TECHNICAL REPORT

An investigation on the ^{137}Cs content of soil collected from the Boeing North America, Inc., Employees' Recreational and Fitness Center in Canoga Park (CA).

20 June 1997

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Title: An investigation on the ^{137}Cs content of soil collected from the Boeing North America, Inc., Employees' Recreational and Fitness Center in Canoga Park (CA).

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Mr. Steve Hall	—	Sample Preparation
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Summary of Findings

A series of 35 surface soil samples collected from 24 different sites around the Boeing North America, Inc., Employees' Recreational and Fitness Center in Canoga Park (CA) contained an average ^{137}Cs concentration of 3.7 ± 2.2 Becquerel per kilogram [Bq kg^{-1}] (dry weight) (or 0.10 ± 0.06 picocuries per gram [pCi g^{-1}]). The levels of ^{137}Cs observed in these soils samples are within the range of 'background' ^{137}Cs concentrations previously reported (see page 5, paragraph 1) over a much wider geographical area within Southern California and can be attributed to direct deposition of global fallout from atmospheric nuclear weapons testing. The total soil inventories are also consistent with estimates based on global fallout deposition in this region. In conclusion, there appears to be no evidence to suggest that soils within the Boeing North America, Inc., property in Canoga Park contain ^{137}Cs that can be directly attributable to local sources of contamination. It is also reasonable to assume that any adjacent soils located within several miles of the study site would contain similarly low 'background' levels of ^{137}Cs.

Site Description, Sample Collection and Analysis

The property under investigation is located at 34° 13'28.7 N, 118° 37'23.4 W in Canoga Park, California, and occupies an area of approximately 5.8 hectares (or 14.2 acres). An outline of the study site and sample site locations are shown in Fig. 1 (**Exhibit B**). The sampling strategy was

to obtain a sufficient number of samples to fully characterize the ^{137}Cs content of soil over the exposed (accessible) areas around the site. This was achieved by using a sample grid (130 x 130 ft) that was placed over a site map. A sample was then collected as near as possible to the center point of each grip reference point. This sampling collection technique yielded a total of 15 accessible sites and provided an unbiased approach to sample site selection. An additional 7 sites were selectively placed along the boundary of the property.

Soil samples from each sample site were collected using a stainless steel 'punch tube' that was hammered into the soil to the desired depth (nominally 10 or 20 cm). The entire contents of the tubes were then transferred into a clean plastic sample bag, and the bag sealed and labeled. Each sample of about 1-1.5 kg consisted of five composite subsamples (taken from the center and each corner of a 1 meter square). This sampling technique has been successfully used for environmental characterization in the Marshall Islands and is considered a standard methodology. On 11 sites a 10-20 cm soil horizon was collected in order to obtain supplementary information on the depth distribution of ^{137}Cs. Two additional surface soil samples (0-2 cm, RB23 & RB24) were collected from the playground and picnic area.

Sample Processing & Analysis

Soil samples were returned to the Lawrence Livermore Laboratory with the field sampling team. Each sample was oven dried at 110 °C, and the dried material homogenized and packed into 200 ml "tuna" cans for measurement by gamma-spectrometry. Each sample was counted on a Ge detector coupled to a DEC VAX Station operating under Canberra/Nuclear Data systems data acquisition and reduction software. ^{137}Cs was quantified using the gamma photon peak at 661 keV. Standards used for detector calibration are indirectly traceable to the National Institute of Standards and Technology. The gamma-spectrometry facility also runs a highly visible data quality control/quality assurance (QC/QA) program and participates in national and international intercomparison exercises on a regular basis.

Raw Data Tabulation

The results of the analysis of ^{137}Cs in soil samples collected from the Boeing North America, Inc., Employees' Recreational and Fitness Center in Canoga Park (CA) are shown in Table 1 (**Exhibit C**). The data has been presented both in units of Bq kg^{-1} and pCi g^{-1} on a dry weight basis.

Explanation of Data & Expert Opinion

The average ^{137}Cs concentration in the 35 surface soils collected over the site was 3.7 ± 2.2 Bq kg^{-1} (dry wt.) (or 0.10 ± 0.06 pCi g^{-1}) **(Table 2-Exhibit D).** Surface soil samples collected from 0-10 cm depth ranged in concentration between 0.6 and 10 Bq ^{137}Cs kg^{-1} (dry wt.) (0.016 to 0.27 pCi g^{-1}) with an average concentration of 4.6 ± 2.2 Bq kg^{-1} (or 0.12 ± 0.06 pCi g^{-1}). This compares with previously reported estimates for 'background' ^{137}Cs in soils over a similar depth interval of 0.13 ± 0.08 pCi g^{-1} (McLaren-Hart Multi-Media Sampling and Area IV Characterization Survey—**see Exhibit E**) carried out as part of a more extensive radiological survey within Southern California The remarkable consistency of these two totally independent sample collection and analysis datasets provides evidence that ^{137}Cs soil concentrations over the Boeing North America, Inc., property in Canoga Park do not contain ^{137}Cs that can be directly attributable to sources of contamination other than that expected from global fallout from atmospheric nuclear weapons testing.

The ^{137}Cs data obtained in this study can also be approximated by a well behaved log-normal distribution plot **(see Fig. 2, Exhibit F)** showing that the ^{137}Cs concentration data appears to be derived from the same population. It should be noted that this data is consistent with previous data **(Exhibit E)** which follow a very similar log-normal distribution for 'background' ^{137}Cs in soils from other parts of Southern California. The best fit to the normalized data provides a mean concentration of 3.04 Bq kg^{-1} (or 0.082 pCi g^{-1}).

Although the soil over much of the Boeing North America, Inc., property in Canoga Park appears to have been disturbed—as shown by the presence of detectable levels of ^{137}Cs in the deeper layer of soil below 10 cm—there is no evidence to suggest a local source of contamination. The presence of ^{137}Cs in the deeper soil horizons can be explained by physical mixing processes as it is well known that ^{137}Cs remains strongly bound to the soil particles.

The estimated average soil ^{137}Cs inventory (0-20 cm depth) measured over the study site is 0.82 ± 0.22 GBq km^{-2} (1 GBq = 1 x 10^9 Bq or 0.027 Ci) with a maximum of 0.98 GBq km^{-2}. The maximum ^{137}Cs soil inventory observed over the site is less than half the expected global fallout deposit for the region (~2.5 GBq km^{-2}, 30-40°N latitude band). The ^{137}Cs soil inventory data provides an accurate assessment of the total ^{137}Cs deposition over the site through time because it effectively removes the influence of physical disturbance of the soil on the ^{137}Cs distribution. For example, surface soils from undisturbed sites will tend to have higher concentrations of ^{137}Cs in the surface soil layers compared with disturbed sites where the ^{137}Cs is diluted by less contaminated material from deeper in the soil profile. In this sense—the inventory data is a more reliable estimate of the total ^{137}Cs deposit.

In summary, the sample collection and analysis did not reveal any evidence that ^{137}Cs present in these soils could have been derived from local contamination. Furthermore, the levels and ^{137}Cs soil inventories over the study site can be adequately explained by direct deposition of global

fallout through the period 1945-1997. This suggests that the data is derived from 'background' concentrations.

Acknowledgment: I thank Marshall Stuart, Henry Jones, Rusty Steele, Steve Hall and Steve Kehl for technical assistance and Ms. Rayla Bradsher for administrative and secretarial support. Work performed under the auspices of the US Department of Energy at Lawrence Livermore National Laboratory under contract W-7405-Eng-48.

Signed: T. F. Hamilton Date: 6/20/97

Dr. Terry Hamilton
Deputy Director, Marshall Islands Program

EXHIBIT A

Curriculum Vitea—Dr. Terry F.Hamilton

EXHIBIT A

CURRICULUM VITEA

TERRY F. HAMILTON

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BIRTH: Port Fairy, Australia, 10 December 1956.

FAMILY:
- Wife: Married (1980) Jan L. Warrnamboal (Australia)
- Children: Sarah (1981), Julie (1991), Luc (1994)

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EDUCATION:

Marine Chemistry Laboratory, Department of Chemistry, Ph.D.
University of Melbourne, Parkville, Vic. 3052 Australia (1983-87).
Special prizes/awards—AINSE student fellowship award (1983-86).

Thesis Title: Environmental Radioactivity: Sediment Chronology and Interactions.

B.Sc. (Hons). First Class Honors—Inorganic Chemistry
University of Melbourne, Parkville, Australia (1982).
Special Awards— Riseborough Prize in Analytical Chemistry and First Class Honors (1981).

Dip. App. Sci. Warrnambool Institute of Advanced Education (WIAE), Warrnambool, Vic. 3080 Australia (1976-78).

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PROFESSIONAL AFFILIATIONS

The Geochemical Society
The Oceanography Society
International Association of Geochemistry and Cosmochemistry
European Association for Geochemistry
Australian Marine Sciences Association (AMSA)

SPECIAL INTERESTS AND EXPERTISE

Radiochemistry and radiological assessments.
Marine Biogeochemistry—radionuclide and trace element fluxes and interactions.
The application of isotopic and nuclear techniques in environmental research.
U and Th decay series dating techniques and related applications.

RECENT APPOINTMENTS/RESEARCH EXPERIENCE

1995-present Deputy Director-Marshall Islands Program, Health & Ecological Assessments, Division, Lawrence Livermore National Laboratory Livermore CA, U.S.A.

My main duties include (1) to supervise operations within the Environmental Radioactivity Analysis (ERA) laboratory facilities used to support research programs in marine and terrestrial radioecology, dose evaluation and reconstruction; (2) to develop field/laboratory methodologies in order to improve technologies for assessing the levels, transfers and fluxes of radionuclides in the environment.; (3) to develop independent and cooperative research programs within the Division; (4) to aid with the analysis and interpretation of data used for integrated exposure/dose assessment and risk analysis and/or for evaluating remedial measures to reduce doses; (5) to develop and maintain a laboratory based data quality assurance program and oversee ERA laboratory participation in national and international intercomparison exercises; and (6) to present results of research studies (open literature, public sector, USDOE as well as other Government Agencies)

1988-95 Group Leader—Radiometrics Section, IAEA-Marine Environment Laboratory, Monaco.

Major duties included responsibility for supervising up to 7 technical and scientific staff engaged in various research, analytical quality control (AQCS) and training programs within the Radiometrics Group of IAEA-MEL in the United Nations. Other main duties included: technical implementation of the Agency's Technical Cooperation Programmes in Asia and the Pacific, management of the laboratories research and technical contracts program (approximately 30-35 contracts per year), and coordination of the radiochemistry work related to several multidisciplinary international research and monitoring projects, e.g., the assessment of radioactive waste dumping in the Arctic Seas, studies on the vertical flux of radionuclides and trace elements in the Mediterranean Sea (EROS-2000) and studies on the carbon assimilation capacity of the northern Adriatic Sea (ELNA). I have also been actively engaged in the formulation of research and funding proposals for several IAEA Coordinated Research Programmes (e.g. approved CRP's on the Black Sea and on Coral Reefs) and for the formulation of projects for support under the Agency's Division of Technical Cooperation. Other duties included evaluation and interpretation of scientific data, assessment of data quality, lecturing and demonstration at IAEA regional and inter-regional training courses, supervision of numerous Agency trainees (radionuclide methodologies, AQCS protocols, trace metal studies, field sampling techniques), preparation of scientific publications, preparation and editing of Agency documents/publications, organization of project coordination meetings, and representing the IAEA at scientific meetings and on numerous expert missions to Member State countries. I also served as Acting Head of the Radiometrics and MESL Sections of laboratory on many occasions.

1988 Awarded a BMR Post Doctoral Fellowship (Bureau of Mineral Resources, Canberra, Australia). Host Institution-Flinders University of South Australia, Adelaide, Australia.

1987 Research Assistant (part time), University of Melbourne. Duties related to analysis and dating of speleothems by U-Th decay series methods.

1981-82 Technical Assistant (part time), Victorian Institute of Marine Science (VIMS), Parliament Place, Melbourne. Contract post held over a two year period. Main duties involved field sampling and maintenance of oceanographic sampling equipment.

1980-81 Research Assistant, Marine Chemistry Laboratory, University of Melbourne. Main activities included the measurement of Po-210

and Pb-210 in marine organisms, studies on the distribution of phosphate and arsenic in Bass Strait waters and of trace elements in the marine environment.

1979-80 Technical Officer. Marine Chemistry Unit, Ministry for Conservation, Melbourne. Engaged in various research and monitoring programmes in SE Australian waters.

1979 Technical Officer, Environment Protection Authority, Ministry for Conservation, Melbourne. Air Quality Division. Duties relating to licensing of discharges to air.

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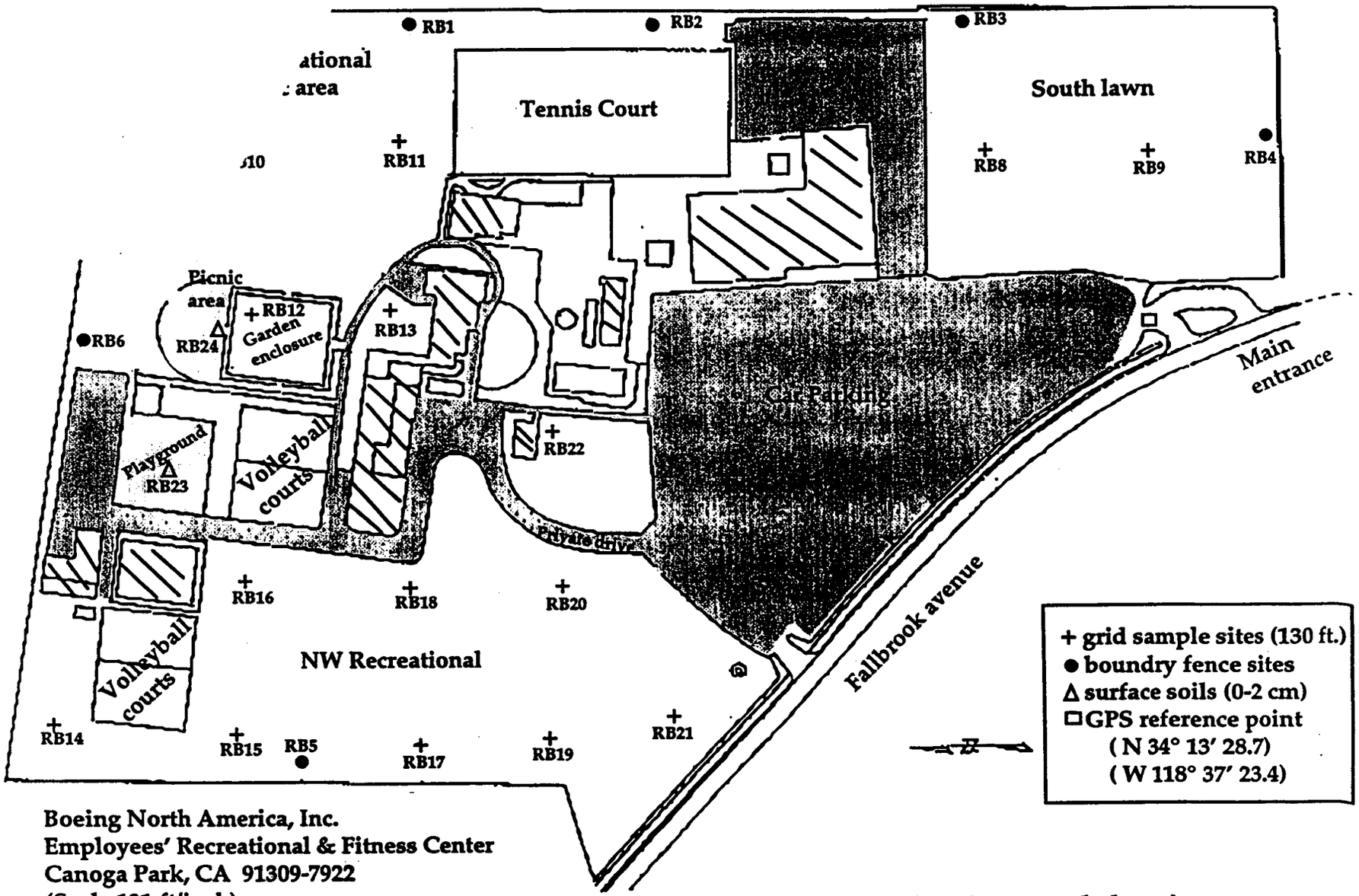
6/20/97

EXHIBIT B

Figure 1. Site map showing sample locations.

EXHIBIT B



Boeing North America, Inc.
Employees' Recreational & Fitness Center
Canoga Park, CA 91309-7922
(Scale 131 ft/inch)

Figure 1. Site map showing sample locations.

EXHIBIT C

Table 1. ^{137}Cs in soil from the Boeing North America, Inc. employees' recreational and fitness center, Canoga Park (June 1997).

EXHIBIT C

Table 1: ^{137}Cs in soil from the Boeing North America, Inc. employees' recreational and fitness center, Canoga Park (June 1997).

Sample ID & map ref.	^{137}Cs Bq/kg (dry wt.)[a]	^{137}Cs pCi/g (dry wt.)[a]	Location Notes
RB97-01A	2.8 ± 0.3	0.076 ± 0.007	Soil, 0-10 cm, east fence line, north side
RB97-01B	2.8 ± 0.4	0.075 ± 0.010	Soil, 10-20 cm, east fence line, north side
RB97-02A	5.6 ± 0.3	0.15 ± 0.009	Soil, 0-10 cm, east fence line, central
RB97-02B	1.8 ± 0.3	0.049 ± 0.007	Soil, 10-20 cm, east fence line, central
RB97-03A	4.7 ± 0.6	0.13 ± 0.016	Soil, 0-10 cm, east fence line, south side
RB97-03B	2.0 ± 0.5	0.05 ± 0.012	Soil, 10-20 cm, east fence line, south side
RB97-04	4.3 ± 0.4	0.12 ± 0.012	Soil, 0-10 cm, south fence line
RB97-05A	4.8 ± 0.3	0.13 ± 0.008	Soil, 0-10 cm, N-W fence line, off slope
RB97-05B	1.2 ± 0.3	0.03 ± 0.008	Soil, 10-20 cm, N-W fence line, off slope
RB97-06	1.3 ± 0.2	0.034 ± 0.006	Soil, 0-10 cm, N fence line, central
RB97-07A	0.61 ± 0.2	0.016 ± 0.005	Soil, 0-10 cm, N fence line, east side
RB97-07B	1.4 ± 0.4	0.037 ± 0.009	Soil, 10-20 cm, N fence line, east side
RB97-08	6.2 ± 0.7	0.17 ± 0.019	Soil, 0-10 cm, south lawn area
RB97-09A	4.0 ± 0.5	0.11 ± 0.014	Soil, 0-10 cm, south lawn area
RB97-09B	3.5 ± 0.4	0.094 ± 0.009	Soil, 10-20 cm, south lawn area
RB97-10A	5.8 ± 0.5	0.16 ± 0.012	Soil, 0-10 cm, N-E recreational & picnic area
RB97-10B	2.5 ± 0.2	0.069 ± 0.006	Soil, 10-20 cm, N-E recreational & picnic area
RB97-11	2.9 ± 0.3	0.079 ±0.007	Soil, 0-10 cm, N-E recreational & picnic area
RB97-12A	6.2 ± 0.3	0.17 ± 0.007	Soil, 0-10 cm, garden enclosure, off picnic area
RB97-12B	2.2 ± 0.3	0.060 ± 0.007	Soil, 10-20 cm, garden enclosure, off picnic area
RB97-13	10.0 ± 0.8	0.27 ± 0.022	Soil, 0-10 cm, lawn off sideway from N-E buildings
RB97-14	2.29 ± 0.33	0.06 ± 0.009	Soil, 0-10 cm, hillside off volleyball court
RB97-15A	3.7 ± 0.4	0.10 ± 0.01	Soil, 0-10 cm, N-W recreational lawns
RB97-15B	3.4 ± 0.2	0.09 ± 0.006	Soil, 10-20 cm, N-W recreational lawns
RB97-16	4.8 ± 0.4	0.13 ± 0.01	Soil, 0-10 cm, N-W recreational lawn area
RB97-17	7.9 ± 0.4	0.21 ± 0.01	Soil, 0-10 cm, N-W recreational lawn area
RB97-18A	4.6 ± 0.3	0.12 ± 0.008	Soil, 0-10 cm, N-W recreational lawn area
RB97-18B	3.2 ± 0.3	0.085 ± 0.007	Soil, 10-20 cm, N-W recreational lawn area
RB97-19A	6.3 ± 0.6	0.17 ± 0.015	Soil, 0-10 cm, N-W recreational lawn area
RB97-19B	1.8 ± 0.3	0.05 ± 0.007	Soil, 10-20 cm, N-W recreational lawn area
RB97-20	4.5 ± 0.4	0.12 ± 0.010	Soil, 0-10 cm, N-W recreational lawn area
RB97-21	1.9 ± 0.3	0.05 ± 0.008	Soil, 0-10 cm, N-W recreational lawn area
RB97-22	6.4 ± 0.4	0.17 ± 0.01	Soil, 0-10 cm, lawn-west of swimming pool
RB97-23	0.96 ± 0.22	0.026 ± 0.006	Soil, surface sample only, childrens playground
RB97-24	0.82 ± 0.22	0.022 ± 0.006	Soil, surface sample only, picnic area

[a] Uncertainties are based on counting errors.

Dr. Terry Hamilton
Deputy Director (Acting)-Marshall Islands Program

EXHIBIT D

Table 2. Summary of ^{137}Cs data in surface soils (Boeing North America, Inc) (June 1997).

EXHIBIT D

Table 2. Summary of ^{137}Cs data in surface soils (Boeing North America, Inc.) (June 1997).

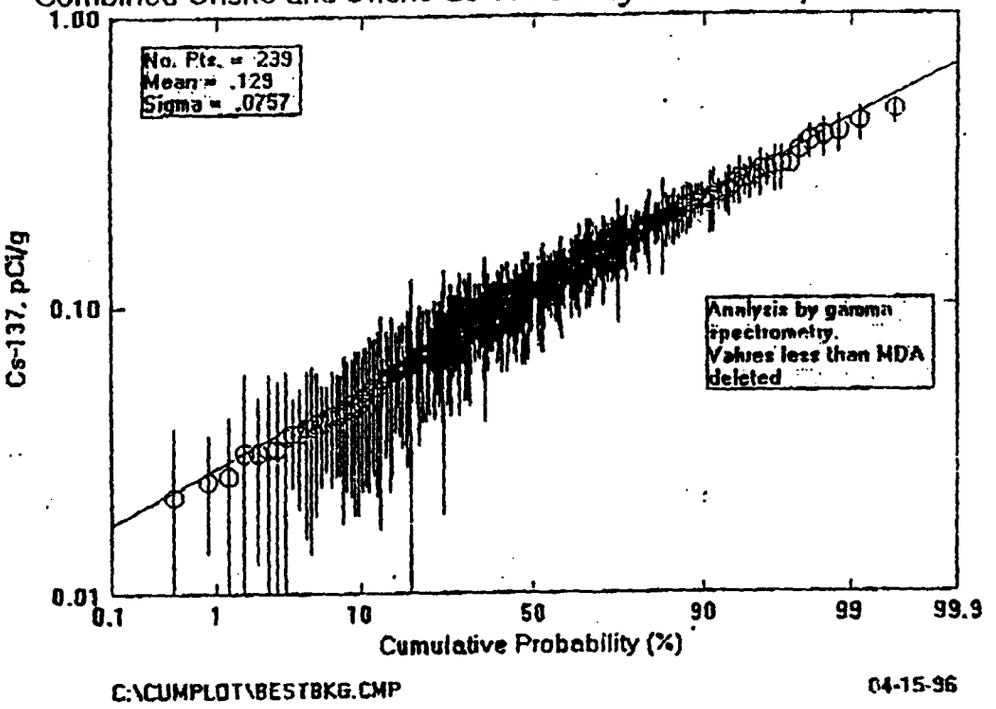
Quantity	Units	Range	Mean	Standard deviation	5th to 95th percentile
concentration (N=35)	Bq kg^{-1}, dry ($pCi\ g^{-1}$, dry)	0.6-10 (0.016-0.27)	3.7 (0.10)	2.2 (0.058)	<0.0-8.0 (<0.00-0.22)
Inventory (n=11)	GBq km^{-2} (Ci km-2)	0.24-0.98 (0.0064-0.027)	0.82 (0.022)	0.22 (0.0058)	0.39-1.25 (0.01-0.034)

EXHIBIT E

Characterization Survey from Rockwell

EXHIBIT E

Combined Onsite and Offsite Cs-137 Background Activity in Surface Soil



Combined Onsite and Offsite Cs-137 Background Activity in Surface Soil

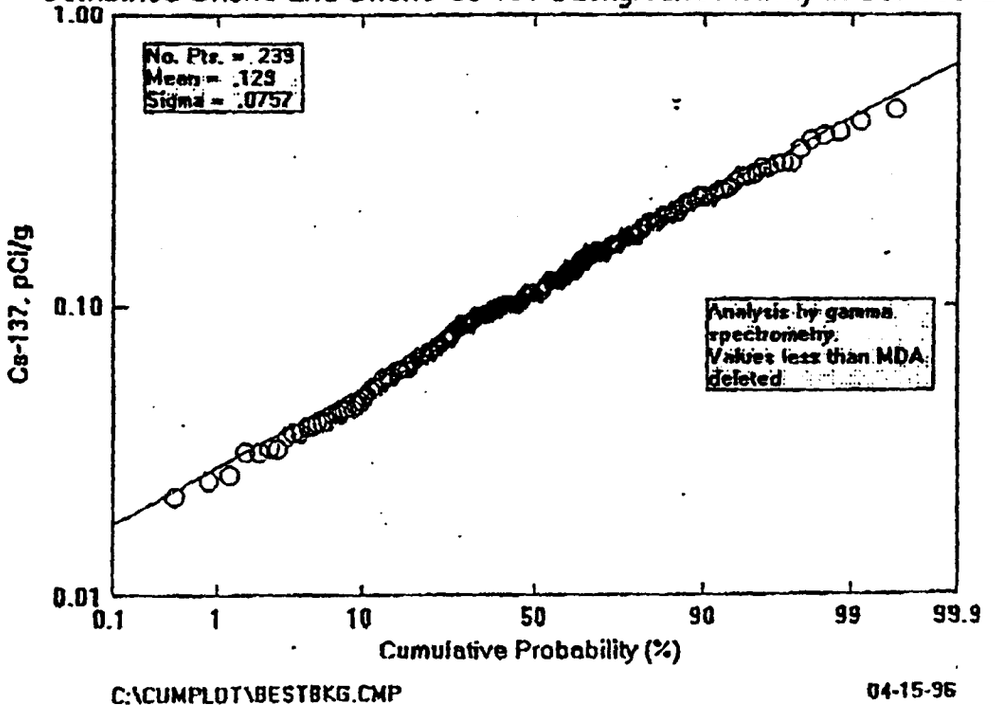
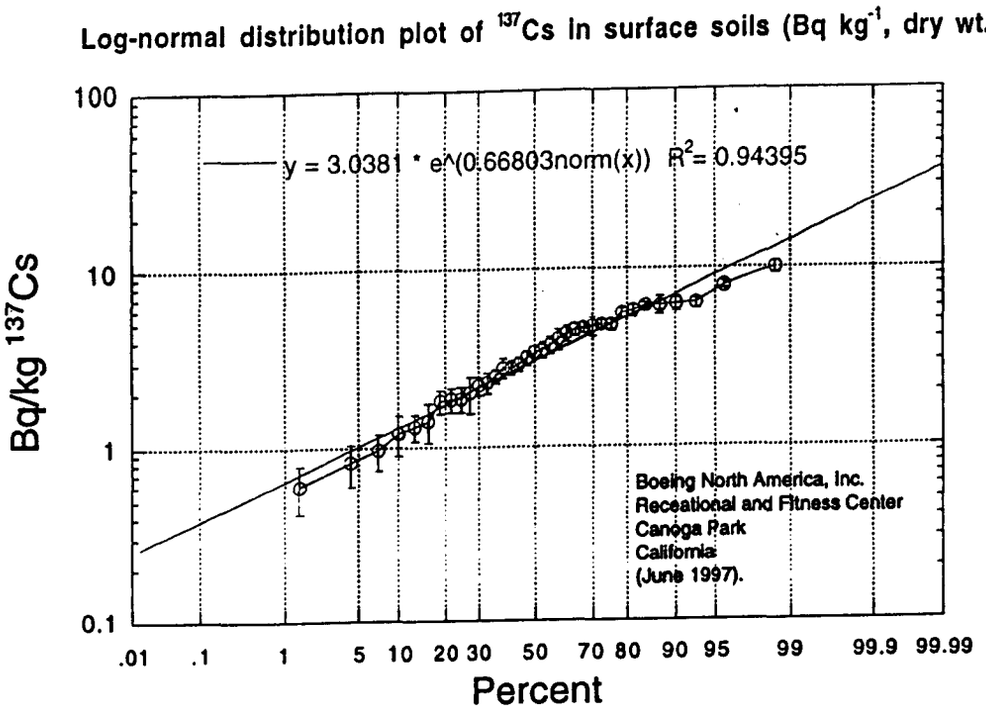


EXHIBIT F

Figure 2. Log-normal distribution of ^{137}Cs in surface soil samples collected from the study site (June 1997).

EXHIBIT F



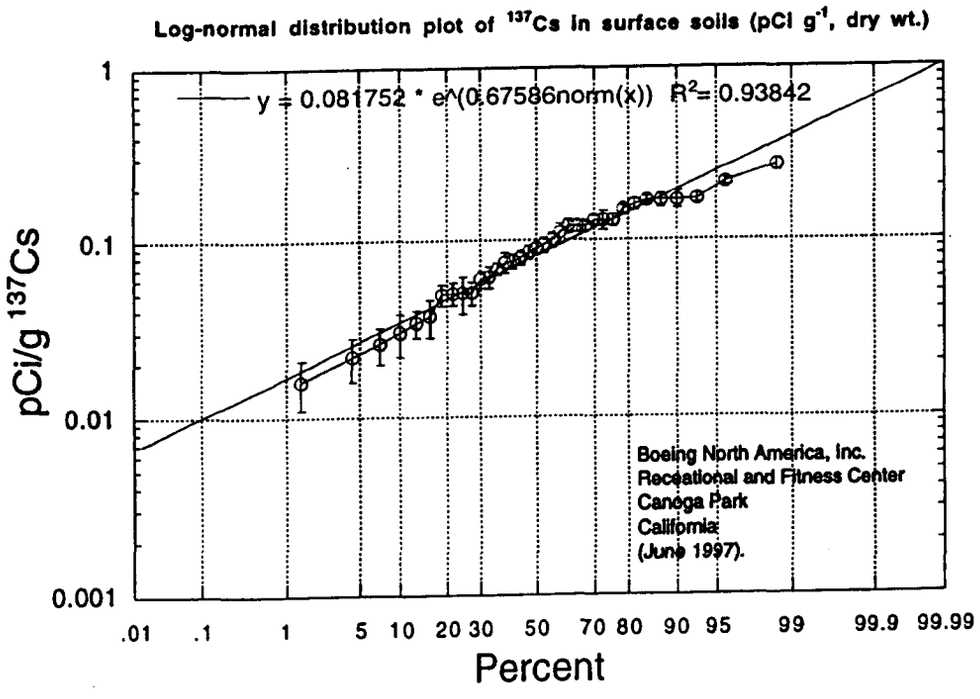


Figure 2. Log-normal distribution of ^{137}Cs in surface soil samples collected from the study site (June 1997).

RULE 26(a)(2)(B) REPORT OF TERRY F. HAMILTON

QUALIFICATIONS

I am a Senior Scientist/Principal Investigator and Acting Deputy Director of Marshall Islands Dose Assessment and Radioecology Program for the Health & Ecological Assessments Division of Lawrence Livermore National Laboratory. I have a Ph.D. in Inorganic Chemistry. Before joining the Lawrence Livermore National Laboratory in November 1995 I served with the United Nations for a period of 7 years as a Group Leader within the International Atomic Energy Agency (IAEA). During this time I served as an IAEA expert on missions to Australia, Bangladesh, Pakistan, India, China, Vietnam, Thailand, Sri-Lanka, Singapore, Malaysia, and Indonesia. I also served as the international observer and adviser on the first joint Norwegian-Russian scientific expedition (1992) to the Arctic to investigate the radiological consequences of dumping of nuclear wastes in the Kara Sea. In July 1996, I was again selected by IAEA to serve as an expert on a study on the radiological conditions on Mururoa and Fangataufa Atolls in the South Pacific.

A copy of my curriculum vitae is set out at Exhibit A of the attachment.

OPINIONS AND BASES THEREFOR

I was the principal investigator engaged in the collection and radiometric analysis of soil samples from the Boeing North America, Inc., Employees' Recreational and Fitness Center in Canoga Park (CA) (June 1997) under auspices of the U.S. Department of Energy, Oakland Operations Office.

This investigation involved a comprehensive study on the cesium-137 (^{137}Cs) content of soils around the property. Soil samples were returned to the Lawrence Livermore National Laboratory where they were dried, homogenized and analyzed for ^{137}Cs using standard sample preparation and radiometric counting techniques. At no stage was the integrity of the samples compromised and the number of samples collected (N=35) was more than adequate to fully characterize the ^{137}Cs content of soil around the site. It is my opinion that this work provides a sound scientific basis for assessing whether or not local contamination could have contributed to a detectable increase in the concentration of ^{137}Cs in adjacent soils above that expected from global fallout deposition.

In my opinion, the sample collection and analysis did not reveal any evidence that ^{137}Cs present in these soils could have been due to local contamination. Accordingly, there is no scientific basis for claiming that ^{137}Cs present in soil around this site can be directly attributable to inputs from Santa Susana. Furthermore, the levels and inventories of ^{137}Cs in soil over the study site can be adequately explained by direct deposition of global fallout through the period 1945-1997. I also believe it is reasonable to assume that adjacent soils located within several miles of the study site would contain similar 'background' levels of ^{137}Cs.

DATA AND OTHER INFORMATION CONSIDERED IN FORMING OPINIONS

Accompanying this statement are copies of my technical report on the ^{137}Cs content of soils collected from the Boeing North America, Inc., Employees' Recreational and Fitness Center in Canoga Park (CA) in June 1997. My opinions are set forth in this report and are based on data collected and materials referred to in the report, my extensive knowledge and experience in this field, and my visit to the site.

EXHIBITS TO BE USED IN SUPPORT OF OPINIONS

I intend to use the Technical Report attached hereto and the exhibits thereto. I may also use additional documents and displays to summarize or support my opinions.

COMPENSATION

The cost of preparing this report has not been fully computed but is anticipated to be approximately Eighteen Thousand Dollars ($18,000). My compensation, including overhead, is $130.50 dollars per hour.

EXPERT DEPOSITION AND TRIAL TESTIMONY IN LAST FOUR YEARS

I have not testified as an expert at trial or by deposition.

DATED: June 20, 1997

T. F. Hamilton

Dr. Terry F. Hamilton