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http://eed.llnl.gov/mi/

DOE-RMI Marshall Islands Program Review Briefing

Majuro Atoll
Republic of the Marshall Islands
25 April 2007

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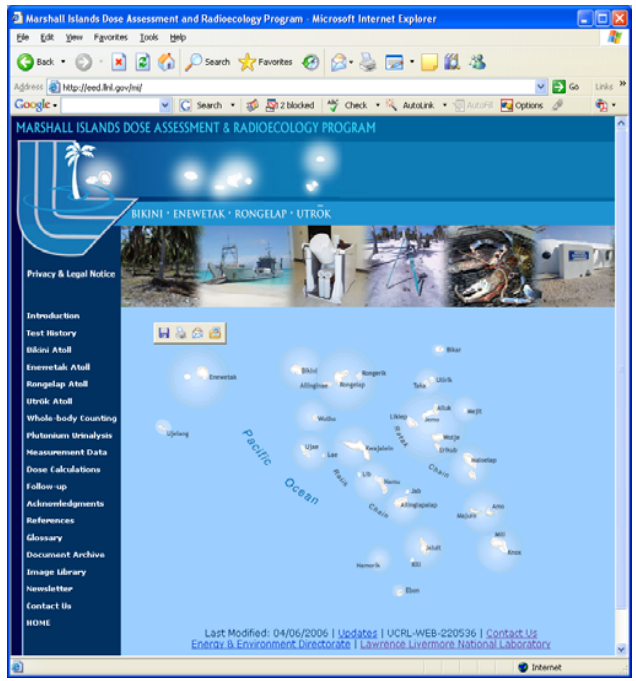
Marshall Islands Dose Assessment & Radioecology Program

Strategic Directives of the Marshall Islands Program

1. To provide technical support services and oversight in establishing radiological surveillance monitoring programs in the Marshall Islands

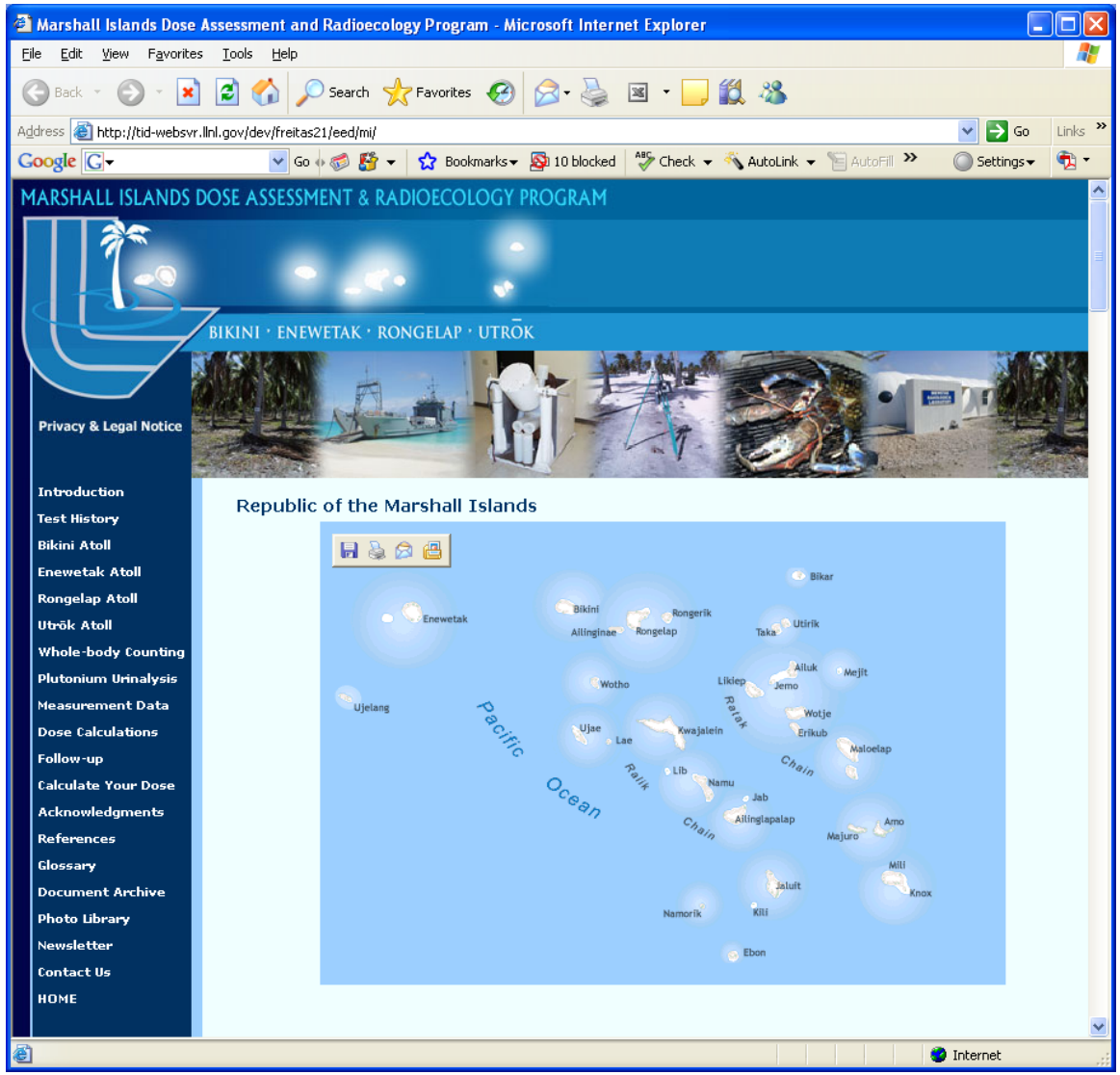
2. To develop comprehensive assessments of current (and potential changing) radiological conditions, and

3. To provide recommendations for remediation of contaminated sites and verify the effects of any actions taken



(http://eed.llnl.gov/mi/)

Marshall Islands Web Site Update



Marshall Islands Web Site Update

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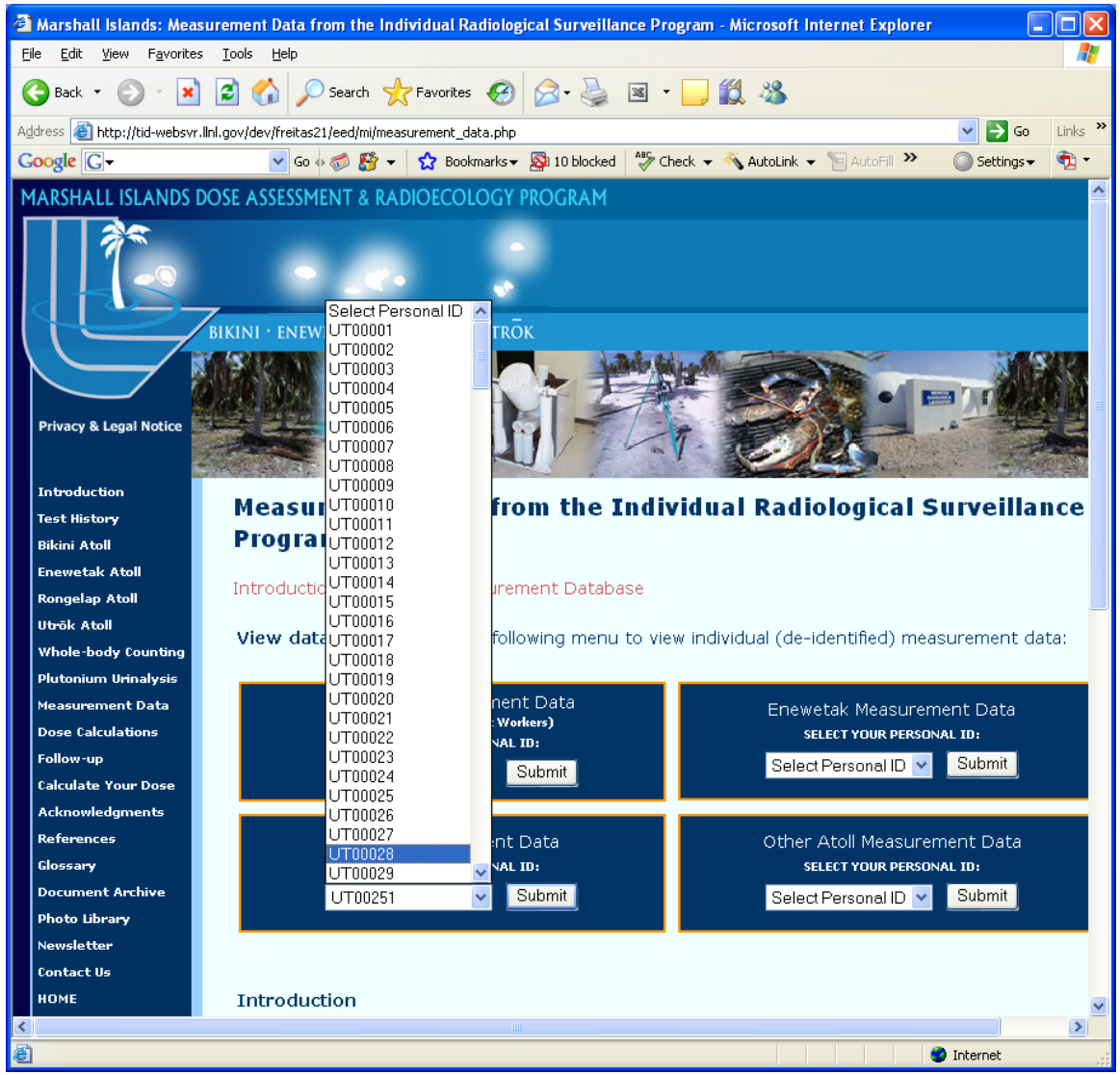


Marshall Islands Web Site Update

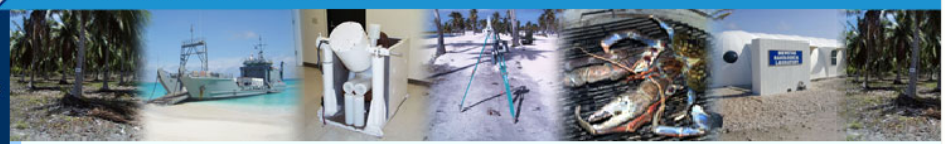
Marshall Islands: Individual Measurement Data - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Address http://tid-websvr.llnl.gov/dev/freitas21/eed/mi/resultsAll.php?id=UT00251&island=Utrik

MARSHALL ISLANDS DOSE ASSESSMENT & RADIOECOLOGY PROGRAM

BIKINI · ENEWETAK · RONGELAP · UTRŌK



Privacy & Legal Notice

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Individual Measurement Data

Utrik Atoll

Personal ID	Age Type	Gender	Collection Date	RadioNuclide	Activity	Error	MDA	Method
UT00251	Adult	Female	12/12/06	Cesium-137	0.00 kBq	± 0.00	0.10	NaI_WBC

Last Modified: 04/06/2006 | Updates | UCRL-WEB-220536 | Contact Us
Energy & Environment Directorate | Lawrence Livermore National Laboratory

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Marshall Islands Web Site Update

Marshall Islands Web Site Update

http://tid-websvr.llnl.gov/dev/freitas21/eed/mi/resultsRecent.php?id=UT00250&island=Utrik - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Address http://tid-websvr.llnl.gov/dev/freitas21/eed/mi/resultsRecent.php?id=UT00250&island=Utrik

Melele ko ilo Pepa in – Renej am wot im jab bar an Juon
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Lawrence Livermore National Laboratory
Marshall Islands Individual Radiological Surveillance Program

Drettan Dose ilo Enbwin loe ilo Juon Iio (Annual Radiation Dose Report for Calendar Year) **2006**

ID Nomba (Identification Number) **UT00250**

Monitoring Program	Type of Dose	Dose Equivalent mrem (mSv)
Whole Body Counting	CEDE	4.74 (0.0474)
Plutonium Bioassay (if available)	CEDE	N/A (N/A)

Drettan Dose ilo Juon Iio (Total Calendar Year Dose) = 4.74 (0.0474) mrem

Notes:

1. Bwe en emman ad melele, drettan dose eo ilo juōn iiō non jukjuk im bed ko einwōt an walok tok jen agency ko ibelaak in lal-in, ej 100 mrem. Emōj an Republic eo an Marshall Islands kille juōn wawein eo ebinlok ikijjien jerbal in kareo non jikin ko turōk-turear in ailiñkein im raar jermatmat jen radiation kin jonane 15 mrem juōn iiō. Jekjek in ear kōmman ekkar non melele ko raar itok jen United States Environmental Protection Agency (EPA) eo iumwin Comprehensive Environmental Response Compensation im Liability Act (CERCLA) eo.
2. Jouj im kebaak takneijen ro an whole body count elañe enej wor am kajitok ikijjien report in nanñinmej eo am.

Notes:

1. For perspective, the annual dose limit for the public as recommended by international agencies is 100 mrem per year. The Republic of the Marshall Islands has adopted a more restrictive standard for cleanup of radioactively contaminated sites in the northern Marshall Islands of 15 mrem per year, as recommended by the United States

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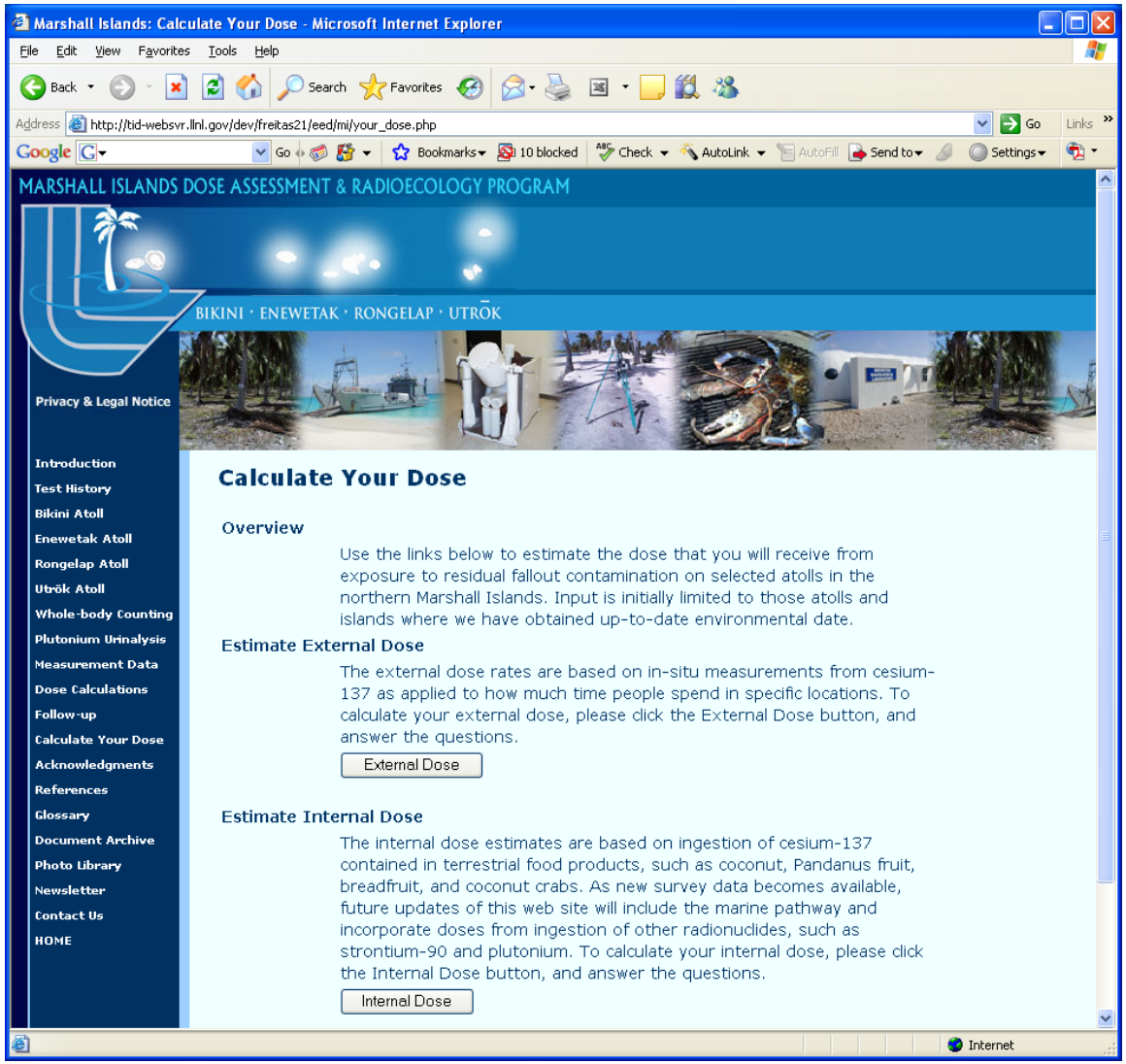
Marshall Islands Web Site Update



Microsoft Excel - MIPROJECT1-jue5(1).xls

File Edit View Insert Format Tools Data Window Help Adobe PDF

B6 Eneu

Please Select the Island	Please Select Your Food	Enter number of products consumed or use standard diet model
Eneu		

Nam
Iroij
Odrik
Lomilik
Aomen
Bikini
Eneu

Dose (mrem)
0.000E+00

Rongelap data tables / Utrok data tables / Enewetak data tables / Bikini data tables / Data ent

Ready NUM

Microsoft Excel - MIPROJECT1-jue5(1).xls

File Edit View Insert Format Tools Data Window Help Adobe PDF

C6 Coconut Juice

Please Select the Island	Please Select Your Food	Enter number of products consumed or use standard diet model
Eneu	Coconut Juice	

Pandanus Nut
Breadfruit
Coconut Juice
Bannna
Arrowroot
Nin
Papaya
Tutle egg

Dose (mrem)
0.000E+00

Rongelap data tables / Utrok data tables / Enewetak data tables / Bikini data tables / Data ent

Ready NUM

Microsoft Excel - MIPROJECT1-jue5(1).xls

Please Select the Island	Please Select Your Food	Enter number of products consumed or use standard diet model
Bikini	Breadfruit	1

Dose (mrem)
6.385E-01

Rongelap data tables / Utrok data tables / Enewetak data tables / Bikini data tables / Data ent

Marshall Islands Whole Body Counting Program Update

Marshall Islands Whole Body Counting Program

MAIN FOCUS

Based on our understanding that cesium-137 ingestion is the main pathway for exposure of Marshall Islanders to residual fallout contamination in the environment;

- **Develop a measurement and local technical capability to ensure that doses to resident populations remain at or below applicable safety standards.**
- **Improve on the monitoring capability of assessing doses to maximal exposed individuals or 'high-end doses'.**
- **Address questions or uncertainties related to seasonality effects and 'future change' in radiological conditions (use individual measurements data rather than depend on dietary scenarios and predictive assessments).**

Marshall Islands Whole Body Counting Program Update

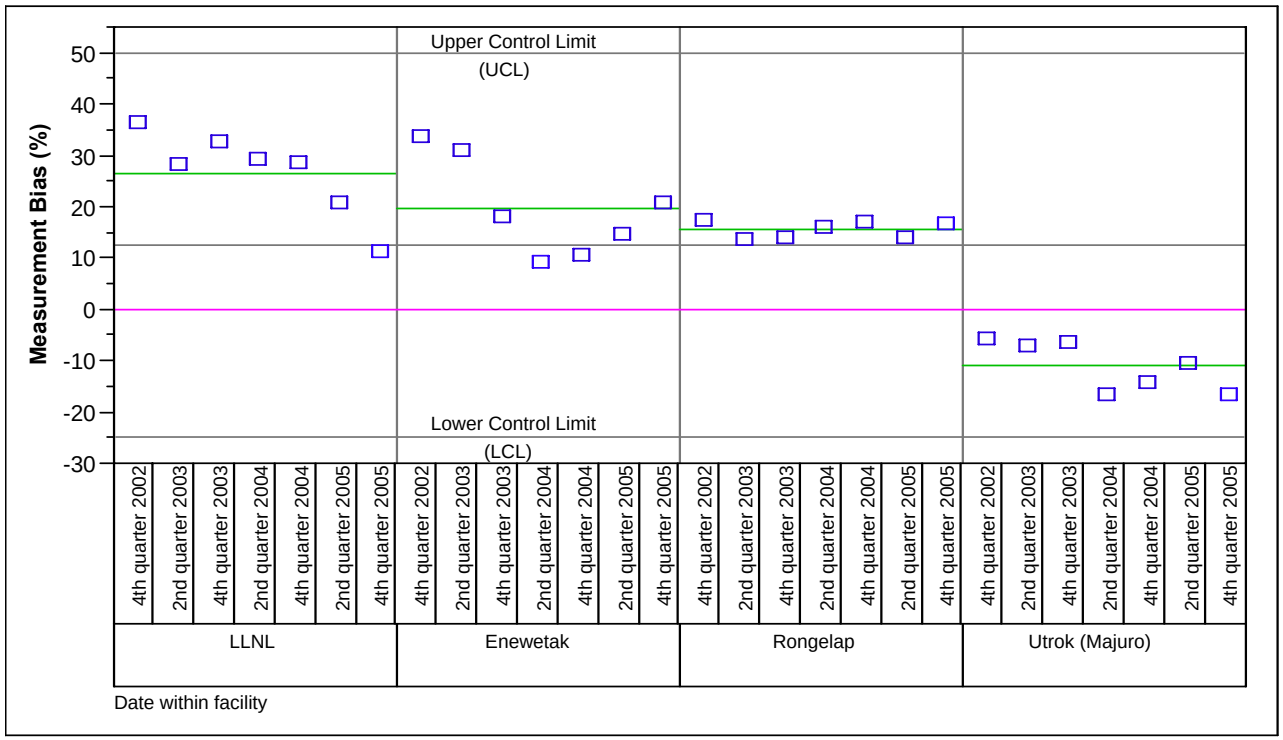
If you were to ask the obvious question;

How reliable are our measurements?

ANS. Is straight forward. The Marshall Islands Whole Body Counting Program is formulated around the same quality requirements as those used in the United States under the DOE Laboratory Accreditation Program (DOELAP)

Marshall Islands Whole Body Counting Program Update

Results of Performance Testing Exercises (2001-2005)



[Statistical reference lines include the null value (----); UCL (Upper Control Limit) = 50% (– - –); UCL (Lower Control Limit) = -25% (– - –); individual facility mean (——); and the overall or combined facility mean (-----)]

Marshall Islands Whole Body Counting Program Update

SUMMARY DATY FROM 2005-2006

	Enewetak Radiological Laboratory	Rongelap Whole Body Counting Facility	Utrōk Whole Body Counting Facility		Grand Total
			Utrōk Atoll Population Group[a]	Other Marshall Islanders[b]	
WBC Operational Summary					
Number of personnel counts	594	372	183 (96)	395	1544
% counts with detectable levels of ^{137}Cs	77%	75%	55% (93%)	11%	57%
Individual number of volunteers	352	102	158 (76)	385	997

[a] (Utrōk Atoll residents in parenthesis)

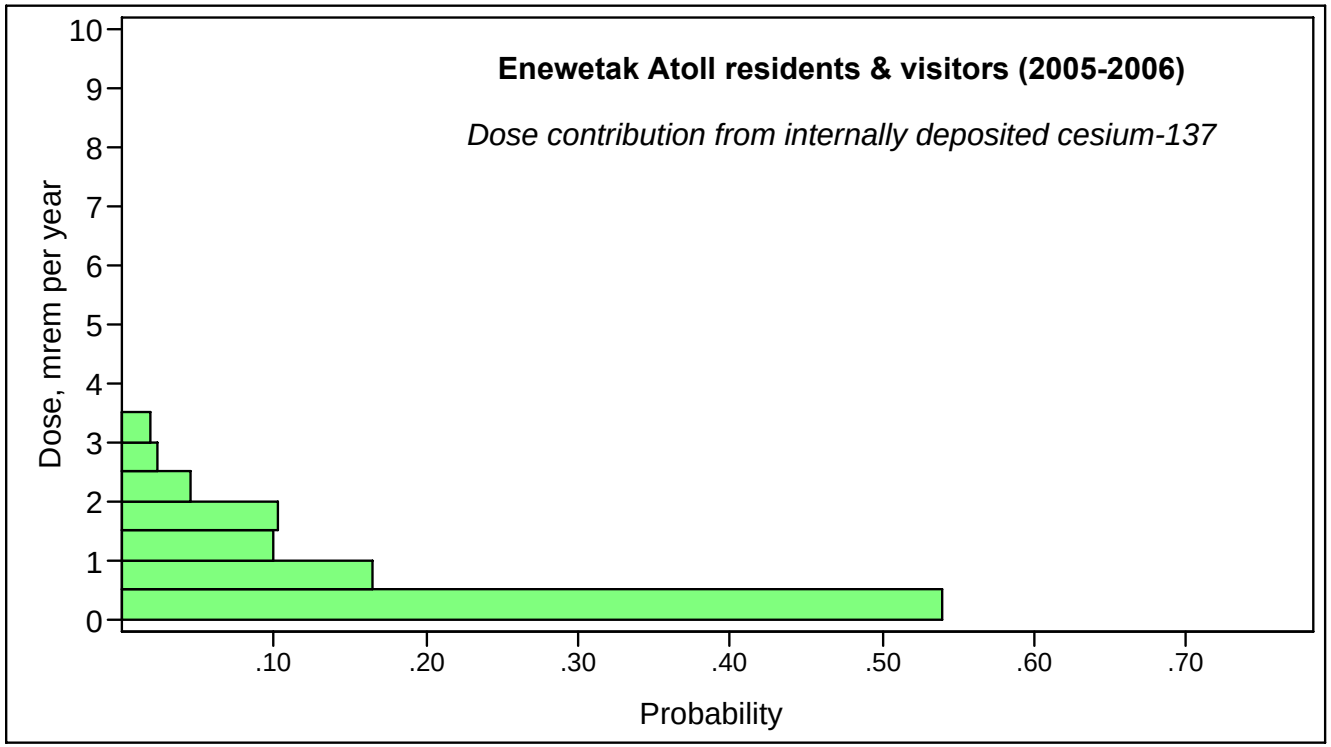
[b] other program volunteers

Marshall Islands Whole Body Counting Program Update

SUMMARY DATA FROM 2005-2006

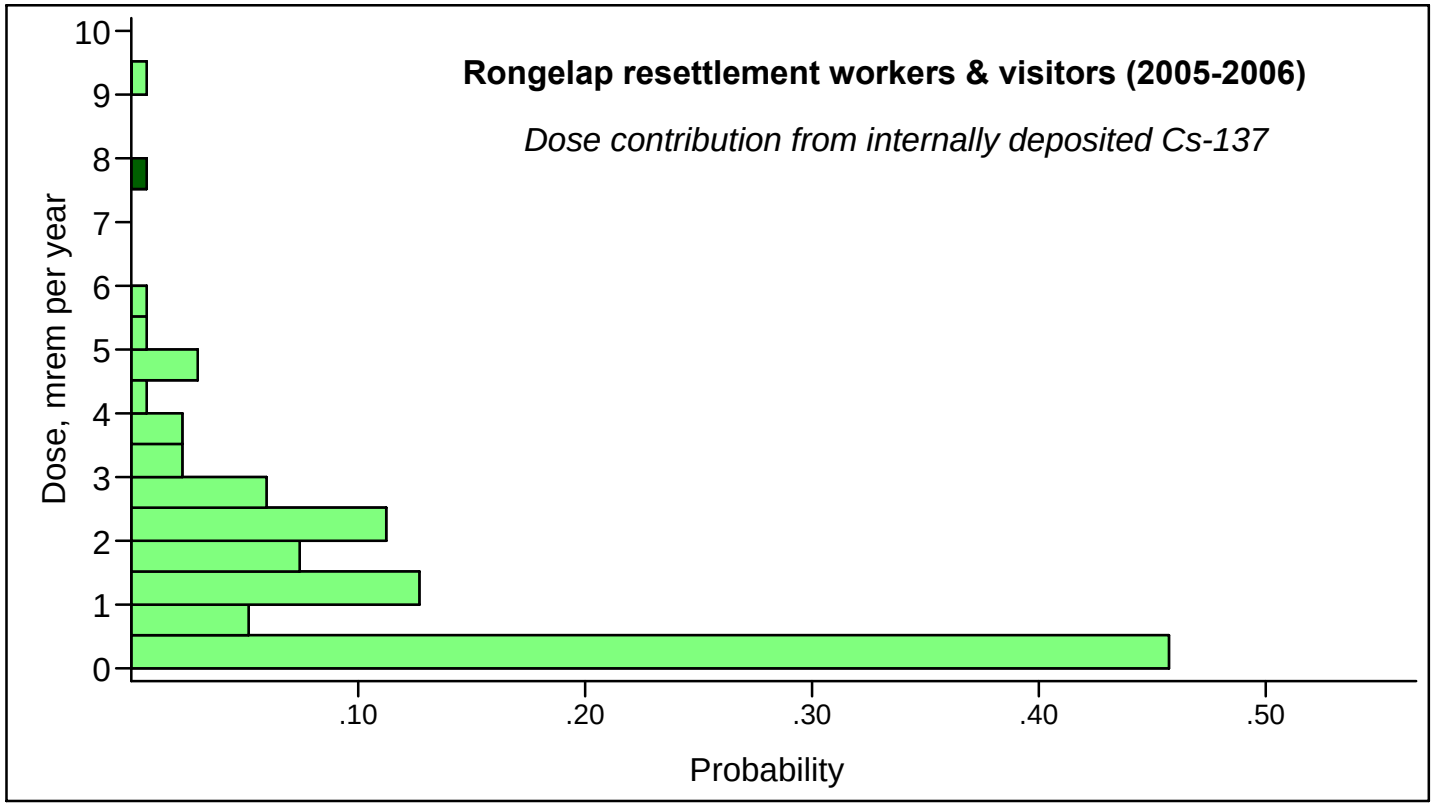
	Enewetak residents & visitors	Rongelap resettlement workers & visitors	Utrōk Atoll Population Group		Other Marshall Islanders	
			Utrōk Atoll residents	Non residents	Northern Atolls	Southern Atolls
WBC Dosimetric Summary (calendar year CEDE, mrem)						
Average	0.73	1.3	3.5	0.2	1.6	0.05
Median	0.43	0.90	3.5	0.0	1.2	0.0
Range	0–3.5	0–9.0	0–9.1	0–4.3	0–5.4	0–5.4
Number of volunteers	368	133	74	82	33	287

Marshall Islands Whole Body Counting Program Update



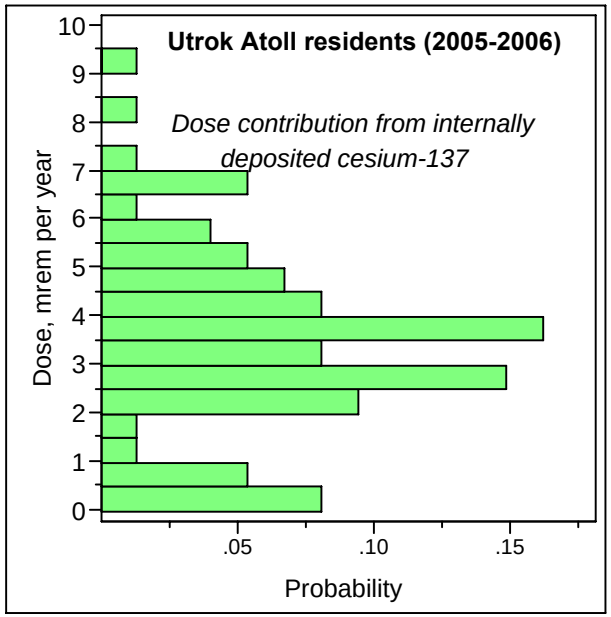
Moments; Median = 0.43; Mean = 0.73; Std. Dev. = 0.82; Std. Err. Mean = 0.04; Upper 95% Confidence Internal Mean = 0.81; Lower 95% Confidence Interval Mean = 0.65; N (number of volunteers) = 368

Marshall Islands Whole Body Counting Program Update

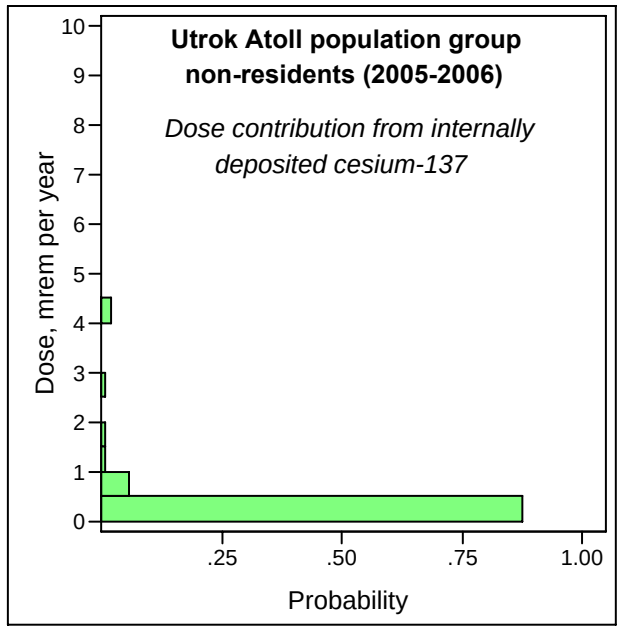


Moments: Mean = 1.3; Median = 0.9; 1.3; Std. Dev. = 1.6; Std. Err. Mean = 0.14; Upper Confidence Interval Mean = 1.59; Lower Confidence Interval = 1.0; N (number of volunteers) = 133

Marshall Islands Whole Body Counting Program Update

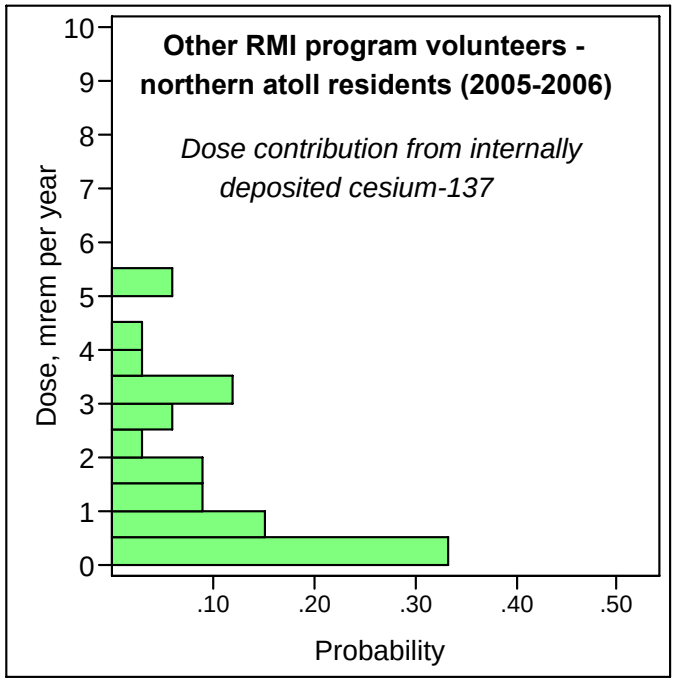


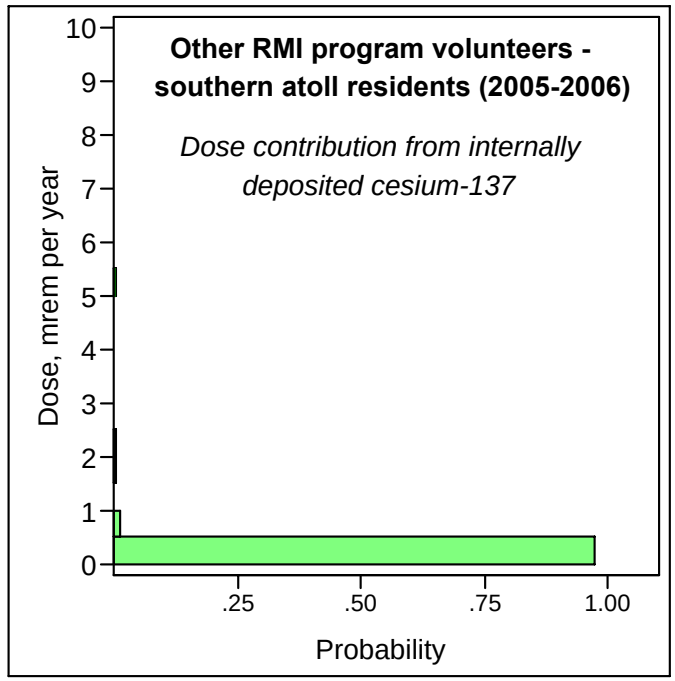
Moments: Mean = 3.5; Median = 3.5; Std. Dev. = 2.0; Std. Err. Mean = 0.23; Upper Confidence Interval Mean = 3.9; Lower Confidence Interval = 3.0; N = 74



Moments: Mean = 0.2; Median = 0.0; Std. Dev. = 0.8; Std. Err. Mean = 0.08; Upper Confidence Interval Mean = 0.38; Lower Confidence Interval = 0.05; N = 82

Marshall Islands Whole Body Counting Program Update

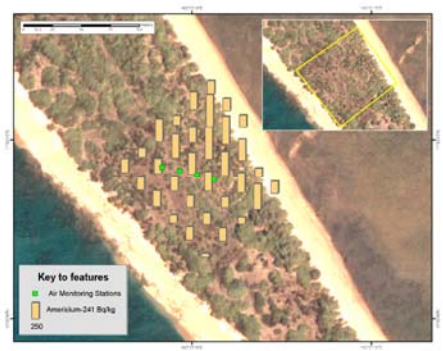


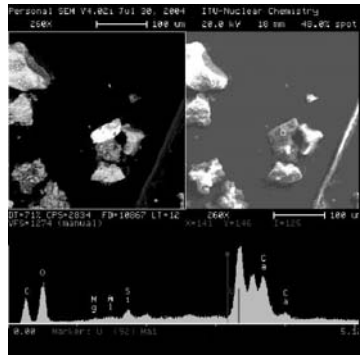


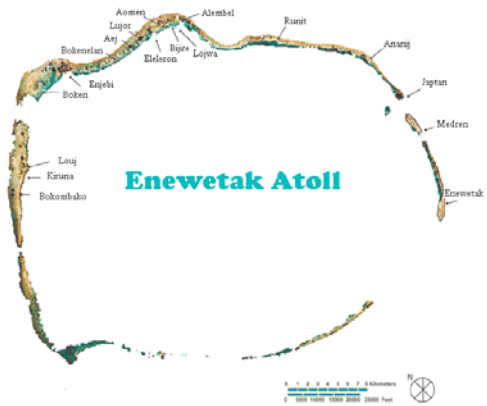
Moments: Mean = 1.6; Median = 1.2; Std. Dev. = 0.4; Std. Err. Mean = 0.28; Upper Confidence Interval Mean = 2.1; Lower Confidence Interval = 1.0; N = 33

Moments: Mean = 0.05; Median = 0.0; Std. Dev. = 2.0; Std. Err. Mean = 0.03; Upper Confidence Interval Mean = 0.1; Lower Confidence Interval = 0.01; N = 287

Marshall Islands Plutonium Bioassay Program Update







WHY WORRY ABOUT PLUTONIUM?

1. **Plutonium is a potential concern in the Marshall Islands because of high residual levels of plutonium contamination in the environment, its long-half-life (T1/2 = 25,00 years) and persistence in the environment**
2. **Plutonium is an alpha-emitting radionuclide with a relatively long biological half-life (20-50 years)**
3. **There was a need to improve on the accuracy and reliable of available bioassay measurement data for the Marshall Islands [Historical data is of questionable quality]**
4. **Protect workers who are more likely to be exposed to plutonium (e.g., soil remediation activities on Rongelap)**
5. **Develop baseline data in order to accurately assess potential incremental intakes associated with resettlement of atolls or islands and/or be able to assess potential long-term changes in radiological exposure conditions (e.g., transfers through the marine food chain)**

Marshall Islands Plutonium Bioassay Program Update

<u>Again, if you were going to ask the obvious question</u>

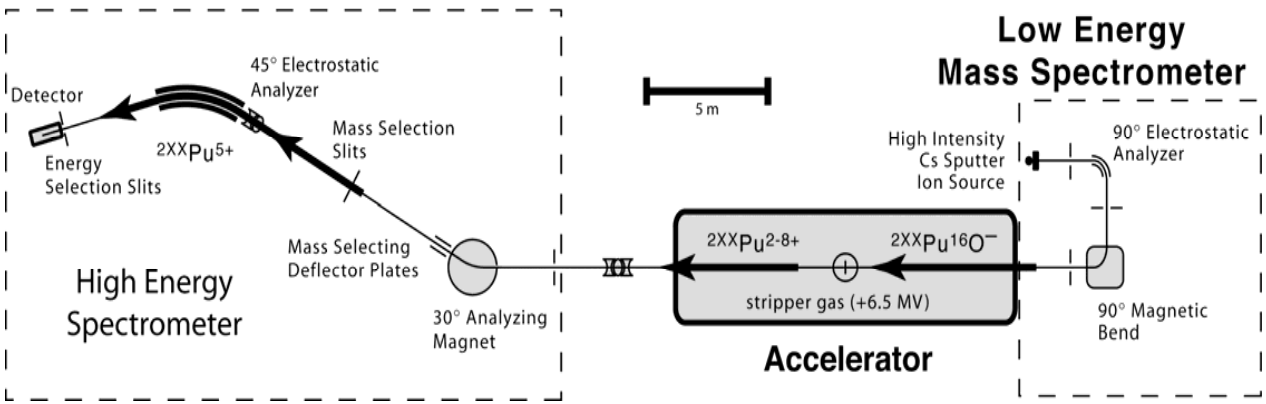
How reliable are our measurements?

ANS. The Marshall Islands Plutonium Bioassay Program is formulated around the same quality requirements as those used in the United States under the DOE Laboratory Accreditation Program (DOELAP).

'We are using state-of-the-art technology based on accelerator mass spectrometry'

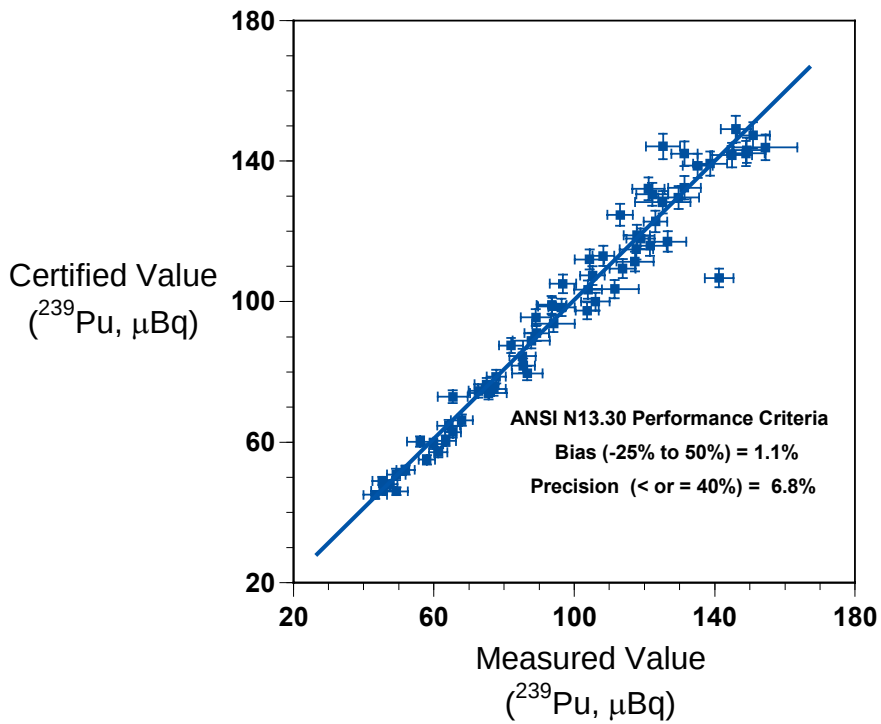
'Our methodologies have been independently validated by the U.S. National Institute of Science and Technology (NIST)'

'Continue to test performance of our measurement technique using externally samples prepared by the Oak Ridge National Laboratory'



Marshall Islands Plutonium Bioassay Program Update

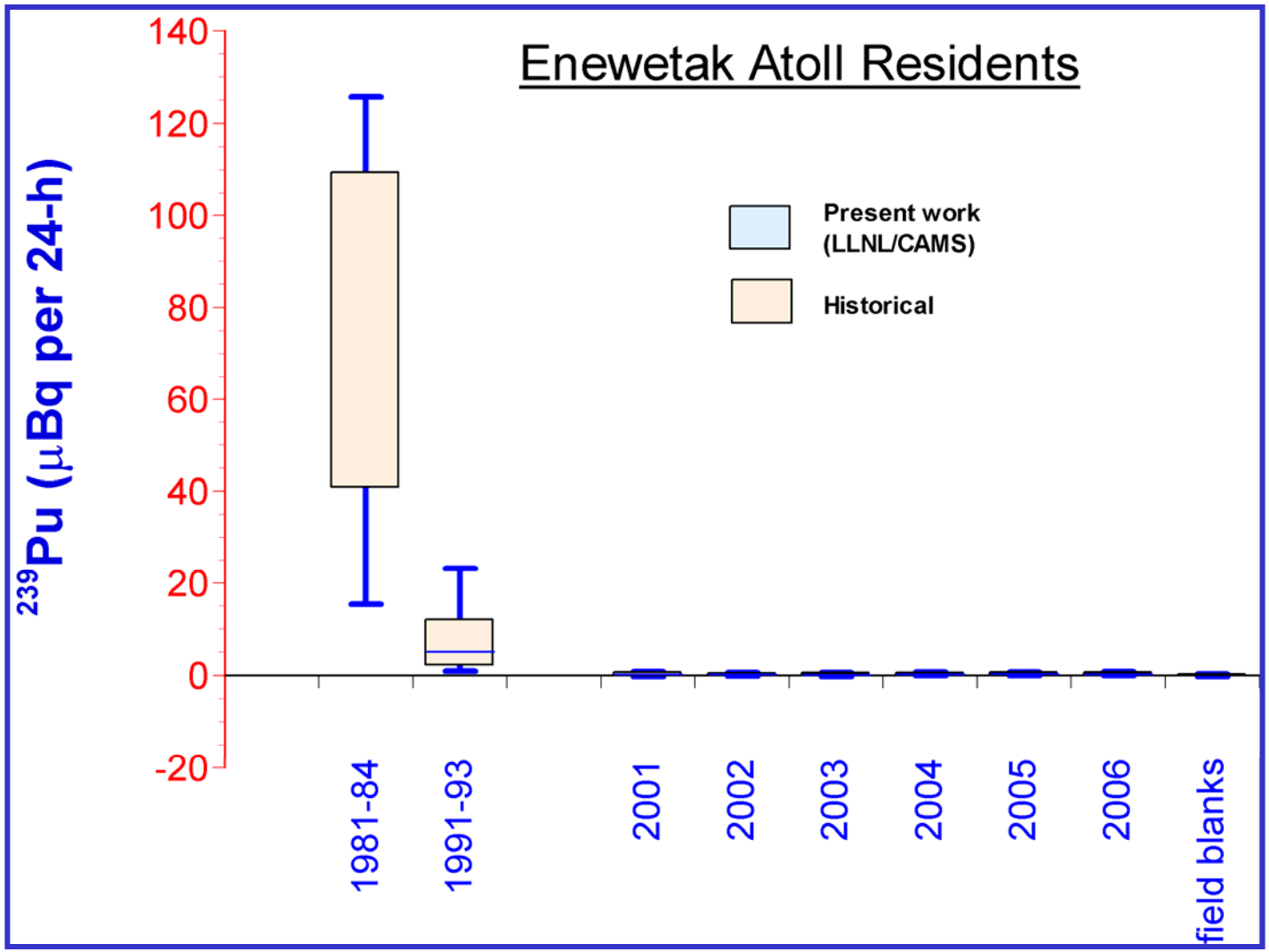
Analysis of plutonium-239 in Oak Ridge performance test samples



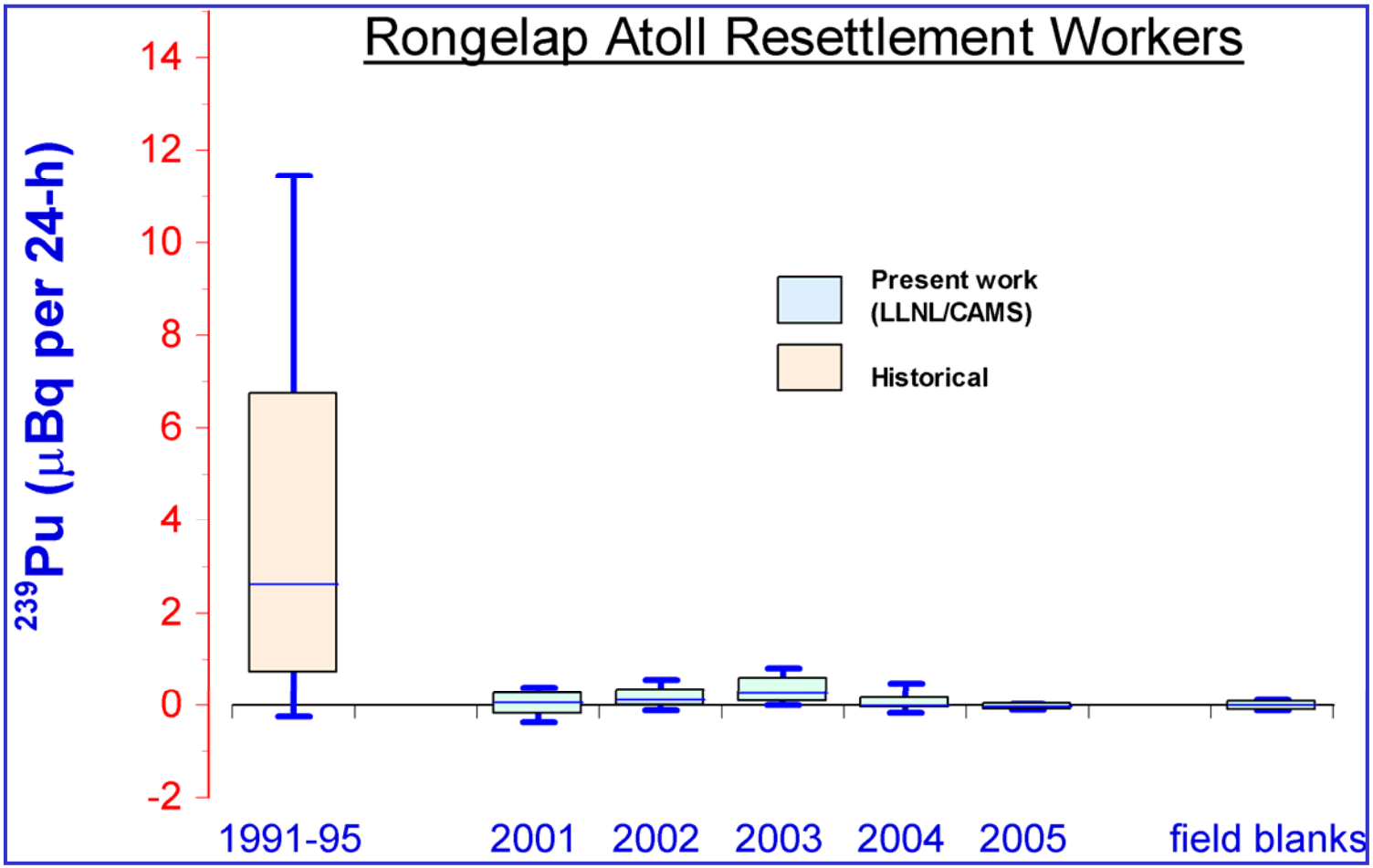
Just how good are we!

'Let results speak for themselves'

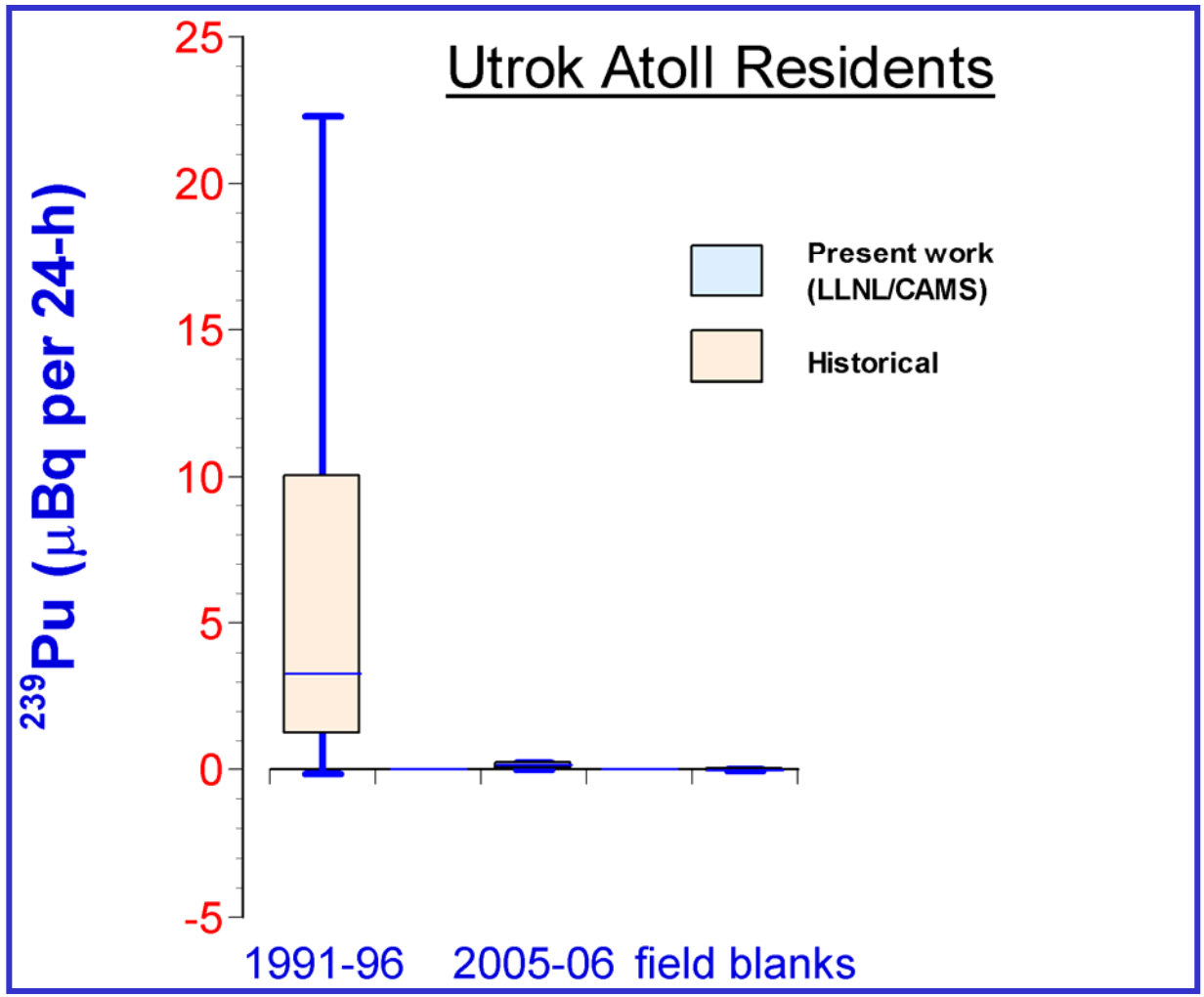
Plutonium bioassay results from Enewetak Atoll (2001-2005)



Plutonium Bioassay results from Rongelap Atoll (2001-2005)



Plutonium Bioassay results from Utrōk Atoll (2006-2007)



Marshall Islands Plutonium Bioassay Program Update

SUMMARY BIOASSAY DATA

Atoll	weighted mean (μBq per 24 h void)			
	field blank	all	male	female
Enewetak	0.01	0.14	0.16	0.11
Rongelap	0.00	0.11		
Utrok #	-0.03	0.10		

#initial data only

Marshall Islands Plutonium Bioassay Program Update

What do the results mean?

From a relative quantity point of view:

A very low level of urinary excretion rates of plutonium that could easily be explained by exposure to world-wide fallout in the Northern Hemisphere.

From a dosimetric perspective:

Atoll	population average 50-y CEDE[@], mrem		individual 50-y CEDE[@], mrem
	mean	max	max
Enewetak	1.7	3.0	28
Rongelap	1.3	1.8	50
Utrok[#]	1.2	2.8	2.8

@Based on a dose maximizing chronic intake scenario (includes outlier values)

#partial dataset

Marshall Islands Plutonium Bioassay Program Update

One interesting scientific finding;

There is a statistical significant age related trend on Enewetak and, to a lesser extent, on Rongelap Atoll

Atoll	Sample group	N	% samples containing >0.35 μBq per 24-h void
Enewetak Atoll (median age = 36.1)	field blank	39	5%
	<35 y	129	22%
	35<45 y	57	39%
	> 45y	83	53%
Rongelap Atoll (median age = 35.5y)	field blank	138	0%
	<35 y	65	22%
	35<45 y	45	30%
	> 45y	28	32%

Marshall Islands Plutonium Bioassay Program Update

Atoll	Sample group	N	% samples containing >0.35 μBq per 24-h void
Enewetak Atoll (median age = 36.1)	field blank	39	5%
	<35 y	129	22%
	35<45 y	57	39%
	> 45y	83	53%
Rongelap Atoll (median age = 35.5y)	field blank	138	0%
	<35 y	65	22%
	35<45 y	45	30%
	> 45y	28	32%

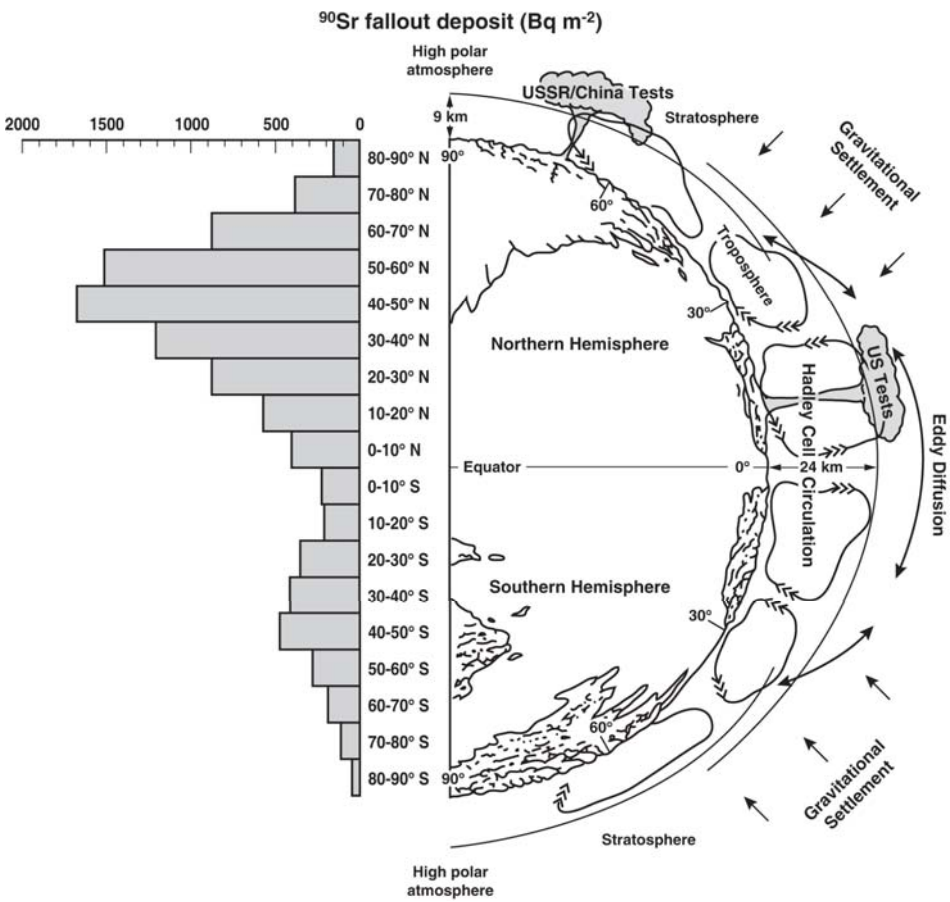
Two possible ways to interpret this trend:

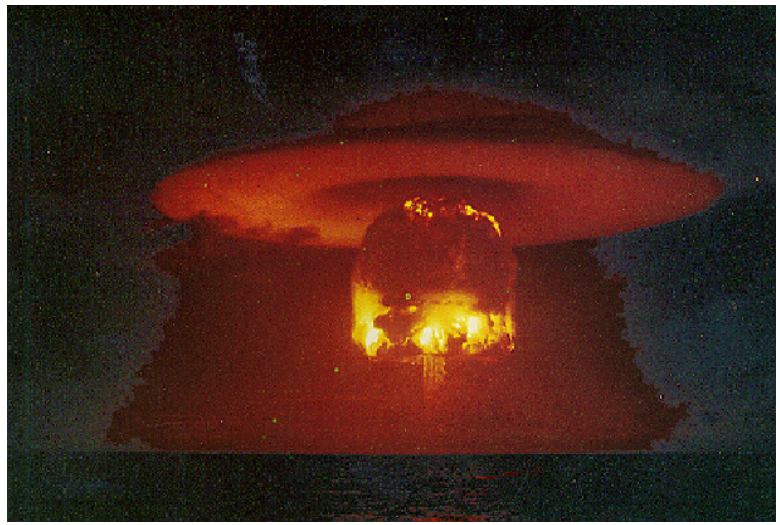
1. **Low-level chronic uptake of plutonium from inhalation or ingestion of plutonium on a local or regional scale**

2. **Systemic plutonium acquired from historical intakes of plutonium (either from worldwide deposition or from regional fallout patterns resulting from atmospheric nuclear weapons test programs through the 1950-60s)**

"We do not currently have data from an appropriate control population group in order to provide a more thorough full interpretation of the age-related trend"

Atmospheric nuclear weapons testing in the Marshall Islands





[Nuclear Weapons Testing in the Marshall Islands]

- **Significant contribution to world-wide fallout (some 11 tests > 4 Mt)**
- **At the same time, most of the tests were conducted in the near surface environment where as much as 50% of the debris was deposited on a local or regional scale**

Environmental Characterization Studies Update

Justification for our on-going program

1. **Verification of remedial actions (on-going work on Rongelap Island)**

2. **Provide understanding of future change and how this impacts on exposure conditions and requirements for cleanup.**

   "Conditions are improving at accelerated rate, e.g., the effective half-life of cesium-137 in plants is less than 10 years rather than 30 years as might be predicted from radiological decay"

   "This is a good news story stemming from our environmental studies program, especially in relation to providing accurate predictions on the long-term consequences of cesium-137 contamination in the environment"

3. **Specific characterization studies at selected sites, e.g., Runit Island on Enewetak Atoll**

Environmental Characterization Studies Update

How does this information impact on the direction of the program? and what approach are we taking?

1. **Advance resettlement of islands or atolls**

   >Provide the most appropriate options for cleanup
   >Potentially lower requirements for cleanup (and therefore reduce the cost to local atoll governments)
   >Provide improved levels of perception management

2. **There is a downside. Conditions are constantly changing so accurate and reliable predictions will depend on the availability of updated information on the levels and distributions of radionuclides in the environment. The ability to make accurate predictions will also be complicated by the effects of variability.., which in turn nearly always means that its best to MEASURE, PREDICT and then VERIFY**

As a reminder, the dose delivered to people results from the sum of the external dose (cesium-137 in the soil) and the internal dose (ingestion of Cs-137, Sr-90 and, to a lesser extent, ingestion and/or inhalation of plutonium and americium-241)

Environmental Characterization Studies Update

Our current emphasis is on Cs-137 and plutonium measurements!

We are hoping to have an opportunity to provide updated information on strontium-90 in the coming year

"In general, I believe we are on a good path. The combination of the individual radiological protection monitoring program and modified approaches to conducting environmental surveys (e.g., pantry sampling) will help sustain resettlement and ensure the radiological protection of the people until such time it is made clear that these measures are no longer required"

Environmental Characterization Studies Update

What is pantry sampling?

To conduct radiological surveys that attempt to mimic how Marshallese utilize atoll resources.

Usually involves the collection and analysis of common marine and terrestrial foods and determining external dose rates at selected locations (to develop what we call a snap-shot of radiological conditions).

Start by introducing some of the work that we have been doing on Bikini this past 12 months.

We place a strong emphasis on trying to manage costs while providing focus on important issues, and developing high quality data and information (the science and technology behind this program will be extremely difficult to replicate elsewhere)

Environmental Characterization Studies Update

This pantry sampling program was developed in response to concerns expressed by Bikini Atoll leadership

During 2006 we conducted two short missions to Bikini where we were able to visit almost all the islands.

The main focus of the survey was to identify if there were any radiological issues related to visiting the outer islands and potentially collecting/eating the local foods.

- Coconuts and coconut crabs
- Sea and land crabs
- Other food crop products, e.g., Pandanus fruit and breadfruit
- Reef and pelagic fish
- Birds and bird eggs
- In-situ gamma dose rate measurements
- Some scrub vegetation and soil

Environmental Characterization Studies Update

In-situ gamma survey data on Bikini Atoll (2006-2007)

Island Name	Island Code	Dose, mrem y^{-1}
Nam	B-1	108
Lomilik	B-4	6.5
Aomen	B-5	1.1
Bikini	–	–
housing area	B-6	10
Interior	B-6	160
Rojkere	B-10	22.0
Eonjebi	B-11	0.6
Eneu	–	–
airport	B-12	1.6
Interior	B-12	6.7
Aerokojlol	B-13	0.5
Bikdrin	B-14	1.7
Lele/Eneman	B-15/16	1.9
Enidrik	B-17	3.7
Lukoj	B-18	198
Jelete	B-19	134
Adrikan	B-20	26
Oroken	B-21	16
Bokaetoktok	B-22	4.1
Borkdriui	B-23	22.2

Environmental Characterization Studies Update

Initial results from Bikini Island (shown with comparative data from Enewetak and Rongelap)

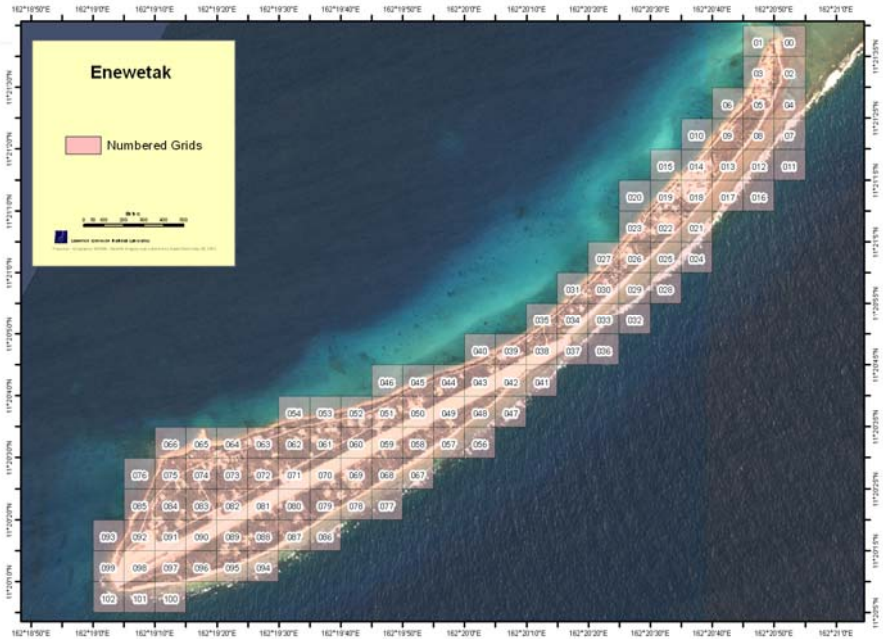
Type of food product	Average concentration of ^{137}Cs (Bq kg^{-1} wet wt.)		
	Enewetak Is.	Rongelap Is.	Bikini Is.
copra meat	9.3	149	1252
drinking coconut meat	4.0	90.1	1016
breadfruit	18.0	401	**192**
Pandanus fruit	16.1	152	1502
payaya	1.4	–	–
nin	–	95.4	–
arrowroot	–	59.6	–
banana	–	35.0	–
lime	7.9	–	–

Environmental Characterization Studies Update

Cesium-137 on Enewetak Atoll

Island Name	Island Code	Bq kg^{-1} wet wt.		
		N	Mean	SD
Drinking Coconut Meat				
Aomen	19E	141	226	289
Bijire	20E	99	146	123
Lojwa	21E	80	103	61
Alembel	22E	45	84	67
Ananij	31E	36	7.8	4.4
Enewetak	37E	70	10	8

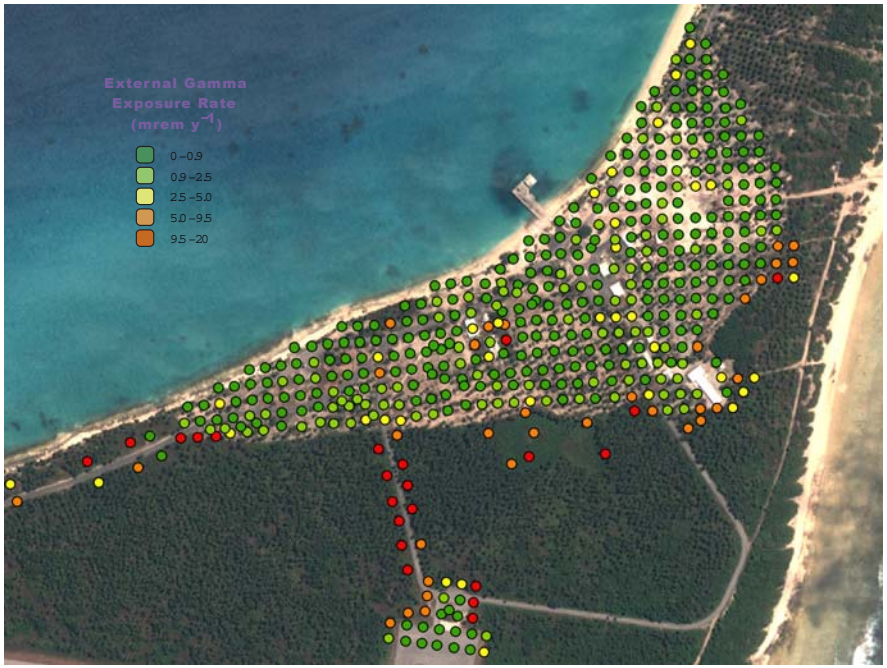
Environmental Characterization Studies Update



In-situ Gamma on Enewetak

Location	N	Cesium-137 external Gamma Dose Rates (mrem y^{-1})	
		range	average
Village & grove	93	<0.5-0.9	<0.5

Environmental Characterization Studies Update



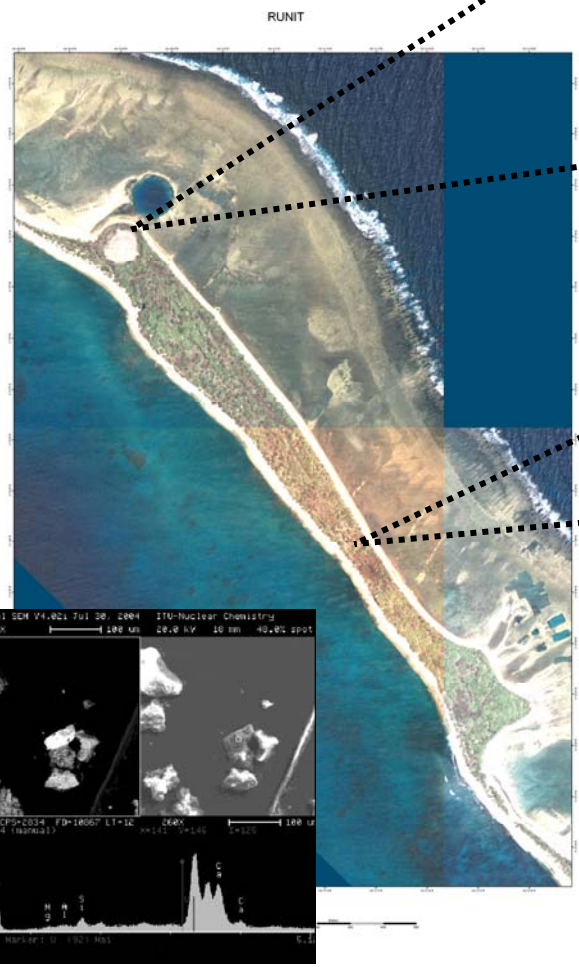
Rongelap external gamma dose

Location	N	Cesium-137 External Gamma Dose Rate (mrem per year)	
		range	average
Inside Houses	17	<0.5 – 1.1	0.7
Around Houses	81	<0.5 – 3.3	1.1
Lagoon#	63	<0.5 – 28	8.5

#excludes one point (53 mrem per year)

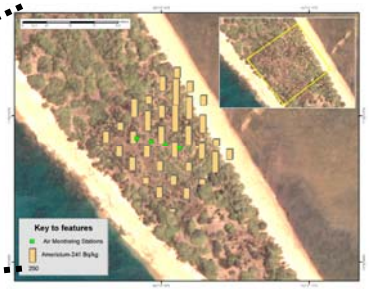
Environmental Characterization Studies Update

Site specific environmental surveys –Runit Island



Runit Dome

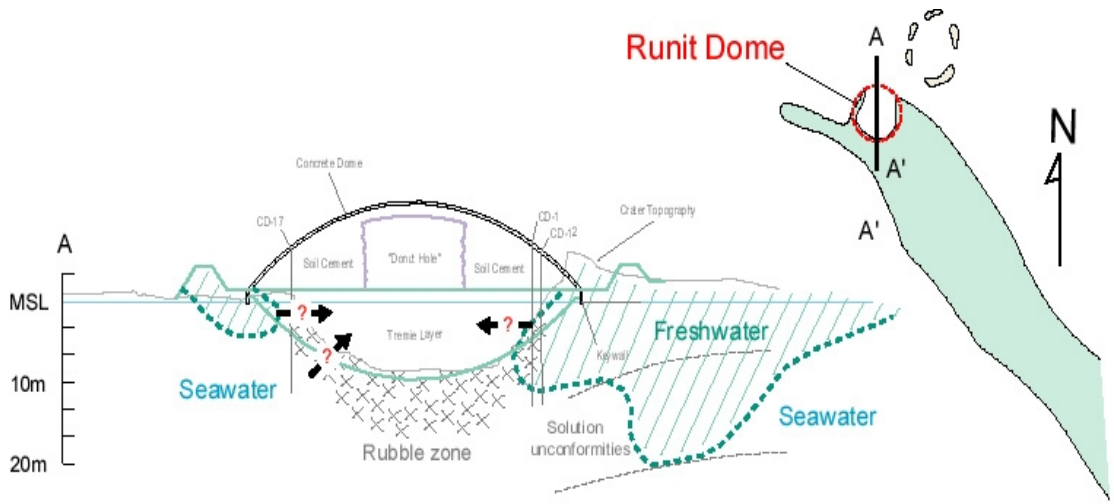
Fig/Quince GZ



Pu isotopes in surface soil on Runit Island

Site	$^{239+240}$Pu (Bq kg^{-1})		^{240}Pu/^{239}Pu atom ratio
	mean	range	
Runit Dome (berm area)	1600 ± 4600	70 – 18,800	0.075 ± 0.009
Fig/Quince Test Site	1440 ± 590	490 – 3060	0.062 ± 0.008

Environmental Characterization Studies Update



Concerning Runit Dome – there are uncertainties in describing conditions beneath the dome structure that could lead to mobility and transport of radionuclides from the near-field to the surface environment

At the same time, our monitoring studies through 2001-2005 show <u>no evidence</u> of leakage from the Dome impacting on the marine environment or increasing risks from radiation exposure

Nor is there ever likely to be any direct impact because of the high residual background of radioactivity around Runit Island and the lagoon

Environmental Characterization Studies Update

Radionuclide concentration data in the vicinity of Runit Dome

Sample	Location	Radionuclide concentration in surface sdiment (Bq kg^{-1}, dry)				^{240}Pu/^{239}Pu atom ratio
		^{241}Am	^{137}Cs	^{239}Pu	^{240}Pu	
05EY-01531	offshore -Runit	0.00 ± 0.0	0.00 ± 0.00	13.5 ± 0.7	3.1 ± 0.2	0.069 ± 0.002
05EY-01533	offshore -Runit	0.00 ± 0.0	0.00 ± 0.00	8.6 ± 0.4	2.1 ± 0.2	0.076 ± 0.002
05EY-01534	offshore -Runit	–	0.00 ± 0.00	11.9 ± 0.6	2.8 ± 0.2	0.071 ± 0.002
05EY-01535	offshore -Runit	80.7 ± 12.0	0.00 ± 0.00	402.1 ± 19.0	105.9 ± 5.1	0.072 ± 0.001
05EY-01538	offshore -Runit	115.5 ± 15.8	0.00 ± 0.00	420.1 ± 20.0	94.1 ± 4.6	0.061 ± 0.001
05EY-01542	offshore -Runit	71.5 ± 2.4	0.00 ± 0.00	400.7 ± 19.0	90.3 ± 4.4	0.061 ± 0.001
05EY-01544	offshore -Runit	50.1 ± 6.0	4.46 ± 1.30	275.7 ± 13.1	65.0 ± 3.2	0.064 ± 0.001
05EY-01549	offshore -Runit	60.1 ± 4.7	2.74 ± 1.60	303.7 ± 14.4	70.0 ± 3.4	0.063 ± 0.001
05EY-01554	offshore -Runit	60.9 ± 5.6	4.65 ± 1.20	278.3 ± 13.2	64.7 ± 3.1	0.063 ± 0.001
05EY-01558	offshore -Runit	47.9 ± 10.1	0.33 ± 2.60	288.4 ± 13.7	66.9 ± 3.2	0.063 ± 0.001
05EY-01582	offshore -Runit	144.2 ± 2.8	3.73 ± 0.60	625.7 ± 29.6	140.3 ± 6.8	0.061 ± 0.001
05EY-01593	offshore -Runit	91.5 ± 5.5	0.00 ± 0.00	449.9 ± 21.3	103.6 ± 5.0	0.063 ± 0.001
05EY-01601	offshore -Runit	65.6 ± 14.7	0.00 ± 0.00	331.6 ± 15.7	77.0 ± 3.7	0.063 ± 0.001
05EY-01606	offshore -Runit	54.1 ± 5.4	0.00 ± 0.00	284.5 ± 13.5	65.8 ± 3.2	0.063 ± 0.001
05EY-01612	offshore -Runit	61.9 ± 5.4	9.62 ± 1.60	274.4 ± 13.0	62.1 ± 3.0	0.062 ± 0.001
					average =	**0.065 ± 0.005**
05EY-01618	**offshore-Enjebi**	115.58 ± 14.00	12.11 ± 2.00	210.5 ± 9.96	97.9 ± 4.73	**0.126 ± 0.001**
05EY-01623	**offshore-Enjebi**	136.37 ± 10.40	10.57 ± 2.20	244.2 ± 11.58	102.1 ± 4.94	**0.114 ± 0.001**
05EY-01631	**offshore-Enjebi**	73.98 ± 2.20	6.40 ± 0.90	87.6 ± 4.15	67.7 ± 3.28	**0.210 ± 0.002**

Summary Remark

1. Whole body counting and plutonium bioassay programs have been highly successful. We are provided an unprecedented level of radiation protection monitoring for Marshallese populations, and producing data of unquestionable quality
2. Our continuing environmental program improves on the accuracy and reliable of our prediction dose assessments by incorporating knowledge of changing conditions. This knowledge will be essential in helping DOE address potential concerns before they could possibly impact on human health, potentially reduce the cost of cleanup programs, and help sustain resettlement
3. Livermore scientists stand ready to offer our services in support of the Marshall Islands Program built on a more trustworthy relationship between LLNL scientists, the DOE and our Marshallese counterparts, a commitment to excellence, and full transparency of data and information.

Kommol tata