June 17, 2011

The Honorable Jim Webb
United States Senate
Washington, D.C. 20510

Dear Senator Webb:

On behalf of the U.S. Nuclear Regulatory Commission (NRC), I am responding to your letter of April 15, 2011, requesting that the NRC provide you with information regarding the assumptions used in recommending a 50-mile evacuation for U.S. citizens following the Fukushima Daiichi nuclear facility events.

The 50-mile evacuation recommendation that the NRC made to the U.S. Ambassador in Japan was made in the interest of protecting the health and safety of U.S. citizens in Japan. We based our assessment on the conditions as we understood them at the time. Since communications with knowledgeable Japanese officials were limited and there was a large degree of uncertainty about plant conditions at the time, it was difficult to accurately assess the potential radiological hazard. The U.S. emergency preparedness framework provides for the expansion of emergency planning zones as conditions require. Acting in accordance with this framework, and with the best information available at the time, the NRC determined that evacuation out to 50 miles for U.S. citizens was a prudent course of action, and would be consistent with what we would do under similar circumstances in the United States, and we made that recommendation to the Ambassador and other U.S. Government agencies.

In order to determine the proper evacuation distance, the NRC staff performed a series of calculations using NRC's RASCAL computer code to assess possible offsite consequences. The computer models used meteorological model data appropriate for the Fukushima Daiichi vicinity. Source terms were based on hypothetical, but not unreasonable, estimates of fuel damage, containment, and other release conditions. These calculations demonstrated that the Environmental Protection Agency's (EPA's) Protective Action Guidelines could be exceeded at a distance of up to 50 miles from the Fukushima site, if a large-scale release occurred from the reactors or spent fuel pools.

Even though these recommendations were made during a time of uncertainty and rapidly changing conditions during the first few days of the accident, these recommendations have been borne out as appropriate. The Japanese government has significantly revised its estimate upward for the amount of radiation released from the plant in the first week of the disaster in its report to the International Atomic Energy Agency and implemented additional protective actions well beyond the initial 12 miles. The more reassuring recent assessment of the situation in the Unit 4 spent fuel pool is countered by the confirmation of significant core damage to Units 1, 2 and 3 and does not invalidate our earlier decision. We continue to assess the situation on a daily basis.

Responses to your six specific information requests are enclosed. I hope that the information fully addresses your interest in this matter. If you have any questions, please contact me or Ms. Rebecca Schmidt, Director of the Office of Congressional Affairs, at (301) 415-1776.

Sincerely,

***/RA/***

Gregory B. Jaczko

Enclosure:
As stated

**Responses to Information Requests from Senator Jim Webb**
**Letter of April 15, 2011**

**(1) The assumed magnitudes of the total releases (in Curies) to the atmosphere of the radioisotopes dominating the inhalation, cloudshine, and 4-day groundshine effective whole body doses and the thyroid inhalation doses.**

The NRC's decision to recommend an evacuation area around the Fukushima Daiichi reactor site out to 50-miles was informed in part by two computer calculations that were conservative, rough estimates that would not necessarily characterize an actual release. The "Calculation 1" assessment assumed an ex-vessel, unfiltered release from a totally failed containment and actual meteorological conditions during early morning hours. The assumed total release to the atmosphere for this assessment was 1.7E+08 Ci. The "Calculation 2" assessment represented multiple unit failures using an increased reactor inventory at Unit 2 as a surrogate for 30 percent core damage at Units 2 and 3 and a 100 percent damaged Unit 4 spent fuel pool. The assumed total release to the atmosphere for this assessment was 2.1E+08 Ci. Information regarding the specific magnitude of total releases to the atmosphere for both of these assessments is included at the end of this enclosure.

**(2) The assumed duration of the releases.**

The NRC had a large degree of uncertainty about plant conditions at the time it made the decision on the 50-mile evacuation zone. The computer calculations and subsequent recommended protective action decisions were based on conservative estimates of fuel damage, containment, and other release and meteorological conditions. Prudent and conservative "durations of release" were assumed for each of the computer calculations and assessments. These assumptions are listed below:

- "Calculation 1" assumed a Unit 2 ex-vessel, unfiltered release from a totally failed containment for approximately 10 hours.

- "Calculation 2" represented multiple unit failures using an increased reactor inventory at Unit 2 as a surrogate for 30 percent core damage at Unit 2 and 3 and a 100 percent damaged Unit 4 spent fuel pool for approximately 15 hours. To account for the combined inventories of the three units, the staff adjusted the reactor power level and the number of assemblies in the calculation. In addition, the source term included two additional days of decay before release. For the multi-unit assessment, the increased decay time before release and the greater atmospheric dispersion significantly reduced the resultant dose estimate.

While these calculations were initially based on a large scale quick release, we are now observing that this has become a long-term chronic release. Nevertheless, it signifies the severity of this accident and the recommended protective actions remain in place.

**(3) The assumed wind speed and deposition velocities.**

Since communications were limited, there was a large degree of uncertainty about plant conditions and associated meteorological data at the time of the decision-making process.

The computer models did, however, use "Actual Observations" as meteorological model data appropriate for the Fukushima Daiichi vicinity.

- "Calculation 1" assumed meteorological data during early morning hours, when there were lower wind speeds, relatively stable air, and light precipitation – conditions that would degrade dispersion and increase downwind doses.

- "Calculation 2" assumed meteorological data during a period of higher wind speeds, less stable atmospheric conditions, and no precipitation – conditions that would improve atmospheric dispersion and decrease downwind doses.

**(4) Any assumptions concerning wind wander.**

The NRC modified winds for topography, however no wind wander assumptions were used.

**(5) The height of the assumed release including any height increase of the mid-line of the plume due to heat buoyancy effects.**

Both calculations used an assumed release height of 10 meters.

**(6) The dose conversion factor that the NRC uses for iodine-131 (I-131) for converting exposure to airborne I-131 measured in Ci-seconds/$m^3$ exposure to thyroid doses in rem for adults and children of different ages.**

The NRC calculates thyroid dose to adults from inhalation by using the dose conversion factors from Table II.1 in EPA Federal Guidance Report (FGR) 11, http://www.epa.gov/radiation/docs/federal/520-1-88-020.pdf. Given a release rate of airborne I-131 measured in Ci-seconds/$m^3$, a standard breathing rate of 20 $m^3$/day is applied to give the intake to the receptor (adult) in curies of I-131. The FGR-11 dose conversion factor for I-131 is $1.08 \times 10^6$ rem/Ci.

For dose from external exposure from submersion in the plume, the NRC uses dose conversion factors from Table III.1 in EPA FGR-12, http://www.epa.gov/radiation/docs/federal/402-r-93-081.pdf. The dose to the thyroid is much less for external exposure to I-131 than for inhalation. The FGR-11 thyroid dose conversion factor for external exposure to I-131 is $6.70 \times 10^{-2}$ rem-$m^3$/Ci-s.

The NRC does not calculate dose to children from a reactor accident plume in our response during the early phase of the event.

## CALCULATION 1

15 March 2011 02:51am (EDT), NRC Operations Center, Protective Measures Team

These data are based on system condition estimates for a hypothetical, single reactor site, 2350 MWt, Boiling Water Reactor. Model results are projections only and may **not** be representative of an actual release. This projection uses modeled forecast meteorological conditions and is subject to change.

## Case Summary

**Event Type** Nuclear Power Plant

**Location**

| | |
|---|---|
| Name: | Fukushima Unit 2 |
| City, county, state: | <undefined>, <undefined>, <undefined> |
| Lat / Long / Elev: | 37.4214° N, 141.0325° E, 0 m |
| Time zone: | <undefined> |
| Population: | not available |

**Reactor Parameters**

| | |
|---|---|
| Reactor power: | 2350 MWt |
| Average fuel burn-up: | 30000 MWD / MTU |
| Containment type: | BWR Mark I |
| Containment volume: | 2.50E+05 ft³ |
| Design pressure: | 60 lb/in² |
| Design leak rate: | 0.54 %/d |
| Coolant mass: | 1.25E+05 kg |
| Assemblies in core: | 550 |

**Source Term**

| | |
|---|---|
| Type: | Time Core Is Uncovered |
| Shutdown: | 2011/03/11 14:46 |
| Core uncovered: | 2011/03/15 00:00 |
| Core recovered: | No |

**Release Pathway**

| | |
|---|---|
| Type: | BWR - Release Through Dry Well via direct, unfiltered pathway |
| Description: | Ex Vessel |
| Release height: | 10. m |

Release events

| | |
|---|---|
| 2011/03/15 00:00 | Leak rate (% vol) Total failure |
| 2011/03/15 00:00 | Sprays Off |

## Meteorology

Type: Actual Observations
Dataset name: Fukushima 2011 03-14 1600
Dataset desc: Obs/fcsts for Fukushima Unit 1

| Summary of data at release point: | Type | Dir deg | Speed m/s | Stab class | Precip | Temp °C |
|---|---|---|---|---|---|---|
| 2011/03/12 14:00 | Obs | 265 | 1.0 | B | ? | |
| 2011/03/12 15:00 | Obs | 265 | 1.0 | B | ? | |
| 2011/03/12 16:00 | Obs | 277 | 1.3 | B | ? | |
| 2011/03/12 17:00 | Obs | 260 | 2.4 | B | ? | |
| 2011/03/12 18:00 | Obs | 241 | 1.4 | E | ? | |
| 2011/03/12 19:00 | Obs | 236 | 2.1 | E | ? | |
| 2011/03/12 20:00 | Obs | 239 | 2.1 | E | ? | |
| 2011/03/12 21:00 | Obs | 229 | 3.8 | E | ? | |
| 2011/03/12 22:00 | Obs | 224 | 5.1 | E | ? | |
| 2011/03/12 23:00 | Obs | 226 | 3.9 | E | ? | |
| 2011/03/13 00:00 | Obs | 228 | 4.1 | E | ? | |
| 2011/03/13 01:00 | Obs | 235 | 2.6 | E | ? | |
| 2011/03/13 02:00 | Obs | 233 | 3.9 | E | ? | |
| 2011/03/13 03:00 | Obs | 225 | 1.8 | E | ? | |
| 2011/03/13 04:00 | Obs | 225 | 1.3 | E | ? | |
| 2011/03/13 05:00 | Obs | 225 | 2.2 | E | ? | |
| 2011/03/13 06:00 | Obs | 225 | 2.2 | E | ? | |
| 2011/03/13 07:00 | Obs | 248 | 2.7 | E | ? | |
| 2011/03/13 08:00 | Obs | 248 | 2.7 | E | ? | |
| 2011/03/13 09:00 | Obs | 270 | 3.1 | E | ? | |
| 2011/03/13 12:00 | Obs | 271 | 7.4 | D | ? | |
| 2011/03/13 13:00 | Obs | 276 | 6.2 | D | ? | |
| 2011/03/13 14:00 | Obs | 312 | 2.8 | B | ? | |
| 2011/03/14 18:00 | Obs | 258 | 4.8 | unk | ? | |
| 2011/03/14 19:00 | Obs | 268 | 5.0 | unk | ? | |
| 2011/03/14 20:00 | Obs | 330 | 2.2 | unk | ? | |
| 2011/03/14 21:00 | Fcst | 337 | 4.6 | unk | ? | |
| 2011/03/14 22:00 | Fcst | 323 | 7.2 | unk | ? | |
| 2011/03/14 23:00 | Fcst | 305 | 6.6 | unk | ? | |
| 2011/03/15 00:00 | Fcst | 015 | 8.6 | unk | ? | |
| 2011/03/15 02:00 | Fcst | 002 | 7.5 | unk | ? | |
| 2011/03/15 03:00 | Fcst | 347 | 5.2 | E | None | |
| 2011/03/15 04:00 | Fcst | 332 | 5.6 | E | None | |
| 2011/03/15 05:00 | Fcst | 332 | 4.0 | E | None | |
| 2011/03/15 06:00 | Fcst | 344 | 3.5 | E | Lgt rain | |
| 2011/03/15 07:00 | Fcst | 026 | 3.8 | E | Lgt rain | |
| 2011/03/15 08:00 | Fcst | 044 | 4.4 | E | Lgt rain | |
| 2011/03/15 09:00 | Fcst | 020 | 4.2 | E | Lgt rain | |
| 2011/03/15 10:00 | Fcst | 010 | 3.4 | E | None | |
| 2011/03/15 11:00 | Fcst | 030 | 3.5 | D | Lgt rain | |
| 2011/03/15 12:00 | Fcst | 027 | 3.0 | D | Lgt rain | |
| 2011/03/15 13:00 | Fcst | 037 | 3.4 | D | Lgt rain | |
| 2011/03/15 14:00 | Fcst | 053 | 3.7 | B | None | |
| 2011/03/15 15:00 | Fcst | 058 | 3.7 | B | None | |
| 2011/03/15 16:00 | Fcst | 067 | 3.2 | C | Lgt rain | |
| 2011/03/15 17:00 | Fcst | 081 | 3.9 | C | Lgt rain | |
| 2011/03/15 18:00 | Fcst | 089 | 4.7 | B | None | |
| 2011/03/15 19:00 | Fcst | 085 | 4.4 | B | None | |

| | | | | | |
|---|---|---|---|---|---|
| 2011/03/15 20:00 | Fcst | 083 | 4.4 | B | Lgt rain |
| 2011/03/15 21:00 | Fcst | 074 | 4.6 | C | Lgt rain |
| 2011/03/15 22:00 | Fcst | 054 | 5.0 | D | Lgt rain |
| 2011/03/15 23:00 | Fcst | 029 | 5.6 | D | Rain |
| 2011/03/16 00:00 | Fcst | 011 | 5.1 | D | Lgt rain |
| 2011/03/16 01:00 | Fcst | 346 | 4.3 | C | Lgt rain |
| 2011/03/16 02:00 | Fcst | 350 | 5.3 | D | Lgt rain |
| 2011/03/16 03:00 | Fcst | 323 | 5.6 | D | Lgt rain |
| 2011/03/16 04:00 | Fcst | 316 | 5.4 | D | None |
| 2011/03/16 05:00 | Fcst | 298 | 4.8 | D | None |
| 2011/03/16 06:00 | Fcst | 314 | 5.6 | D | None |
| 2011/03/16 07:00 | Fcst | 312 | 4.7 | D | None |
| 2011/03/16 08:00 | Fcst | 331 | 4.9 | D | None |
| 2011/03/16 09:00 | Fcst | 353 | 4.1 | D | None |

Dataset options: Est. missing stability using: Wind speed, time of day, etc.
Adjust stability for consistency: No
Modify winds for topography: Yes

### Calculations

Case description: Fukushima Unit 2 ex-vessel met 14MAR 1600
End of calculations: 2011/03/15 10:00
Start of release to atmosphere + 10 h
Distance of calculation: Close-in + to 50 miles
Close-in distances: 0.5, 1.0, 1.5, 2.0, 3.0, 5.0, 7.0, 10.0 miles

## Source Term

**Total amount released to atmosphere:** 1.7E+08 Ci

| Nuclide | Ci | Nuclide | Ci | Nuclide | Ci |
|---|---|---|---|---|---|
| Am-241 | 5.3E-01 | Nb-97 | 7.6E+02 | Sr-92 | 2.8E-03 |
| Ba-140 | 8.8E+06 | Nd-147 | 1.4E+05 | Tc-99m | 1.5E+05 |
| Ce-141 | 4.4E+05 | Np-239 | 2.1E+06 | Te-127 | 1.0E+06 |
| Ce-143 | 7.2E+04 | Pm-147 | 4.2E+02 | Te-127m | 2.2E+05 |
| Ce-144* | 3.7E+05 | Pr-143 | 3.4E+05 | Te-129 | 5.7E+05 |
| Cm-242 | 1.1E+04 | Pr-144 | 3.7E+05 | Te-129m | 8.8E+05 |
| Cs-134 | 3.6E+06 | Pu-238 | 9.1E-01 | Te-131 | 9.6E+04 |
| Cs-136 | 1.2E+06 | Pu-239 | 1.1E+00 | Te-131m | 4.3E+05 |
| Cs-137* | 2.5E+06 | Pu-241 | 3.5E+04 | Te-132 | 1.0E+07 |
| I-131 | 1.9E+07 | Rb-86 | 4.6E+04 | Xe-131m | 7.0E+05 |
| I-132 | 1.9E+07 | Rb-88 | 3.1E-02 | Xe-133 | 8.2E+07 |
| I-133 | 3.1E+06 | Rh-103m | 3.2E+05 | Xe-133m | 1.4E+06 |
| I-135 | 7.0E+03 | Rh-105 | 4.9E+04 | Xe-135 | 5.1E+05 |
| Kr-83m | 1.7E-07 | Ru-103 | 3.2E+05 | Xe-135m | 9.1E+03 |
| Kr-85 | 5.1E+05 | Ru-105 | 4.7E-01 | Y-90 | 2.4E+04 |
| Kr-85m | 3.9E+01 | Ru-106* | 9.5E+04 | Y-91 | 3.2E+05 |
| Kr-88 | 6.1E-02 | Sb-127 | 7.1E+05 | Y-91m | 2.8E+03 |
| La-140 | 5.4E+05 | Sb-129 | 5.9E+00 | Y-92 | 8.7E-02 |
| La-141 | 1.4E-01 | Sr-89 | 5.2E+06 | Y-93 | 7.5E+02 |
| Mo-99 | 1.6E+05 | Sr-90 | 4.2E+05 | Zr-95 | 4.4E+05 |
| Nb-95 | 4.6E+05 | Sr-91 | 1.4E+04 | Zr-97* | 1.3E+04 |

Notes:
• Nuclides with * in name include implicit daughters.

## Maximum Dose Values (rem) - Close-In

| Dist from release miles (kilometers) | 0.5 (0.8) | 1. (1.61) | 1.5 (2.41) | 2. (3.22) | 3. (4.83) | 5. (8.05) | 7. (11.27) | 10. (16.09) |
|---|---|---|---|---|---|---|---|---|
| Total EDE | 5.4E+03 | 2.0E+03 | 1.2E+03 | 8.2E+02 | 4.8E+02 | 2.4E+02 | 1.6E+02 | 9.5E+01 |
| Thyroid CDE | 2.8E+04 | 1.1E+04 | 6.2E+03 | 4.3E+03 | 2.5E+03 | 1.3E+03 | 8.4E+02 | 5.1E+02 |
| Inhalation CEDE | 3.7E+03 | 1.4E+03 | 8.0E+02 | 5.6E+02 | 3.3E+02 | 1.7E+02 | 1.1E+02 | 6.7E+01 |
| Cloudshine | 1.9E+01 | 9.3E+00 | 5.8E+00 | 4.1E+00 | 2.5E+00 | 1.4E+00 | 9.7E-01 | 6.2E-01 |
| 4-day Groundshine | 1.7E+03 | 6.5E+02 | 3.8E+02 | 2.6E+02 | 1.5E+02 | 7.3E+01 | 4.6E+01 | 2.8E+01 |
| Inter Phase 1st Yr | 2.4E+04 | 9.4E+03 | 5.4E+03 | 3.8E+03 | 2.2E+03 | 1.1E+03 | 6.6E+02 | 3.9E+02 |
| Inter Phase 2nd Yr | 1.1E+04 | 4.4E+03 | 2.6E+03 | 1.8E+03 | 1.0E+03 | 4.9E+02 | 3.1E+02 | 1.8E+02 |

## Maximum Dose Values (rem) - To 50 mi

| Dist from release miles (kilometers) | 15 (24.1) | 20 (32.2) | 30 (48.3) | 40 (64.4) | 50 (80.5) |
|---|---|---|---|---|---|
| Total EDE | 8.6E+01 | 6.3E+01 | 3.7E+01 | 1.8E+01 | 8.1E+00 |
| Thyroid CDE | 3.3E+02 | 2.7E+02 | 1.3E+02 | 5.9E+01 | 2.3E+01 |
| Inhalation CEDE | 3.9E+01 | 3.1E+01 | 1.3E+01 | 4.4E+00 | 1.3E+00 |
| Cloudshine | 4.5E-01 | 3.8E-01 | 1.7E-01 | 7.4E-02 | 2.7E-02 |
| 4-day Groundshine | 4.7E+01 | 3.2E+01 | 2.4E+01 | 1.3E+01 | 6.7E+00 |
| Inter Phase 1st Yr | 7.2E+02 | 4.8E+02 | 3.8E+02 | 2.2E+02 | 1.3E+02 |
| Inter Phase 2nd Yr | 3.4E+02 | 2.3E+02 | 1.8E+02 | 1.1E+02 | 6.9E+01 |

Notes:
- Doses exceeding PAGs are underlined.
- Early-Phase PAGs: TEDE - 1 rem, Thyroid (iodine) CDE - 5 rem
- Intermediate-Phase EPA PAGs: 1st year - 2 rem, 2nd year - 0.5 rem
- *** indicates values less than 1 mrem
- To view all values - use Detailed Results | Numeric Table
- Total EDE = Inhalation CEDE + Cloudshine + 4-Day Groundshine

TEDE - Total Effective Dose Equivalent
CDE - Committed Dose Equivalent
CEDE - Committed Effective Dose Equivalent
PAGs – Protective Action Guidelines
EPA – Environmental Protection Agency

## CALCULATION 2

16 March 2011 02:24am (EDT), NRC Operations Center, Protective Measures Team

These data are based on system condition estimates for a hypothetical, four reactor site. Model results are projections only and may **not** be representative of an actual release. This projection uses modeled forecast meteorological conditions and is subject to change.

# Case Summary

**Event Type** Nuclear Power Plant

**Location**

| | |
|---|---|
| Name: | Fukushima unit 2, 3, 4 |
| City, county, state: | <undefined>, <undefined>, <undefined> |
| Lat / Long / Elev: | 37.4214° N, 141.0325° E, 0 m |
| Time zone: | <undefined> |
| Population: | not available |

**Reactor Parameters**

| | |
|---|---|
| Reactor power: | 3760 MWt |
| Average fuel burn-up: | 30000 MWD / MTU |
| Containment type: | BWR Mark I |
| Containment volume: | 2.50E+05 ft³ |
| Design pressure: | 60 lb/in² |
| Design leak rate: | 0.54 %/d |
| Coolant mass: | 1.25E+05 kg |
| Assemblies in core: | 917 |

**Source Term**

| | |
|---|---|
| Type: | Time Core Is Uncovered |
| Shutdown: | 2011/03/11 14:46 |
| Core uncovered: | 2011/03/16 19:50 |
| Core recovered: | No |

**Release Pathway**

| | |
|---|---|
| Type: | BWR - Release Through Dry Well via direct, unfiltered pathway |
| Description: | total failure |
| Release height: | 10. m |

Release events

| | |
|---|---|
| 2011/03/16 19:50 | Leak rate (% vol) Total failure |
| 2011/03/16 19:50 | Sprays Off |

**Meteorology**

| | |
|---|---|
| Type: | Actual Observations |
| Dataset name: | Fukushima 2011-03-16 0935 |
| Dataset desc: | Obs/fcsts for Fukushima Unit 1 |

| Summary of data at release point: | Type | Dir deg | Speed m/s | Stab class | Precip | Temp °C |
|---|---|---|---|---|---|---|
| 2011/03/12 14:00 | Obs | 265 | 1.0 | B | ? | |
| 2011/03/12 15:00 | Obs | 265 | 1.0 | B | ? | |

| | | | | | |
|---|---|---|---|---|---|
| 2011/03/12 16:00 | Obs | 277 | 1.3 | B | ? |
| 2011/03/12 17:00 | Obs | 260 | 2.4 | B | ? |
| 2011/03/12 18:00 | Obs | 241 | 1.4 | E | ? |
| 2011/03/12 19:00 | Obs | 236 | 2.1 | E | ? |
| 2011/03/12 20:00 | Obs | 239 | 2.1 | E | ? |
| 2011/03/12 21:00 | Obs | 229 | 3.8 | E | ? |
| 2011/03/12 22:00 | Obs | 224 | 5.1 | E | ? |
| 2011/03/12 23:00 | Obs | 226 | 3.9 | E | ? |
| 2011/03/13 00:00 | Obs | 228 | 4.1 | E | ? |
| 2011/03/13 01:00 | Obs | 235 | 2.6 | E | ? |
| 2011/03/13 02:00 | Obs | 233 | 3.9 | E | ? |
| 2011/03/13 03:00 | Obs | 225 | 1.8 | E | ? |
| 2011/03/13 04:00 | Obs | 225 | 1.3 | E | ? |
| 2011/03/13 05:00 | Obs | 225 | 2.2 | E | ? |
| 2011/03/13 06:00 | Obs | 225 | 2.2 | E | ? |
| 2011/03/13 07:00 | Obs | 248 | 2.7 | E | ? |
| 2011/03/13 08:00 | Obs | 248 | 2.7 | E | ? |
| 2011/03/13 09:00 | Obs | 270 | 3.1 | E | ? |
| 2011/03/13 12:00 | Obs | 271 | 7.4 | D | ? |
| 2011/03/13 13:00 | Obs | 276 | 6.2 | D | ? |
| 2011/03/13 14:00 | Obs | 312 | 2.8 | B | ? |
| 2011/03/14 18:00 | Obs | 258 | 4.8 | unk | ? |
| 2011/03/14 19:00 | Obs | 268 | 5.0 | unk | ? |
| 2011/03/14 20:00 | Obs | 330 | 2.2 | unk | ? |
| 2011/03/14 21:00 | Fcst | 337 | 4.6 | unk | ? |
| 2011/03/14 22:00 | Fcst | 323 | 7.2 | unk | ? |
| 2011/03/14 23:00 | Fcst | 305 | 6.6 | unk | ? |
| 2011/03/15 00:00 | Fcst | 015 | 8.6 | unk | ? |
| 2011/03/15 02:00 | Fcst | 002 | 7.5 | unk | ? |
| 2011/03/15 03:00 | Fcst | 347 | 5.2 | E | None |
| 2011/03/15 04:00 | Fcst | 332 | 5.6 | E | None |
| 2011/03/15 05:00 | Fcst | 332 | 4.0 | E | None |
| 2011/03/15 06:00 | Fcst | 344 | 3.5 | E | Lgt rain |
| 2011/03/15 07:00 | Fcst | 026 | 3.8 | E | Lgt rain |
| 2011/03/15 08:00 | Fcst | 044 | 4.4 | E | Lgt rain |
| 2011/03/15 09:00 | Fcst | 020 | 4.2 | E | Lgt rain |
| 2011/03/15 10:00 | Fcst | 010 | 3.4 | E | None |
| 2011/03/15 11:00 | Fcst | 030 | 3.5 | D | Lgt rain |
| 2011/03/15 12:00 | Fcst | 027 | 3.0 | D | Lgt rain |
| 2011/03/15 13:00 | Fcst | 037 | 3.4 | D | Lgt rain |
| 2011/03/15 14:00 | Fcst | 053 | 3.7 | B | None |
| 2011/03/15 15:00 | Fcst | 058 | 3.7 | B | None |
| 2011/03/15 16:00 | Fcst | 067 | 3.2 | C | Lgt rain |
| 2011/03/15 17:00 | Fcst | 081 | 3.9 | C | Lgt rain |
| 2011/03/15 18:00 | Fcst | 089 | 4.7 | B | None |
| 2011/03/15 19:00 | Fcst | 085 | 4.4 | B | None |
| 2011/03/15 20:00 | Fcst | 083 | 4.4 | B | Lgt rain |
| 2011/03/15 21:00 | Fcst | 074 | 4.6 | C | Lgt rain |
| 2011/03/15 22:00 | Fcst | 054 | 5.0 | D | Lgt rain |
| 2011/03/15 23:00 | Fcst | 029 | 5.6 | D | Rain |
| 2011/03/16 00:00 | Fcst | 011 | 5.1 | D | Lgt rain |
| 2011/03/16 01:00 | Fcst | 346 | 4.3 | C | Lgt rain |
| 2011/03/16 02:00 | Fcst | 350 | 5.3 | D | Lgt rain |
| 2011/03/16 03:00 | Fcst | 323 | 5.6 | D | Lgt rain |
| 2011/03/16 04:00 | Fcst | 316 | 5.4 | D | None |
| 2011/03/16 05:00 | Fcst | 298 | 4.8 | D | None |

| | | | | | |
|---|---|---|---|---|---|
| 2011/03/16 06:00 | Fcst | 314 | 5.6 | D | None |
| 2011/03/16 07:00 | Fcst | 312 | 4.7 | D | None |
| 2011/03/16 08:00 | Fcst | 331 | 4.9 | D | None |
| 2011/03/16 09:00 | Fcst | 299 | 4.2 | D | None |
| 2011/03/16 10:00 | Fcst | 312 | 5.4 | C | None |
| 2011/03/16 11:00 | Fcst | 309 | 7.5 | C | None |
| 2011/03/16 12:00 | Fcst | 304 | 7.2 | C | None |
| 2011/03/16 13:00 | Fcst | 314 | 8.8 | C | None |
| 2011/03/16 14:00 | Fcst | 325 | 10.4 | C | None |
| 2011/03/16 15:00 | Fcst | 324 | 12.3 | C | None |
| 2011/03/16 16:00 | Fcst | 304 | 14.7 | D | None |
| 2011/03/16 17:00 | Fcst | 299 | 14.2 | D | None |
| 2011/03/16 18:00 | Fcst | 297 | 11.3 | D | None |
| 2011/03/16 19:00 | Fcst | 316 | 9.8 | D | None |
| 2011/03/16 20:00 | Fcst | 309 | 9.4 | D | None |
| 2011/03/16 21:00 | Fcst | 294 | 9.5 | D | None |
| 2011/03/16 22:00 | Fcst | 299 | 7.6 | D | None |
| 2011/03/16 23:00 | Fcst | 300 | 9.7 | D | None |
| 2011/03/17 00:00 | Fcst | 294 | 5.0 | D | None |
| 2011/03/17 01:00 | Fcst | 286 | 7.0 | D | None |
| 2011/03/17 02:00 | Fcst | 287 | 6.6 | D | None |
| 2011/03/17 03:00 | Fcst | 293 | 6.5 | D | None |
| 2011/03/17 04:00 | Fcst | 300 | 6.3 | D | None |
| 2011/03/17 05:00 | Fcst | 311 | 5.9 | D | None |
| 2011/03/17 06:00 | Fcst | 295 | 7.4 | D | None |
| 2011/03/17 07:00 | Fcst | 303 | 8.4 | C | None |
| 2011/03/17 08:00 | Fcst | 333 | 4.8 | C | None |
| 2011/03/17 09:00 | Fcst | 321 | 5.9 | C | None |
| 2011/03/17 10:00 | Fcst | 307 | 5.0 | C | None |
| 2011/03/17 11:00 | Fcst | 292 | 8.4 | C | None |
| 2011/03/17 12:00 | Fcst | 315 | 9.3 | C | None |
| 2011/03/17 13:00 | Fcst | 299 | 11.1 | C | None |
| 2011/03/17 14:00 | Fcst | 292 | 11.8 | C | None |
| 2011/03/17 15:00 | Fcst | 286 | 10.7 | C | None |
| 2011/03/17 16:00 | Fcst | 298 | 9.3 | D | None |
| 2011/03/17 17:00 | Fcst | 286 | 8.5 | D | None |
| 2011/03/17 18:00 | Fcst | 285 | 10.6 | D | None |
| 2011/03/17 19:00 | Fcst | 288 | 11.1 | D | None |
| 2011/03/17 20:00 | Fcst | 301 | 11.3 | D | None |
| 2011/03/17 21:00 | Fcst | 311 | 10.1 | D | None |
| 2011/03/17 22:00 | Fcst | 307 | 8.4 | D | None |
| 2011/03/17 23:00 | Fcst | 303 | 8.7 | D | None |
| 2011/03/18 00:00 | Fcst | 311 | 7.1 | D | None |
| 2011/03/18 01:00 | Fcst | 316 | 3.4 | D | None |
| 2011/03/18 02:00 | Fcst | 310 | 6.0 | D | None |
| 2011/03/18 03:00 | Fcst | 319 | 7.4 | D | None |
| 2011/03/18 04:00 | Fcst | 316 | 6.3 | D | None |
| 2011/03/18 05:00 | Fcst | 307 | 4.9 | D | None |
| 2011/03/18 06:00 | Fcst | 311 | 4.4 | D | None |
| 2011/03/18 07:00 | Fcst | 326 | 5.1 | C | None |
| 2011/03/18 08:00 | Fcst | 343 | 5.4 | C | None |
| 2011/03/18 09:00 | Fcst | 344 | 6.1 | C | None |

Dataset options: Est. missing stability using: Wind speed, time of day, etc.
Adjust stability for consistency: No
Modify winds for topography: Yes

### Calculations

Case description: Unit 2 and 3 with 33% core damage each, Unit 4 with 100% spent fuel full core

End of calculations: 2011/03/17 10:50
Start of release to atmosphere + 15 h

Distance of calculation: Close-in + to 50 miles

Close-in distances: 0.5, 1.0, 1.5, 2.0, 3.0, 5.0, 7.0, 10.0 miles

## Source Term

**Total amount released to atmosphere:** 2.1E+08 Ci

| Nuclide | Ci | Nuclide | Ci | Nuclide | Ci |
|---|---|---|---|---|---|
| Am-241 | 1.3E+00 | Nd-147 | 2.1E+05 | Tc-99m | 1.6E+05 |
| Ba-140 | 1.3E+07 | Np-239 | 2.0E+06 | Te-127 | 1.2E+06 |
| Ce-141 | 6.7E+05 | Pm-147 | 9.5E+02 | Te-127m | 3.5E+05 |
| Ce-143 | 4.6E+04 | Pr-143 | 5.0E+05 | Te-129 | 8.9E+05 |
| Ce-144* | 6.0E+05 | Pr-144 | 5.9E+05 | Te-129m | 1.4E+06 |
| Cm-242 | 1.8E+04 | Pu-238 | 2.2E+00 | Te-131 | 5.6E+04 |
| Cs-134 | 5.7E+06 | Pu-239 | 2.1E+00 | Te-131m | 2.5E+05 |
| Cs-136 | 1.8E+06 | Pu-241 | 5.6E+04 | Te-132 | 1.1E+07 |
| Cs-137* | 4.0E+06 | Rb-86 | 6.8E+04 | Xe-131m | 1.0E+06 |
| I-131 | 2.6E+07 | Rb-88 | 1.1E-06 | Xe-133 | 1.0E+08 |
| I-132 | 2.0E+07 | Rh-103m | 5.0E+05 | Xe-133m | 1.2E+06 |
| I-133 | 1.1E+06 | Rh-105 | 3.3E+04 | Xe-135 | 3.0E+04 |
| I-135 | 1.1E+02 | Ru-103 | 5.0E+05 | Xe-135m | 1.7E+02 |
| Kr-85 | 8.1E+05 | Ru-105 | 8.0E-04 | Y-90 | 3.8E+04 |
| Kr-85m | 7.2E-02 | Ru-106* | 1.5E+05 | Y-91 | 4.9E+05 |
| Kr-88 | 2.1E-06 | Sb-127 | 8.2E+05 | Y-91m | 1.8E+02 |
| La-140 | 8.0E+05 | Sb-129 | 8.4E-03 | Y-92 | 2.7E-05 |
| La-141 | 9.9E-05 | Sr-89 | 8.1E+06 | Y-93 | 6.0E+01 |
| Mo-99 | 1.6E+05 | Sr-90 | 6.7E+05 | Zr-95 | 6.9E+05 |
| Nb-95 | 7.4E+05 | Sr-91 | 9.0E+02 | Zr-97* | 3.5E+03 |
| Nb-97 | 2.0E+02 | Sr-92 | 6.1E-08 | | |

Notes:
• Nuclides with * in name include implicit daughters.

## Maximum Dose Values (rem) - Close-In

| Dist from release miles (kilometers) | 0.5 (0.8) | 1. (1.61) | 1.5 (2.41) | 2. (3.22) | 3. (4.83) | 5. (8.05) | 7. (11.27) | 10. (16.09) |
|---|---|---|---|---|---|---|---|---|
| Total EDE | 5.4E+03 | 1.5E+03 | 6.7E+02 | 3.9E+02 | 1.8E+02 | 7.5E+01 | 4.0E+01 | 1.4E+01 |
| Thyroid CDE | 2.9E+04 | 7.9E+03 | 3.6E+03 | 2.1E+03 | 9.6E+02 | 4.0E+02 | 2.1E+02 | 7.5E+01 |
| Inhalation CEDE | 3.8E+03 | 1.0E+03 | 4.8E+02 | 2.8E+02 | 1.3E+02 | 5.4E+01 | 2.9E+01 | 1.0E+01 |
| Cloudshine | 2.2E+01 | 8.0E+00 | 3.9E+00 | 2.3E+00 | 8.0E-01 | 2.6E-01 | 2.1E-01 | 1.1E-01 |
| 4-day Groundshine | 1.5E+03 | 4.1E+02 | 1.9E+02 | 1.1E+02 | 5.0E+01 | 2.1E+01 | 1.1E+01 | 4.4E+00 |
| Inter Phase 1st Yr | 2.6E+04 | 7.0E+03 | 3.2E+03 | 1.9E+03 | 8.5E+02 | 3.5E+02 | 1.9E+02 | 7.5E+01 |
| Inter Phase 2nd Yr | 1.3E+04 | 3.5E+03 | 1.6E+03 | 9.2E+02 | 4.2E+02 | 1.8E+02 | 9.5E+01 | 3.8E+01 |

Notes:
- Doses exceeding PAGs are underlined.
- Early-Phase PAGs: TEDE - 1 rem, Thyroid (iodine) CDE - 5 rem
- Intermediate-Phase EPA PAGs: 1st year - 2 rem, 2nd year - 0.5 rem
- *** indicates values less than 1 mrem
- To view all values - use Detailed Results | Numeric Table
- Total EDE = Inhalation CEDE + Cloudshine + 4-Day Groundshine

## Maximum Dose Values (rem) - To 50 mi

| Dist from release miles (kilometers) | 15 (24.1) | 20 (32.2) | 30 (48.3) | 40 (64.4) | 50 (80.5) |
|---|---|---|---|---|---|
| Total EDE | 1.5E+01 | 1.3E+01 | 1.1E+01 | 1.0E+01 | 9.9E+00 |
| Thyroid CDE | 8.6E+01 | 7.0E+01 | 5.2E+01 | 4.9E+01 | 4.8E+01 |
| Inhalation CEDE | 1.1E+01 | 9.2E+00 | 7.7E+00 | 7.6E+00 | 7.3E+00 |
| Cloudshine | 1.2E-01 | 9.7E-02 | 7.3E-02 | 7.0E-02 | 6.6E-02 |
| 4-day Groundshine | 4.1E+00 | 3.4E+00 | 2.8E+00 | 2.7E+00 | 2.5E+00 |
| Inter Phase 1st Yr | 7.1E+01 | 6.0E+01 | 4.7E+01 | 4.5E+01 | 4.3E+01 |
| Inter Phase 2nd Yr | 3.6E+01 | 3.0E+01 | 2.3E+01 | 2.2E+01 | 2.1E+01 |

Notes:
- Doses exceeding PAGs are underlined.
- Early-Phase PAGs: TEDE - 1 rem, Thyroid (iodine) CDE - 5 rem
- Intermediate-Phase PAGs: 1st year - 2 rem, 2nd year - 0.5 rem
- *** indicates values less than 1 mrem
- To view all values - use Detailed Results | Numeric Table
- Total EDE = CEDE Inhalation + Cloudshine + 4-Day Groundshine
- Total Acute Bone = Bone Inhalation + Cloudshine + Period Groundshine

TEDE - Total Effective Dose Equivalent
CDE - Committed Dose Equivalent
CEDE - Committed Effective Dose Equivalent
PAGs – Protective Action Guidelines
EPA – Environmental Protection Agency