 12 hrs to 1 year + 12 hrs (12 to 8,772 hrs).
  - Second year dose accumulated from beginning to end of year two (i.e. 8,760 hrs to 17,520 hrs). 50 year dose accumulated from 12 hrs to 50 years + 12 hrs.
- Projected dose assumes individuals are unsheltered and unprotected, and no mitigation or remediation actions are taken (maximally exposed individual).
- Dose reduction factors associated with simple, rapid decontamination techniques are not included in calculating projected dose for decisions on relocation, as prescribed by EPA PAGs.
- Some special cases may also require consideration of beta radiation from surface contamination and direct ingestion of contaminated soil.
- The sizes of the relocation and the affected population areas can be reduced by reducing dose in the area by removal/shielding of radioactive material.
- Radioactive contamination is expected outside the contoured areas, but not at levels expected to exceed guidelines for relocation based on current information.
- Additional technical and background information is provided in the Consequence Report containing the detailed, technical version of this calculation.
- Briefing Products are intended for presenting a common operating picture to key leaders and decision makers. Other more technical products are available (Standard Products and associated Consequence Reports).
- Contact the FRPCC Subcommittee for Environment, Food and Health (Advisory Team) for advice and recommendations. Available by calling FDA Emergency Operations Center (EOC) at 866-300-4374.

**Technical Details: CMHT 702-794-1665**

**Advice & Recommendations: A-Team 866-300-4374**

## #6 Predicted Area of Concern for Long Term Recovery

Addresses only the 50-year long term objective.  
 (due to long term risk from residual radioactivity on the ground)



Relocation potentially warranted due to dose expected to be received over the next 50 years (exceeds predicted 5 rem {50 mSv} over 50 years). Estimated population: 61,000, Area: 17,565 km<sup>2</sup>, Extent: 203 km

### Notes:

- This is NOT an area identified for Relocation. It is the area in which remediation/cleanup and other recovery activities may be necessary.
- These are large scale, long term operations undertaken with deliberation and broad stakeholder participation (no urgency).
- The goal is to balance health protection with the desire of the community to resume normal life.
- Long term recovery involves:
  - 1) Characterization and stabilization,
  - 2) Development of goals and strategies,
  - 3) Implementation and Reoccupancy.
- Interim steps can be found in the "Operational Guidelines"

### Assumptions:

- Areas shown are model predictions based on an estimated release of airborne radioactivity, but no measurements yet available.
- Only residual radioactive ground contamination (with associated inhalation of resuspended contamination) is considered.
- Predicted dose assumes adult receives maximum dose without benefit of mitigation measures or any protection actions.
- Based on 1992 EPA PAG Manual (ICRP 23/26/30 dosimetry).

## #6 Predicted Area of Concern for Long Term Recovery

Addresses only the 50-year long term objective.  
(due to long term risk from residual radioactivity on the ground)

### **Key Points**

- Recovery was not addressed by the 1992 EPA PAG Manual. These points are drawn from the new EPA PAG Manual and National Disaster Recovery Framework.
- Recovery seeks best path to restore, redevelop and revitalize the health, social, economic, natural and environmental fabric of the community.
- Recovery considerations include 1) Mitigation/cleanup measures, 2) Permanent housing solutions, 3) Restoring infrastructure, and 4) Revitalizing business/agriculture.
- Priority shifts from supporting protective actions to characterizing the nature and extent of contamination to facilitate stabilization and cleanup.
- Earliest considerations must address:
  - ♦ Stabilization and mitigation actions to prevent further damage/loss,
  - ♦ Return and reoccupation by population, plus recovery of valuable property.
- The "Operational Guidelines" offer criteria to facilitate initial infrastructure and business recovery.
- Contact Advisory Team (A-Team) for additional information regarding Recovery.

## #6 Predicted Area of Concern for Long Term Recovery

Addresses only the 50-year long term objective.  
(due to long term risk from residual radioactivity on the ground)

### Presenter Notes - Additional Information

- The 50-year long term objective (5 rem {50 mSv} accumulated over 50 years) is focused on dose that can be avoided in the future. Therefore, it does not include any dose received from plume passage or dose from ground contamination during the first 12 hours (received before 15 Apr 2014 11:00 UTC).
- PAGs will not be used to guide restoration and recovery of areas impacted by a radiological incident; rather, a process that involves stakeholders in setting priorities and determining actions will be developed that is adaptable to a given situation.
- Informed judgment must be exercised to prioritize recovery for individuals in areas having the highest exposure rates.
- Reoccupying households and businesses should be considered in balance with progress made in reducing radiation risks through decontamination, radioactive decay and managing contaminated waste.
- Exposure limits in a range of one in a population of ten thousand (10-4) to one in a population of one million (10-6) excess lifetime cancer incidence outcomes are generally considered protective, though this may not be achievable after a large radiological incident.
- Recovery can include a combination of cleanups and use restrictions
- Disposal of large volumes of radioactively contaminated waste will be a problem, because it would likely overwhelm existing radioactive waste disposal capacity in the U.S.
- Criteria for free release of personal property may be an issue.
- Dose rate tends to naturally diminish with time due to radioactive decay and weathering of contamination into the soil. The rate of decline will decline rapidly for the first weeks then slow in subsequent months to years, because radioactive iodine and other short-live radionuclides will nearly vanish but longer-lived radionuclides will persist.

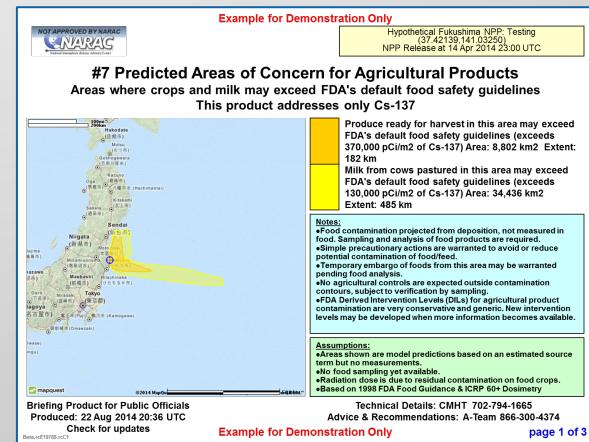
### Presenter Notes - Technical Background

- Guidance based on EPA and DHS PAGs, as given in:
  - ♦ "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents", (EPA 400-R-92-001, May 1992).
  - ♦ "Preliminary Report on Operation Guidelines Developed for Use in Emergency Preparedness and Response to a Radiological Dispersal Device Incident", (DOE/HS-0001: ANL/EVS/TM/09-1).
  - ♦ "National Disaster Recovery Framework", (FEMA, Sept 2011)
- This assessment is based on the ICRP 23/26/30 dosimetry model (1992 EPA PAG Manual). Assessment based on the more recent ICRP 60+ dosimetry model is also available (2013 EPA PAG Manual).
- Dose considered is the projected Total Effective Dose Equivalent (TEDE) which includes external irradiation and inhalation of re-suspended material, accounting for weathering of material and radioactive decay. Only ground contamination contributes to the dose. There is no plume contribution.
- Projected dose assumes individuals are unsheltered and unprotected, and no mitigation or remediation actions are taken (maximally exposed individual).
- Dose reduction factors associated with simple, rapid decontamination techniques are not included in calculating projected dose for decisions on relocation, as prescribed by EPA PAGs.
- The sizes of the relocation and the affected population areas can be reduced by reducing dose in the area by removal/shielding of radioactive material.
- Radioactive contamination is expected outside the contoured areas, but not at levels expected to exceed guidelines for relocation based on current information.
- Additional technical and background information is provided in the Consequence Report containing the detailed, technical version of this calculation.
- Briefing Products are intended for presenting a common operating picture to key leaders and decision makers. Other more technical products are available (Standard Products and associated Consequence Reports).
- Contact the FRPCC Subcommittee for Environment, Food and Health (Advisory Team) for advice and recommendations. Available by calling FDA Emergency Operations Center (EOC) at 866-300-4374.

# LATE PHASE

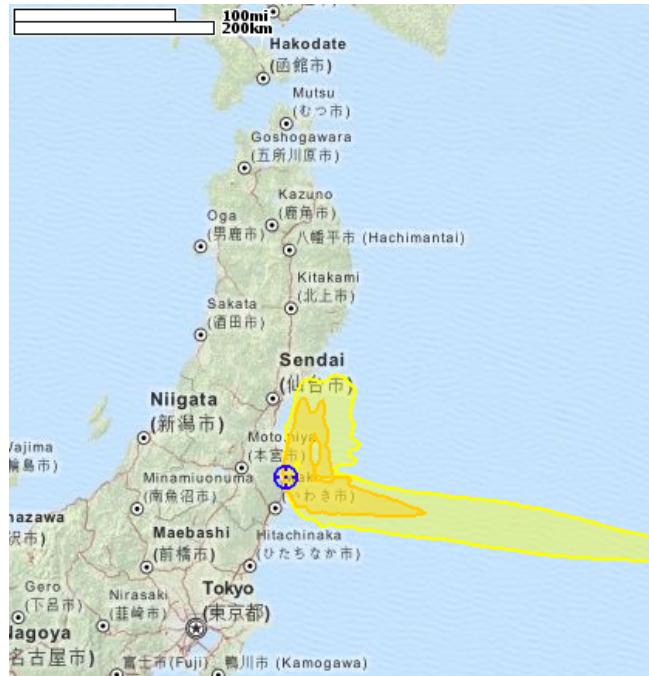
# Predicted Areas of Concern for Agricultural Products

- This product is used to determine where there is the potential to exceed food safety guidelines and may be used to guide crop sampling efforts
- Contours displayed are DRLs (Derived Response Levels) corresponding to FDA DILs (Derived Intervention Levels)
- Levels displayed on this product are very low and are difficult to measure directly
- May reflect measurements (indicated in the green box)



## #7 Predicted Areas of Concern for Agricultural Products

Areas where crops and milk may exceed FDA's default food safety guidelines  
 This product addresses only Cs-137



Produce ready for harvest in this area may exceed FDA's default food safety guidelines (exceeds 370,000 pCi/m<sup>2</sup> of Cs-137) Area: 8,802 km<sup>2</sup> Extent: 182 km

Milk from cows pastured in this area may exceed FDA's default food safety guidelines (exceeds 130,000 pCi/m<sup>2</sup> of Cs-137) Area: 34,436 km<sup>2</sup> Extent: 485 km

### Notes:

- Food contamination projected from deposition, not measured in food. Sampling and analysis of food products are required.
- Simple precautionary actions are warranted to avoid or reduce potential contamination of food/feed.
- Temporary embargo of foods from this area may be warranted pending food analysis.
- No agricultural controls are expected outside contamination contours, subject to verification by sampling.
- FDA Derived Intervention Levels (DILs) for agricultural product contamination are very conservative and generic. New intervention levels may be developed when more information becomes available.

### Assumptions:

- Areas shown are model predictions based on an estimated source term but no measurements.
- No food sampling yet available.
- Radiation dose is due to residual contamination on food crops.
- Based on 1998 FDA Food Guidance & ICRP 60+ Dosimetry

## #7 Predicted Areas of Concern for Agricultural Products

Areas where crops and milk may exceed FDA's default food safety guidelines

This product addresses only Cs-137

### ***Key Points***

- FDA guidance applies to concentration of radioactivity in foods as prepared for eating.
- This product is based on projection of food concentration from expected and/or measured environmental deposition, not measured food concentration. Assumes no reduction of contamination by washing, peeling, cooking or other processing.
- Extensive, time consuming sampling and analysis will be required to properly assess food contamination.
- FDA recommends consultation with the FDA on: 1) simple precautions to avoid/reduce contamination of food/feed and 2) use of temporary food embargoes to prevent introduction of contaminated food into commerce.
  - ◆ Precautions include covering exposed products, moving animals to shelter and corralling livestock plus providing uncontaminated (or clean) feed and water.
  - ◆ The temporary embargo permits opportunity for monitoring and sampling to be performed as the basis of future protective actions.
- Food products not yet ready for harvest will require analysis prior to harvest.
- Food and beverages packaged before the accident are generally not affected.
- FDA guidance assumes 30% of all food eaten is contaminated (very conservative).
- Drinking water concerns are not addressed by this product.

# #7 Predicted Areas of Concern for Agricultural Products

## Areas where crops and milk may exceed FDA's default food safety guidelines

### This product addresses only Cs-137

#### **Presenter Notes - Additional Information**

- This is a preliminary assessment based on predicted radioactivity levels in the environment, not concentration of radioactivity in foods. FDA food safety guidance is based on concentration in foods as prepared for consumption.
- This preliminary assessment pertains only to food products that are ready for immediate consumption, not foods to be harvested at a future date, or to foods grown underground or indoors.
- No food sampling has taken place. Confidence and accuracy will be improved once results of food sampling are obtained.
- "Protective actions can be taken before the release or arrival of contamination if there is advance knowledge that radionuclides may accidentally contaminate the environment."
- "Protective actions which can be taken within the area likely to be affected and prior to confirmation of contamination consist of:
  - ♦ simple precautionary actions to avoid or reduce the potential for contamination of food and animal feeds, and
  - ♦ temporary embargoes to prevent the introduction into commerce of food which is likely to be contaminated."
- "Protective actions which should be implemented when the contamination in food equals or exceeds the DILs consist of:
  - ♦ temporary embargoes to prevent the contaminated food from being introduced into commerce,
  - ♦ normal food production and processing actions that reduce the amount of contamination in or on food to below the DILs."
- "Normal food production and processing procedures that could reduce the amount of radioactive contamination in or on the food could be simple, (such as holding to allow for radioactive decay, or removal of surface contamination by brushing, washing, or peeling)..."
- Food products that are not yet ready for harvest should be analyzed at a later time before consumption to determine if they are suitable for consumption.
- Pre-packaged food and beverages in these areas are not affected.
- This map is valid for only this growing season.
- Protective actions may be initiated over larger areas and at lower contamination/dose levels if advantageous (e.g., in order to account for uncertainties in the predicted dose and mapped areas, and/or to use boundaries, such as roads, that are convenient).

Briefing Product for Public Officials

Produced: 22 Aug 2014 20:36 UTC

Check for updates

Example for Demonstration Only

#### **Presenter Notes - Technical Background**

- Guidance based on EPA and DHS PAGs, as given in:
  - ♦ "Guidance on Accidental Radioactive Contamination of Human Food and Animal Feeds: Recommendations for State and Local Agencies", (Federal Register, Vol. 63, No. 156, Aug. 3, 1998, pg 43402).
- This prediction employs the updated ICRP 60+ dosimetry model and dose factors.
- Preliminary assessment based on FDA's food safety guidelines, termed Derived Intervention Levels (DILs), expressed as activity per unit mass of food. These food guidelines have been projected to obtain limits for deposition of radioactivity in the environment, which can be easily predicted and quickly measured. These are termed Derived Response Levels (DRLs).
- DRLs for the current growing season consider the amount of radioactivity deposited ON the plant (e.g., on leaves and fruit).
- DRLs for future growing seasons also consider uptake of radioactivity by roots from soil and INTO the plant (e.g., in leaves and fruit). This is a slow process.
- FDA DILs limit the radiation dose due to consumption of contaminated food to a predicted 0.5 rem {0.5 cSv} for the effective whole body or predicted 5 rem {5 cSv} to any one organ. They are computed for the most sensitive age group.
- Radioactive contamination is expected outside the contoured areas, but not at levels expected to exceed federal guidelines based on current information.
- Briefing Products are intended for presenting a common operating picture to key leaders and decision makers. Other more technical products are available (Standard Products and associated Consequence Reports).
- Contact the FRPCC Subcommittee for Environment, Food and Health (Advisory Team) for advice and recommendations. Available by calling FDA Emergency Operations Center (EOC) at 866-300-4374.

Technical Details: CMHT 702-794-1665

Advice & Recommendations: A-Team 866-300-4374

# EXAMPLE COMPARISON OF NPP TECHNICAL AND BRIEFING PRODUCT

TECHNICAL PRODUCTS INCLUDE BOTH TED AND CDE  
CALCULATION

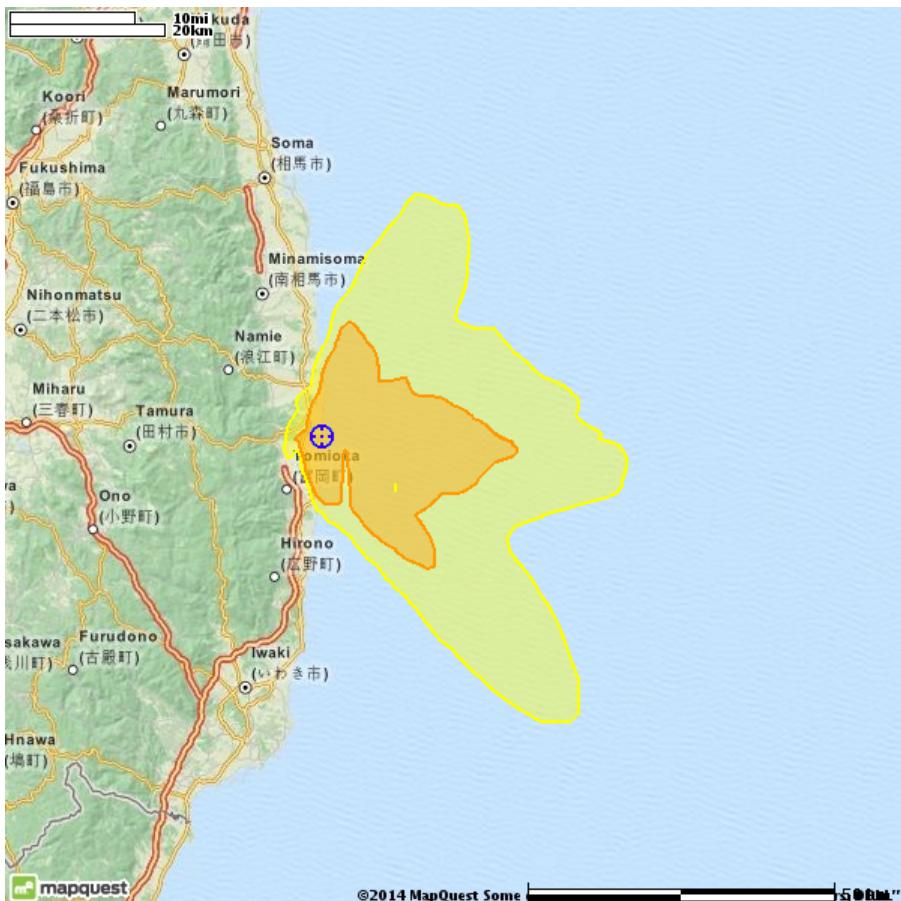
BRIEFING PRODUCT IS BASED ON THE CDE AS THE LIMITING  
CASE

## Example for Demonstration Only

### Early Phase TED (0-96 Hrs) (Total Effective Dose Including Plume Passage)

## Thyroid Case Bigger Grid Technical Products

### Hypothetical Fukushima NPP - Testing



Early Phase Dose			
	Description	(rem) Extent Area	Population
Orange	Exceeds 5 rem total effective dose.	>5 31.7km 646 km <sup>2</sup>	15,100
Yellow	Exceeds 1 rem total effective dose.	>1 61.1km 2,322 km <sup>2</sup>	29,000

Areas and counts in the table are cumulative. Population Source = LandScan2005.

Effects or contamination from April 14, 2014 23:00 UTC to April 18, 2014 23:00 UTC

**Release Location:** 37.421389 N, 141.032500 E

**Material:** CS-137 + I-131 + XE-133

**Generated On:** November 10, 2014 23:09 UTC

**Model:** ADAPT/LODI

**Comments:** Doses shown are total accumulated from the beginning of release.

Hypothetical release starting at 04/14/2014 23:00:00 UTC for 23 hr

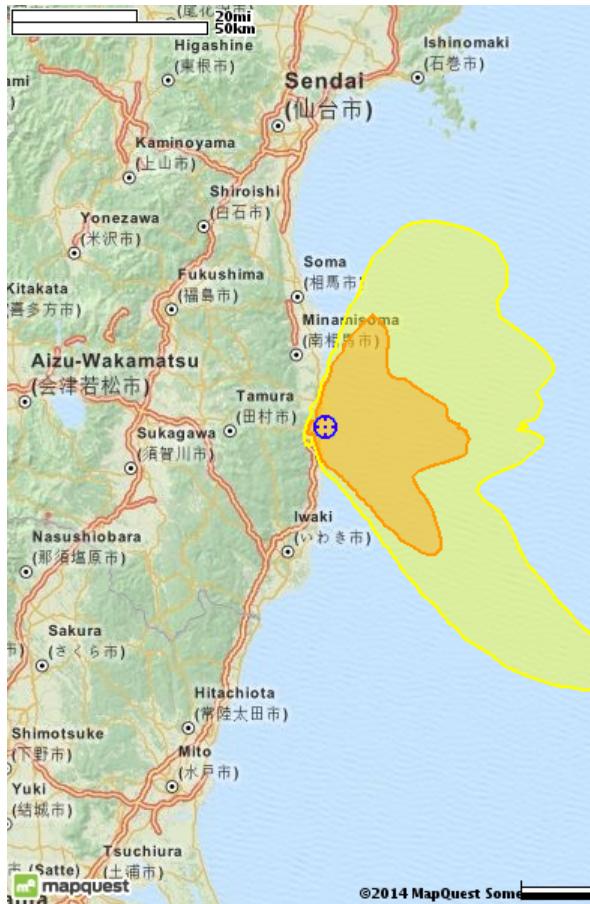
met obs at 1 hr intervals from 04/14/2014 23:00:00 UTC to 04/15/2014 22:00:00 UTC  
 ICRP30 DCF's were used for this plot

Example for Demonstration Only

Early Phase Thyroid CDE (0-96 hrs)  
 (Thyroid Committed Dose Equivalent Including Plume Passage)

Thyroid Case Bigger Grid Technical Products

Hypothetical Fukushima NPP - Testing



Early Phase Dose			
	Description	(rem) Extent Area	Population
Orange	Exceeds 25 rem thyroid dose.	>25 54.5km 1,959 km <sup>2</sup>	24,200
Yellow	Exceeds 5 rem thyroid dose.	>5 123km 7,320 km <sup>2</sup>	37,400

Areas and counts in the table are cumulative. Population Source = LandScan2005.

Effects or contamination from April 14, 2014 23:00 UTC to April 18, 2014 23:00 UTC  
**Release Location:** 37.421389 N, 141.032500 E

**Material:** CS-137 + I-131

**Generated On:** November 10, 2014 23:09 UTC

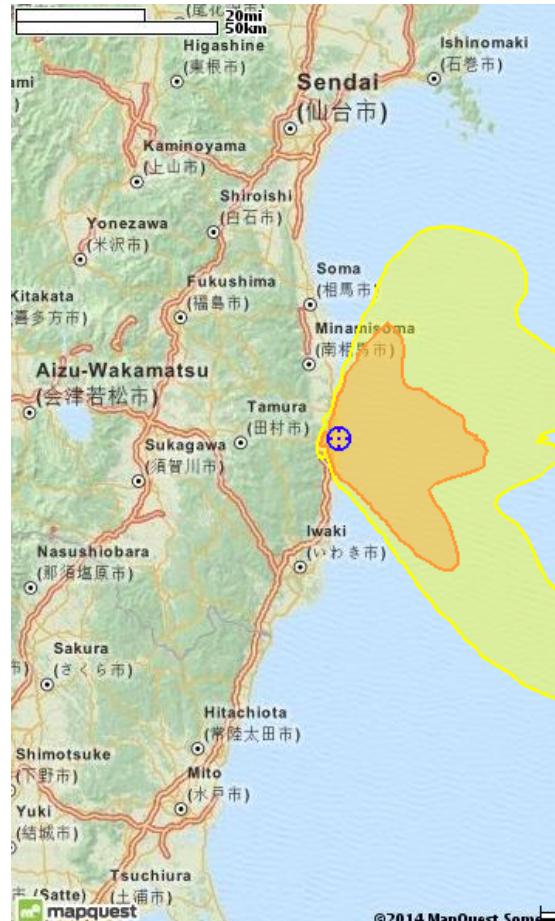
**Model:** ADAPT/LODI

**Comments:** Doses shown are total accumulated from the beginning of release.

Hypothetical release starting at 04/14/2014 23:00:00 UTC for 23 hr  
 met obs at 1 hr intervals from 04/14/2014 23:00:00 UTC to 04/15/2014 22:00:00 UTC  
 ICRP30 DCF's were used for this plot

# #1 Predicted Evacuation and Sheltering Areas

Dose to the thyroid primarily due to inhalation of radioiodine is the greatest concern  
Projected Total Thyroid Dose - Applicable prior to start of release



Evacuation/sheltering warranted, unless additional unusually hazardous circumstances exist (exceeds 25 rem {250 mSv} for adult). Est. Population: 24,200 Area: 1,959 km<sup>2</sup> Extent: 54.5 km  
Evacuation/sheltering normally initiated (5 to 25 rem {50 to 250 mSv} predicted for adult). Estimated Population: 37,400 Area: 7,320 km<sup>2</sup> Extent: 123 km

#### Notes:

- Prompt evacuation and/or sheltering reduces radiation dose and cancer risk. Sheltering-in-place may be more protective than evacuation while the radioactive cloud is present.
- Administration of Potassium Iodide (KI) may be warranted. See Predicted Areas Warranting Administration of Potassium Iodide (KI).
- Protective actions are only based on dose that can be avoided.

#### Assumptions:

- Areas shown are model predictions based on an estimated release of airborne radioactivity, but no measurements yet available.
- Prediction shows total dose over four days beginning at the start of the release (0 to 96 hrs).
- Predicted dose assumes adult receives maximum dose without protective actions or mitigations, who inhales contamination from the radioactive cloud and resuspended contaminated dust.
- Based on 1992 EPA PAG Manual (ICRP 23/26/30 dosimetry).

## #1 Predicted Evacuation and Sheltering Areas

Dose to the thyroid primarily due to inhalation of radioiodine is the greatest concern

Projected Total Thyroid Dose - Applicable prior to start of release

### *Key Points*

- EPA's Early Phase Guides provide separate criteria to limit dose to both the whole body and the thyroid. Separate predictions were considered. The Thyroid Dose was found to be the greatest concern and affects the largest area.
- Dose to the thyroid is caused by inhalation of radioiodine.
- Those already outdoors should seek shelter or evacuate per issued recommendation(s).
- Sheltering-in-place may be preferable to evacuation in some cases, such as for limited mobility populations or if unusually hazardous environmental conditions exist.
- Greatest hazard is due to exposure to the radioactive cloud. Sheltering followed by delayed evacuation after cloud passage may be preferable. Evacuation before radioactive cloud arrival is best, but avoid evacuation in the radioactive cloud.
- Predicted dose is accumulated from the start of the release for a period of 96 hours (4 days), specifically 14 Apr 2014 23:00 UTC to 18 Apr 2014 23:00 UTC.
- Refer to the separate Briefing Product Predicted Areas Warranting Administration of Potassium Iodide (KI), because administration of KI can reduce thyroid dose.

# #1 Predicted Evacuation and Sheltering Areas

**Dose to the thyroid primarily due to inhalation of radioiodine is the greatest concern**  
**Projected Total Thyroid Dose - Applicable prior to start of release**

## **Presenter Notes - Additional Information**

- PAG - Protective Action Guide is a projected dose at which a specific protective action to reduce or avoid that dose is warranted.
- The EPA Early Phase PAG has a primary guideline for the dose to the whole body and a supplementary guideline for dose to the thyroid and skin.
- Protective actions are based only on dose that can be avoided, not dose acquired prior to implementation of the protective action.
- Reduce radiation dose to minimize long-term cancer risk.
- Evacuation and/or sheltering-in-place is an effective protective action to avoid or reduce both dose to the whole body and dose to the thyroid.
- Sheltering may be the preferred protective action when it will provide protection equal to or greater than evacuation (example: evacuation through a plume).
- No specific minimum level is established for initiation of sheltering.
- Completion of evacuation before plume arrival is best. Evacuation in radioactive cloud may result in more dose than sheltering until cloud passage. Evacuees in cloud should cover mouth & nose with available filter materials (handkerchief).
- Sheltering followed by delayed evacuation may be best if radioactive decay is very rapid (e.g. dominated by radioiodine).
- Thyroid Dose criteria (Committed Dose Equivalent) for evacuation and sheltering are obtained by a modification of the Early Phase PAG's Whole Body Dose (i.e., Total Effective Dose Equivalent) criterion.
  - ◆ Evacuation (or, for some situations, sheltering) should normally be initiated at 5 rem dose to the thyroid.
  - ◆ Because of the higher risk associated with evacuation of some special groups in the population (e.g. those who are not readily mobile), sheltering may be the preferred alternative for such groups as a protective action at projected doses up to 25 rem dose to the thyroid.
  - ◆ Under unusually hazardous environmental conditions use of sheltering at projected doses up to 25 rem dose to the thyroid for the general population (and up to 50 rem dose to the thyroid for special groups) may become justified.
- Thyroid Dose can be reduced by timely administration of stable iodine (KI).
- Protective actions may be initiated over larger areas and at lower contamination/dose levels if advantageous (e.g., in order to account for uncertainties in the predicted dose and mapped areas, and/or to use boundaries, such as roads, that are convenient).

**Briefing Product for Public Officials**

**Produced: 05 Nov 2014 23:53 UTC**

**Check for updates**

## **Presenter Notes - Technical Background**

- Guidance based on EPA Protective Action Guides (PAGs), as given in:
  - ◆ "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents", (EPA 400-R-92-001, May 1992).
  - ◆ Jetter, J. J. and C. Whitfield. "Effectiveness of Expedient Sheltering in Place in a Residence", Journal of Hazardous Materials. Elsevier, Amsterdam, Holland, 119(1-3):31-40, (2005).
- The PAG for evacuation and/or sheltering is expressed in terms of the committed effective dose to the thyroid due to inhalation of radioactive iodine from 1) Inhalation of the contaminated air as the cloud passes and 2) Inhalation of resuspended contaminated dust.
- Hazard is greatest while the radioactive cloud is present, because both pathways above contribute. After the radioactive cloud passes only inhalation of resuspended contaminated dust will continue to contribute significantly.
- Although Table 2-1 "PAGs for the Early Phase of a Nuclear Incident" of the EPA PAG Manual is the whole body dose criteria, footnote "b" guides how the Early Phase PAGs can be expressed in terms of thyroid dose. "Committed dose equivalents to the thyroid and skin may be 5 and 50 times larger, respectively." Therefore, the dose guidelines for thyroid dose are five times (5X) that for the whole body dose.
- This assessment is based on the ICRP 23/26/30 dosimetry model (1992 EPA PAG Manual). Assessment based on the more recent ICRP 60+ dosimetry model is also available (2013 EPA PAG Manual).
- Prolonged infiltration of contaminated air may diminish the protective value of sheltering-in-place.
- Radioactive contamination is expected outside the contoured areas, but not at levels expected to exceed federal guidelines for evacuation and sheltering based on current information.
- Additional technical and background information is provided in the Consequence Report containing the detailed, technical version of this calculation.
- Briefing Products are intended for presenting a common operating picture to key leaders and decision makers. Other more technical products are available (Standard Products and associated Consequence Reports).
- Contact the FRPCC Subcommittee for Environment, Food and Health (Advisory Team) for advice and recommendations. Available by calling the FDA Emergency Operations Center (EOC) at 866-300-4374.

**Technical Details: CMHT 702-794-1665**

**Advice & Recommendations: A-Team 866-300-4374**

# Additional Information



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