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Overview of DOE/NNSA's Consequence Management Response to the Fukushima Daiichi Nuclear Power Station Releases

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Department 6631

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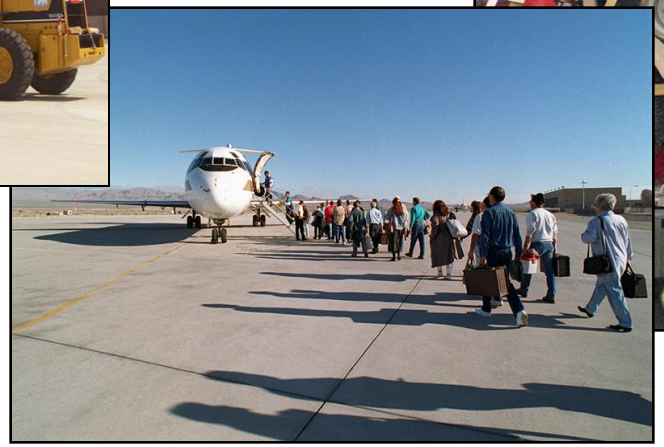
DOE's Consequence Management (CM) Program

Mission:

- Develop and maintain rapidly-deployable equipment and technical expertise for world-wide response to nuclear and radiological terrorism events, and nuclear/radiological accidents and emergencies.



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Purpose of Consequence Management

Assist the Federal, State, Local, Tribal and foreign governments in protecting the health and well being of their citizens:

- Estimate/determine the radionuclide source term
- Provide initial predictions (data products) using atmospheric dispersion models and source term estimates
- Verify, validate and update predictions based on ground monitoring data, fixed wing surveys and laboratory analysis data
- Provide comprehensive characterization of environmental and public impacts based on models and data
  - Predict radiation dose impacts over various time phases
  - Predict food contamination impacts
  - Comprehensive characterization of environmental and public impacts based on this data
- Provide centralized point of contact for federal assets
- Provide data to Decision Makers for public protection decisions

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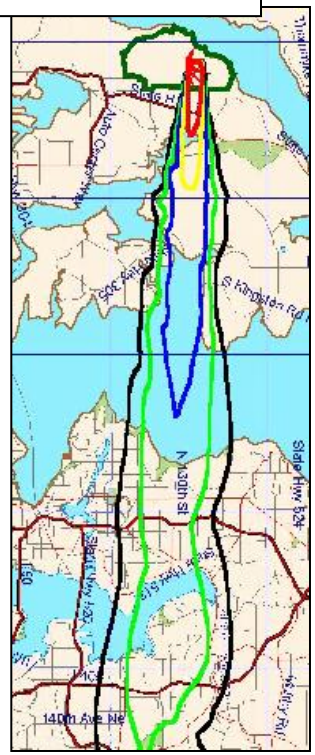
Consequence Management (CM) Assets

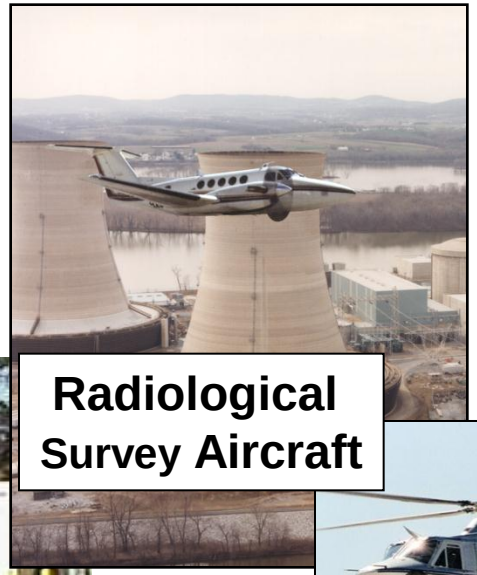
Data Analysis/ Management

Field Personnel

SNL & LLNL Models



Laboratory Personnel



Radiological Survey Aircraft

Mobile Laboratories

Great East Japan Earthquake

- Earthquake occurred March 11, 2011 @ 14:46 Local Time
- Earthquake Magnitude 9.0, depth 24 km
- Dai-ichi NPS earthquake design basis = Magnitude 8
- 4th Largest Recorded Earthquake
- Estimated energy released was 9.3E6 Mt of TNT
- Moved Japan 8 feet closer to the United States
- Shifted earth's axis 10 cm

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Big Tsunami

- Wave Amplitude along Japanese Coast ~ 6 – 19 m (19 – 62 ft.)
- Run-up (Wash-up) Height ~ 7 – 38 m (23 – 125 ft.)
- ~ 25,000 killed/missing due to earthquake and tsunami

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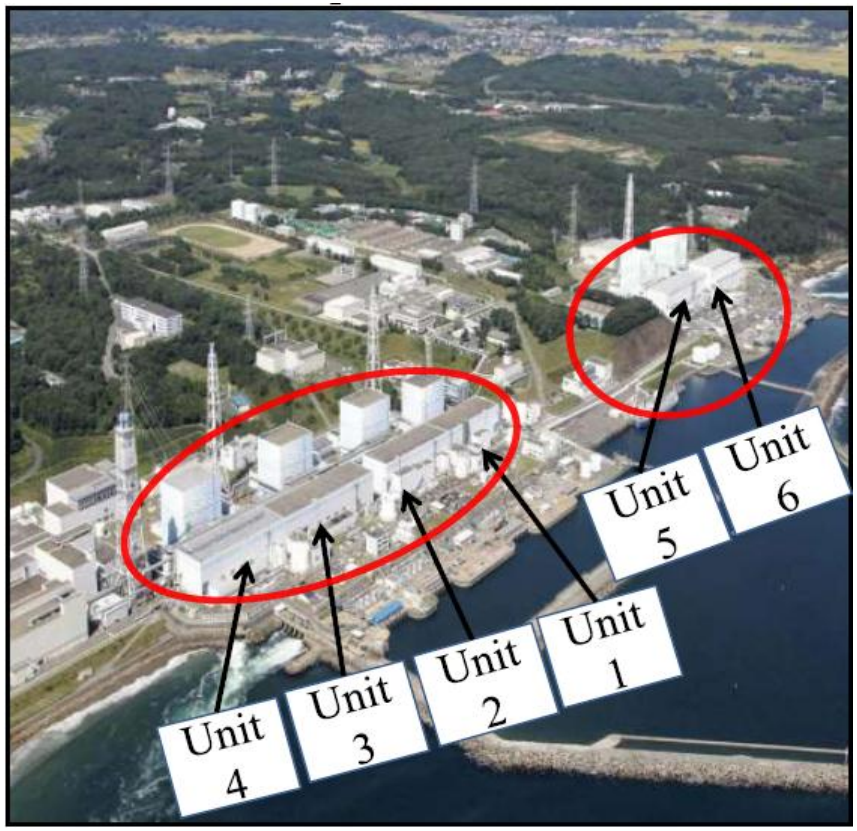
Tsunami Devastation

Fukushima Dai-ichi Nuclear Power Plant Site



- 6 Boiling Water Reactor Units at Fukushima Dai-ichi NPS site
- Each unit also had Spent Fuel Pool (SFP) with mix of old and “new” spent fuel.
- Units 1, 2 & 3 were at full power
- Unit 4 was de-fueled for re-fueling
- Units 5 and 6 were in cold shutdown for planned maintenance.
- All units were immediately shut down by automatic safety systems after earthquake.

- Tsunami wave (~14 m, 46 ft.) hit Dai-ichi site approximately 1 hour after earthquake.
- Design Basis for tsunami was 5.7 m

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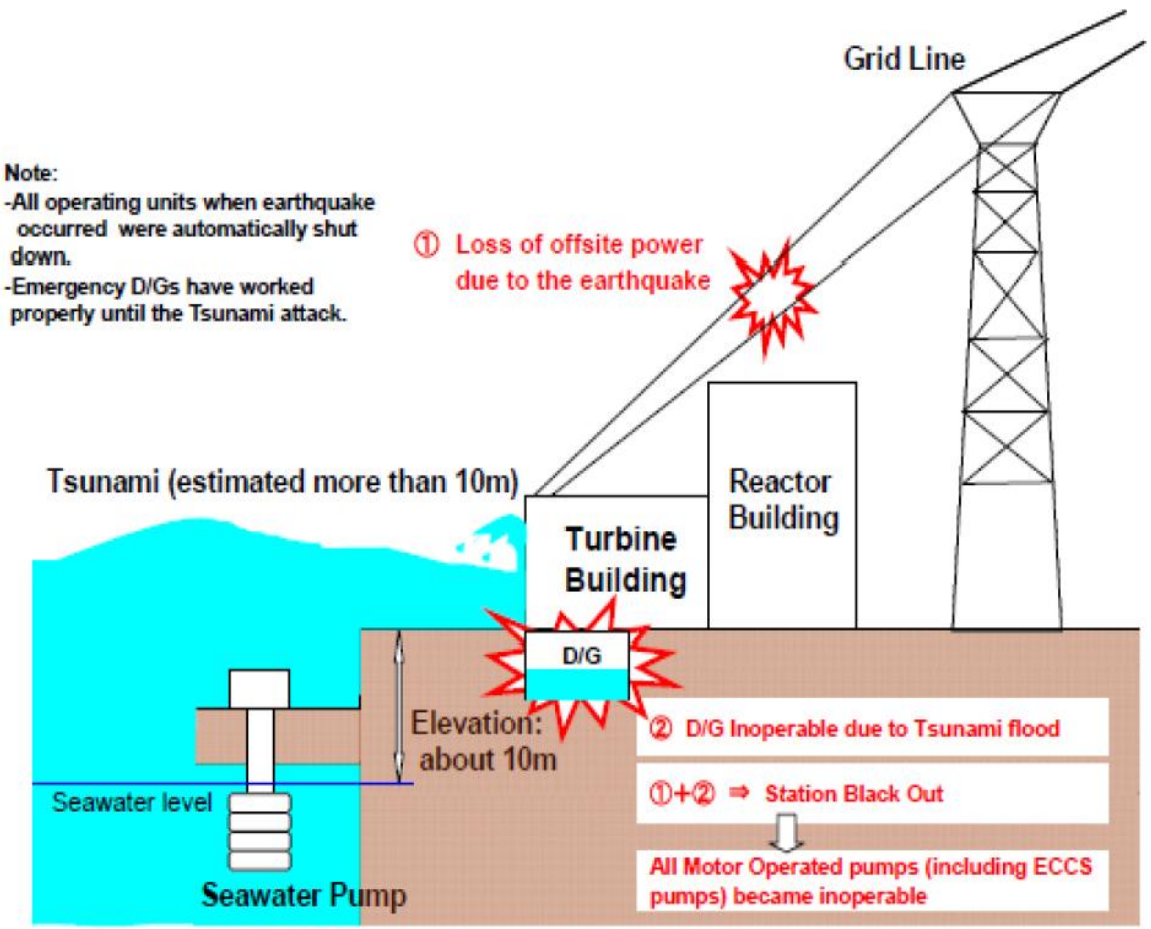
Root Cause of Damage



Source: Nuclear and Industrial Safety Agency (NISA)

- Off-site power to NPS site lost due to earthquake
- All emergency diesel generators disabled by Tsunami flood (generators were 10 – 13 m above sea level)
- Emergency battery power depleted after 8 hr
- Unable to cool fuel in reactors and spent fuel pools

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Decay Heat

During operation decay heat accounts for ~10% of reactor power

- After shutdown decay heat decreases as fission products decay away
- Within hours decay heat is down to 1% of operating power
- Still a significant source of heat for power reactors
- Without cooling decay heat can cause fuel to melt

For a 1000 MWt reactor decay heat is:

- 70 MW immediately after shutdown
- 10 MW after 3 hours
- 5 MW after 5 days
- 1 MW after 2 months
- 100 kW after 1 year

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Fuel Degradation

- Flow of cooling water stopped due to lack of power.
- Water boiled away and level in core dropped below top of fuel.
- Temperature increased caused fuel degradation.
  - Fuel cladding failed (rupture) releasing gaseous fission products
  - Zirconium in cladding oxidized in presence of water creating hydrogen gas (exothermic reaction producing more heat)
  - Fuel melt (how much???) releases fission products (Cs, I, Xe)
- Pressure buildup threatened containment structures.
- Operators manually opened valves to prevent over-pressurization of Primary Containment Vessel (PCV) releasing gaseous fission products (e.g., Cs-134 and 137, I-131) and hydrogen into reactor building.
- Hydrogen explosions in Units 1, 3 and 4 (SFP).

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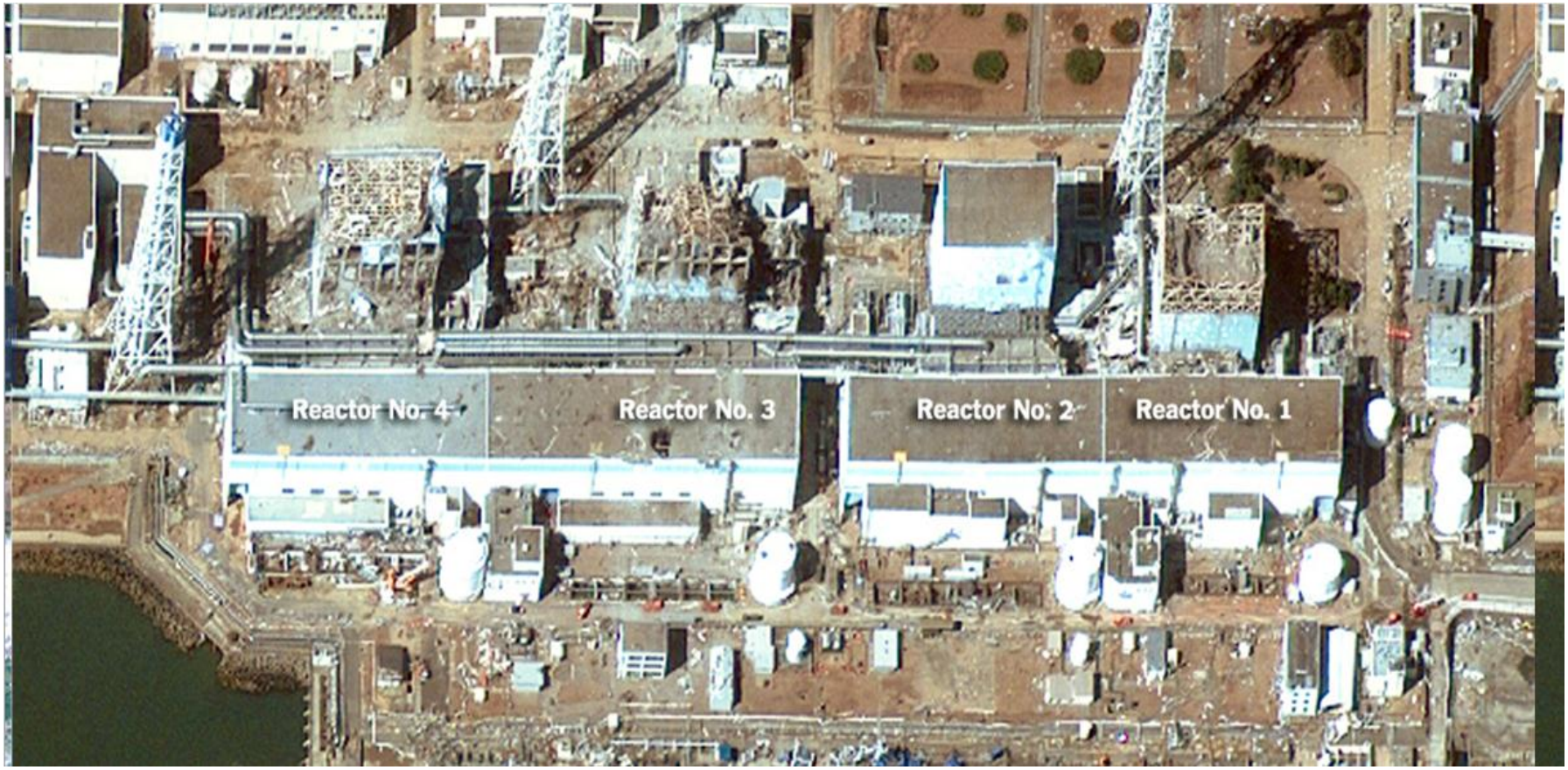
Hydrogen Explosions



Gas venting systems were inoperable without electrical power leading to hydrogen buildup and explosions.

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Stabilization of Units 1 - 4

- Pumping of fresh water and seawater helped cool the reactors and spent fuel pools
- Boric acid was injected reactors to prevent/reduce meltdown
- N_2 was injected into Primary Containment Vessel to reduce possibility of hydrogen explosions
- Eventually power was restored to pump water to cool the fuel

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Initial Japanese Public Protection Actions

- March 12: Government of Japan established mandatory evacuation zone for people living within a 20 km radius of the Fukushima Dai-ichi NPS and recommended shelter-in-place for people living within 20-30 km
- March 13: U.S. Embassy issued an advisory restricting travel US citizens within 80 km of the Fukushima NPS
- March 16: U.S. Embassy and U.S. Forces Japan (USFJ) authorized voluntary departure for dependents

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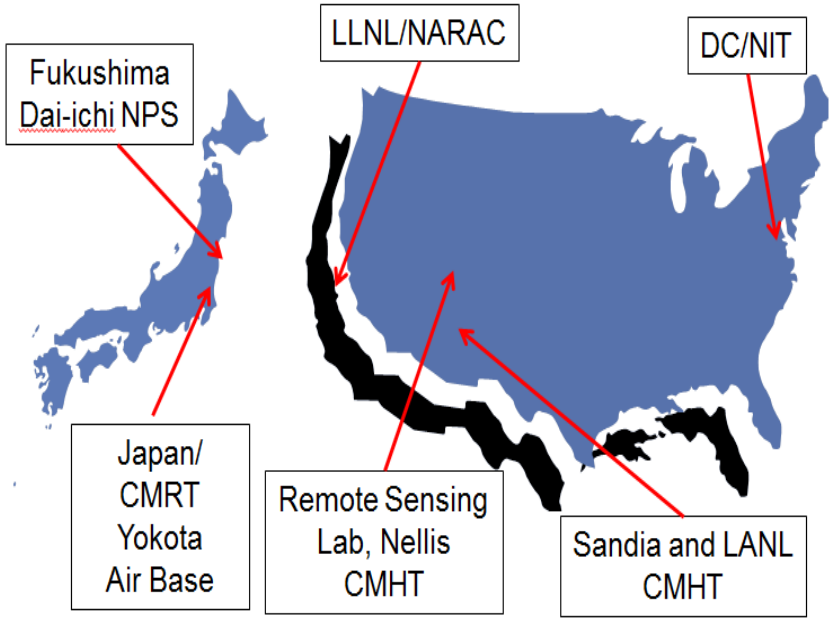
DOE Support of Operation Tomodachi

March 11, 2011 DOE/NNSA activated the following assets

- Nuclear Incident Team (NIT) in Washington, DC
- DOE/NNSA Consequence Management expertise from the U.S.
- Agency for International Development (USAID) Disaster
- Assistance Response Team (DART) in Tokyo



- National Atmospheric Release Advisory Center (NARAC) at
- Lawrence Livermore National Laboratory (LLNL)
- Consequence Management Home Team (CMHT) assets at Remote Sensing Laboratory (RSL), Sandia National Laboratories (SNL), LLNL and Los Alamos National Laboratory (LANL)
- The Radiation Emergency Assistance Center/Training Site (REAC/TS) in Oak Ridge, TN

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DOE Support of Operation Tomodachi

Objectives of DOE Response:

- Assess consequences of release from Fukushima Dai-ichi Nuclear Power Station
- Assist the State Department mission to advise American citizens on protective action and evacuation guidelines.
- Assist DoD in its mission to safely conduct humanitarian assistance/disaster relief operations and to provide advice on departure/return of military dependents.
- Partner with the Government of Japan (GOJ) through the State Department to aid in developing guidelines for protection of the public potentially affected by the releases.

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Partners

United States

- Department of State
  - American Embassy
- Department of Defense
  - US Forces Japan (USFJ)
- Department of Energy (DOE)
- National Nuclear Security Administration (NNSA)
  - All consequence management assets
  - And then some
- Nuclear Regulatory Commission
- Advisory Team for Environment, Food and Health

Japan

- Japan Atomic Energy Agency (JAEA)
- Nuclear Safety Commission
- Ministry of Defense (MOD)
- Ministry of Economy, Trade and Industry (METI)
  - Nuclear and Industrial Safety Agency (NISA)
- Ministry of Education, Culture, Sports, Science & Technology (MEXT)
  - Nuclear Safety Technology Center (NUSTEC)
- Ministry of Agriculture, Forestry and Fisheries (MAFF)
- Ministry of Health, Labor & Welfare (MLHW)

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Coordination & Advice

- Partnership with USFJ for AMS
- Radiological consequence management advice for US ambassador and USFJ
- Planning, operations, and assessment with several ministries of the government of Japan
- Field expedient early warning system to be used while reactors were considered unstable

These activities aided key leaders in decision-making and informed DOE monitoring and assessment efforts

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Consequence Management Timeline

March 14, 2011

- At White House direction, DOE deployed a tailored CMRT and Aerial Measuring System (AMS) capability via military airlift to Yokota Air Base, Fusa, Japan

March 16, 2011:

- CM Assets arrive at Yokota AB and fly first AMS Test flight

March 17, 2011:

- Conducted first aerial measurement activities over plant and first field monitoring activities

March 22, 2011:

- Initial data published on DOE website

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DOE Assets

Field

- Monitoring and sampling
- Preliminary data assessment
- Data product development

CMHT

- Detailed assessment
- Coordination of sample analysis
- Response to requests for information/assistance

Nuclear Incident Team

- Initial command and control of deploying assets
- Coordination and communication for field assets and headquarters elements

U.S. Embassy in Japan

- Assessment interpretation for Ambassador
- Coordination of bilateral monitoring and assessment activities

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What Radionuclides and How Much Radioactivity was Released?

Potential Source Terms

- 4 Boiling Water Reactors at risk
- 4 Spent Fuel Pools, holding spent fuel of various age, at risk
- Fuel
  - Low Enriched Uranium
  - Mixed Oxide (< 6% in Unit 3)
- Many different species of radionuclides produced by nuclear fission
  - Different half-lives (seconds to thousands of years)
  - Different radiations (alpha, beta, gamma)
- Difficult to determine the exact condition of reactors and spent fuel pools

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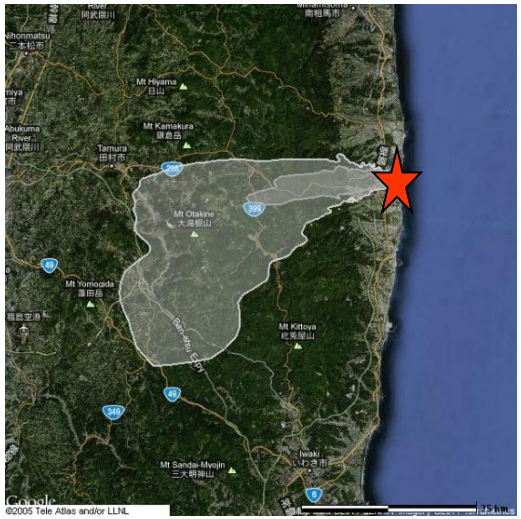
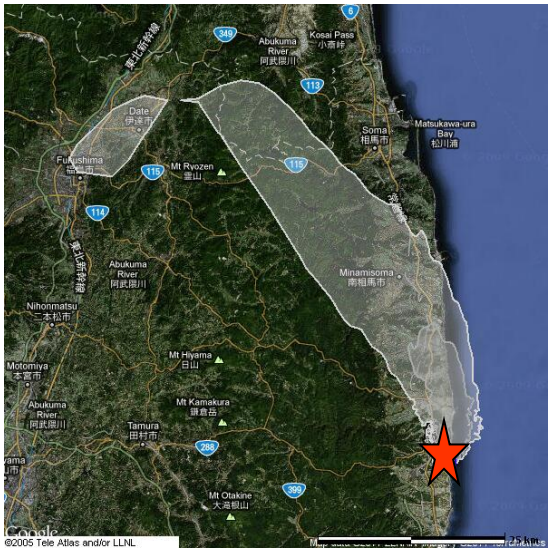
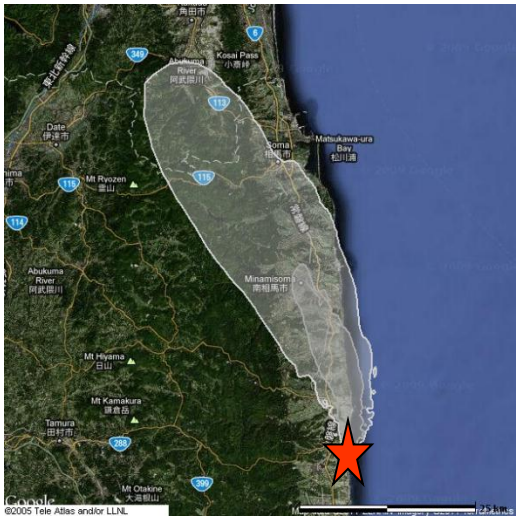
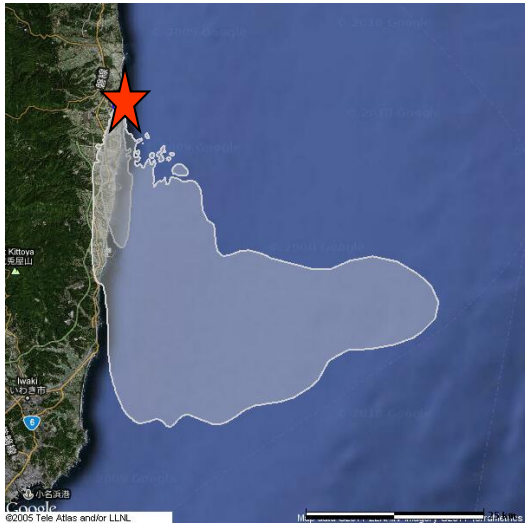
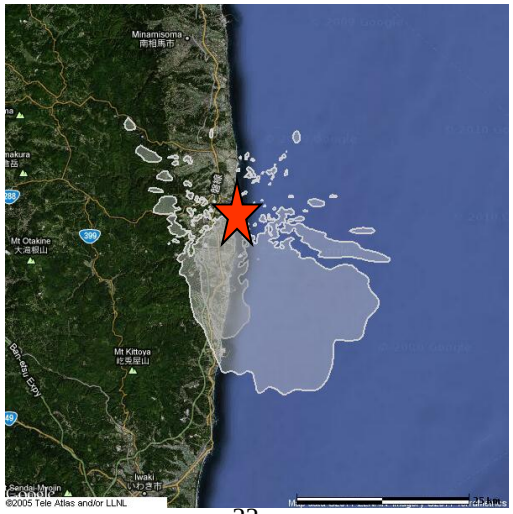
Where Did the Radionuclides Go?
Example of Diurnal Winds

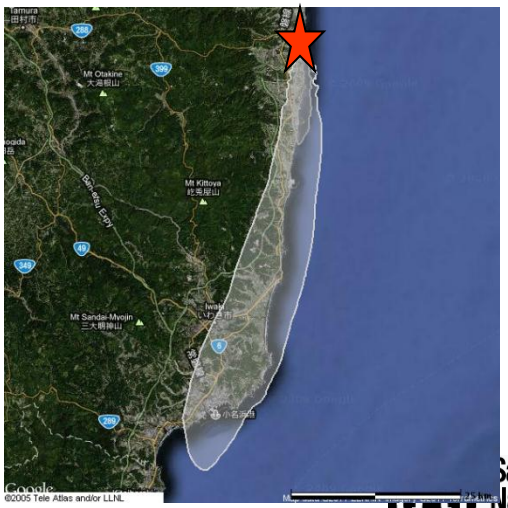












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Consequence Management Home Team (CMHT) Activities

- Consequence Management Home Team (CMHT) supported response 24/7 for ~8 weeks starting on 3/12/11 and then continued support with 1 shift for multiple weeks.
- CMHT included personnel from LANL, LLNL, RSL and SNL.
- Nuclear Incident Team (NIT) directed CMHT activities.
- DOE reported directly to the White House Office of Science and Technology Policy (OSTP) on issues of worst case planning for US interests and assessing real-time radiological conditions.
- OSTP had many questions and verified/scrutinized calculations and data products.
- OSTP requested numerous analyses and data products.
- CMHT personnel worked with personnel at the NIT, in the field, at the U.S. Embassy to Japan, Naval Reactors and U.S. Government agencies (e.g., OSTP, EPA, FDA).

CMHT Activities

- CMHT reviewed and assessed many thousands of data points, including: AMS data, in-situ measurements (e.g., gamma spectroscopy), air samples, soil samples.
- Evaluated cesium and strontium uptake by rice and the potential doses from eating contaminated rice.
- Evaluated potential doses to personnel in Guam, Hawaii, Alaska and West coast of U.S. from fallout.
- Worked with EPA, FDA, USDA etc. to assess U.S. impacts
- Evaluated potential doses from ingestion (e.g., reindeer milk).
- CMHT Assessment personnel did many one-off calculations.
- CMHT provided many data products, presentations and advice to the OSTP to enable White House to make protective action decisions.

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What Role Did SNL Assets Fill?

- SNL assets led the technical details of the radiological assessments
- SNL assets led the Lab Analysis support (analysis, data management)
- SNL assets collaborated with the NRC to identify source terms.
- At the direction of the White House, taking worst case release source terms provided by the NRC/MELCOR, worked with NARAC to model the plume dispersion and estimated potential doses to receptors in Tokyo, Guam, Hawaii, Alaska, and US West Coast
  - Challenge, this is a rapidly decaying and ingrowing mixture and so each day the key nuclides in the mixture change.
- Participated in many teleconferences with OSTP and the NIT to assess impacts to U.S. citizens in the U.S., its territories and Japan.
- Calculated potential worker doses from direct exposure, and airborne material to help protect all US personnel in the area.
- Assessed potential iodine thyroid doses to Japan and US locations.
- Performed numerous other radiological dose analysis requests.
- Dealt with sample data that was poorly collected and managed, extracted useful information and corrected the process as the response progressed.

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Radionuclide Mixtures??

Preliminary Mixtures:

- Trans-Pacific (18 parent, 13 daughter, Total of 31 radionuclides)
- SNL MELCOR mixture for reactors, SFPs and combination (45 parent, 133 daughter, Total of 178 radionuclides)
- NRC SUPERCOR Mixture for reactors and SFPs and combination (63 parent, 187 daughter, 250 radionuclides)

SUPERCOR Parent Radionuclides

Radionuclide	Activity
^{241}Am	3.64E-3
^{140}Ba	2.63E5
^{141}Ce	6.89E3
^{143}Ce	1.07E3
^{144}Ce	5.92E3
^{242}Cm	74.6
^{134}Cs	4.26E5
^{136}Cs	1.44E5
^{137}Cs	2.96E5
^{131}I	2.69E6
^{132}I	2.23E6
^{133}I	3.86E5
^{135}I	6.70E2
^{83m}Kr	7.62E-9
^{85}Kr	1.86E5
^{85m}Kr	6.17
^{88}Kr	5.80E-3
^{140}La	4.64E3
^{141}La	5.25E-4
^{99}Mo	1.65E4
^{95}Nb	3.04E3
^{97}Nb	4.37
^{147}Nd	9.37E2
^{239}Np	3.27E4
^{147}Pm	2.80
^{143}Pr	2.22E3
^{144}Pr	3.73E3
^{238}Pu	1.49E-2
^{239}Pu	1.70E-2
^{241}Pu	5.59E2
^{86}Rb	5.42E3
^{88}Rb	2.87E-3

63 parents, 187 daughters, 250 total

Ci

Radionuclide	Activity
^{88}Rb	2.87E-3
^{103m}Rh	3.42E4
^{105}Rh	4.85E3
^{103}Ru	3.44E4
^{105}Ru	2.70E-2
^{106}Ru	1.01E4
^{127}Sb	2.08E4
^{129}Sb	0.105
^{89}Sr	1.55E5
^{90}Sr	1.25E4
^{91}Sr	3.26E2
^{92}Sr	3.54E-5
^{99m}Tc	1.59E4
^{127}Te	2.96E4
^{127m}Te	6.67E3
^{129}Te	1.72E4
^{129m}Te	2.65E4
^{131}Te	2.68E3
^{131m}Te	1.19E4
^{132}Te	2.95E5
^{131m}Xe	2.54E5
^{133}Xe	2.91E7
^{133m}Xe	4.61E5
^{135}Xe	1.23E5
^{135m}Xe	3.56E2
^{90}Y	1.93E2
^{91}Y	2.06E3
^{91m}Y	41.1
^{92}Y	3.11E-4
^{93}Y	4.00
^{95}Zr	2.88E3
^{97}Zr	76.4

63 parents, 187 daughters, 250 total

Ci

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Derived Response Level Calculations

CM Assessment Scientists performed many Derived response Level (DRL) calculations.

- Deposition Derived Response Level - the areal radioactivity, at time t_n, of a marker radionuclide *i* at which the radiation dose from all radionuclides in the mixture would result in a dose equal to a specified dose over the time phase under consideration, $\mu Ci/m^2$
- Dose Rate Derived Response Level, the dose rate, at time t_n, from the radionuclide mixture at which the radiation dose from all radionuclides in the mixture would result in a dose equal to a specified dose over the time phase under consideration, mrem/hr
- Crop Derived Response Level, the areal radioactivity of radionuclide *i* deposited on a field or pasture that would result in the crop or product (e.g., milk) being contaminated at the Derived Intervention Level (Dose limit), $\mu Ci/m^2$

- **DRLs based on very conservative assumptions**

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Trans-Pacific FIREHOSE, Worst Case Source Term and Meteorology Prediction

- Dose projections performed to assess worst-case dose impacts to U.S. citizens outside of Japan.
- Unrealistic assumptions:
  - 40% Units1 & 3 core release
  - 100% Unit 2 core release
  - Constant wind direction to receptors

Location	96-hr Projected Dose (mrem)	1-Year old Child Thyroid Dose based on I-131 deposition (mrem)
Southern Alaska	4.79E-2	1.94E+3
Hawaii	7.99E-3	2.78E+2
Midway	3.09E-3	1.26E+2
Southern CA	7.52E-2	4.00E+3
Northern CA	7.64E-2	4.06E+3
Oregon	6.04E-2	3.06E+3
Washington (state)	5.24E-2	2.76E+3

- No projected dose exceeded U.S. Environmental Protection Agency guidelines for taking public protection measures (e.g., evacuation, sheltering, relocation).
- No projected dose exceeded U.S. Food & Drug administration guidelines for issuing potassium iodide (KI) to protect the thyroid.

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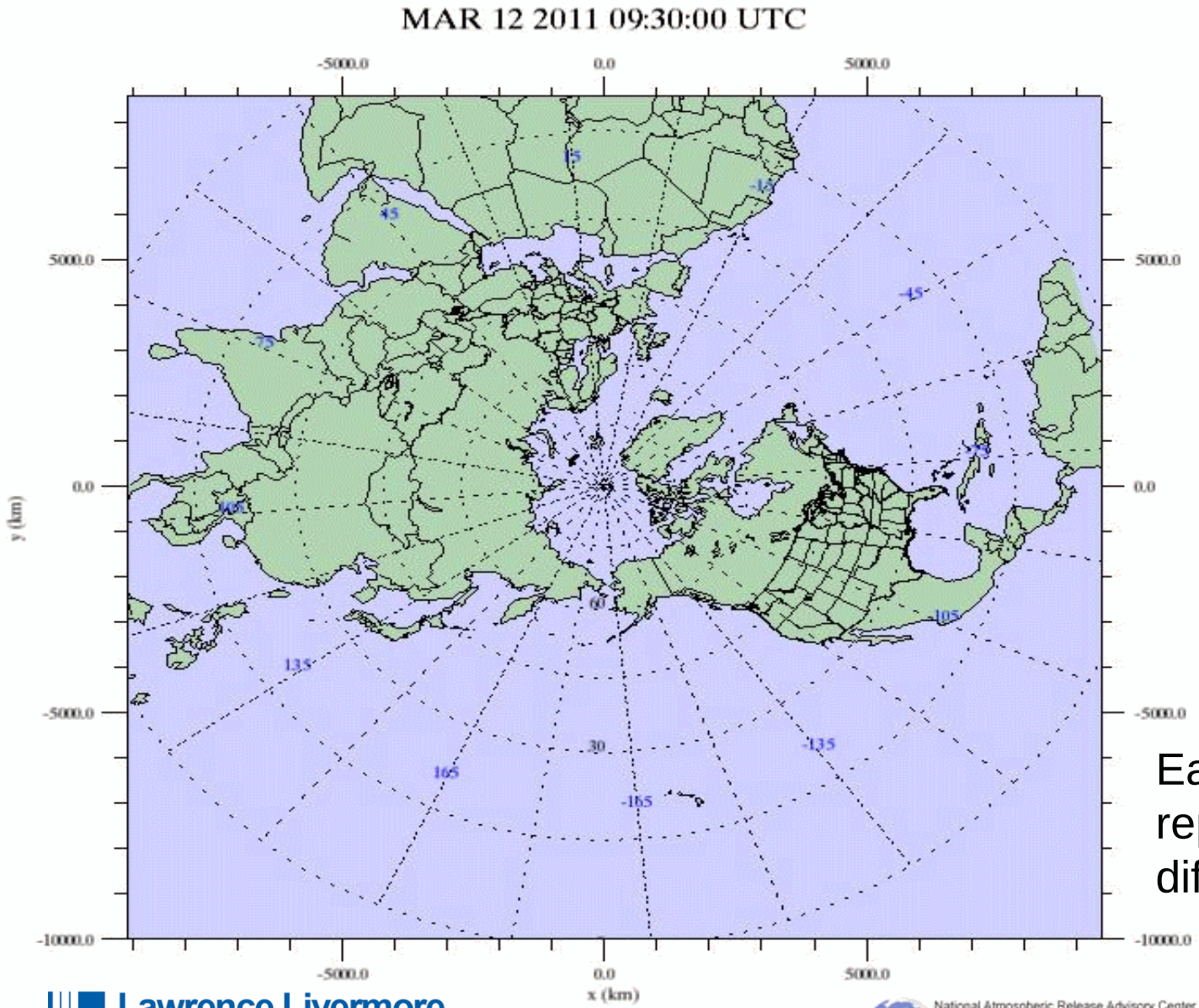
Realistic Modeling of Trans-Pacific Transport



Each color represents a different day

Lawrence Livermore National Laboratory

National Atmospheric Release Advisory Center NARAC

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Aerial Measuring System Activities

What Was Done?

- Surveys over US Bases
- Joint DOE and Government of Japan surveys
- Fixed wing and helicopter AMS systems utilized

Why?

- Map ground deposition out to 80 km from damaged Fukushima Dai-ichi NPS
- Provide information to support evacuation, relocation and public protection decisions
- Provide information to support agricultural protective actions
- Support dose assessments.

Summary of Activities?

- 1 – 3 aircraft/day (more than 85 flights and 490 flight hours)

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RSI Radiation Detectors

Sodium Iodide Radiation Detector

On-board Helicopter

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Field Monitoring Activities

What Was Done?

- Mobile monitoring
- In-situ measurements
- Exposure/dose rate measurements
- Air sampling
- Soil samples
- Swipe samples

Why?

- Calibrate AMS measurements
- Define radionuclide mixture
- Support radiological assessments
- Assess resuspension of deposited materials
- Assess horizontal and vertical and migration of radionuclides

Summary of Activities?

- > 620 air samples
- > 117 in-situ spectra
- > 141 soil samples

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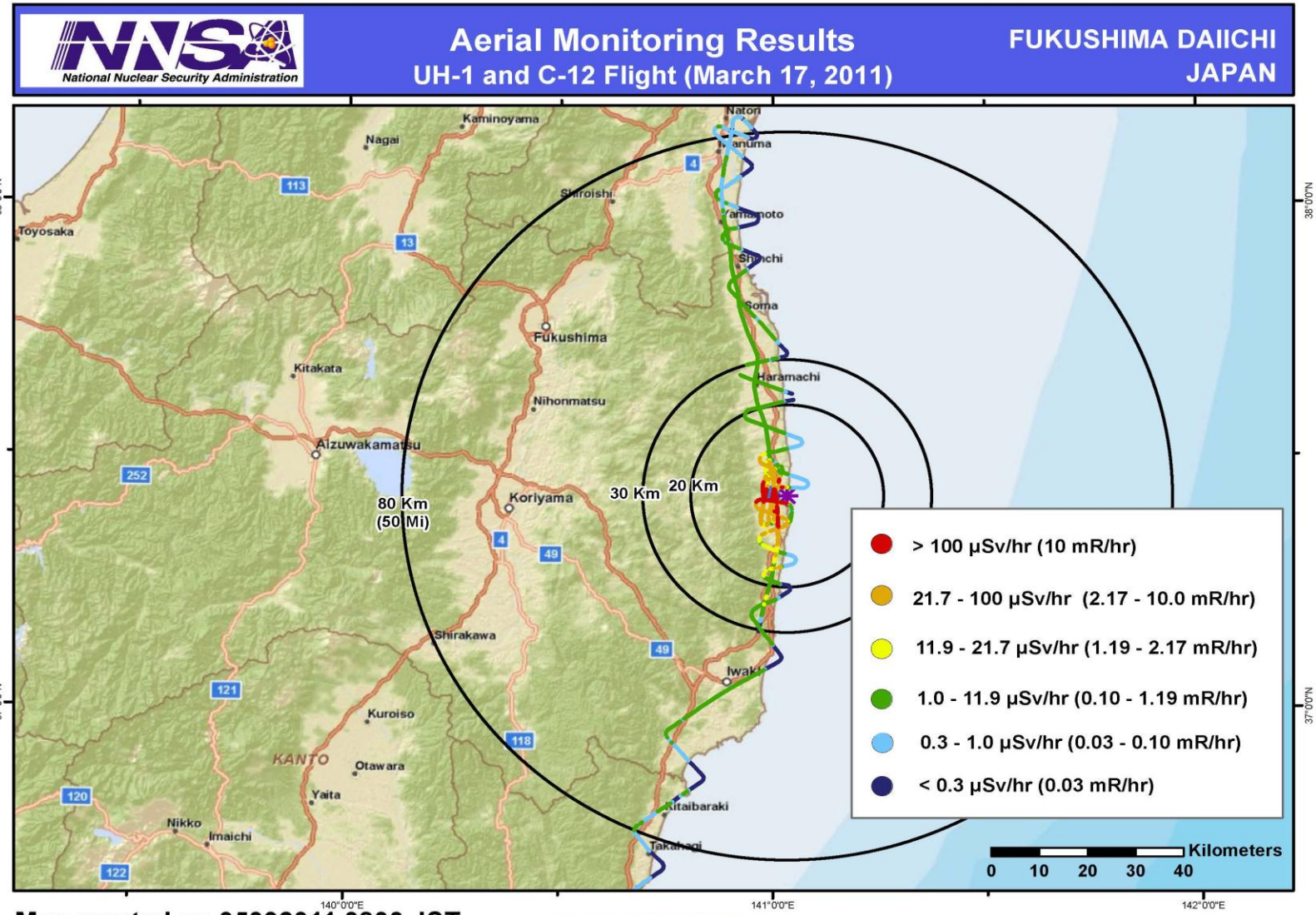
Maiden Aviation (AMS) Voyages (3/16/11)



Map created on 05092011 0800 JST

Name: CMOC UH-1 and C12 Results from 03172011

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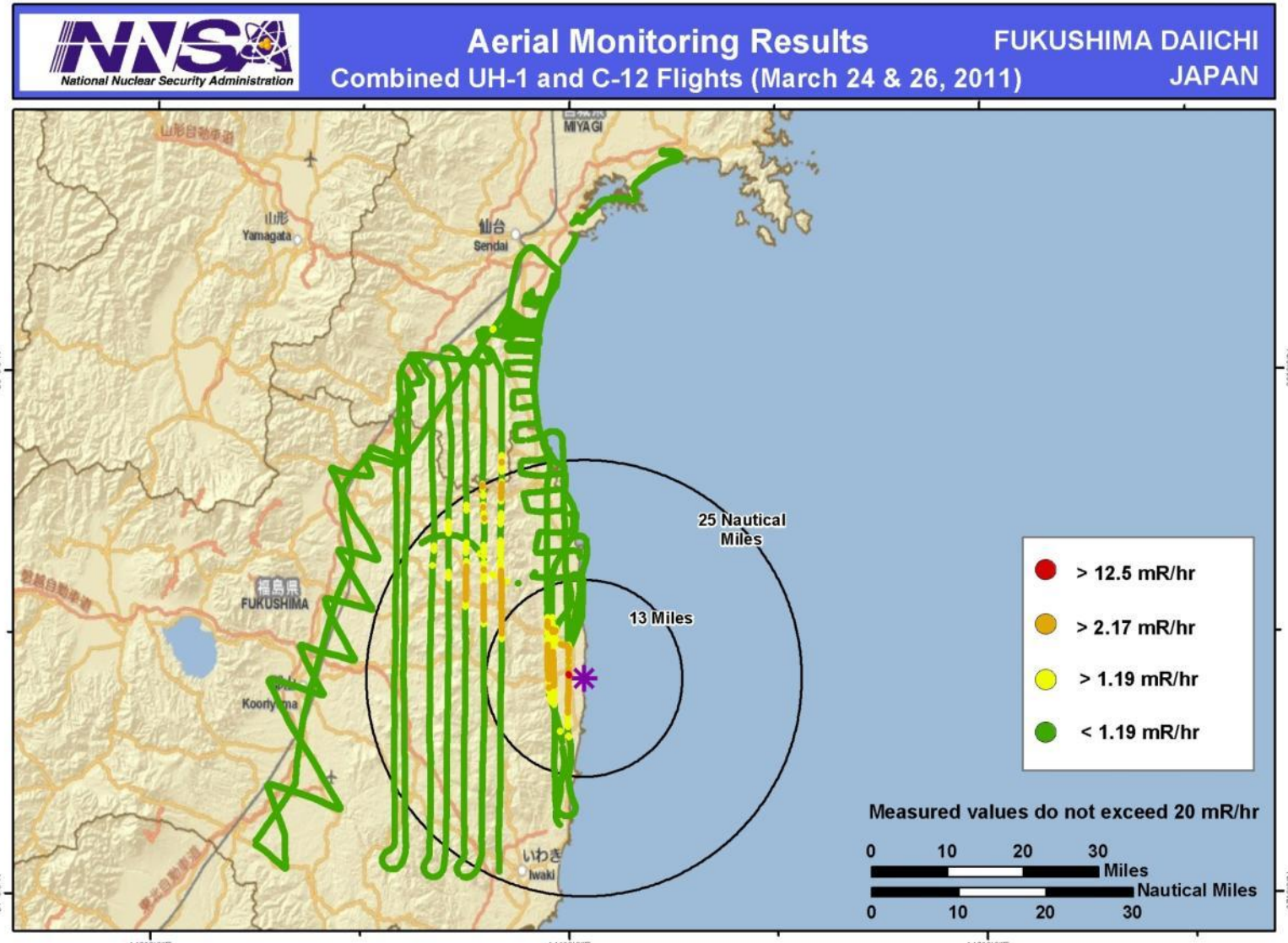
AMS Data Product (3/24&26/11)



Map created on 03272011 0220 JST
Name: NIT Combined C12 and UH1 26Mar2011 Results

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Nuclear Incident Team DOE NIT
Contact (202) 586 - 8100

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Final Radionuclide Mixture

- AMS Test Line Mixture

Radionuclide	Relative Activity of Parent Radionuclide on 3-16-11 (µci/m²)	Half-Life of Parent Radionuclide
Cs-134	3.36	2.06 year
Cs-136	0.72	13.1 day
Cs-137 Ba-137m	3.29	30.0 year
I-131 Xe-133m	5.49	8.04 day
Te-132 I-132	13.05	3.26 day

- Other Radionuclides identified in low concentrations (e.g., Sr-89, Sr-90, Pu-239)

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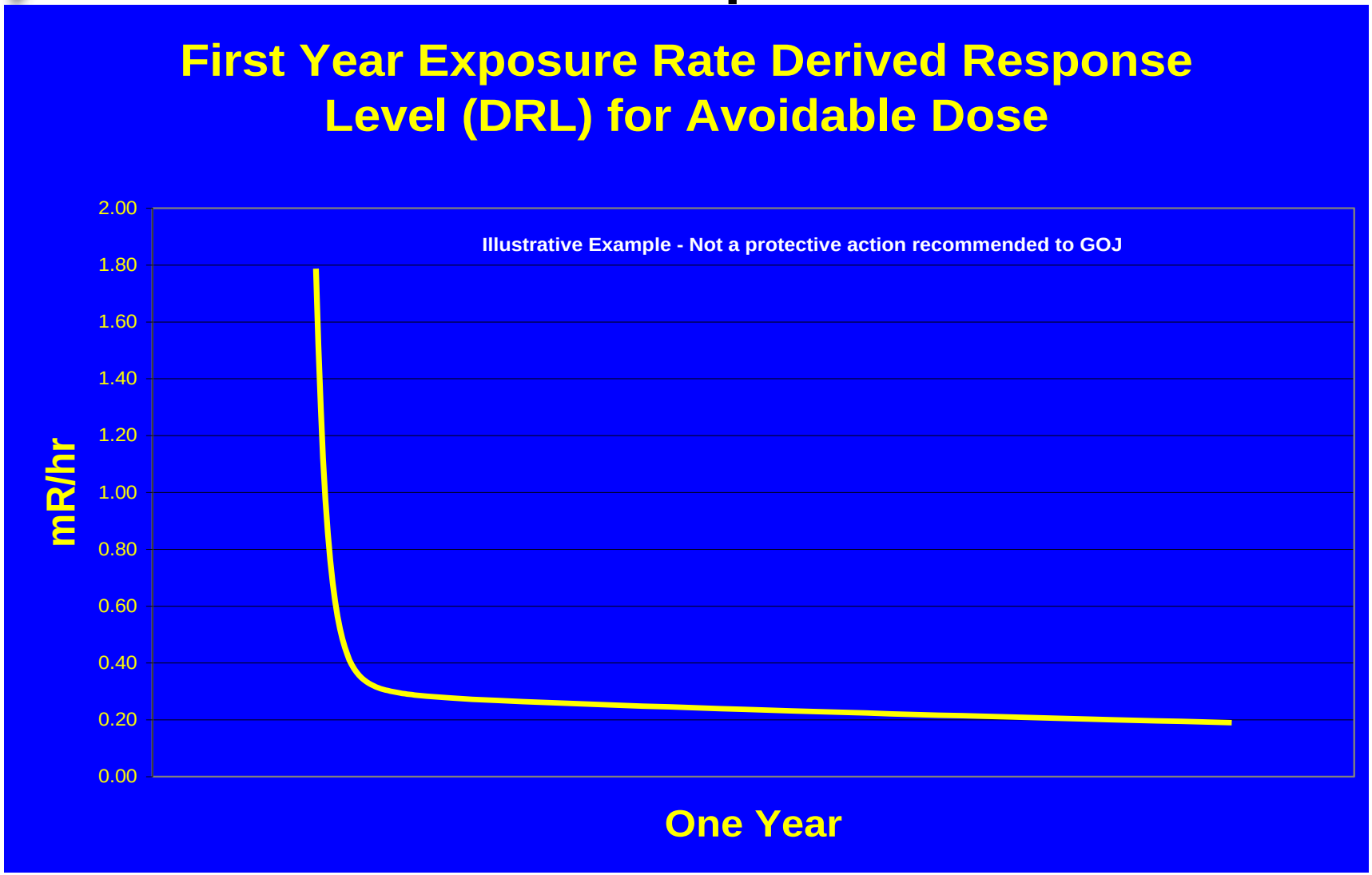
1st-Year Exposure Rate Derived Response Level



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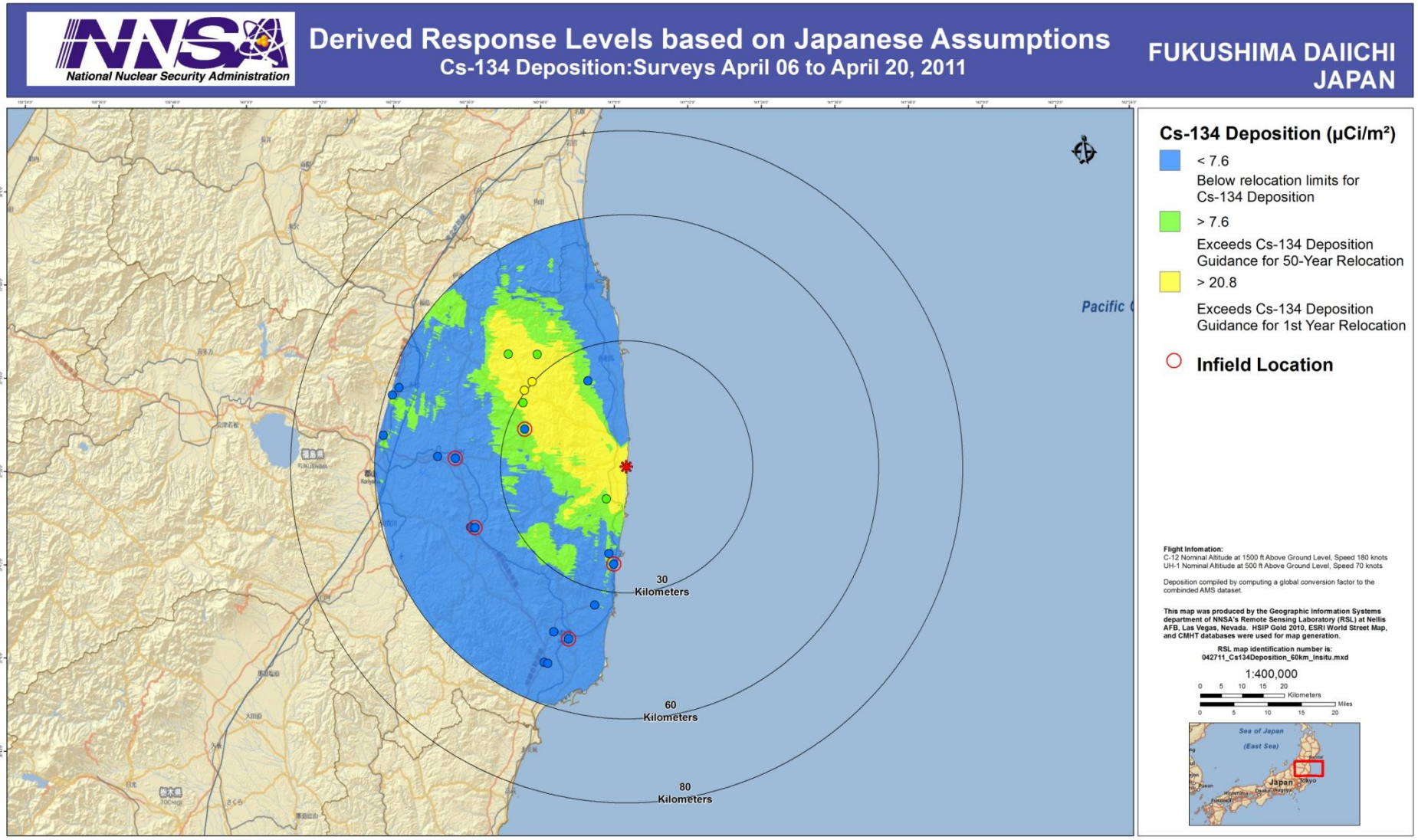
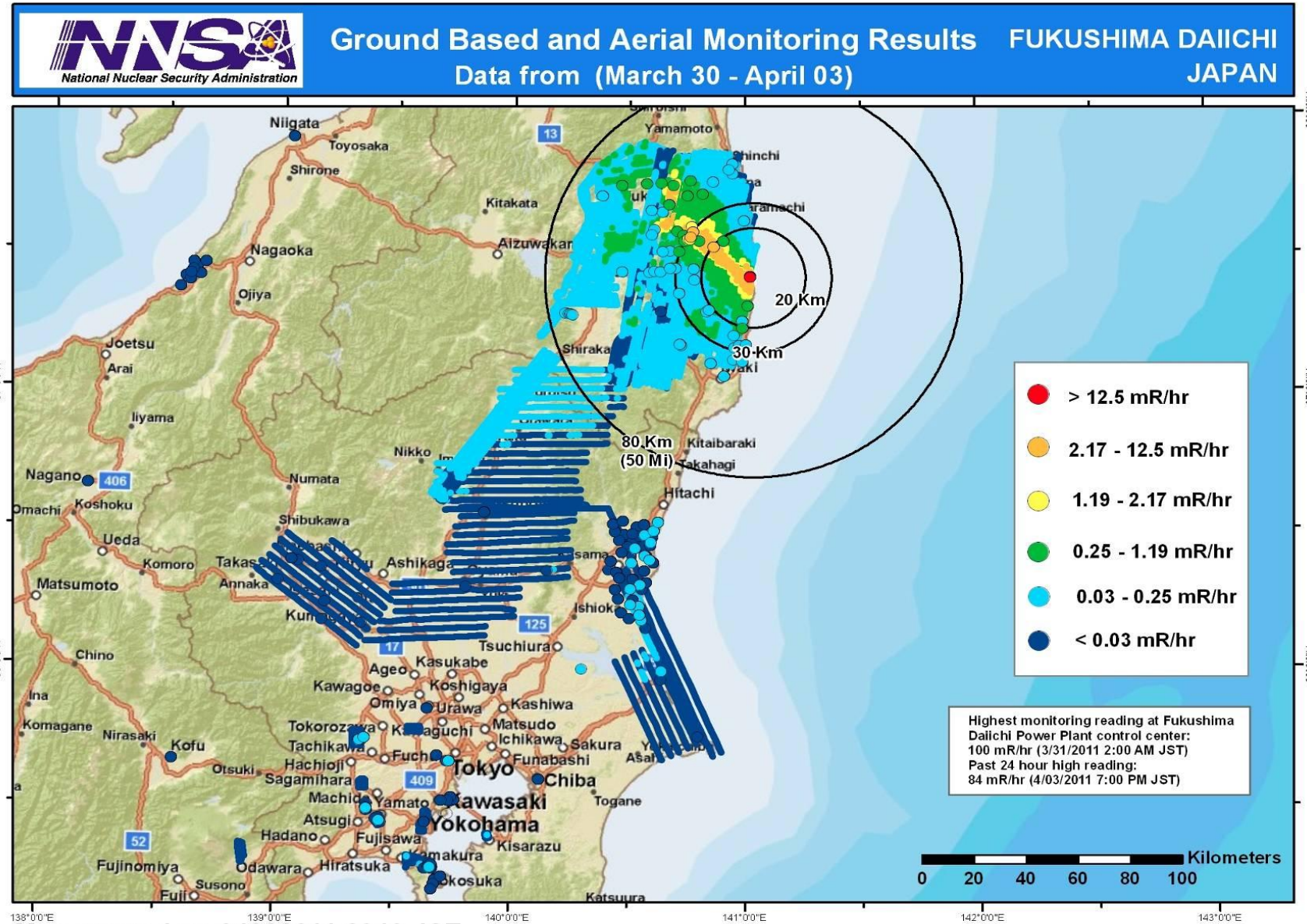
Derived Response Levels



Ground and Aerial Monitoring



Map created on 04032011 2340 JST

Name: NIT Combined Flights Ground Measurements 30Mar_03Apr2011 Results

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Nuclear Incident Team DOE NIT
Contact (202) 586 - 8100

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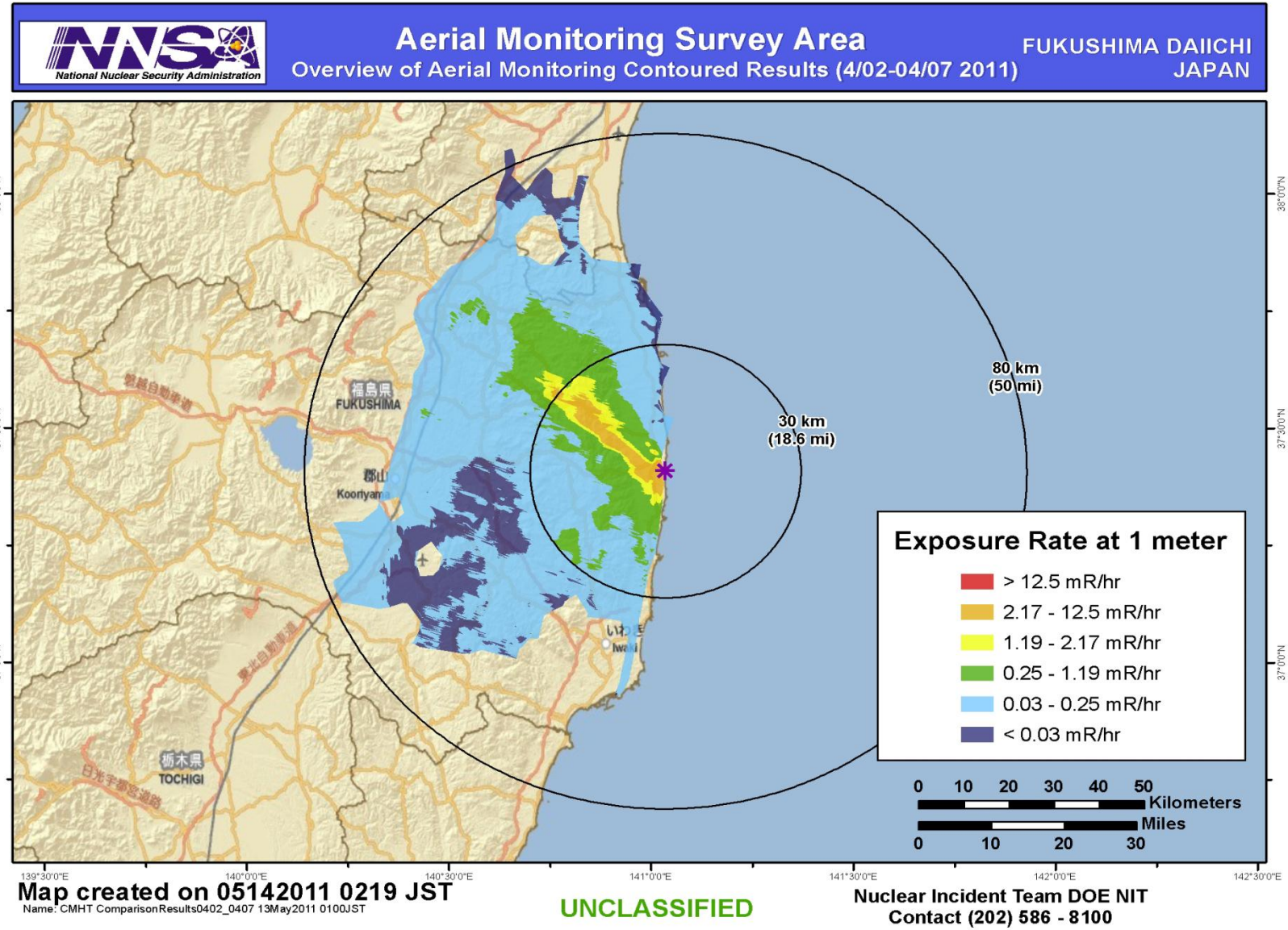
Complete Footprint



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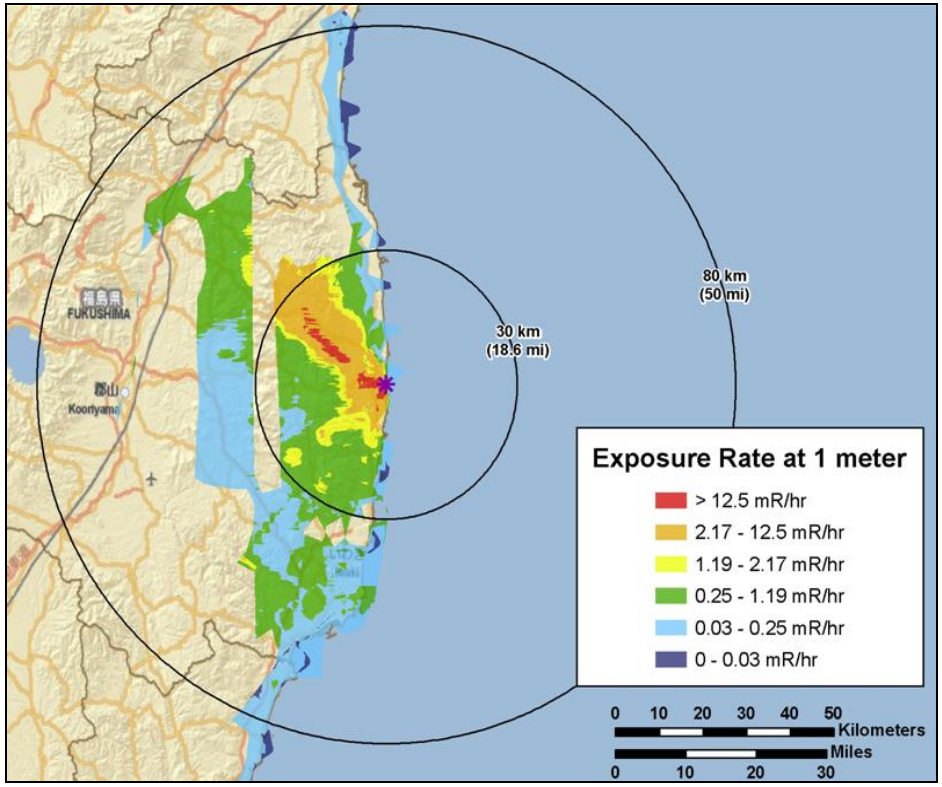
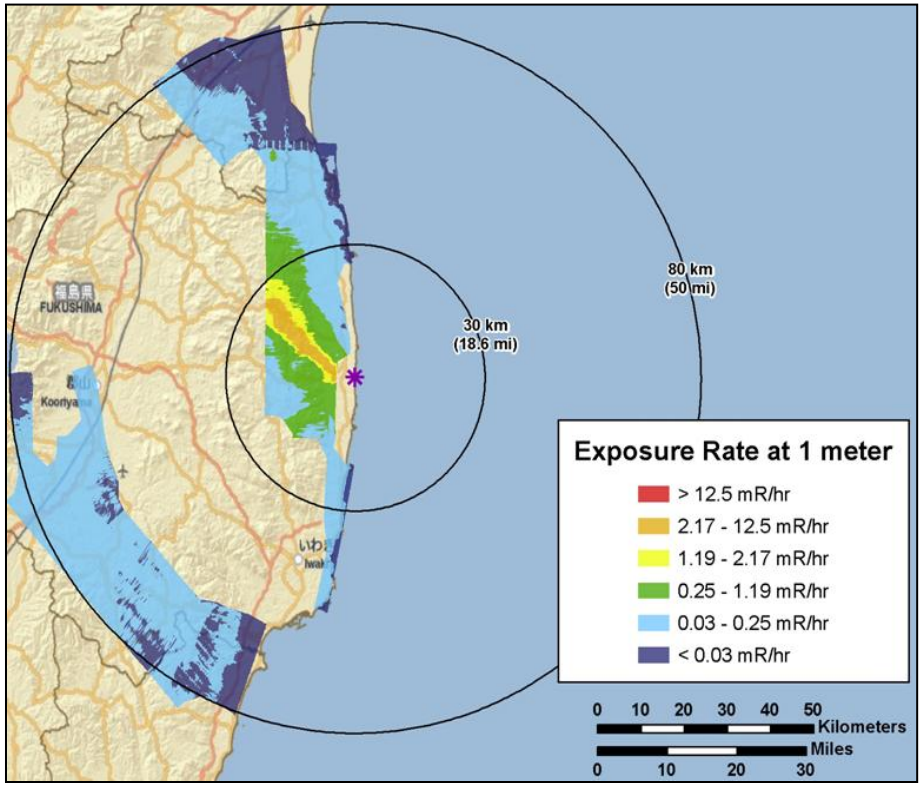
Effects of Radioactive Decay and Weathering

- Aerial Overview
- 3/17-19/2011 Data



- Aerial Overview
- 4/18-29/2011 Data



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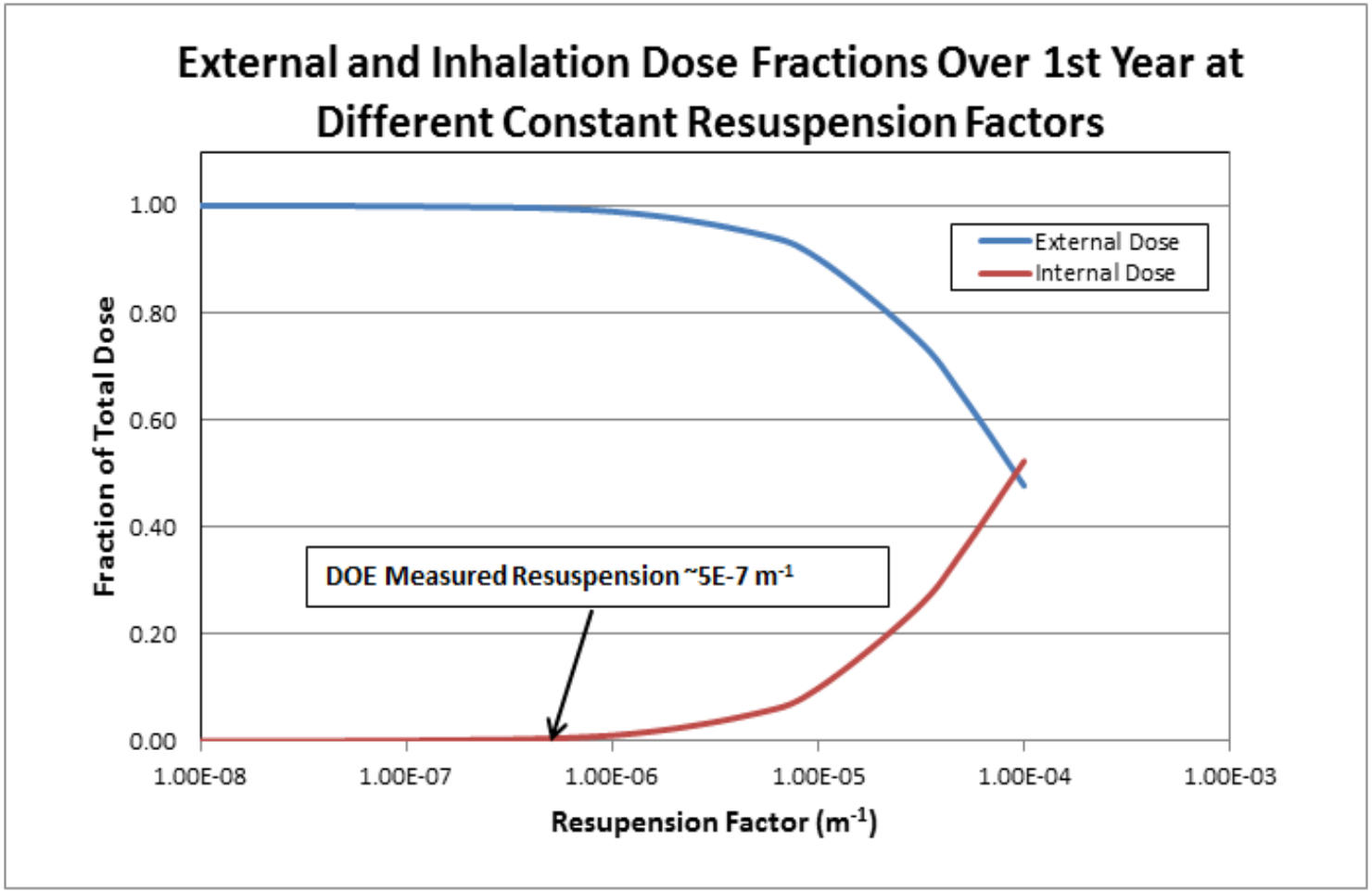
Analysis of Dose Pathways

Fraction of Dose from External and Inhalation Routes at Varying Resuspension Values



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Cesium Deposition and Exposure Rate DRLs for 4/25/11- Based on Japanese Assumptions

The table below provides the Deposition Derived Response Levels and the Exposure Rate DRLs for the 1st-Year, 2nd-Year and 50-Year Time Phases for the AMS Calibration Test Line Source Term.

- The source term was assumed to have been deposited on 3/16/11
- The 1st-Year and 50-Year Time Phases start on 4/25/11
- The 2nd-Year Time Phase starts on 4/25/12

Date (Dose)	Cs-134 ($\mu Ci/m^2$)	Cs-137 ($\mu Ci/m^2$)	Exposure Rate DRL (mR/hr)
1St- Year (2,000 mrem)	20.83	21.17	0.48
2nd-Year (500 mrem)	7.62	7.72	0.18
50-Year (5,000 mrem)	7.58	7.68	0.18

∗DRLs adjusted for GOJ guidance that assumes an overall dose reduction of 40% for remaining indoors 16 hours per day, 0.4 attenuation factor, and 8 hours per day outdoors.

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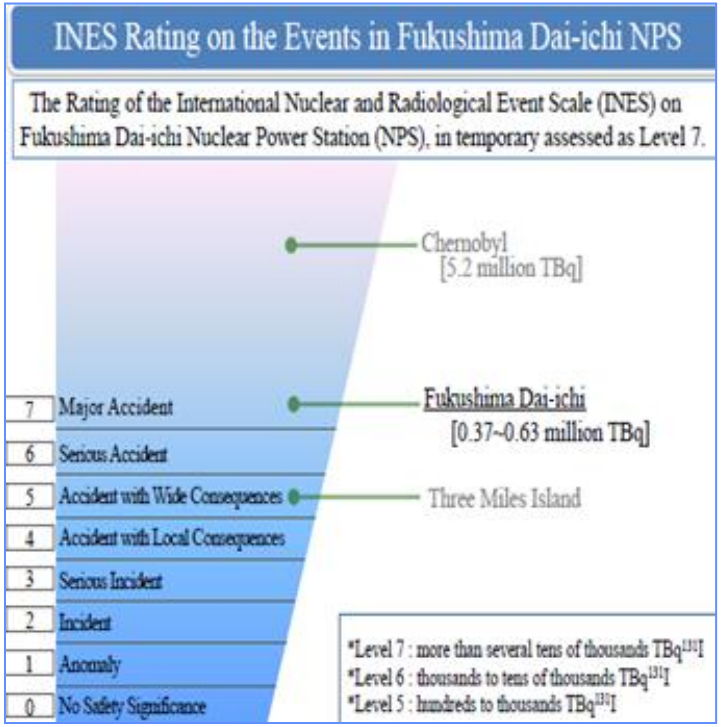
Estimated Releases

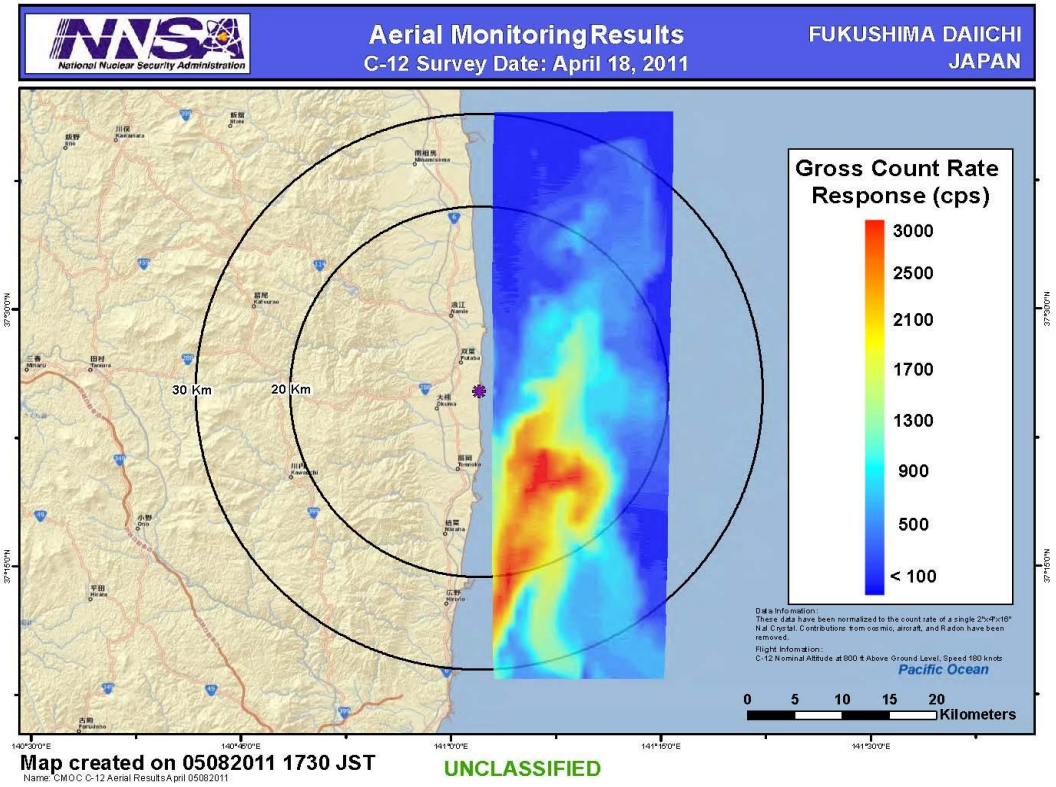
Nuclide	NISA[1]	NSC[2]	Chernobyl
I-131	$1.3X10^{17}$ Bq	$1.5X10^{17}$ Bq	$1.8X10^{18}$ Bq
Cs-137	$6.1X10^{15}$ Bq	$1.2X10^{16}$ Bq	$8.5X10^{16}$ Bq

[1] Nuclear and Industrial Safety Agency

[2] Japan Nuclear Safety Commission

Fortunately the diurnal winds pushed much of the radioactive material out to sea





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Radiological Assessments

- Derived Response Levels for public protection
- Worker protection calculations
- Estimate when (future) Japanese could return to contaminated area without exceeding dose limits
- Estimate food (e.g., milk, rice, produce, beef) contamination levels in Japan and U.S.
- Dose from consuming milk from reindeer feeding on forage contaminated by I-131
- Dose from eating contaminated shellfish
- Early warning system
- Train and roadway assessments
- Resuspension
- Weathering
- Accounting for shielding inside buildings

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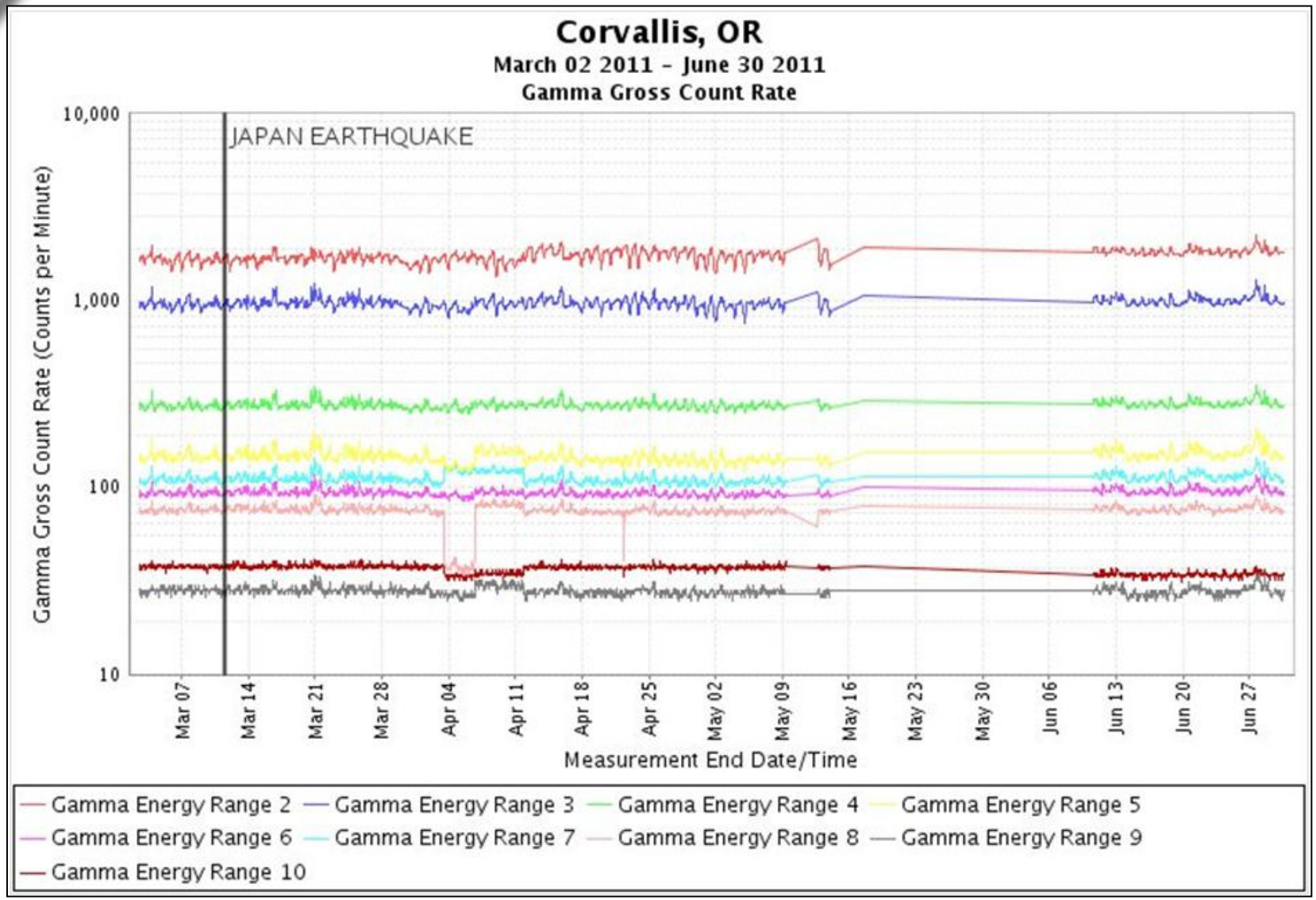
Real Data from EPA's RadNet Monitors



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Estimated U.S. Impacts

- The assessment of the radionuclide mixture released from the Japanese facilities indicates that the doses resulting from the maximum projected radionuclide deposition at the indicated areas does exceed the guidelines established by the U.S. Environmental Protection Agency for taking public protection measures (e.g., evacuation, sheltering, relocation) or the protective action guides for protection of food as established by the U.S. Food and Drug Administration.
- The assessment projects the following:
- Based on a 4-day dose conversion factor of 11.4 mrem per 1 µCi/m^2 of Cs-137
- Based on a DRL for Cs-137 for milk-cow-forage pathway of 0.13 µCi/m^2 (500 mrem)

Location	Max Ground Concentration (uCi/m2)	96-hr Projected Dose (mrem)	Ingestion Pathway Projected Dose (mrem)
Anchorage, AS	1.70E-07	1.94E-06	6.54E-04
Kauai, HI	5.00E-08	5.70E-07	1.92E-04
Los Angeles, CA	8.60E-07	9.80E-06	3.31E-03
Portland, OR	5.30E-06	6.04E-05	2.04E-02
San Francisco, CA	8.90E-07	1.01E-05	3.42E-03
Seattle, WA	4.10E-07	4.67E-06	1.58E-03

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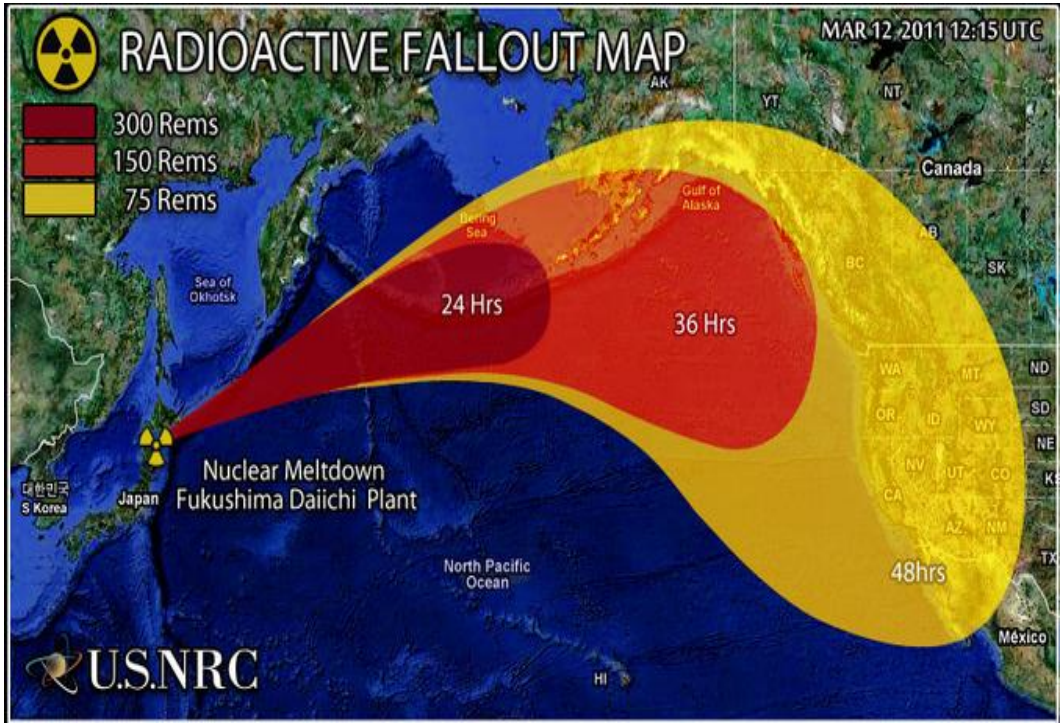
FEARMONGERING

- After Fukushima, California drugstores sold out of potassium iodide (or KI) – a potentially hazardous drug that protects the thyroid gland from absorbing radioactive iodine.
- According to Jessica Wehrman, from the American Association of Poison Control Centers, there have been at least 33 calls to poison control centers from people suffering negative side effects after exposure to KI. Symptoms include irritability, dizziness, drowsiness, nausea, vomiting, and tachycardia – a condition that causes the heart to beat faster than usual. (RDTN.org, 4/1/11)

DSI GLOBAL VIEW



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Worker Radiation Doses

Site safety

To date, the Fukushima Daiichi nuclear accident itself has not caused any documented deaths. However, there have been six deaths on site: two workers were killed by the tsunami, and four site workers have fallen ill and died from unrelated causes (two heart attacks, one case of acute leukaemia and one case of sepsis). The number of workers exposed to radiation to 31 December, the latest figures available, are shown (Table 1). Although an annual dose of 100 mSv was the standard radiation limit for nuclear power plant workers, the government raised the limit to 250 mSv for emergency tasks. ■

Table 1: Number of Fukushima Daiichi site workers receiving a measurable amount of radiation in 2011 (mSv)

More than 250	6
200-250	3
150-200	23
100-150	135
50-100	697
20-50	2521
10-20	3032
Less than 10	13,177
Total	19,594
Maximum individual dose	678.8

- Heroic efforts by many Japanese workers
- No workers have died because of radiation exposures
- risk estimators (EPA1998):
  - Fatal cancer, is ~6×10^{-5}/mSv (6 in 100,000 exposed to 1 mSv)
  - Total cancer, is ~7×10^{-5}/mSv (7 in 100,000 exposed to 1 mSv)

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Confounding Factors

福島第一(1F) 正門付近前(MP-6付近)(2号機より西南西約1.0キロ)

3月16日													
モニタリングカー	5:00	5:30	6:00	6:30	6:40	6:50	7:00	7:10	7:20	7:30	7:40	7:50	8:00
測定値(μSv/h)	918.2	868.0	884.0	848.0	837.0	815.0	808.8	670.3	661.8	651.1	644.0	636.8	627.5
中性子	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
風向	北西	北北西	北西	西	西北西	西北西	北西	北西	北西	北西	西	西	北北西
風速(m/s)	2.9	2.6	2.0	1.4	1.4	1.4	1.4	1.4	1.2	1.3	1.2	1.2	1.2

3月16日													
モニタリングカー	9:40	9:50	10:00	10:10	10:20	10:30	10:45	10:54	10:55	11:00	11:10	11:20	11:30
測定値(μSv/h)	641.8	700.6	810.3	988.5	2399.0	1361.0	6400.0	2300.0	2900.0	9391.0	2720.0	1900.0	5350.0
中性子	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
風向	西	北北西	東北東	北東	東北東	東	東北東	北東	−	北東	北北東	東北東	北東
風速(m/s)	1.6	1.5	1.8	1.5	1.4	2.2	4.9	−	−	2.0	1.9	2.3	1.6

3月16日													
モニタリングカー	13:10	13:20	13:30	13:40	13:50	14:00	14:10	14:20	14:30	14:40	14:50	15:00	15:10
測定値(μSv/h)	2536.0	2430.0	2331.0	2257.0	2182.0	2122.0	2059.0	2022.0	1937.0	1888.0	1835.0	1788.0	1752.0
中性子	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
風向	西南西	西南西	北	北西	北西	東北東	南南西	南南西	西	西北西	西南西	北西	北西
風速(m/s)	1.0	1.2	2.4	2.7	2.1	1.7	1.9	2.3	2.1	2.1	3.1	2.3	3.4

福島第一(1F) 体育館付近(MP−5東側)(2号機より西北西約0.9キロ) ※消防活動の支障になるため移動

3月16日										
モニタリングカー	17:08	17:10	17:20	17:30	17:40	17:50	18:00	18:10	18:20	18:30
測定値(μSv/h)	752.0	749.3	745.6	741.3	738.2	735.0	731.0	728.0	725.9	723.3
中性子	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
風向	−	北	北西	西北西	北北西	北北西	西北西	北西	西	北西
風速(m/s)	−	3.6	3.5	3.5	4.0	4.0	4.3	3.9	3.6	3.6

Japanese speak and write Japanese

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Data Translated

Fukushima Daiichi (1F) area in front of the main gate (MP-6 Area) (about 1.0 km WSW of Unit 2)													
March 16th													
Monitoring Car	500	530	600	630	640	650	700	710	720	730	740	750	800
Measured Value (mSv/hr)	918.2	868.0	884.0	848.0	837.0	815.0	808.8	670.3	661.8	651.1	644.0	536.8	627.5
Neutrons	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Wind Direction	NW	NNW	NW	W	WNW	WNW	NW	NW	NW	NW	W	W	NNW
Wind Speed (m/s)	2.9	2.6	2.0	1.4	1.4	1.4	1.4	1.4	1.2	1.3	1.2	1.2	1.2
March 16th													
Monitoring Car	940	950	1000	1010	1020	1030	1045	1054	1055	1100	1110	1120	1130
Measured Value (mSv/hr)	641.8	700.6	810.3	908.5	2399.0	1361.0	6400.0	2300.0	2900.0	9391.0	2720.0	1900.0	5350.0
Neutrons	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Wind Direction	W	NNW	ENE	NE	ENE	E	ENE	NE	-	NE	NNE	ENE	NE
Wind Speed (m/s)	1.6	1.5	1.8	1.5	1.4	2.2	4.9	-	-	2.0	1.9	2.3	1.6
March 16th													
Monitoring Car	1310	1320	1330	1340	1350	1400	1410	1420	1430	1440	1450	1500	1510
Measured Value (mSv/hr)	2636.0	2430.0	2331.0	2257.0	2182.0	2122.0	2059.0	2022.0	1937.0	1888.0	1835.0	1788.0	1752.0
Neutrons	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Wind Direction	WSW	WSW	ND	NW	NW	ENE	SSW	SSW	W	WNW	WSW	NW	NW
Wind Speed (m/s)	1.0	1.2	2.4	2.7	2.1	1.7	1.9	2.3	2.1	2.1	3.1	2.3	3.4

Fukushima Daiichi (1F) area of gymnasium (MP-5 East side) (about 0.9 km WNW of Unit 2) Moved because of a hindrance to firefighting activity										
March 16th										
Monitoring Car	1703	1710	1720	1730	1740	1750	1800	1810	1820	1830
Measured Value (mSv/hr)	752.0	749.3	745.6	741.3	738.2	735.0	731.0	728.0	725.9	723.3
Neutrons	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Wind Direction	-	N	NW	WNW	NNW	NNW	WNW	NW	W	NW
Wind Speed (m/s)	-	3.6	3.5	3.5	4.0	4.0	4.3	3.9	3.5	3.6

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Confounding Factors

- 15 hr time difference between teams in Japan and New Mexico.
- Japanese regulations were not understood
- Insufficient staffing led to burnout
- Massive amounts of data were available for review and assessment.
- Management of data flow and communication (email) was very difficult
- It was difficult to get current data on the actual status (health) of the reactors
- Multiple releases occurred under varying weather (snow, rain, sunshine) and wind conditions
- Difficult to perform accurate radiological assessments for quite some time because the radionuclide mixture and released activities were not known

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Confounding Factors

- Command and Control was overwhelmed, everything was given top priority
- Leadership struggled to coordinate taskings and current status of CM assets at multiple laboratories in the U.S. and multiple locations in Japan
- The CMHT was put under a lot of pressure to produce assessments and data products too quickly, and therefore, QA/QC measures were not always adequate
- Rapidly changing wind and precipitation created complex dispersion patterns
- Complex terrain challenged models to predict and explain deposition patterns
- Rain and snow created complex deposition patterns
- Many different individuals and agencies making their own predictions

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Continuing Activities

- USFJ and Government of Japan to continue monitoring activities as needed
- Japanese trained and equipped to fly DOE AMS
- Japanese equipped with an enhanced laboratory analysis capability
- USFJ trained & equipped to fly contingency AMS
- DOE continues to support Japanese and USFJ from Home Team
- Additional radiological assessments

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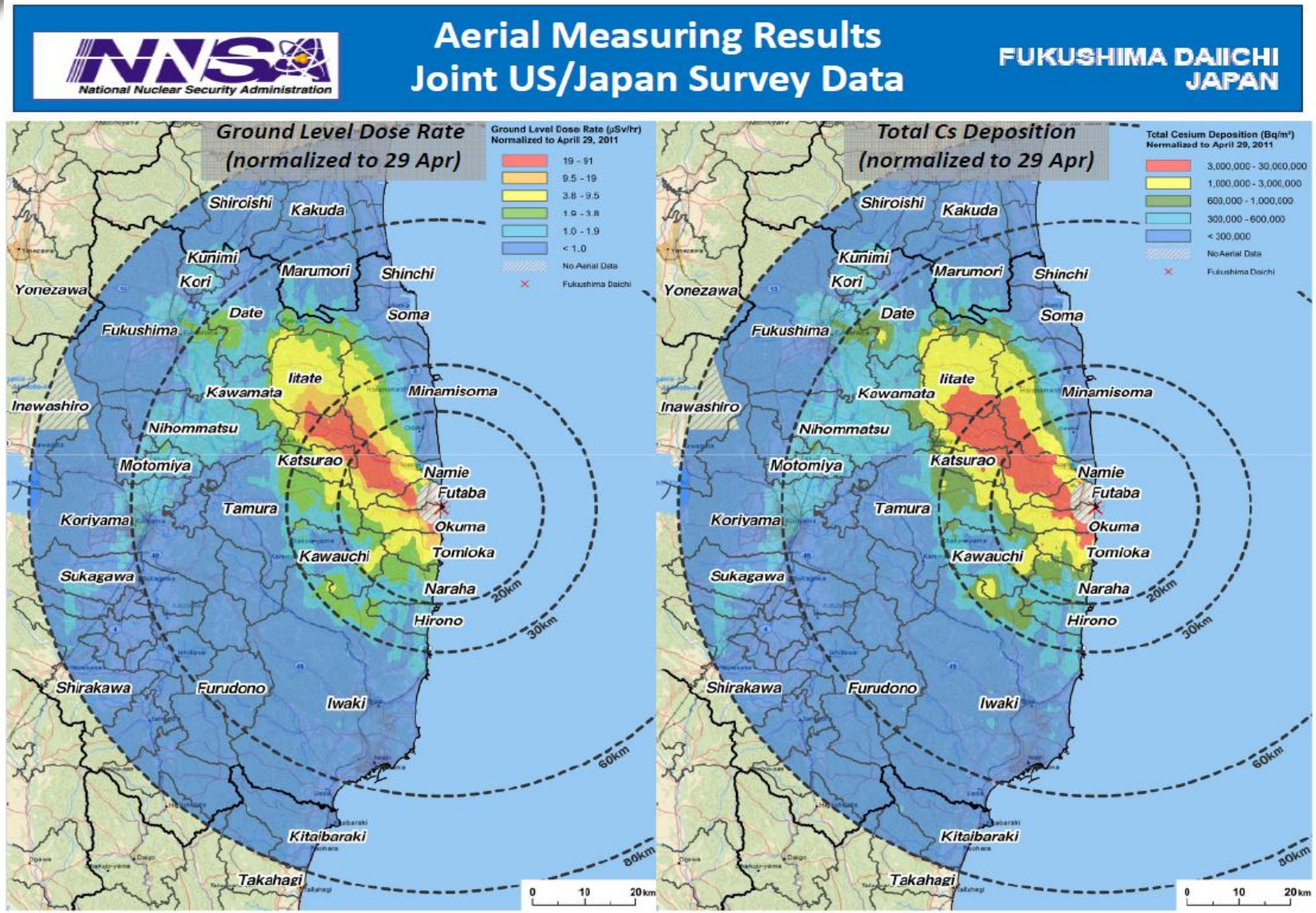
Continuing Activities



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QUESTIONS?