

# Comparison of Calculated and Measured REMP Data at SONGS

**2010 RETS REMP**

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San Jose, CA

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**SONGS**



# Regulatory Drivers

- 10CFR50 App. I, Section IV.B.2
  - “.. licensee shall... provide data on measurable levels of radiation and radioactive materials in the environment to evaluate the relationship between quantities of radioactive material released in effluents and resultant doses to individuals from principal pathways of exposure”
- NRC Inspection Manual
  - *“The REMP supplements the effluent monitoring program by verifying that the measurable concentrations of radioactive materials and levels of radiation in the environment are in agreement with the values predicted”*

# Media Evaluated

- Soil (Cs-137)
- Sediment (Cs-137)
- Kelp (I-131)
- Deer Meet (Cs-137) Bone (Sr-90)
- Air Samples
- TLD's from ISFSI Operations

# Cs-137 Background in Soil?

- Data Sources

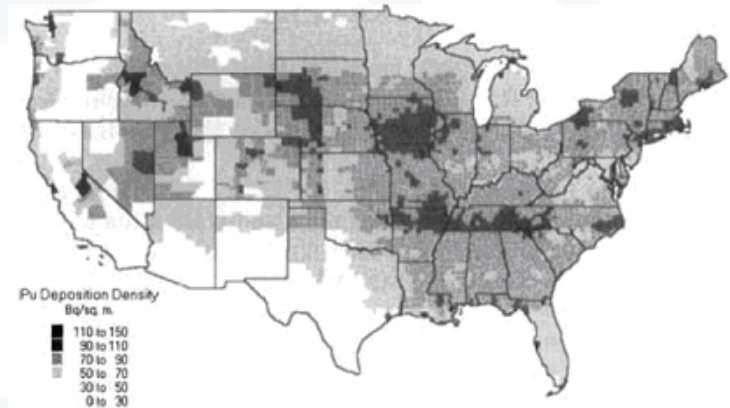
- Health Physics; May 2002, Volume 82, Number 5, Historical Overview of Atmospheric Weapons Testing And Estimates Of Fallout In The Continental United States, Harold L. Beck and Burton G. Bennett.
- Health Physics, October 1995, Volume 69, Number 4: Surveillance Monitoring Of Soils For Radioactivity: Lawrence Livermore National Laboratory 1976 To 1992, Gretchen Gallegos.
- Health Physics Vol. 59, No. 5 (November), pp. 565-576, 1990, Estimates Of Fallout In The Continental U.S. From Nevada Weapons Testing Based On Gunned-Film Monitoring Data, Beck et.al., EML, US. DOE

# More References

- Health Physics, Volume 82, Number 5, *Laboratory Analyses: Environmental and Biological Measurements*, N. Harley, May 2002.
- Health Physics, Volume 68, Number 1 *Residence Times Of Global Weapons Testing Fallout  $^{237}\text{Np}$  In A Grassland Soil Compared To  $^{239+240}\text{Pu}$ ,  $^{241}\text{Am}$ , and  $^{137}\text{Cs}$* , K. Bunzl, H. Kofuji, W. Schimmack, A. Tsumura, K. Ueno, and M. Yamamoto, January 1995.
- Health Physics, Volume 74, Number 1, *Modeling The Migration Of Fallout Radionuclides In Soil Using A Transfer Function Model*, Gerald Kirchner, January 1998.

# BKG Soil Data Assessment

- Much reported in “Activity/Area”
  - REMP Data: pCi/g
- Soil Depths not Always Provided
- Soil Types?
- Soil Conditions?
  - Plowed?
  - Heavy Cover (Forested)
  - Open Fields
- Some Assumptions Required



Estimated current average inventory of  $^{137}\text{Cs}$  in soil from all weapons tests in each county in the continental United States.

# Cs-137 Soil Background

	Decay Corrected Cs-137 Soil Concentrations from Fall-out, pCi/g in S. CA		
Sample Depth cm	Max	Average	Min
5	0.86	0.13	0.0041
10	0.43	0.07	0.0021
15	0.29	0.04	0.0014
20	0.22	0.03	0.0010
25	0.17	0.03	0.0008
30	0.14	0.02	0.0007

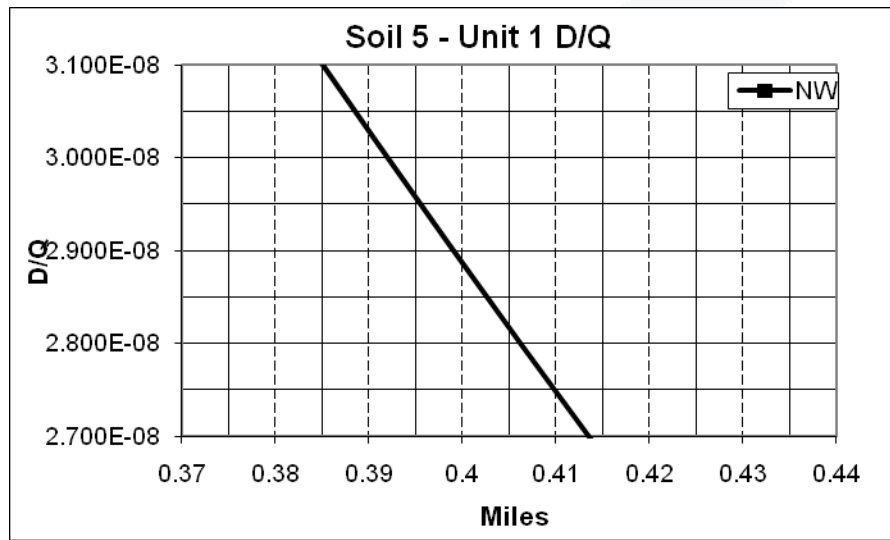
# Cs-137 Gaseous Releases (Ci)

<b>Year</b>	<b>Unit 1</b>	<b>Unit 2/3</b>
<b>2001</b>	7.66E-11	5.23E-04
<b>2002</b>	1.80E-06	1.98E-04
<b>2003</b>	NDA*	9.38E-05
<b>2004</b>	9.92E-06	3.44E-05
<b>2005</b>	4.45E-07	1.88E-05
<b>2006</b>	2.71E-06	4.91E-04
<b>2007</b>	N/A	1.35E-05
<b>2008</b>	N/A	2.65E-05



# REMP Soil Sample Location

Sample Point	Soil Samples	Mile	Direction
1	Camp San Onofre	2.6	NE
2	Old Route 101 - East Southeast	3	ESE
3	Basilone Road / I-5 Freeway Off ramp	2	NW
5	Former Visitor=s Center	0.4	NW
6	Oceanside (CONTROL)	16	SE



NRC Regulatory Guide 1.109  
equation C-1

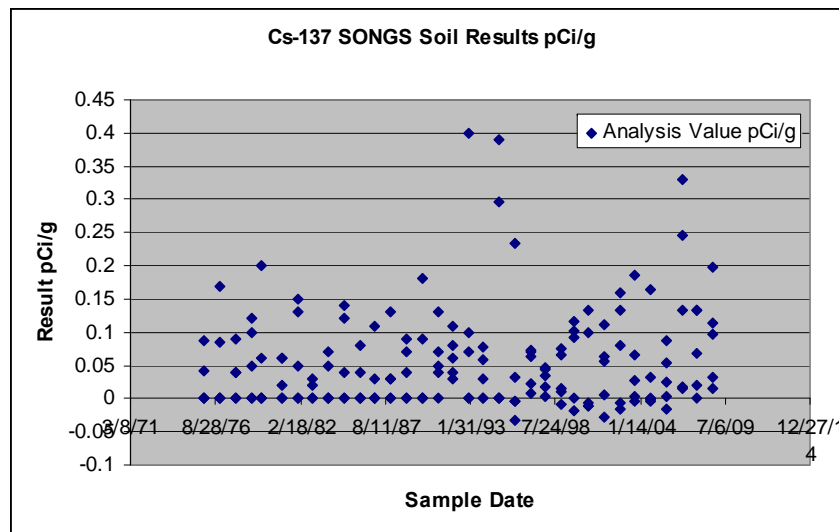
$$C_i^G = \frac{(D/Q_i) * Q_i}{\lambda_i} [1 - \exp(-\lambda_i t_b)]$$

# Predicted Soil Concentrations (Cs-137) at REMP Locations – 2001 through 2008

Soil Samples Locations		Max 0 - 5 cm Soil pCi/g	Avg 0 - 5 cm Soil pCi/g	Min 0 - 5 cm Soil pCi/g	RG 1.109 15 cm pCi/kg
1	Camp San Onofre	2.39E-05	2.39E-05	2.39E-05	7.98E-06
2	Old Route 101 - East Southeast	2.26E-05	2.26E-05	2.26E-05	7.54E-06
3	Basilone Road / I-5 Freeway Off ramp	4.57E-05	4.57E-05	4.57E-05	1.52E-05
5	Former Visitors Center	8.04E-04	8.04E-04	8.04E-04	2.68E-04

# Actual Cs-137 Soil Data 1975 - 2008

	TS 01 pCi/g	TS 02 pCi/g	TS 03 pCi/g	TS 04 pCi/g	TS 05 pCi/g	TS 06 pCi/g
Max	0.28	0.31	0.05	0.07	0.12	0.23
Min	0.00	0.00	-0.02	-0.02	-0.01	-0.02
Avg	0.07	0.07	0.01	0.02	0.02	0.06



Data Clearly Indicates Cs-137  
from Fallout

# Predicted Soil Concentrations for Other Nuclides

	<b>Soil Samples ***</b>	<b>Br-82 pCi/g</b>	<b>Cr-51 pCi/g</b>	<b>Mn-54 pCi/g</b>	<b>Co-57 pCi/g</b>	<b>Co-58 pCi/g</b>	<b>Co-60 pCi/g</b>
1	Camp San Onofre	5.7E-09	7.1E-09	1.4E-07	7.2E-09	7.1E-07	1.1E-06
2	Old Route 101 - East Southeast	5.4E-09	6.7E-09	1.3E-07	6.8E-09	6.7E-07	1.0E-06
3	Basilone Road / I-5 Freeway Off ramp	1.1E-08	1.4E-08	2.7E-07	1.4E-08	1.4E-06	2.0E-06
5	Former Visitors Center	1.9E-07	2.4E-07	4.7E-06	2.4E-07	2.4E-05	3.6E-05
6	Oceanside (CONTROL)						
		<b>Fe-59 pCi/g</b>	<b>Nb-95 pCi/g</b>	<b>Zr-95 pCi/g</b>	<b>Sb-125 pCi/g</b>	<b>I-131 pCi/g</b>	<b>Cs-137 pCi/g</b>
1	Camp San Onofre	3.3E-09	1.0E-08	5.3E-09	7.7E-11	3.5E-08	4.8E-08
2	Old Route 101 - East Southeast	3.1E-09	9.7E-09	5.0E-09	7.3E-11	3.3E-08	4.6E-08
3	Basilone Road / I-5 Freeway Off ramp	6.3E-09	2.0E-08	1.0E-08	1.5E-10	6.6E-08	9.3E-08
5	Former Visitors Center	1.1E-07	3.4E-07	1.8E-07	2.6E-09	1.2E-06	1.6E-06

Concentrations Below MDA



# Crop Deposition and Bioaccumulation Calculations

	Crop Samples	Unit 2 Annual pCi/kg					Total Conc
		Cs-137	Co-57	Co-58	Co-60	Mn-54	
1	San Clemente Ranch (San Mateo Canyon)	7.4E-05	1.6E-05	3.3E-03	1.7E-03	2.1E-04	8.4E-03
4	San Clemente Resident w/Garden	2.9E-05	6.2E-06	1.3E-03	6.6E-04	8.1E-05	3.3E-03
6	SONGS garden	1.6E-03	3.5E-04	7.3E-02	3.7E-02	4.6E-03	1.8E-01
		Cr-51	Fe-59	I-131	Nb-95	Zr-95	
1	San Clemente Ranch (San Mateo Canyon)	6.5E-05	2.2E-05	2.9E-03	8.1E-05	2.7E-05	
4	San Clemente Resident w/Garden	2.6E-05	8.6E-06	1.1E-03	3.2E-05	1.0E-05	
6	SONGS garden	1.4E-03	4.8E-04	6.4E-02	1.8E-03	5.9E-04	

Regulatory Guide 1.109 equation C-5

Regulatory Guide 1.109 table E-1 provides values for the bioaccumulation factors (*B<sub>iv</sub>*) for various elements in vegetation.

Concentrations Below MDA



# Outfall Liquid Discharge Concentrations

Nuclide	U2/3 Max pCi/L	ODCM LLD	Nuclide	U2/3 Max pCi/L	ODCM LLD
H-3	1.52E+02	<b>2.00E+03</b>	Fe-55	8.85E-04	None
Gross	< LLD	None	Fe-59	1.05E-04	<b>3.00E+01</b>
Sb-124	5.00E-05	None	La-140	< LLD	<b>1.50E+01</b>
Sb-125	9.01E-04	None	Mn-54	1.09E-04	<b>1.50E+01</b>
Ba-140	< LLD	<b>1.50E+01</b>	Mo-99	< LLD	None
Ce-141	< LLD	None	Nb-95	1.16E-04	<b>1.50E+01</b>
Ce-144	< LLD	None	Nb-97	7.55E-07	None
Cs-134	2.23E-05	<b>1.50E+01</b>	Ag-110m	3.06E-05	None
Cs-137	3.14E-04	<b>1.80E+01</b>	Sr-89	< LLD	None
Cr-51	1.71E-04	None	Sr-90	< LLD	None
Co-57	5.70E-07	None	Tc-99m	< LLD	None
Co-58	1.05E-03	<b>1.50E+01</b>	Sn-113	4.22E-06	None
Co-60	6.47E-04	<b>1.50E+01</b>	Zn-65	< LLD	<b>3.00E+01</b>
I-131	< LLD	None	Zr-95	6.71E-05	<b>1.50E+01</b>
Fe-55	8.85E-04	None	Zr-97	< LLD	None

Concentrations Below MDA



# Predicted Sediment Concentrations

Nuclide	$\lambda$ (hrs <sup>-1</sup> )	U2,3 2007 Avg Water pCi/L	U2,3 2007 Sediment pCi/kg	U2,3 2007 Long Term Sediment pCi/kg
Discharge Volume (liters)		2.89E+12		
H-3	6.44E-06	6.28E+02	N/A	N/A
Sb-124	4.80E-04	1.29E-04	2.76E-02	2.81E-02
Sb-125	2.86E-05	2.96E-03	2.39E+00	1.05E+01
Cs-134	3.84E-05	8.11E-05	6.29E-02	2.19E-01
Cs-137	2.63E-06	1.15E-03	1.03E+00	1.33E+01
Cr-51	2.86E-06	6.76E-04	6.09E-01	7.72E+00
Co-57	1.07E-04	1.50E-06	8.92E-04	1.47E-03
Co-58	4.08E-04	3.91E-03	9.70E-01	9.98E-01
Co-60	1.50E-05	2.52E-03	2.15E+00	1.51E+01
Fe-55	2.93E-05	5.60E-03	4.51E+00	1.95E+01
Fe-59	6.47E-04	3.07E-04	4.93E-02	4.95E-02
Mn-54	9.24E-05	4.34E-04	2.72E-01	4.90E-01
Nb-95	8.11E-04	6.49E-04	8.33E-02	8.33E-02
Nb-97	9.61E-03	2.00E-06	2.17E-05	2.17E-05
Ag-110m	1.16E-04	2.21E-04	1.27E-01	1.99E-01
Sn-113	6.09E-07	1.73E-05	1.57E-02	2.28E-01
Zr-95	4.51E-04	4.05E-04	9.16E-02	9.34E-02

- Predicted Concentrations Below MDA

$$C_{is} = K_c \frac{C_{iw} [1 - \exp(-\lambda_i t_p)]}{\lambda_i}$$

K = Water to Sediment Transfer Factor  
K= 0.1042 L/Kg/hr

Equation A-4 of Regulatory Guide  
1.1095.16



# Non-Migratory Marine Animals

- At the Outfall Concentrations
- Standard Bioaccumulation Factors
- Predicted Concentrations Well Below MDA's
- Units in pCi/Kg

Nuclide	Fish			Invertebrates		
	Max	Average	Min	Max	Average	Min
H-3	1.37E+02	6.02E+01	1.10E+01	1.42E+02	6.22E+01	1.14E+01
Cs-134	8.92E-04	4.56E-04	1.68E-04	5.57E-04	2.85E-04	1.05E-04
Cs-137	1.26E-02	4.97E-03	1.54E-03	7.86E-03	3.11E-03	9.63E-04
Cr-51	6.84E-02	6.84E-02	6.84E-02	3.42E-01	3.42E-01	3.42E-01
Co-58	1.04E-01	4.19E-02	7.31E-03	1.04E+00	4.19E-01	7.31E-02
Co-60	6.46E-02	2.71E-02	1.33E-02	6.46E-01	2.71E-01	1.33E-01
Fe-55	2.65E+00	1.65E+00	8.16E-01	1.77E+01	1.10E+01	5.44E+00
Fe-59	9.56E-02	9.56E-02	9.56E-02	6.37E-01	6.37E-01	6.37E-01
Mn-54	5.97E-02	2.56E-02	9.00E-03	4.34E-02	1.86E-02	6.55E-03
Nb-95	3.41E+00	1.99E+00	7.71E-01	1.14E-02	6.63E-03	2.57E-03
Nb-97	1.80E-02	1.80E-02	1.80E-02	6.00E-05	6.00E-05	6.00E-05
Zr-95	1.17E-02	6.62E-03	2.41E-03	4.69E-03	2.65E-03	9.63E-04

**Equation A-3 of Regulatory Guide 1.109**

**Table A-1 RG 1.109 Marine Animal Bioaccumulation Factors**





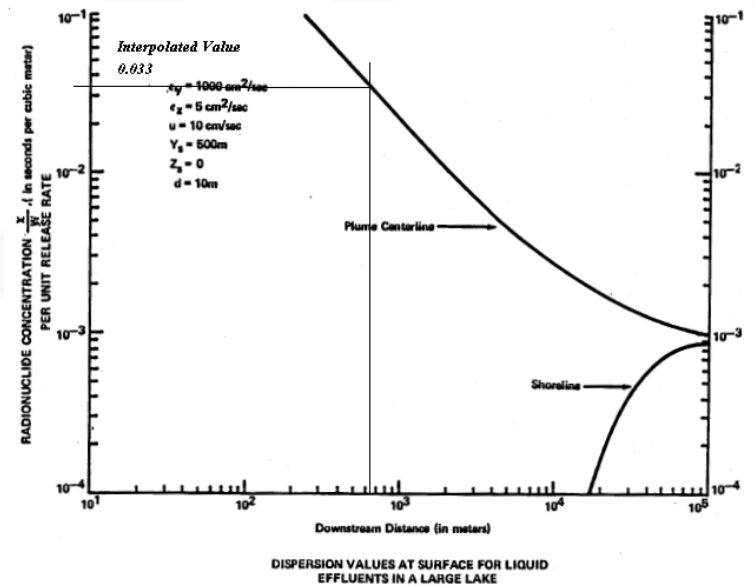
# I-131 in Kelp

- Three of Four Kelp-Beds Showed Positive I-131 in 2007/2008
- Evaluation of Effluent MDA for I-131

Sample Date	Aquatic Kelp San Onofre Kelp Bed Station A			Aquatic Kelp San Mateo Kelp Bed Station B		
	Activity pCi/g	2 Sigma	MDC	Activity pCi/g	2 Sigma	MDC
4/17/07	0.083	0.024	0.03	<b>0.028</b>	<b>0.022</b>	<b>0.035</b>
10/18/07	<b>0.026</b>	<b>0.021</b>	<b>0.032</b>	<b>0.036</b>	<b>0.028</b>	<b>0.043</b>
4/15/08	0.0258	0.0244	0.0252	<b>0.00721</b>	<b>0.016</b>	<b>0.02</b>
10/15/08	<b>0.0385</b>	<b>0.0265</b>	<b>0.044</b>	<b>0.0278</b>	<b>0.0255</b>	<b>0.0582</b>
Sample Date	Aquatic Kelp Barn Kelp Bed Station C			Aquatic Kelp Salt Creek (Control) Station E		
	Activity pCi/g	2 Sigma	MDC	Activity pCi/g	2 Sigma	MDC
4/17/07	0.038	0.019	0.026	0.035	0.02	0.029
10/18/07	<b>0.013</b>	<b>0.02</b>	<b>0.034</b>	<b>0.021</b>	<b>0.021</b>	<b>0.033</b>
4/15/08	0.0349	0.0252	0.0237	0.14	0.0276	0.0217
10/15/08	<b>0.0492</b>	<b>0.0221</b>	<b>0.0542</b>	0.066	0.0425	0.0422

# Dilution Factor for I-131

- Reg Guide 1.133 Factors
- Very Conservative
  - Distance Offshore
  - 2X Current Flow
  - Outfall Height Above Floor
- Dilution Factor = 15



# Conservative Calculation

- Outfall Dilution Factor = 10
- Kelp Bed Dilution = 15
- Bioaccumulation Factor = 1200
- I-131 LLD =  $4.6E-8$  uCi/cc

# Results

Calculated Concentrations			
Time Period	Discharge Quantity	Calculated Concentration at Discharge, pCi/L	Kelp Concentration, pCi/g
Q1	7.41E-04	9.90E-05	<b>8.42E-05</b>
Q2	6.62E-04	8.68E-05	<b>7.38E-05</b>
Q3	6.72E-04	8.74E-05	<b>7.43E-05</b>
Q4	4.22E-04	6.87E-05	<b>5.84E-05</b>

Measured Concentrations, pCi/g		
Min	7.2E-03	(Includes MDA)
Avg	3.3E-02	
Max	1.4E-01	

I-131 in Kelp not from SONGS Effluent

# Source of I-131?

- Likely from Sewage Treatment Facilities
- Outfall from San Juan Waste Water Facility in Nov., 2008: 28 pCi/L

**Kelp I-131 Sample Results Near Sewage Treatment Outfall**

Location	Description	Date	Activity pCi/g	2 Sigma	MDC
AV 26	Aquatic Kelp Dana Point Kelp Bed Station C	4/15/08	0.0559	0.0214	0.0239
AV 26	Aquatic Kelp Dana Point Kelp Bed Station C	10/15/08	0.137	0.0341	0.0493
AV 27	Aquatic Kelp Capistrano Beach Reef	4/15/08	0.0578	0.0253	0.026
AV 27	Aquatic Kelp Capistrano Beach Reef	10/15/08	0.111	0.0448	0.0521
AV 28	Aquatic Kelp San Clemente Pier Reef	4/15/08	0.0917	0.025	0.0269
AV 28	Aquatic Kelp San Clemente Pier Reef	10/15/08	0.0521	0.0339	0.0459
AV 29	Aquatic Kelp Wheeler North Artificial Reef Station I	4/15/08	0.0914	0.022	0.0182
AV 29	Aquatic Kelp Wheeler North Artificial Reef Station I	10/15/08	0.0695	0.0296	0.0403
		Maximum	0.137		

# Deer Meat, Bone, Liver Cs-137 & Sr-90

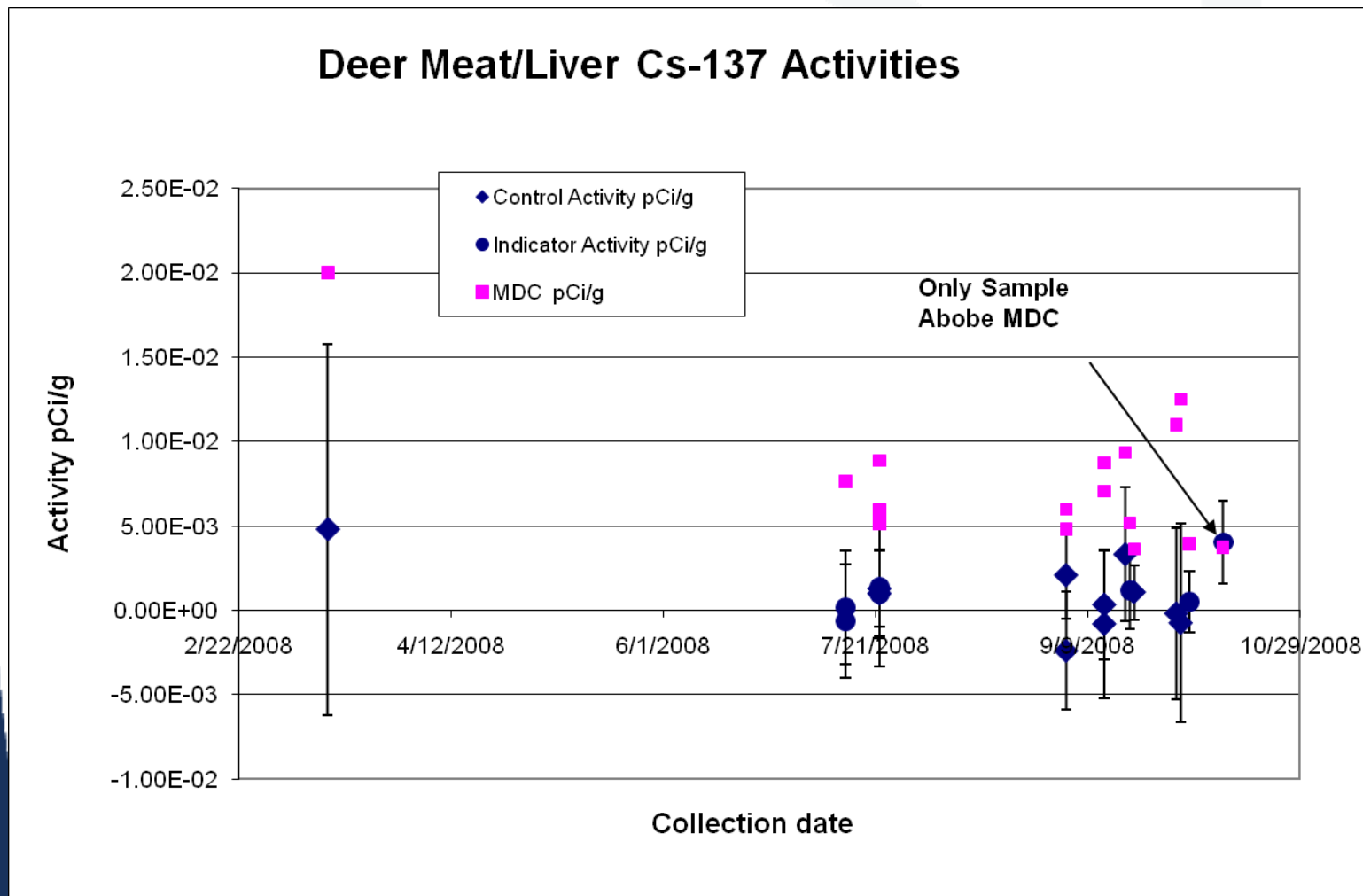
- Camp Pendleton Marine Corps Base and SONGS cooperated to collect mule deer tissue samples in 2008.
- 27 road kill deer discovered on Base in 2008
- 13 deer carcasses were collected and sampled
- Tissue samples collected from femur bone, hind quarters muscle, and the entire liver.

# Control and Indicator Comparison

	Control Activity pCi/g	Indicator Activity pCi/g
<b>Cs-137</b>		
Average	8.82E-04	1.09E-03
Max	4.80E-03	4.04E-03

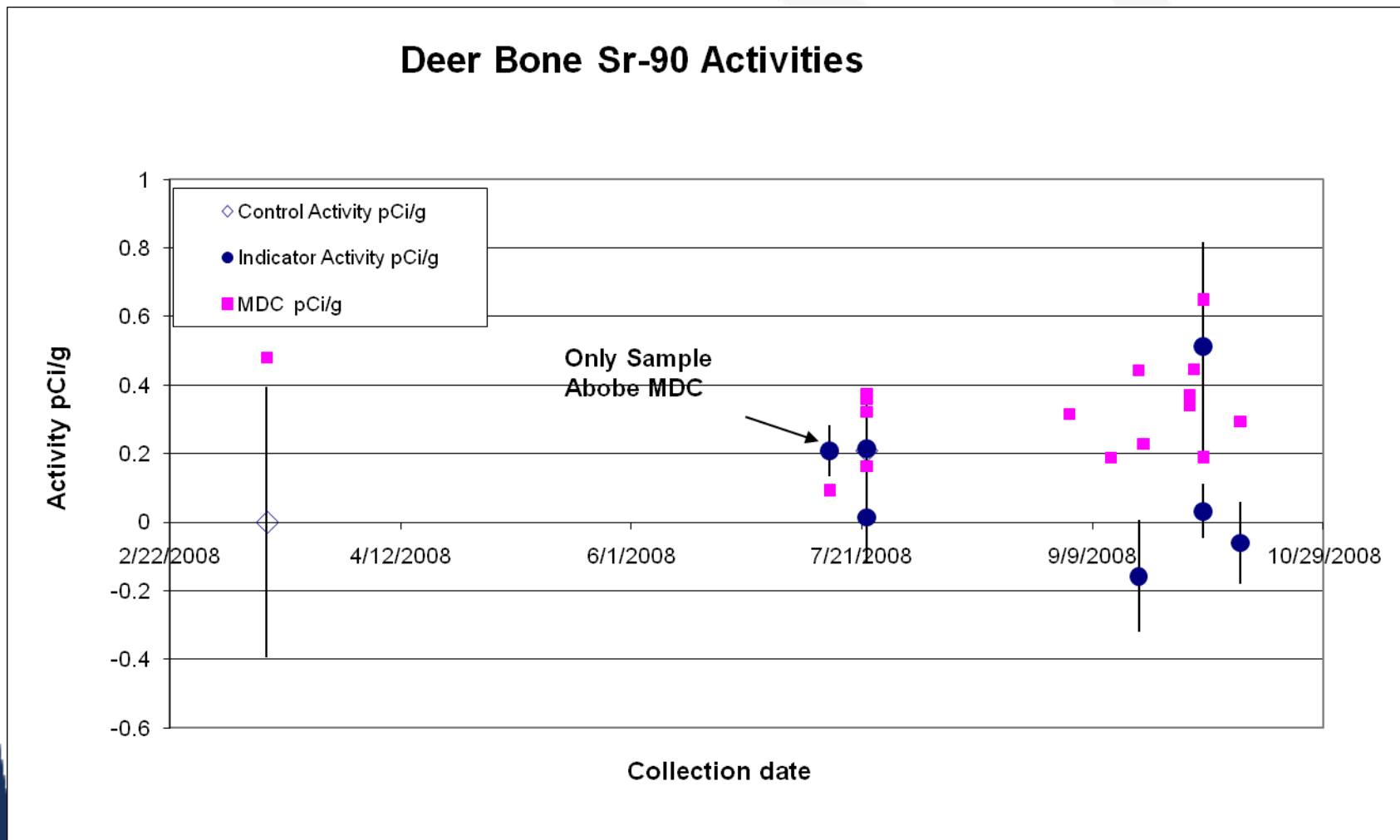
- Range Cs-137 in Muscle and Liver
- Indicator Samples - Within 5 miles of SONGS.
- Control Samples – greater than 5 miles from SONGS.
- T-test showed no statistical difference between control group and indicator groups.

# Cs-137 Most Results less than MDC





# Sr-90 Most Results less than MDC



# Historical Cs-137 in CA Deer

Start Date	End Date	# Samples	Min pCi/g	Max pCi/g	Mean pCi/g	SD pCi/g	Decay Years	Decay Corrected Min pCi/g	Decay Corrected Max pCi/g
<b>Oak</b>									
9/5/1967	9/14/1967	5	0.05	0.30		0.20	40.85	0.02	0.12
2/24/1968	3/2/1968	5	0.08	0.55		0.33	40.38	0.03	0.22
8/19/1968	10/3/1968	6	0.15	0.45		0.25	39.89	0.06	0.18
11/22/1968	12/16/1968	6	0.15	0.30		0.23	39.63	0.06	0.12
2/25/1969	2/26/1969	5	0.25	0.38		0.33	39.37	0.10	0.15
5/19/1969	5/22/1969	5	0.15	0.33		0.23	39.14	0.06	0.13
<b>Mean</b>		32	0.05	0.55	<b>0.25</b>	0.13	40.85	0.02	<b>0.21</b>
<b>Burned Chaparral</b>									
9/1/1967	9/12/1967	5	0.03	0.13		0.05	40.86	0.01	0.05
3/11/1968	3/21/1968	5	0.05	0.08		0.05	40.33	0.02	0.03
8/29/1968	10/1/1968	6	0.01	0.13		0.10	39.86	0.00	0.05
11/22/1968	12/11/1968	3	0.08	0.13		0.10	39.63	0.03	0.05
2/20/1969		2	0.15	0.35		0.25	39.38	0.06	0.14
5/20/1969	5/22/1969	5	0.13	0.15		0.13	39.14	0.05	0.06
<b>Mean</b>		26	0.03	0.35	<b>0.10</b>	0.05	40.86	0.01	<b>0.14</b>
<b>Mixed Vegetation</b>									
12/12/1968		2	0.15	0.18		0.18	39.58	0.06	0.07
2/24/1969	2/27/1969	3	0.28	0.30		0.28	39.37	0.11	<b>0.12</b>
<b>Unburned Chaparral</b>									
3/26/1969	4/8/1969	5	0.15	0.25		0.20	39.29	0.06	<b>0.10</b>

# Comparison of ISFSI TLD Data

- Average exposure rate 1998 to summer 2003 location 56 is 17.9 +/- 1.2 mR/quarter.
- Average exposure rate September 2003 to end of 2008 is 18.6 +/- 1.8 mR/quarter.
- Data show that for the 5 year periods before and after fuel placement at the ISFSI, there is no discernable difference in the quarterly exposure rates.

# Direct Exposure - ISFSI

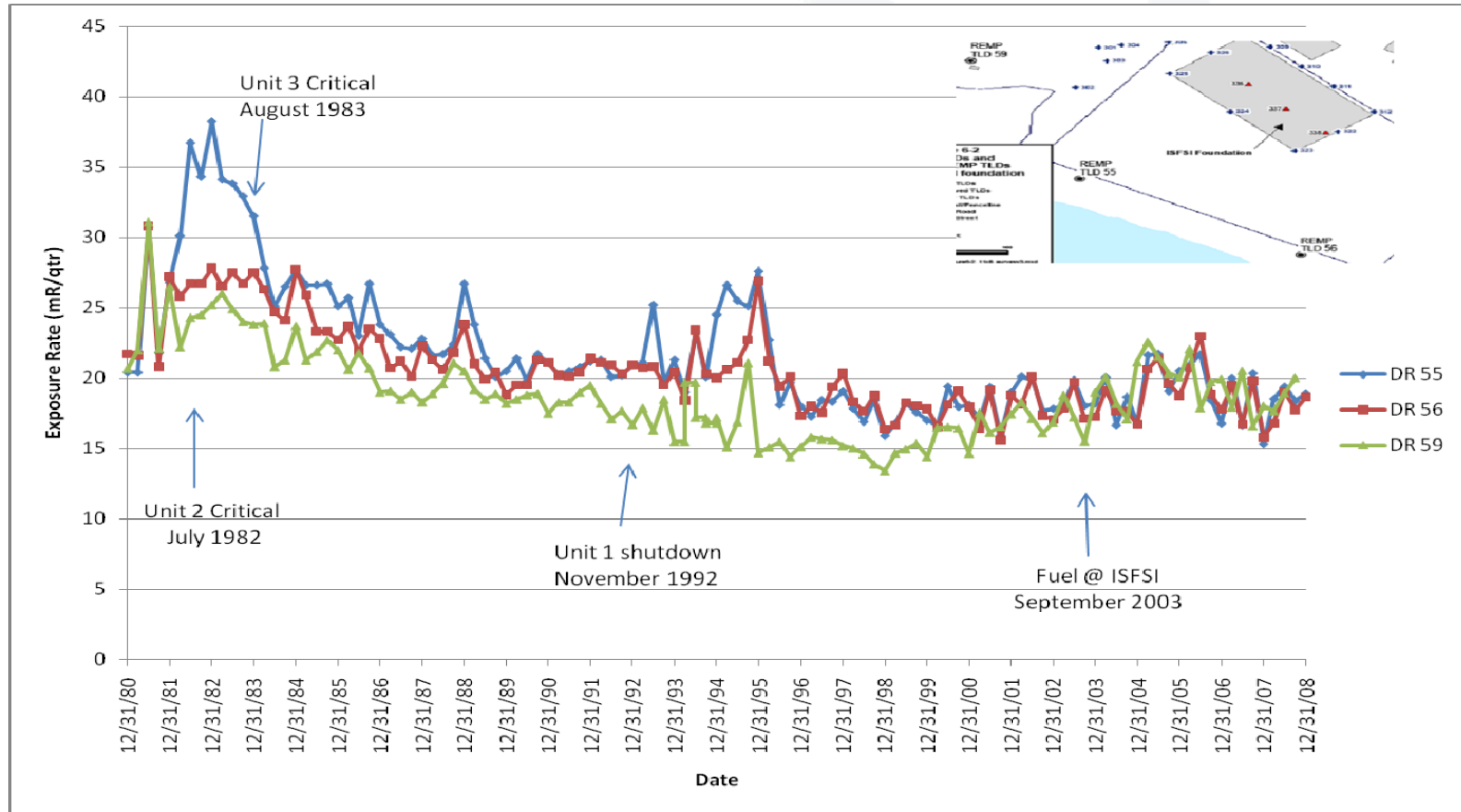
<b>Duration</b>	<b>Event</b>	<b>Average mR/quarter</b>	<b>2 Sigma Error mR/hr</b>
1988 through summer 2003 location 55	Pre Fuel in ISFSI	18.0	1.2
Sept 2003 to end of 2008 location 55	Fuel in ISFSI	18.9	1.9
1988 through summer 2003 location 56	Pre Fuel in ISFSI	17.9	1.2
Sept 2003 to end of 2008 location 56	Fuel in ISFSI	18.6	1.8

- REMP TLD locations adjacent to ISFSI compared to several ISFSI TLD locations.

# Direct Exposure SONGS Operation

- Determine if there is any measurable direct radiation impact from the site.
  - REMP Indicator TLD locations between 0.5 and 1.0 miles from the center of the site
  - REMP Control TLD locations greater than 5.0 miles from the site

# Plotted Area TLD Data



Questions?