Challenges in Determining the Isotopic Mix from the Fukushima Daiichi Accident

“What Can We Learn From the Response”

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SAND2011-3983C
Nuclear Incident Response Programs
The Objective

• Assess the dose to individuals including a dose per day and in relationship to the PAG like guidance.

• Using:
  – Field Measurements
  – Aerial Measurements
  – Model Results
  – In-situ Measurements
  – Field Samples followed by Lab Analysis

• Need the mixture to assess doses.
The First Weeks

- Reactors Failing
- Hydrogen Explosions
- Huge Pressure for Information
- Releases continue for weeks
The First Weeks

- NRC Developed 4 Hypothetical Release Scenario Estimates

- White House Requesting Hypothetical Dose Impacts in Japan, West Coast, Hawaii, Guam, and Alaska

- DOE Dose Assessment Teams begin modeling various releases to each location updating each day as hypothetical mixtures decays/in-grows.
Complexity in Spatial Distribution of Lab Analysis Resources

Fukushima Reactor

Japan/CMRT Yokota Air Base

Remote Sensing Lab, Nellis CMHT

LLNL

GEL Lab

DC/NIT

Savannah River

Sandia and LANL CMHT
Complication of Weather
Hypothetical Behavior During One 24-hour Period
AMS Measurements

- Large number of flights and data mapped and compared to ground measurements the help build the overall footprint.
- AMS information was key to defining the footprint, but AMS only measures gamma emissions.
- It took weeks to overfly all the area.
Air Filter Samples

- Collected daily to assess real-time risk to personnel located at US Facilities.
- Field counted and then submitted to laboratory for additional analysis.
- Over 580 air filter samples collected.

Challenges:
  - Field counting presented challenges as background in the counting area varied significantly.
  - Could not get a Strontium results for few weeks so had to assume a ratio.
Daily Inhalation Dose at Yokota Air Base (upper bound)

- 1-day Adult CED (mrem)
- 1-day Adult Thyroid Dose (mrem)

Graph showing daily dosages from March 16 to April 10, 2011.
Field Measurements/Sample

- Performing Field Readings, sampling and In-situ measurements.
- It takes weeks to get reasonable numbers of measurement points.
- Measurements mapped and began helping develop the footprint.

Challenges:

- Using measurements to characterize the footprint, but things continue to change with several releases and a decaying mixture.
- Only getting data on gamma emitting nuclides
- It takes long drives (100+ miles) to get to these sampling locations so a lot of time spent in this effort.
Soil Samples

- First Soils were from the Government of Japan – 89 samples.

- AFRAT collected an additional 6 soil samples, 4 from near the reactor.

- DOE collected 35 samples from higher levels areas.

- DOE collected 6 soil cores to measure how deep Cesium was migrating.
Government of Japan Soil Samples

- Gov. of Japan sent 89 soil samples to the US for Radiochemistry analysis from Rice Crop Areas.
- There was specific interest in Sr-89 and Sr-90 and Sr to Cs ratios.
- Gamma Spec analysis was also performed.

Challenges:
- Sr-89/90 Analysis is time consuming, it requires several days to allow ingrowth as part of the analysis process.
- Activity on these samples was near detection levels and as a result the Sr to Cs ratios varied widely from 1:1 to 2000:1. The fact that they were all near detection level seemed to be causing this variability.
Total Strontium Compared to MDA
DOE Soil Samples

- US collected 35 Surface Soil Samples and 6 Soil Cores.

- US Sampled Higher Activity Locations
  - Trying to get samples that would be well above detection level to make more definitive Sr to Cs ratio estimates.

- Soil Core was to determine penetration of contaminants.
  - This was a process developed on the fly to answer the penetration question.
  - Developed the sampling protocol and analysis processes real-time.
Soil Sample Challenges

- It took time to get the samples to the US. The short-lived nuclides were decaying away over this time.
- USDA requires Sterilization of the foreign samples before any analysis. This involved heating so there was concern that the Iodines and Cesiums (i.e., Volatiles) would be driven out of the samples.
  - Were able to show this was not an issue based upon required temperatures and gamma counts before and after sterilization.
- Cs-137 to Cs-134 ratios was observed to be changing over the 3 month period causing a 2% variation over the time period.
  - Cs-134 with its 2.06 year half-life could not be ignored over this time frame.

- Discovered that labs typically were not correcting for a peak summing issue that exists for nuclides like Cs-134 with cascade decay schemas. Caused a 13% bias between In-Situ and Samples, correcting for the summing occurred.
Peak Summing Issue

\[ ^{134}_{55}Cs^{79} \]  
\[ Q(\gamma) = 2058.7 \text{ keV} \]  
\[ \beta^- : 99.99970 \% \]  

\[ 4^+ \rightarrow 0.0 \rightarrow 2.0652 \text{ Y} \]  
\[ 0.027 \% \]  
\[ 0.0162 \% \]  
\[ 15.373 \% \]  
\[ 8.688 \% \]  
\[ 3.017 \% \]  
\[ 1.477 \% \]  
\[ 0.990 \% \]  
\[ 5.0 \times 10^{-4} \% \]  
\[ 8.338 \% \]  
\[ 5.46 \% \]  
\[ 9.762 \% \]  
\[ 1.79 \% \]  
\[ 0.0 \]  
\[ 604.7 \]  
\[ 1168 \]  
\[ 1400.6 \]  
\[ 1643.3 \]  
\[ 1960.9 \]  
\[ ^{134}_{56}Ba^{78} \]
Other Issues

- There was a lot of rain making AMS flights difficult and impacting other ground operations.
- The rugged terrain impacted both ground and aerial measurements (note road condition)
- Were never able to definitively determine the source term during the active DOE Response
Need to remember all that Japan was dealing with at this time.
### Challenges Just To Get Work Done

**Typical Day’s**

**Daily Conference Call/Meeting Schedule**

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<tr>
<th>Time</th>
<th>MST</th>
<th>JST</th>
<th>Details</th>
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<td>7:00 AM</td>
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Trying to get any work done with all of these calls is very difficult.
Data Came from Many Sources, but Not Always Readily Usable

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<tr>
<th>Date</th>
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<th>Dose Rate (μSv/h)</th>
<th>Wind Direction</th>
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福島第一（1F）正門付近前（MP-8付近）(2号機より西南西約1.0キロ)

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福島第一（1F）体育館付近（MP-5付近）(2号機より西北西約0.9キロ) ※消火活動の支援になるため移動

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Complexity in Just Getting Sample
FedEx Shipping Routes

Some sample were held in Alaska until Tax Status could be determined

Quote of the Response Carolyn Wong of LLNL Reporting

“There will be no new samples today. Our FedEx package got Shanghai’d, literally, the package is in Shanghai, China.

😊”
Does Anyone Know What Time It Is?

“One Laptop is set for JST and the other is set for PDT!”

NARAC uses UTC

UTC = PDT + 7 hrs

UTC = JST – 9 hrs

RAMS is in PDT

PDT = JST – 16 hrs

“Both Detectives are set to JST!”
Other Big Lessons Learned

- Sample results will take a long time to obtain and they won’t be definitive
  - Everyone will want answers yesterday
- MDA’s are vital at the very early phases.
  - This is one of the first question that needs to be answered for the labs and if you choose the wrong MDA this will result in data that does not answer your questions.
- Need to ensure proper information is recorded for samples or you will not be able to use the results as intended (location, surface area, depth, etc).
- Sampling is far more involved than normally played in exercises.
- Everyone will be giving their assessments and you will need to be prepared to not only work on your assessment but also to address their assessments.
- If the release and response occurs for weeks (as will likely be the case) you will need significantly more people resources than one would expect, people just start to wear out.
Successes

- No injuries
- Coordinated a multi-laboratory response
- Highlighted the importance of deployable laboratory capability
- Laboratories met requested MQOs and Turn-around times
- RAMS used for the first time for real-world samples
- First time Triage involved in this type of event
- 734 samples analyzed
  - 593 Air Filter Samples
  - 4 Swipe Samples
  - 131 Soils
  - 6 Soil Cores
- Gross Beta, Gamma Spec, Sr-89,90, Total Sr, Plutonium, Uranium, Americium/Curium
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• Ted Redding

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Questions

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