

Marshall Islands Radiological Safety Program
and Rongelap/Utirik Dose Reassessment Project
- A Historical Synopsis

Preface

From the mid 1940's to 1958, the United States conducted its' high-yield nuclear weapons tests at Bikini and Enewetak Atolls in the tropical Pacific. These remote groups of small islands lie about 2,500 miles southwest of Hawaii, and are part of the Marshall Islands District of Micronesia. At that time, most of Micronesia was the political ward of the United States which acted as trustee under a United Nations mandate establishing the Trust Territory of the Pacific Islands (Micronesia) after World War II. Currently, this region, known as the Marshall Islands, intends to enter into a Compact of Free Association with the United States.

The largest of the nuclear tests was the "BRAVO" event which took place at Bikini Atoll on March 1, 1954. Radioactive fallout from this detonation was carried eastward by prevailing winds, and resulted in radiation exposures to Marshallese people living at Rongelap and Utirik Atolls a few hundred miles away. The exposed population of these atolls plus a comparison population are frequently examined by Brookhaven National Laboratory Medical personnel to detect and care for long-term health effects due to their exposure to radiation from the weapons testing program.

In addition to the high-level radiation exposures to the Rongelap and Utirik people, the nuclear tests also left a legacy of environmental radioactivity which, because of its lower level, is not expected to cause adverse health effects. However, residual radioactivity in the environment will contribute radiation exposures above natural background levels to people living in these areas.

In 1968, President Johnson authorized the return of Bikini Atoll to its original inhabitants, most of whom were living on Kili Island about 500 miles to the south of Bikini Atoll. A similar authorization was given for the Enewetak people who had been moved to Ujelang prior to the testing at their home atoll. Because of the residual radioactivity at Bikini and Enewetak, environmental monitoring programs were established to assure the people that the low-level radiation exposures (which residents would receive from living in these places) remain within acceptable limits. The dose-equivalent limits are those recommended by the International Commission on Radiological Protection (ICRP) for people not occupationally exposed to radiation.

The U.S. Department of Energy had assumed the old Atomic Energy Commission's commitment to provide continuing followup for the medical and environmental problems caused by the Pacific testing programs. Beginning in March 1954 to the present, the Brookhaven medical team has provided medical care and radiation protection guidance to the exposed population. They studied internal radioactivity levels through radiochemical analysis of urine and blood and through whole-body counting. Since the logistical support for Brookhaven medical team visits to Rongelap and Utirik had been established, it seemed reasonable to have the environmental and radiological safety assessments done by the Safety and Environmental Protection Division of Brookhaven National Laboratory as well.

The Safety and Environmental Protection Division undertook environmental measurements for radioactivity as early as 1974. In 1973, whole-body counting and radiochemical analysis of biological samples were transferred from the Medical Department to this division. At present, the program

involves up to 3 field trips a year to the Northern Marshalls. Measurements are made of external and in vivo radiation levels. Samples are collected for laboratory analysis at Brookhaven National Laboratory to assess the radioactive content in soil, food products and humans. A major component of the field work involves having representative individuals monitored for radioactivity content in their bodies. The following is a brief description of the Safety and Environmental Protection Division's programs in the Marshall Islands starting from 1974 and covering current activities.

FY 1974

Negotiations between the Division of Operational Safety of the old Atomic Energy Commission (AECDOS) and the old Health Physics and Safety Division of Brookhaven National Laboratory (BNLHPS) resulted in a proposal submission to begin the Marshall Islands Radiological Safety Program (MIRSP). Lawrence Livermore Laboratory (LLL) had and still has a parallel program, Marshall Islands Radioecology, which concentrates on Enewetak and Bikini Atolls.

An orientation field trip was arranged for Greenhouse and Ash of BNLHPS. They accompanied the BNL Medical Department's spring medical survey to Utirik, Rongelap and Bikini, in April 1974. Nelson, of the University of Washington's Laboratory of Radiation Ecology (UWLRE) also participated in this field trip. Plans were made to collaborate with UWLRE in the future. This field trip included physical examinations, in-vivo whole-body counting and urine bioassay sampling of all three atoll populations by the BNL medical team. External radiation measurements and sampling of groundwater, soil, plants, fish and coconut crabs were performed by Greenhouse and Nelson.

FY 1975

The Marshall Islands Radiological Safety Program was formally initiated. Funding levels were \$125,000 for operating and \$20,000 for capital equipment. Staffing levels were 1.5 man years scientific and professional and 1.0 man year technical support. Greenhouse directed the program. Arrangements were made to upgrade the BNLHPS analytical lab with the additions of a computer based multi-channel analyzer and a high efficiency GeLi detector.

Greenhouse and Nelson, in a joint UWLRE/BNLHPS field trip to the Northern Marshalls in December 1974, collected environmental samples and made external radiation measurements at Rongelap, Utirik, Rongerik and Bikini Atolls. Greenhouse, Williams, and Kuehner of BNLHPS, Reilly of the State of Pennsylvania, Davis of Pacific Gas and Electric, and Nelson of UWLRE participated in an April 1975 field trip to Bikini Atoll. They collected samples and defined the external radiation environments of Bikini and Enue Islands. Limited soil and vegetation sampling were done at Bikini and comparison environmental samples were collected at Wotho and Kwajalein Atolls. This field trip established the groundwork for a major interagency survey of Bikini and Enue Islands in June in which Greenhouse participated. This survey included soil, groundwater and some vegetation sampling. It was performed jointly by LLL, UWLRE, the Environmental Protection Agency, and BNLHPS. Their primary objective was selection of locations for the second increment of house construction on Bikini and Enue Islands by the Department of the Interior.

FY 1976

Funding levels were \$172,000 operating and \$20,000 capital equipment. Staffing levels were 2.0 man years scientific and professional and 1.0 man

years technical support. Major equipment purchases included a Lawrence Livermore Laboratory Portable Gamma Spectrometer and two Reuter Stokes Environmental Radiation Monitors. Naidu (BNLHPS) joined Greenhouse to form the program's principle staff.

Nelson and Greenhouse collaborated on a field trip to Majuro, Ponape, Truk, Guam, and Palau, as part of the UWLRE Pacific Basin Study. Greenhouse, Naidu, and Kuehner of BNLHPS, Haughey of Rutgers University, Terpilak of the Department of Health, Education and Welfare, Bureau of Radiological Health and Kastens of University of New York at Stony Brook, Marine Science Center participated in a March-April field trip to Bikini Atoll. Their primary objectives were beta and gamma dose rate measurements on Bikini Island and a general radiological survey of Nam Island in the northwestern sector of the atoll. This survey included limited soil and vegetation sampling. A joint BNLHPS and UWLRE survey with the BNL Medical Department was undertaken in September. The BNLHPS objective was to perform an environmental radiation survey at Wotje, Ailuk, Utirik, Rongelap and Bikini Atolls. Special efforts focussed on several northern islands at Rongelap.

PUBLICATION: Marshall Islands Radiological Followup, N. A. Greenhouse and T. F. McCraw, BNL #20767.

PRESENTATIONS: Marshall Islands Radiological Followup, N. A. Greenhouse, Presented at the Ninth Midyear Topical Symposium, Operational Health Physics, Denver, Colorado, February 1976.

FY 1977

Funding levels were \$207,000 for operating and \$80,000 for capital equipment. Staffing levels were 2.0 man years scientific and professional

and 1.25 man years technical. An additional 0.25 man years for technical support was obtained from the new Safety and Environmental Protection Division (BNLSEP formerly BNLHPS). Miltenberger (BNLSEP) replaced Naidu and joined Greenhouse as principle staff. A request from the Energy Research and Development Administration, Division of Safety, Standards and Compliance (ERDADSSC formerly AECDOS) to add air sampling equipment to the radiological surveillance program at Bikini was received. ERDADSSC also requested in vivo counting of the Bikini and Enewetak people. Major equipment purchases included four wind-powered electrical generators, three multichannel analyzers and two sodium iodide (NaI) detectors.

During a September 1976 BNL medical survey to Rongelap, Knudsen, a Medical Department physician, was requested by the residents of Rongelap to have Naidu of BNLSEP stay on Rongelap Island and instruct the people in radiation sciences. Naidu was funded by the Energy Research and Development Administration's Division of Biomedicine and Environmental Research (ERDADBER) and spent six weeks during January and February 1977 educating the Rongelap people on matters pertaining to the effects of radiation on man.

During April and May of 1977, BNLSEP's Greenhouse, Miltenberger and Levine went to Utirik, Rongelap and Bikini to do site planning for wind-powered electrical generators and air sampling stations. Together with a conventionally powered comparison air sampling station, which they installed at Kwajalein Island, Kwajalein Atoll, these stations initiated the long-term sampling program for air activity concentrations of plutonium. Fossil-fueled generators were judged incapable of supplying continuous year round power on outer atolls. Wind-powered generators were thought to be capable of supplying

power for a 12 month period without needing repairs. In addition, wind-powered electrical generators were virtually noiseless compared to gasoline powered electrical generators. They offered the possibility of collecting a large volume air sample without disruption of quiescent village living patterns on outer atolls. A plutonium excretion study was also undertaken by collecting pooled large-volume urine samples from three to five families at each atoll except Kwajalein.

Early in 1977, the question of the past dose equivalent to the Marshallese who have lived on Rongelap and Utirik, had become an important scientific and health related question with considerable political overtones. Bond, Borg, Conard, Cronkite, Greenhouse, Naidu and Meinhold, all members of BNL, and Sondhaus of the University of California, College of Medicine (UCCM) initiated technical evaluation of the issue.

FY 1978

MIRSP funding levels were \$207,000 for operating and \$10,000 for capital equipment. Staffing levels were 2.0 man years scientific and professional and 2.5 man years technical support. Greenhouse and Miltenberger made up the program's principle staff, Cua and Knight joined the program staff part time. Major equipment purchases consisted of peripheral alpha spectroscopy equipment for plutonium analyses of environmental and biological samples. As a result of earlier discussions by Bond, Meinhold, Naidu and others of BNL, a proposal for Rongelap and Utirik Dose Reassessment (RUDR) had been forwarded to the Department of Energy's Division of Biological and Environmental Research (DOEDBER formerly ERDADBER) and the program was funded with an operational budget of \$50,000. Staffing levels were 0.5 man years scientific and professional, Naidu and Greenhouse were the RUDR program's primary staff.

In October 1977, three wind-powered electrical generators and long term air sampling stations were installed at Utirik, Rongelap and Bikini Islands by members of BNLSEP and the owner/operator of Eneritech Corporation, the seller of the wind-powered systems. A second comparison station was installed at Roi-Namur Island, Kwajalein Atoll. In addition, large volume urine samples were collected under controlled conditions from five to seven Marshallese males at Utirik, Rongelap and Bikini. All of this work was performed by Greenhouse, Levine, Dillingham, DeAngelis and Cua of BNLSEP and by Sherwin of Eneritech Corporation. Also in October 1977 Miltenberger of BNLSEP and Cohn, Rothman and Clareus of BNL medical attempted to whole-body count the Marshallese population residing at Japtan Island, Enewetak Atoll. Due to an uncertain political and social atmosphere, it was decided by the new Department of Energy's Division of Safety, Standards and Compliance (DOEDSSC formerly ERDADSSC) that BNL refrain from involvement with the Marshallese on Japtan Island. At that time, the focus of the field work was switched to counting 35 Holmes and Narver employees who were residents of Enewetak Island.

In January 1978 Balsamo and Sherwin returned to Bikini, Rongelap and Utirik to complete wind-powered electrical generator installation and repair. In April 1978 Miltenberger, Lessard and Naidu of BNLSEP participated in a joint field trip with BNL Medical on Rongelap, Utirik and Bikini Atolls. At Utirik, the BNLSEP team collected urine, soil, vegetation and fish samples for radiochemical analysis. They also collected 5 day high-volume air samples and Anderson cascade impactor air samples. The wind-powered electrical generator at Utirik was not working and could not be repaired. Naidu remained behind on Utirik for several weeks to teach the biological effects of radiation, a pro-

gram similar to the one given on Rongelap in 1977. Lessard and Miltenberger proceeded to Rongelap to collect additional urine and environmental samples and conducted an external exposure study at the northern islands of Rongelap Atoll. The wind-powered electric generator had malfunctioned here too. An attempt to repair the wind-powered generator also was made, however, no long term successful operation of the system could be achieved. Greenhouse and Kuehner of BNLSEP joined the field team at Bikini. Of the 143 persons residing on Bikini, 99 were whole-body counted. Additionally, urine samples and environmental soil, air and vegetation samples were collected. Samples of locally prepared indigenous food items such as jekaro (coconut sap), jekami (coconut syrup) and powdered taro flour (a starchy tuber based flour) were obtained. The wind-powered generator on Bikini was not working nor could it be repaired. The Bikinians were made aware of the fact that their prior body burdens had increased to new levels and many of them knew they exceeded the internationally accepted annual guidelines for dose-equivalent commitment.

In June 1978, the RUDR program contracted the meteorological group at LLL, headed up Gudiksen, to provide a computer simulation of the dispersion, transport and deposition of fallout from the 1954 atmospheric nuclear test, BRAVO. Also, a contract to provide neutron activation analyses of environmental samples for I-127 and I-129 resulting from the deposition of fallout on Rongelap and Utirik Atolls was given to the Radiological Sciences Department, Battelle-Pacific Northwest Laboratory (BPNL) under the guidance of Brauer and Ballou. Historic soil samples from Rongelap and Utirik Atolls were provided by Seymour, the director of UWLRE. In August, Sondhaus of UCCM was asked to collaborate on the dose reassessment project (RUDR).

In September 1978, Naidu, Craighead and Greenhouse of BNLSEP began a diet and living pattern study of Rongelap, Utirik, Likiep and Ailuk Atolls. Initial observations had been performed by Naidu during prior visits (Rongelap 6 weeks, January-February 1977 and Utirik 2 weeks, April 1978) and by Knight during FY 78. Basic data was gathered on age distribution, family size, seasonal variations of locally grown food, food from other islands, individual diet patterns and individual daily activity patterns. Greenhouse also performed ground level exposure rate measurements and surface soil sampling. This work was performed in support of the Northern Marshall Islands Radiological Survey and expenses totalling \$37,000 were reimbursed through Robison of LLL and Liverman of DOE.

PUBLICATIONS: External Radiation Survey and Dose Predictions for Rongelap, Utirik, Rongerik, Ailuk and Wotje Atolls, N. A. Greenhouse and R. P. Miltenberger, BNL #50797, December 1977.

Radiological Analyses of Marshall Islands Environmental Samples 1974-1976, N. A. Greenhouse, R. P. Miltenberger and F. T. Cua, BNL #50796, December 1977.

FY 1979

MIRSP was funded with \$281,000 operating and \$25,000 capital. RUDR was funded with \$50,000 operating. Total staffing levels were 3.4 man years scientific and professional and 1.6 man years technical support. Lessard, a prior collaborator on MIRSP joined with Greenhouse, Miltenberger and Naidu as principle staff for MIRSP and RUDR. Major equipment purchases included a portable Davidson multi-channel analyzer and tower extensions for the wind-powered electrical generators.

Twelve two week Marshallese comparison urine samples were collected in October 1978 by Shoniber, Department of Health Services, Trust Territory of the Pacific Islands and forwarded to BNL for analyses. Each sample was to have been analyzed for Sr-90, Cs-137, Pu-239 and Pu-240 from world-wide fallout and for natural K-40. The results were to be used to establish the baseline excretion rates for these radionuclides so that a reference against which urine samples from the atolls contaminated with tropospheric fallout could be compared.

During November 1978, Marshall Island's whole-body counting, environmental, demographic, physiologic and bioassay data bases were initiated by Miltenberger. Preliminary diet and living pattern reports were submitted to Robison (LLL) by Naidu. Under the RUDR program, 62 teeth samples from Bikini, Rongelap and Utirik were collected by BNL Medical for future analyses of Sr-90, Pu-239 and Pu-240. Naidu invited The Institute of Physical and Chemical Research of Japan to contribute some Bikini ash to RUDR research.

During January and February 1979, Lessard constructed appropriate dosimetric models and determined retrospective and prospective dose equivalents to various body organs for all former Bikini residents. This work also compared urine bioassay derived body burdens to whole-body counting measured body burdens for Cs-137.

In January, a whole body counting field trip to Majuro to examine the former Bikini Island residents was undertaken by Miltenberger, Greenhouse and Craighead. They whole-body counted 101 persons and collected 49 urine samples, 64 whole-body counts were from the relocated former Bikini residents. Miltenberger and Greenhouse continued to cross the Trust Territory to finish

the Pacific Basin Study, a collaborative effort with Nelson of UWLRE which had commenced in 1975. During May, another field trip to Majuro and Kili was completed by Miltenberger and Lessard. They whole-body counted 129 persons, 79 of which had been relocated from Bikini Island in August of 1978. The whole-body counts on Marshallese persons other than the former Bikinians provided baseline body burden and urine radionuclide excretion rate data for comparison purposes.

During August and September 1979, Miltenberger, Lessard, Balsamo, Hunt and Dillingham of BNLSEP, Sherwin of Enertech Corporation, and Rademacher of St. Mary's College, participated in a field trip. They re-established the air sampling programs at Kwajalein, Rongelap and Utirik, continued the routine environmental monitoring program at Rongelap and Utirik and continued the whole-body counting programs formerly performed by BNL medical. At Utirik and Rongelap, Brown of DOE Pacific Area Support Office (PASO) restated a former BNL promise. He said that the electric generating windmill apparatus would be given to the people in working order following collection of air sampling data for one year. During this trip, 150 whole-body counts and 146 urine samples had been collected. In addition, the windmills were left generating electricity. Coconut, pandanus and breadfruit had been obtained from traditional selection sites. Brown of DOEPASO, Otterman of US Oceanography, and Miltenberger and Lessard of BNLSEP prepared sketches and plans for a new whole-body counting trailer. The new design incorporated two chair type counters. Their design maximized the use of available equipment and space, minimized the discomfort of the Marshallese and eliminated many of the previous trailer design deficiencies.

By August 1979, members of the RUDR program completed a draft of the diet and living pattern study. Also, results of the soil analyses for I-129 on samples collected during the 1950's indicated samples from recent times could be analyzed. In addition, soil samples from Likiep were submitted for analyses. Efforts were initiated to procure excised thyroid glands taken from the Marshallese who were resident on Rongelap and Utirik. These samples were to be analyzed for Tc-99 and I-129. The computer simulation of fallout data was expected to be completed by September. McInroy of Los Alamos Scientific Laboratory had begun analyses of Marshallese teeth samples for Pu, U, Th and Sr radionuclides.

A September 1979 visit to Rongelap and Utirik was performed by US Oceanography. They reported the wind-powered electrical generators were not working and according to the run time indicators, they had failed shortly after their repair in August. It was becoming apparent that to keep the wind-powered generators operational, routine maintenance by a trained individual equipped with spare parts and proper tools was required.

PUBLICATION: External Exposure Measurements at Bikini Atoll, N. A. Greenhouse, R. P. Miltenberger and E. T. Lessard, BNL #51003, January 1979.

PRESENTATIONS: 137 Cs Body Burdens at Bikini: To Move or Not to Move, N. A. Greenhouse, Presented at the Chemical Physics Section, Health and Safety Research Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee, January 1979.

The Anatomy, Physiology, and Radiobiology of The Gastrointestinal Tract, E.T. Lessard, Presented at the Twenty-Fourth Annual Meeting of the Health Physics Society, Philadelphia, Pennsylvania, July 1979.

FY 1980

Funding levels were \$351,000 operating and \$50,000 capital equipment for MIRSP. An operating budget of \$50,000 was provided for RUDR. Staffing levels were 3.8 man years scientific and professional and 2.2 man years technical support. Major equipment purchased was a computer based multi-channel pulse height analyzer to replace and upgrade the existing BNLSEP analytical laboratory equipment. By September 1980, Greenhouse, Cua and Knight had left the program and Miltenberger, Naidu and Lessard performed as primary staff with Lessard as program director.

During October 1979, Miltenberger and Lessard finalized plans for the new whole-body counting trailer with Dillingham, Otterman and Brown. Chair construction began at BNL. Enertech was informed in October of the failure of the wind-generators supplied and repaired by them. During the next few months, the whole-body counting chairs were built, disassembled, packed and forwarded to Kwajalein along with the new trailer. Naidu and Greenhouse, of BNLSEP and Pratt of BNL Medical prepared an educational program on the effects of fallout from nuclear tests for the inhabitants of Bikini, Enewetak, Rongelap and Utirik Atolls. This effort documented the original training presented to the Rongelapese and Utirikese by Naidu during 1977 and 1978.

In February 1980, a personnel monitoring field trip was undertaken to Japtan and Enewetak Islands, Enewetak Atoll and Ujelang Island, Ujelang Atoll to obtain baseline body-burden data on the Enewetak population prior to the repatriation of Enewetak Atoll in April 1980. Miltenberger, Levine and Greenhouse of BNLSEP and Manalastas, a Phillipine national and a fellow of the International Atomic Energy Agency performed whole-body counting and collected

urine samples from persons 5 years of age and older. At Ujelang, non-participants of the whole-body counting program were invited to provide urine samples. Approximately 400 urine samples were collected and are currently being spectrometrically analyzed for gamma emitters and radiochemically analyzed for Sr-90. Additionally, participants provided physical and demographic data.

As previously mentioned, whole-body counting was conducted with two independent chair counting systems in which a sodium iodide detector was positioned in front of a sitting person. This geometry allowed safe entry and egress with comparable sensitivity relative to the bed geometry used in prior field trips. Approximately 400 spectra were obtained in this way and analyzed for Cs-137 and K-40 using calibration standards which best matched the sex, height and weight of the individual. Additional analyses were performed to determine frequency distribution statistics for various age and sex groupings of the data. Quality assurance was obtained by duplicate whole-body counts and repetitive point-source standard counts.

During January and February 1980, Lessard undertook retrospective assessment of chronic external and internal dose equivalents to the residents of Rongelap and Utirik. The dose interval assessed was after they returned home following the BRAVO test and evacuation and prior to January 1, 1980. Lessard, Miltenberger and Greenhouse also completed the Sr-90 and Cs-137 dose equivalent-commitment estimates for former residents of Bikini Atoll. Additionally they determined dietary radioactivity intake for Cs-137 in the Bikini population and compiled whole-body counting results for the years 1974 to 1979. These Bikini related works were prepared as 3 primary scientific publications.

In January 1980, Naidu, Greenhouse, Craighead and Knight summarized information on diet and living patterns for the Marshallese. The data was derived from literature, from personnel observations through living with the Marshallese for periods extending from months to years, from answers to questionnaires and from direct participation in their activities. It was recognized at that time that the study needed to be extended in order to identify trends in local food consumption and living patterns.

During March 1980, at the request of McCraw of the Department of Energy's Division of Health and Environmental Research, Lessard and Miltenberger identified individual Bikinians who exceeded the recommended 500 mRem per year limit to the whole body and red bone marrow. They also explained the discontinuity which appeared in the Sr-90 estimated body burden between residence and post residence periods for Bikini adult females and Bikini youths. Additionally, they evaluated LLL's calculations relating body burden, dose equivalent and activity ingestion rate.

In March, Public Law 96-205 was enacted which authorized the Secretary of the Interior to provide for certain people medical care and treatment and environmental research and monitoring for any injury, illness or condition which may be the result directly or indirectly of the Pacific Nuclear Weapon Testing Program. The Secretary of Energy was authorized to assume all costs associated with the development and implementation of the program. Later that year, at the request of Robison of LLL, Lessard and Greenhouse related to him an outline of MIRSP and RUDR program history and costs. Robison would draw upon this information in order to set forth a general plan for the periodic comprehensive survey and analyses of the radiological status of the atolls,

the development of an updated radiation dose assessment and an estimate of the risks associated with the predicted human exposure.

In April, Greenhouse began to summarize external exposure rate data for the Micronesian islands outside of the Northern Marshalls. Much of this data was collected in collaboration with Nelson of UWLRE during 1975 and 1976.

During the summer months Kaplan, an undergraduate student from Yale University, and Lessard performed the initial analysis relating I-129 activity in soil to acute thyroid dose equivalents in persons on Rongelap and Utirik Atolls in March 1954. The analysis accounted for I-129 atom distribution with depth of soil and the kinetic relationships between the iodine isotopes, time post detonation and fission neutron energy. The dosimetry accounted for differences in uptake, excretion and retention of iodine as a function of age of the individual. Preliminary estimates of thyroid dose from the March 1, 1954 exposure were determined for Rongelap and Utirik residents.

During July and August 1980, whole-body counts and urine samples were obtained at Majuro Atoll and Kili Island by Greenhouse, Moorthy, Watts and Rivera of BNLSEP. Former Bikini Island residents and a comparison population contributed approximately 200 spectra and 100 urine samples. Fifty percent of the April 1978 population at Bikini were recounted. Consecutive measurements of a Bikini residents body burden post departure allowed for computation of individual long-term biological removal rate constants. This data was reviewed and written up by Miltenberger, Lessard and Greenhouse and submitted to a scientific journal.

In September, a meeting of RUDR was held between Bond, Borg, Conard, Cronkite, Hull, Lessard, Meinhold, Miltenberger and Naidu of BNL, and Sondhaus

of UCCM. The meeting centered on dose reassessment and was conducted in two parts aimed at reviewing past accomplishments and assigning future tasks. A review of the circumstances that led to the study was presented by Naidu who also discussed the status of the Sr and Pu in teeth samples. Lessard presented a draft of the chronic phase dose-equivalent estimates for Rongelap and Utirik residents and reviewed the acute phase dosimetric methods and dose-equivalent estimates based on the I-129 soil analysis. The second stage of the meeting led to detailed discussions on the chronic and acute dosimetry. The outcome was to define specific tasks in order to further substantiate the dose estimates to the thyroid.

During September, as part of the ongoing quality assurance program for MIRSP, an interlaboratory analysis for Sr-90 in urine samples from the Marshall Islands was initiated.

PUBLICATIONS:

Dosimetric Results for the Bikini Population, N.A. Greenhouse, R.P. Miltenberger and E.T. Lessard, Health Physics, Vol 38, pp. 846-851, May 1980.

Marshall Islands: A Study of Diet and Living Patterns, J. Naidu, N.A. Greenhouse, J. Knight, BNL#51313, July 1980.

Dietary Radioactivity Intake from Bioassay Data: A Model Applied to Cs-137 Intake By Bikini Island Residents, E.T. Lessard, R.P. Miltenberger, and N.A. Greenhouse, Health Physics Vol. 39, pp.177-183, August 1980.

Whole Body Counting Results from 1974 to 1979 for Bikini Island Residents, R.P. Miltenberger, N.A. Greenhouse and E.T. Lessard, Health Physics, Vol. 39, pp. 395-407, August 1980.

Co-60 and Cs-137 Long Term Biological Removal Rate Constants for the Marshallese Population, R.P. Miltenberger, E.T. Lessard and N.A. Greenhouse, Health Physics (In press).

PRESENTATIONS:

Rate Constants for Biological Elimination of Strontium and Cesium in the Marshallese Population, E.T. Lessard. Presented at the Twenty-Fifth Annual Bioassay Conference, Las Vegas, Nevada, October 31-November 2, 1979.

Body Burden Measurements as Determined from Whole-Body Counting and Urine Bioassay, E.T. Lessard, Presented at the Twenty-Fifth Annual Bioassay Conference, Las Vegas, Nevada, October 31-November 2, 1979.

Dosimetry Methods and Results for the Former Residents of Bikini Atoll, N.A. Greenhouse, Presented at the IRPA Congress, Manilla, Phillipines, November 5-9, 1979.

An Educational Program on the Effects of Fallout from Nuclear Tests for the Inhabitants of Bikini, Enewetak, Rongelap and Utirik (Marshall Islands), J. Naidu, Presented at the Thirteenth Midyear Symposium of the Health Physics Society, Honolulu, Hawaii, December 10-13, 1979.

Dose Assessment for Rongelap and Utirik Residents 1954 to Present, E.T. Lessard, Presented at the Twenty Fifth Annual Meeting of the Health Physics Society, Seattle, Washington, July 21-25, 1980.

FY 1981 (Progress to Date)

Funding levels were \$415,000 operating and \$5,000 capital equipment for MIRSP. In November, \$30,000 operating were withheld by DOE, thus reducing the MIRSP operating dollars to \$385,000. An operating budget of \$53,000 was directed to RUDR. Lessard, Miltenberger and Naidu form the primary staff.

During October Lessard completed the reconstruction of chronic dose equivalents for Rongelap and Utirik residents for the time interval 1954 to 1980. Retrospective and contemporary external exposure rate data, whole-body counting data, and radiochemical analysis of urine and blood data were reviewed. Dosimetric models which best described the uptake regime were constructed for the nuclides of interest. Daily activity ingestion rates, whole-body dose-equivalent rates and dose-equivalent commitments to various organs were determined. Population dosimetry results and methods were written up and reported in a BNL publication. Individual dosimetric records are maintained at the Laboratory.

At the request of McCraw (DOEDHER), Lessard and Miltenberger analyzed former Bikini and Rongelap personnel monitoring data in order to estimate Cs-137 body burdens for the population who may return to Enue Island, Bikini Atoll. This projection involved a determination of activity transfer factors calculated from Rongelap and Bikini whole-body counting data and from activity concentration analyses of coconut tree products. These factors were comparable for both atolls and dose-equivalent commitments were projected for adults.

In December, Naidu contacted Dr. Shinji Okano of Japan regarding analyses of the "Bikini Ash of Daigo-Fukuryumara". Lessard, Miltenberger and Moorthy outlined a radiochemical separation/neutron fission radioassay technique to be used on urine collected from Marshallese exposed to tropospheric weapons-test plutonium. Sondhaus (UCCM) visited Lessard to discuss his work related to acute phase dose reassessment for Rongelap and Utirik residents. Thiessen, the new Director of the Human Health and Assessments Division of the Department of Energy was appraised of the RUDR program's activities. Also in

December, Lessard, Naidu, Miltenberger, Baum and Olmer began preparations for site review scheduled for May 1981.

During October through March, Miltenberger, Lessard and Steimers of BNLSEP summarized the data regarding human milk samples which had been obtained from four lactating adult former Bikini females whose Cs-137 body burden had been defined by whole-body counting. Also, coconut tree sap and nuts were analyzed by gamma spectroscopy to determine the presence of Cs-137 and K-40. Results were used to estimate the Cs-137 body burden for Marshallese infants whose primary food supply was human milk and coconut tree products. Dose estimates for a hypothetical infant resident on Bikini Island during August 1977 to August 1978 were derived from the Cs-137 body burden estimate.

During January, Miltenberger and Roesler of BNLSEP and Bennett of BNL Medical conducted a personnel monitoring field trip to Enewetak Atoll and performed a health physics survey of the x-ray machine located aboard the Liktanur II. Analysis of the Enewetak results indicated Bi-207 in one person out of several hundred who were spectroscopically examined. Body burdens of Cs-137, noted in all individuals examined the year before, had declined during this first year in residence on Enewetak Atoll. The survey of the x-ray machine provided an estimate of the operator and patient dose equivalent.

During January and February, McCraw (DOEDHER) requested a review and response to questions posed by Johnson of the Micronesia Support committee regarding repatriation of Rongelap and Utirik Atolls. Additionally, McCraw requested a reanalysis of dose equivalent due to ingestion of coconut crab from the northern islands of Rongelap Atoll. Conard and Cronkite of BNL Medical

and Hull, Naidu, Miltenberger and Lessard of BNLSEP prepared the formal responses.

A whole-body counting protocol by Miltenberger and radiochemical analyses protocol by Olmer were prepared in March. A review of quality assurance data for the Marshall Islands was also prepared by Miltenberger, Naidu and Lessard. Brauer of BPNL and Naidu prepared radiochemical analysis and analytical procedures for determination of I-129 in soil. Lessard prepared a historical synopsis, a summary of MIRSP and RUDR highlights and a collection of publications and protocols.

PUBLICATIONS FY 81 to date:

Reconstruction of Chronic Dose Equivalents for Rongelap and Utirik Residents-1954 to 1980, E.T. Lessard, N.A. Greenhouse and R.P. Miltenberger, BNL #51257, October 1980.

Thyroid Absorbed Dose Assessment for Rongelap and Utirik Residents, E.T. Lessard, J.R. Naidu, R.P. Miltenberger, N.A. Greenhouse and L.V. Kaplan, BNL #28939, Draft.

Body Burden and Dose Assessment for Bikini Island Residents-1969 to 1980. Editors: R.P. Miltenberger and E.T. Lessard, Contributors: J. Balsamo, S. Cohn, E. Craighead, F. Cua, N.A. Greenhouse, A. Hunt, S. Johnson, A. Kuehner, E.T. Lessard, G. Levine, R.P. Miltenberger, A. Moorthy, J. Naidu, N. Rivera, J. Steimers and K. Watts, BNL Report, Draft.

Cs-137 in Human Milk and Dose Equivalent Assessment, R.P. Miltenberger, E.T. Lessard, J. Steimers, and N.A. Greenhouse, BNL Report, Draft.

Whole-Body Counting Operations Manual, R.P. Miltenberger, BNL Protocol, Draft.

Standard Procedure for Air Sampling, F. Cua, BNL Protocol, Draft.

Protocol for Radiochemical Analysis of Urine Teeth and Milk, Editor: L.L. Olmer, Contributors: D.M. Henze and J.R. Steimers, BNL Protocol, Draft.

An Evaluation of Physiological Parameters and Their Influence on Doses Calculated from Two Alternative Dosimetric Models for the Gastrointestinal Tract, E.T. Lessard and K.W. Skrable, Proceedings of the Third International Radiopharmaceutical Dosimetry Symposium, Oak Ridge, Tennessee, October 1980 (In Press).

An Intercomparison of Natural and Technologically Enhanced Background Radiation Levels in Micronesia, N.A. Greenhouse, and R.P. Miltenberger, LBL Report, Draft.

Review of Quality Assurance Data-Marshall Islands Radiological Safety Program, E.T. Lessard, R.P. Miltenberger, and J. Naidu, BNL Report, Draft.

I-129 Analysis of Marshall Islands Environmental Samples, Analytical and Quality Assurance Procedures, F.P. Brauer and J.R. Naidu, Draft.

PRESENTATIONS FY 81 to date:

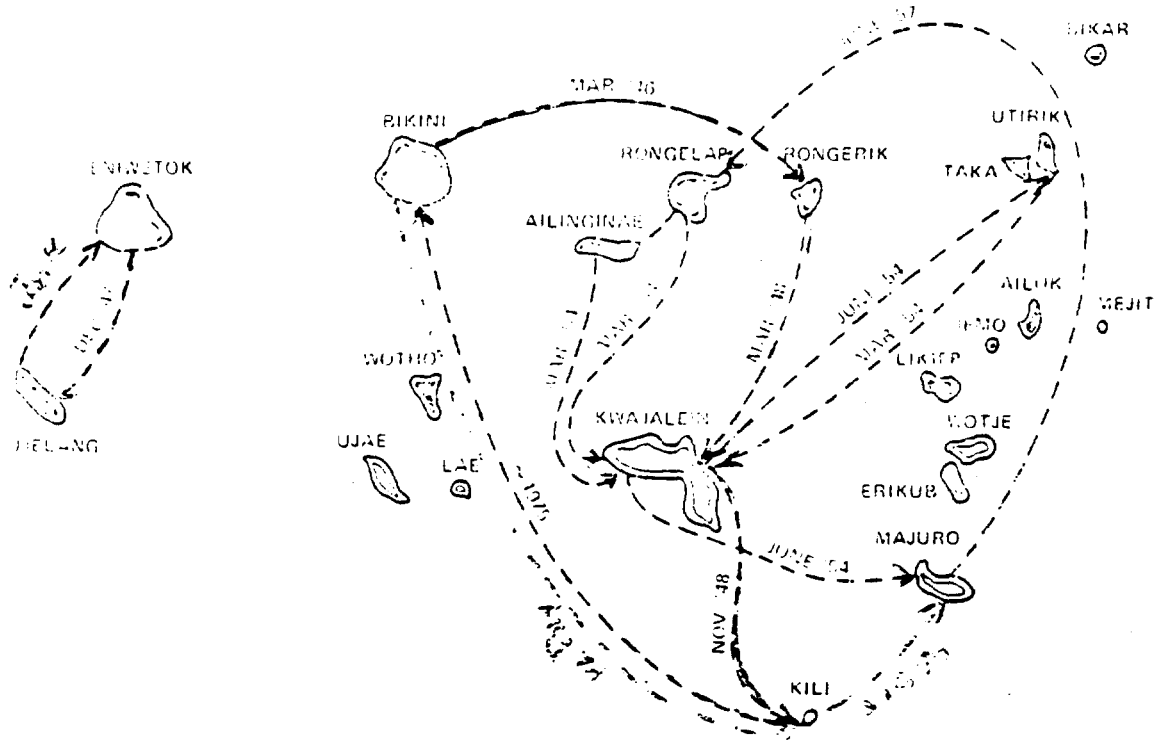
Cs-137 In Mother's Milk, R.P. Miltenberger. Presented at the 26th Annual Bioassay Conference, Ottawa, Canada, October 14-15, 1980.

An Evaluation of Physiological Parameters and Two Alternative Dosimetric Models for the Gastrointestinal Tract, E.T. Lessard. Presented at the Third International Radiopharmaceutical Dosimetry Symposium, Oak Ridge, Tennessee, October 6-10, 1980.

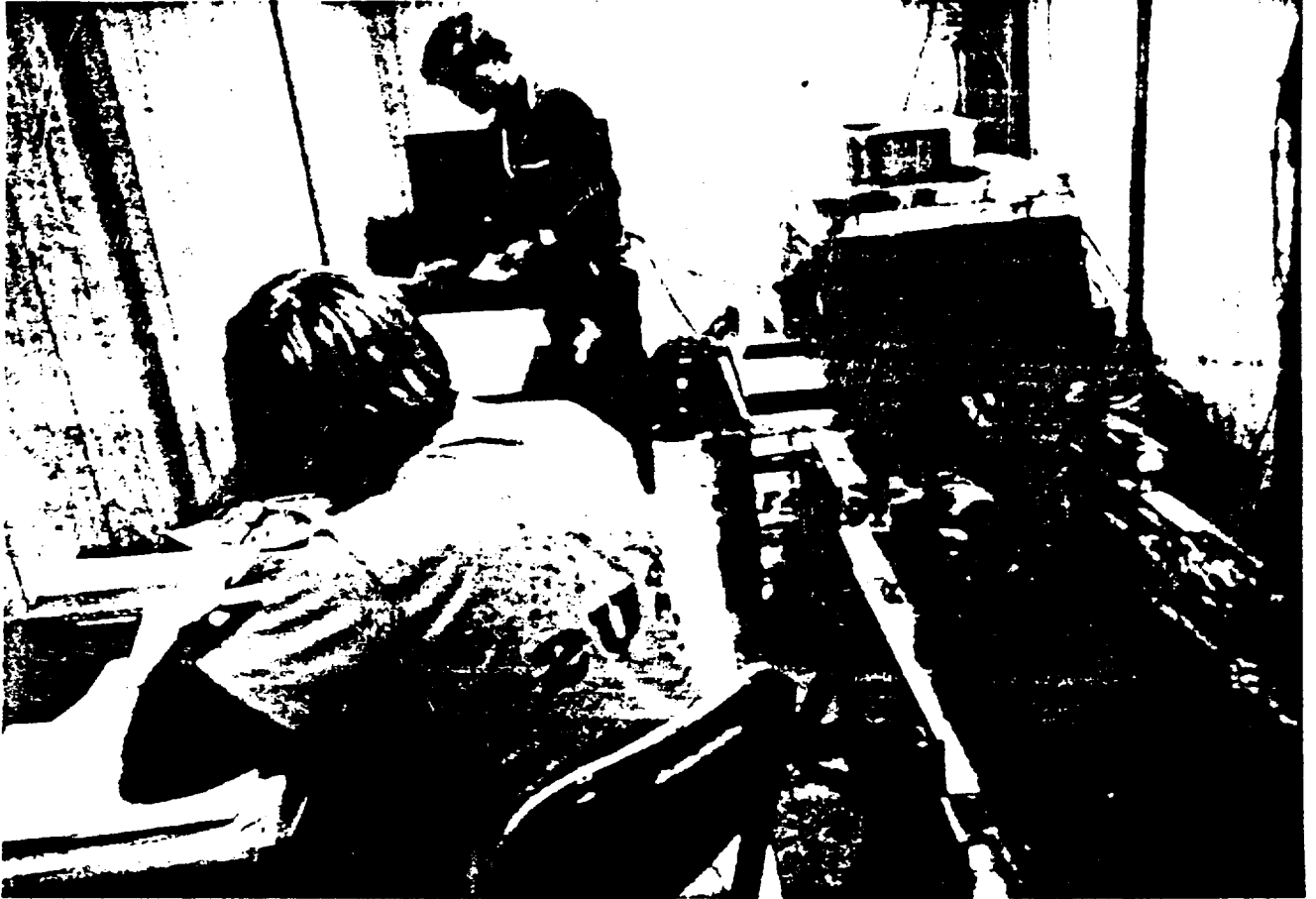
Expected Man Made Radionuclides to be
Encountered in the Marshall Islands

<u>Source</u>	<u>Nuclide</u>	<u>Origin</u>	<u>Source</u>	<u>Nuclide</u>	<u>Origin</u>
Soil	^3H	Unfused fuel	Animals	^3H	Unfused fuel
Soil	^{14}C	Activation	Animals	^{55}Fe	Activation
Soil	^{55}Fe	Activation	Animals	^{60}Co	Activation
Soil	^{60}Co	Activation	Animals	^{90}Sr	Fission
Soil	^{63}Ni	Activation	Animals	^{137}Cs	Fission
Soil	^{90}Sr	Fission	Animals	^{207}Bi	Activation
Soil	^{102}Rh	Activation	Animals	^{239}Pu	Unfissioned fuel
Soil	^{125}Sb	Fission	Animals	^{240}Pu	Unfissioned fuel
Soil	^{147}Pm	Fission	Fish	^3H	Unfused fuel
Soil	^{151}Sm	Fission	Fish	^{55}Fe	Activation
Soil	^{152}Eu	Activation	Fish	^{60}Co	Activation
Soil	^{154}Eu	Fission	Fish	^{90}Sr	Fission
Soil	^{155}Eu	Fission	Fish	^{137}Cs	Fission
Soil	^{207}Bi	Activation	Fish	^{207}Bi	Activation
Soil	^{235}U	Unfissioned fuel	Fish	^{239}Pu	Unfissioned fuel
Soil	^{238}U	Unfissioned fuel	Fish	^{240}Pu	Unfissioned fuel
Soil	^{238}Pu	Unfissioned fuel			
Soil	^{239}Pu	Unfissioned fuel			
Soil	^{240}Pu	Unfissioned fuel			
Soil	^{241}Am	Unfissioned fuel			
Plants	^3H	Unfused fuel			
Plants	^{60}Co	Activation			
Plants	^{90}Sr	Fission			
Plants	^{102}Rh	Activation			
Plants	^{137}Cs	Fission			
Plants	^{239}Pu	Unfissioned fuel			
Plants	^{240}Pu	Unfissioned fuel			

MOVEMENT OF PEOPLE PACIFIC TESTING



Movement of the Marshallese People
Following the Weapons Testing Programs
at Bikini and Enewetak Atoll



Bed Geometry Whole-Body Counting
at Bikini Atoll



External Radiation Measurements
at Bikini Atoll



Collection of Demographic, Anthropometric
and Physiologic Data and Selection of
Individuals for the Bioassay Programs



Whole-Body Counting in One of the
New Chair Geometry Systems. Two Independent
Systems are Used Throughout a Field Study