Assessment of Baseline Cs-137 Soil Concentrations to Support ISFSI Construction

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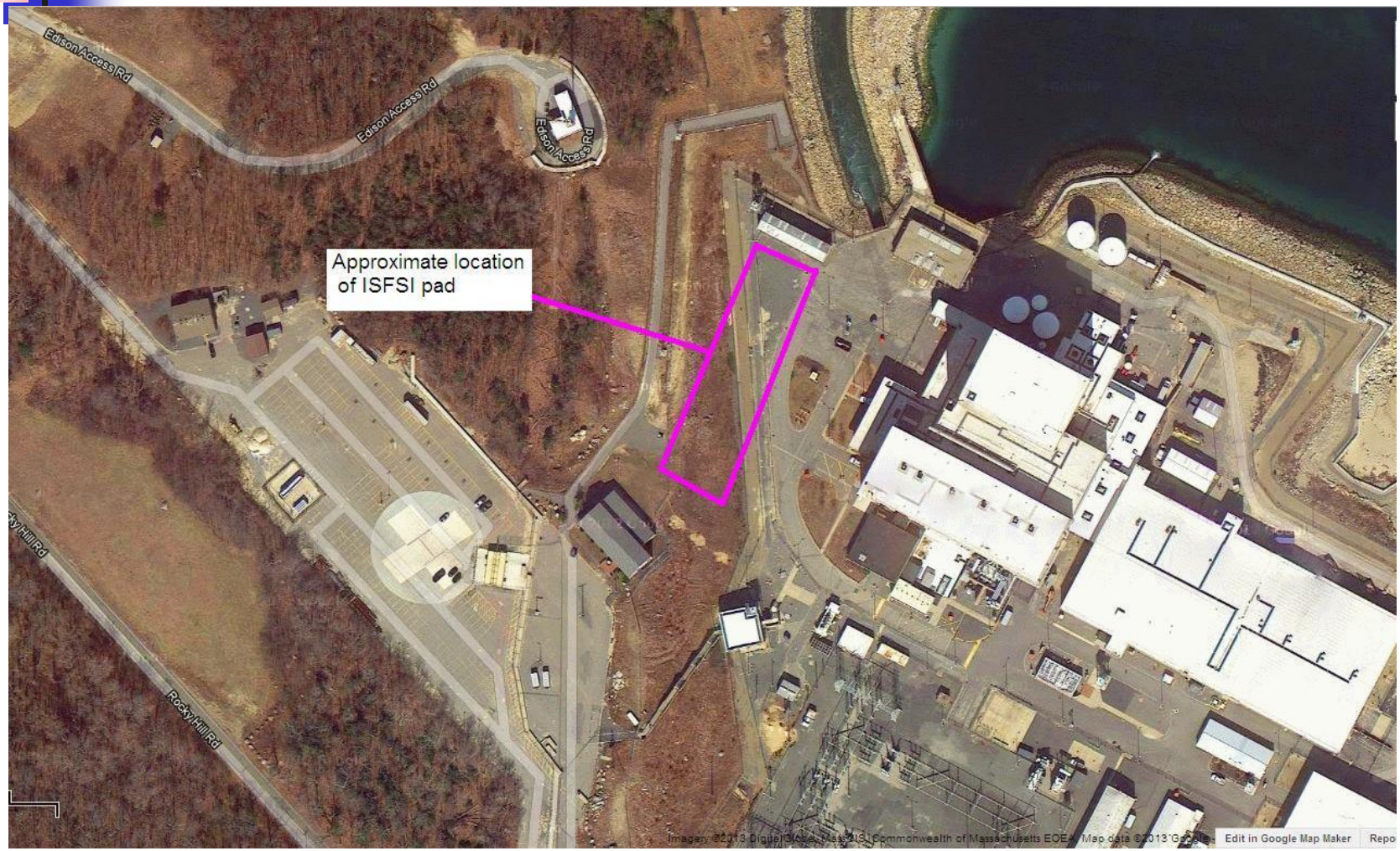
Reason for Concern - 1

- Construction of new ISFSI location at Pilgrim Station would involve excavation and relocation of a ~10,000 cubic yards of soil from a hillside adjacent to the plant; most soil relocated on site
- Due to close proximity to site effluent release locations, the presence of plant-related radioactivity was a possibility that had to be dealt with

Aerial View of ISFSI Location



Regulatory Basis and Guidance

- Radiological “free-release” of bulk materials such as soil is to be performed to environmental LLDs specified in the REMP sampling and analysis program; established in 1988 under NRC IE Information Notice 88-22
- There is no “*de minimus*” value for release of bulk material such as soil... if you detect plant-related radioactivity, material must be controlled and disposed of as radioactive material

Regulatory Basis and Guidance

- REMP LLD table in NUREG-1301/1302 and most site ODCMs does not contain a list of radionuclide LLDs specifically for soil
- Most similar media type to soil is “sediment”, which lists LLDs for only 2 nuclides: Cs-134 at 150 pCi/kg, Cs-137 at 180 pCi/kg
- *Question: What LLDs should be applied for other common plant-related radionuclides?*

Derived LLDs – Logical Approach

- Table 2 in Branch Technical Position on Radiological Environmental Monitoring Program Requirements, Revision 1 1979, lists LLD requirements for 12 gamma emitters in water
- The LLD requirements for Cs-134 and Cs-137 in sediment were 10-times higher than those for water
- A full set of LLD requirements for sediment/soil was derived based on multiplying the water LLDs for the 12 gamma emitters by a factor of 10

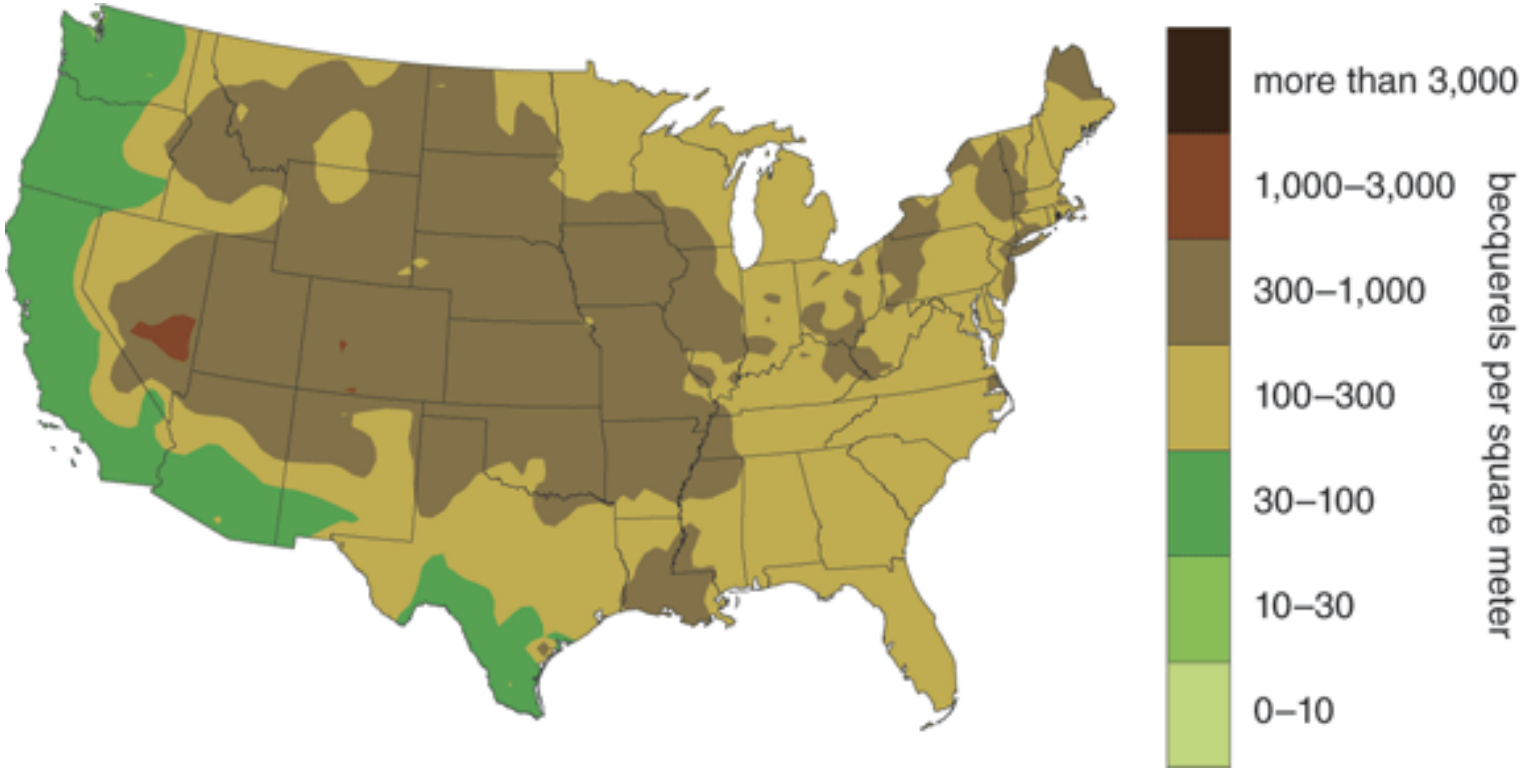
Derived LLDs for Soil

Nuclide	pCi/kg	Nuclide	pCi/kg
Mn-54	150	Nb-95	150
Fe-59	300	I-131	150
Co-58	150	Cs-134	150
Co-60	150	Cs-137	180
Zn-65	300	Ba-140	600
Zr-95	300	La-140	150

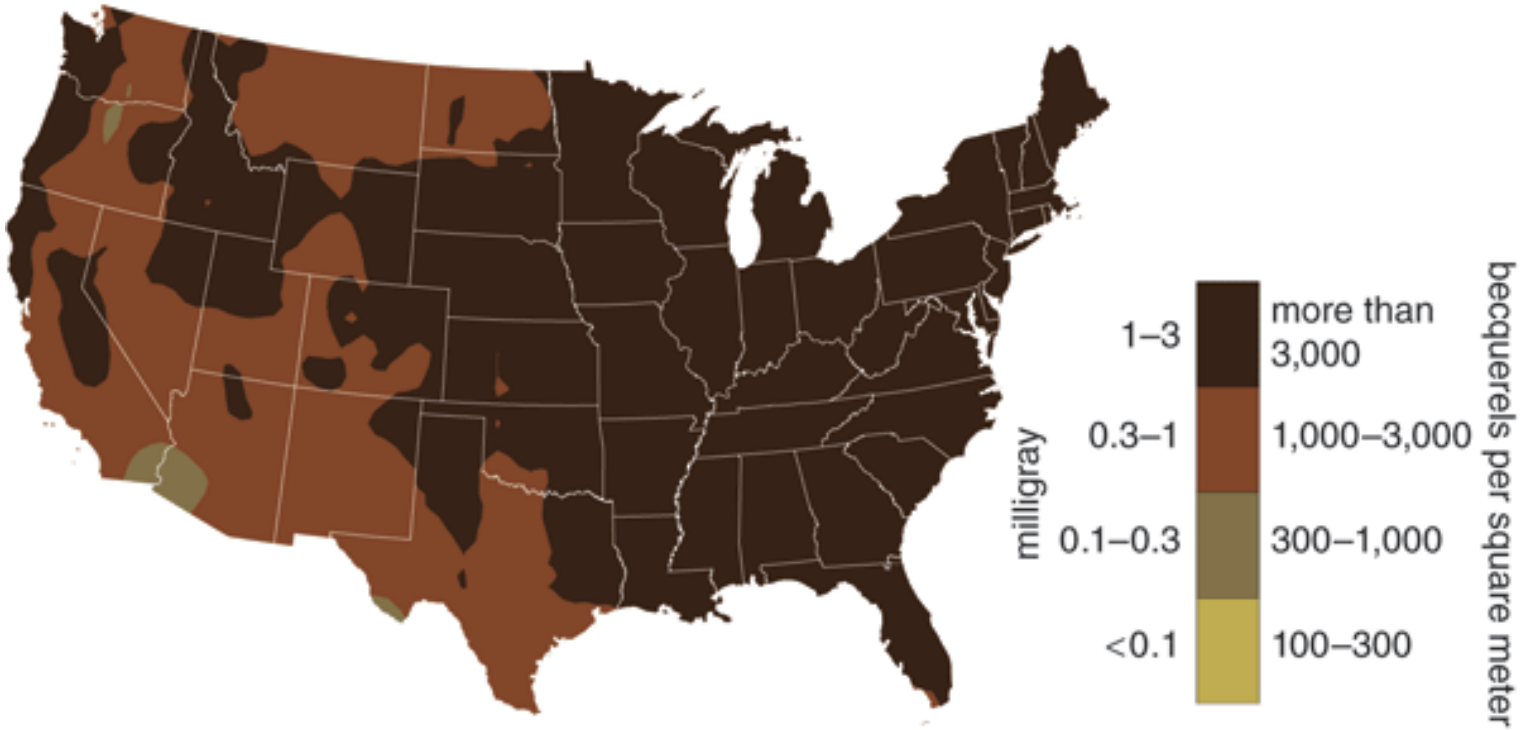
Reason for Concern - 2

- There is a known global distribution of Cs-137 from fallout from nuclear weapons testing in the 1940s through 1970s
- Fallout Cs-137 has been detected in a number of REMP media collected at Pilgrim Station, including distant Control locations
- *Question: What levels of fallout Cs-137 would we expect to detect in surface soil?*

Cs-137 Fallout from Nevada Test Site Nuclear Testing

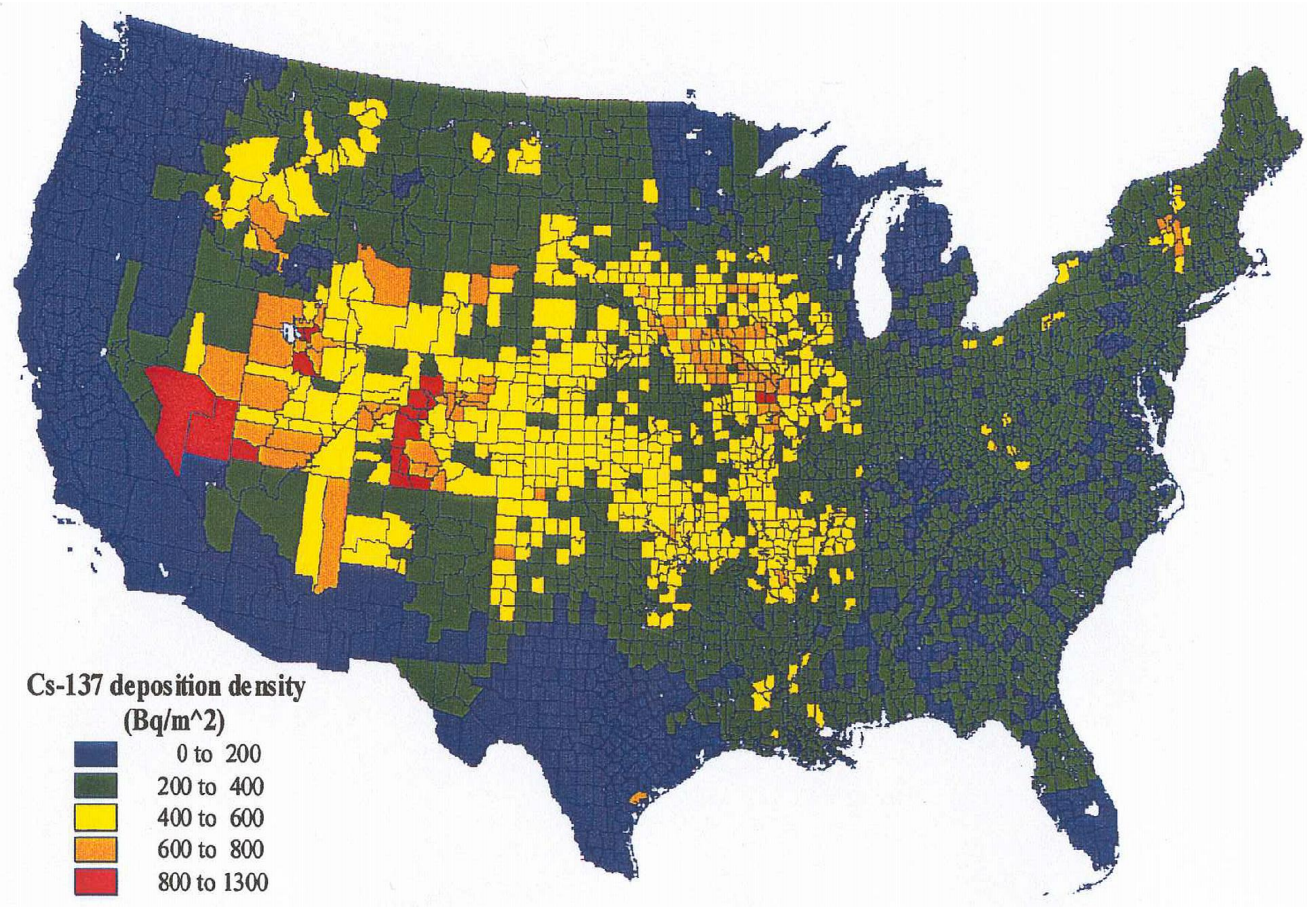


Cs-137 Fallout from Global Nuclear Testing



Cs-137 Fallout from Nevada Test Site Nuclear Testing 1951-1962

CDC/NCI 2002, Progress Report to Congress



Cs-137 Fallout from Global Nuclear Testing 1951-1962

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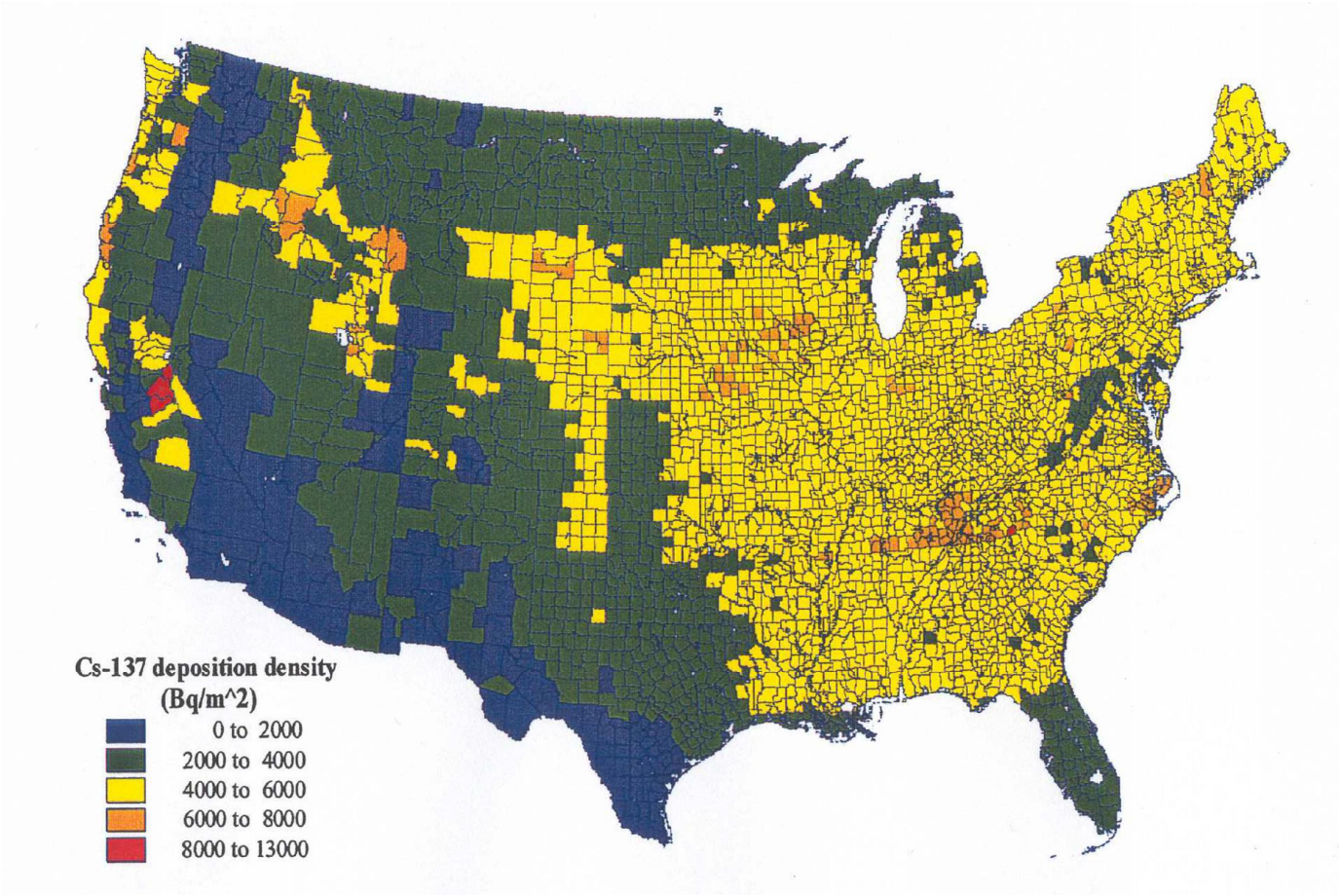

Potential Cs-137 Fallout Concentrations – 1

- Expected areal concentration from CDC/NIS maps is in range of 4000 to 6000 Bq/m^2, or 110,000 to 160,000 pCi/m^2
- Regulatory Guide 1.109 assumes a plow layer of 6-inches and soil density of 1.6 g/mL, yielding an effective surface density of 240 kg/m^2
- Expected soil concentration in plow layer would be in range of 450 to 675 pCi/kg

Potential Cs-137 Fallout Concentrations – 2

- Hillside represents undisturbed area, so most Cs-137 fallout would not be re-distributed into 6-inch plow layer, but is most likely confined to upper 0.5 to 1 inches of soil, corresponding to a surface density of 20 to 40 kg/m^2
- Cs is chemically active, and once adsorbed onto organic matter and silt/clay in soil, is relatively immobile, not leaching deeper into soil profile

Potential Cs-137 Fallout Concentrations – 3

- Revised soil concentration in upper 0.5 to 1 inch of soil would be expected to be between 2500 and 8000 pCi/kg
- Assuming two half-lives of decay since 1960s, expected concentration would be 625 to 2000 pCi/kg; possibly higher considering French and Chinese atmospheric testing after 1962, and potential deposition following Chernobyl and Fukushima accidents

Selection of Baseline Locations

- Locations to be greater than 10-miles from Pilgrim Station to preclude any potential for deposition of Cs-137 from plant operations
- Location must represent terrain that has been relatively undisturbed for the past 50-years to represent an unaltered surface distribution of fallout
- Decision was made to collect surface soil samples at state parks and reserves that have not been subject to construction or agricultural activities

Sampling at Baseline Locations

- Two samples were collected within ~200 meters of each other at each sample location; GPS coordinates were collected to facilitate resampling if necessary
- Collection are should be a relatively flat area away from exposed hilltops or low areas subject to water collection
- Surface detritus was scraped away from an area of ~ 2-ft x 2-ft and hand garden tools were used to collect soil to a depth of about 6-inches
- The two samples were stored and analyzed separately to yield replicate samples results at each location
- 16 locations were sampled, yielding 32 baseline samples

Analysis of Baseline Samples

- "Clean" soil was obtained from a location 40-miles west of Pilgrim Station to establish *a priori* counting protocol to meet REMP LLDs for 12 gamma emitters in soil...
  REMP Water Nuclide LLDs * 10
- Selected geometry was a 500-mL Marinelli beaker filled to top, containing approximately 550 to 700 grams of soil
- Counting was performed on "field wet" soil; soil was not oven dried prior to analysis to match conditions for sampling during ISFSI excavation
- Count time of 1000 seconds was sufficient to achieve sensitivity ~20% below REMP LLDs for most limiting radionuclide, usually La-140

Results of Baseline Samples

- Prior to counting samples, an acceptance criterion was established based on a one-tailed Student's t-statistic at the 1% confidence level for exceeding the baseline threshold for soil screening, yielding a critical t-value of 2.457
- 30 of 32 baseline samples contained detectable Cs-137 at concentrations ranging from 8.08E-8 to 7.97E-7 uCi/g, or 81 to 797 pCi/kg; two <MDC values not used in calculating statistics
- Average Cs-137 concentration was 3.64E-7 ± 1.97E-7 uCi/g, yielding a 99% U.C.L. screening threshold of 8.47E-7 uCi/g, or 847 pCi/kg

Results of ISFSI Excavation Samples

- All samples were analyzed using established *a priori* counting protocol... 500 mL Marinelli for 1000 seconds
- 18 of 22 surface soil samples contained detectable Cs-137; no other plant-related gamma activity detected, but K-40 and U/Th progeny were detected in all samples
- Detectable Cs-137 concentrations ranged from 9.04E-8 to 1.01E-6 uCi/g; Average 2.59E-7 uCi/g, slightly lower than baseline results
- After removal of first 6-inches of topsoil, numerous subsurface samples were collected... none contained any detectable Cs-137; all Cs-137 appeared to be confined to upper layer of soil

Summary

- Surface soil samples contained detectable Cs-137 from nuclear weapons testing fallout, which could be mistaken for plant-related radioactivity
- Literature search indicated soil concentrations as high as 2000 pCi/kg might be expected
- Established *a priori* sampling and analysis protocol for baseline and site excavation samples

Summary (continued)

- Measured baseline concentrations of 81 to 797 pCi/kg were consistent with expected values from literature search
- Student's t-statistical analysis of 30 baseline samples yielded an upper threshold of 897 pCi/kg for screening construction soil
- None of the construction soil contained Cs-137 above the screening threshold, greatly simplifying soil relocation efforts

Summary (continued)

- Important Factors for Free-Release Screening
  - *Must* consider fallout Cs-137; county-level information available from CDC-NCI study
  - Establish baseline Cs-137 concentrations
  - Establish *a priori* baseline sampling and analysis protocol; selection of undisturbed locations
  - Establish *a priori* screening criteria
  - Sample and analyze construction material under same protocol used for baseline determination

Questions?