

# CEER-X-115

r

CEER-x-115,

RADIOLOGICAL SURVEY REPORT

for

EL VERDE RESEARCH STATION

CENTER FOR ENERGY AND ENVIRONMENT RESEARCH

HEALTH AND SAFETY DIVISION

November, 1961

Revised May, 1983,

CENTER FOR ENERGY AND ENVIRONMENT RESEARCH

---Page Break---

RADIOLOGICAL SURVEY REPORT

for

EL VERDE RESEARCH STATION

CENTER FOR ENERGY AND ENVIRONMENT RESEARCH

HEALTH AND SAFETY DIVISION

November, 1981

Revised May, 1983,

---Page Break---

RADIOLOGICAL SURVEY REPORT

for

EL VERDE RESEARCH STATION

CENTER FOR ENERGY AND ENVIRONMENT RESEARCH

HEALTH AND SAFETY DIVISION

Prepared by:

November, 1981

oe

Revised: May, 1983

Keonts tage i

---Page Break---

?ASL: OF conreNTS

CERTIFICATION

BMT ly

INTRODUCTION Se

NISTORICAL BACKGROMND ©. tea

SOMARY OF THE RADTOLOGICAL SURVEY 2... g

RESULTS OF TUF RADIOLOGICAL SURVEY BEFORE DECONTAMINATION . 10

STROMENTS USED. eee ee sR

DECONTAMINATION, PRESENT STATUS AXD CONCLUSIONS . . on

TEPERNCES betes 6

APO T bette e eee

APEX bee eeeeeeee

MPMI ee

MPM TE eee

## AePENDIX IV

---Page Break---

10,

13.

Me

om

16.

Hap of Puerto Rico Showing the Location

Verde i esearch area.

f Luquitlo Forest and £1

soproni: ute sousery ef Lue 150 Acres Under Hi ~ Forest

Service arresnact

eseareh ares

yes imate Location

Lsboratory Area, FI Verde Fesearch Station,

Detesl of Old Laboratory efling, Ares 4. Nusbers Indicate

Survey Points. Se Aypundix 1A for Resulie,

betati of old Lat

survey Pos

Sory Hlding, ares 5. Numbers Indicate

See Appendix 1A for results

Detail of Olé Labor -tory Euilding, Area ç and Shops. tunbers

Indicote Surves roiut., Se Appendix 1d fer Reavbees

Approxtnate Lee:

used.

on of the Six Areas where Kediotracers vere

Radiation Levels, Expresved in uR/hr, in the Laboratory Ar

Radiation Levels snd Sampling Locations in Area 2.

See Appendix 1 for Kesulte of Sacples Analyzed.

Radiation Levels and Sazpling Locations in Area 3.

See appendix 1 for Results of Samples Analyzed.

Radiation Levels and Sampling Locations in Area 4.

See Appendix 1 for Results of Samples Analyzed,

Radiation Levels and Sampling

See Appendix 1 for Results of

Radiation Levels and Sampling

See Appendix 1 for Results of Samples Analyzed.

Radiation Levels and Sampling Locations in Area

See Appendix I for Results of Samples Analyzed.

Radiation Levels After Decontamination of Area 8.

Radiation Levels, at the Present Time, in Area 4,

---Page Break---

CERTIFICATION

We 4s hereby certified that the areas described in this report do

"ek Neprssene a radiation hazard to the public nor to any person working

in £1 Verde Research Station.

(appendix 1)

Mead, Health and Safety division

Fry

---Page Break---

2SSTRACT

The Kadielezies?

ood the Decontamination, ax indzeated



has been completed.

4 were found contaminated, All contamination was

removed from areas @ and S. Figures 12, 14 and 15.

The contamination in orca & (Figure 16) was identified as Cs-137

was removed from cow @ radiation level of 200 uR/hr. Even though

for. isvel does not constitute @ hazard for the public or

to

& ares. cecess co it hes b:

controllec ty a

propicte

ns. On December 196; au

Yen requested for tie use of Cen137 ané Tritium in the forest. The

Nuclear Regulatory Cossission granted to CEER-UPR license No. \$2-1934-02

fon March 1982,

?The contaminated soll that was renoved from are:

3, 5 and 4 ws

packed in DOT approved containers and was shipped to a low level waste

disposal site in Osk Ridge, Tennessee on September 1982.

w

---Page Break---

clear Center was developed during the early

Ship of the Atomic Energy Commission with the

main goal of developing a comprehensive program for research and

ning dr nucleer plication: of

uelear energy in edseine, agricul:

re and anévetry.

AS part of the projects developed in order to achieve this goal,

the Terrestrial Ecology Pivision uss started in 1963, In 1964 a

Renorandun of egreenent vas rigned betueen the Atoric Energy Conzision

and the Forest Service, 'S ips

ent of Agriculture, separating 156

acres in the Luguille Experimenta: Forest, 4... 5) Verde Rain Forest,

for conducting detailed ecological studies, Figures 1 and 2

The main study area is located on the northwestern slope of the Bountain and the research station is built on the site of a former coffee plantation. Several study areas were developed just up the

Bountain and to the east across the Sonadora River. (9). Access to the

area is controlled by means of a hog wire fence, 8 ft high, The

Presence of patrol dogs also aids in the security of the area.

From 1964 on, large amount of research projects were made in the

Verde, Vegetation was quantified and identified, pollen was analyzed, a

detailed study of the climate was made, soil was studied and many other

aspects of the Rain Forest were thoroughly studied. (11)

Radio tracers were used, besides other techniques, during the study

Of mineral cycling and forest netabelisn.

In 1976 the goals and objectives of PRNC changed, FANC became the  
Center for Energy and Environment Research and the AEC-ORO (then ERDA

and now the Department of Energy) concurred on transferring CEER

---Page Break---

fa

ities to the University of Puerto Rico and terminating the agree-  
ment with the Forest Service, CEER/UPR will continue to use this  
Festarch area under @ use permit from the Forest Service.

In the process, 9 radiologicet survey vas planned and has been done

during the lost three years. The area under CEER's responsibility vas

thoroughly surveyed using portable survey seters, Instrumentation used  
for this survey 4s Listed on page 12. During this walk-through survey,

some soil plots were found fenced and marked with radiation safety signs. These areas or plots were surveyed in more detail and samples

were taken and analyzed for gross beta:

gamma and alpha contamination.

Also spectrometric analysis was done to representative samples of each

of these areas, Except for three of these plots, no other are

found with contamination or radiation levels higher than background.

This Report summarizes the activities carried out during the

radiological survey and documents the results.

---Page Break---

Terrestrial Ecosystem Program was initiated on April 1963. A

month later, the work at El Verde Rain Forest started with three major

8 Follows:

objectives

1. To determine the effects of gamma radiation from a 10,000 Ci

+ Sealed source, on a plot of lowland rain forest

2. To measure the cycles of fallout elements in the rain forest

3. To determine the circuits of energy flow and metabolic

Processes of the ecosystem in order to understand the phenomena



observed, (8).

b

In the first year of work at El Verde, all efforts were directed towards the study of the general conditions before gamma irradiation,

There is no record of major tracer studies during 1963 except in August when three trees were tagged by injecting 1 mCi of  $^{32}\text{P}$ -phosphoric acid into each of the tree stems. (9)

On September 16, 1966 an agreement was reached and « memorandum of understanding between the Atomic Energy Commission and the Forest Service, United States Department of Agriculture was signed in order to separate 156 acres of the El Verde Rain Forest for conducting detailed ecological studies of the effects of gamma radiation, ( $^{137}\text{Cs}$ ), upon tropical forests.

Figures 1 and 1-A show the location and details of the area included

in the Agreement,

---Page Break---

A preliminary irradiation with a  $^{60}\text{Co}$  sealed source, was

carried out on August 1964 to help predict the attenuation of gamma

DI,

Hotion in the forest and to verify the hazards report for the  $^{60}\text{Co}$

sealed source,

0,000 Ch cease

The scaled 0

es was installed on top of a

small ridge in the Rain Forest on December 7, 1964. The area was

exposed to gamma radiation for the period between January 19, 1965 to

April 27, 1965, 16 was removed and shipped to USA during July 1966.

This source had no record of leakage and therefore did not constitute a potential source of contamination to any area in the forest. (10).

It must be mentioned, though, that during the arrangements made for this irradiation project, El Verde site was fenced at radii of 80 m, 160 m and 500 m from the radiation center. These fences have been used as reference points during the radiological survey being reported at present. See Figure 2.

When the irradiation was completed and the immediate post irradiation effects were under study, plans were developed for studying mineral cycling, cycles of fallout elements and metabolic processes.

Among other methods, radioactive tracers were used in numerous experi-

ments during this period of time.

In January 1966 tracer experiments involving the use of Strontium-85, Cesium-134 and Manganese-54 were initiated. These experiments were carried out throughout the whole year and ended in December 1966, "The objective of the experiment was to determine whether these nuclides could be transferred from litter to soil to roots

of understory plants, and, if so, at what rates.

---Page Break---

Four plots were established within a fenced enclosure on a gently sloping ridge top within E] Verde contract area. These plots, which

ranged from 1 to 1.5 ha, were encircled with corrugated

galvanized steel edging to a depth of 3 inches, and roots

at this depth

to prevent export of nutrients to trees outside of the plots.

© plots were stripped of s11 litter and two were left intact

Prior to the application of nuclides. On January 6, 1966, approximately

5

uncisa? of each cs, sr and hin were applied to the plots, in the

form of = spray from a hand-pumped garden sprayer. 411 plants within

the Pots, at this time, were covered with plastic bags and aluminum

{ed to prevent contamination when sprayed." (3)(2)(10)

Purchase order records indicate that on May 1966, the Terrestrial

Ecology Project bought 1 Curie of Tritium to be used in future experiments

within the Rain Forest.

D

ing February 1967, twenty microcuries of Tritium were diluted to  
1 Liter of water and the mixture was applied to the surface of a 0.94 m<sup>2</sup>  
soil plot. (5).

Lae

on August 3, 1967, three trees

trunks were tagged by

spraying each with 1  $\mu\text{Ci}$  of carrier free Zn solution. This study was

designed to evaluate the utilization by the snail *Ca*

*olus caracola*, of

lower plants growing on the tree trunks. (5)

On August 10, 1957, 1  $\mu\text{Ci}$  of <sup>45</sup>Sr and 0.8  $\mu\text{Ci}$  of <sup>137</sup>Cs were applied

in 2,500 ml of water and evenly applied to a small plot of soil. (5)

Teitiua

repeatedly used during 1968 and 1969, Five more

experiments using this radiotracer were planned and carried out.

---Page Break---

One of the experiments consisted on injecting three trees with

different amounts of  $^{14}\text{C}$  and  $^{3}\text{H}$

Large *Dacryodes excelsa* 20 trees

*Sloanea berteriana* 6 trees

3. Small *Recrvades excelsa* 1 tree

Another experiment, done during May 1958, consisted of evenly

spying four liters of water containing 50  $\mu\text{Ci}$  of tritium to a 3.7  $\mu\text{Ci}$  of  
soil plot.

Two more experiments involving the use of tritium were reported in

June 1969, but there is no record of the amount of the isotope used. (1)

Experiments us

$^{137}\text{Cs}$ ,  $^{90}\text{Sr}$

$^{55}\text{Mn}$

continued, In September 18, 1968 4 trees of the species:



sha

doninguensis was injected with 0.46 mci of  $^{27}\text{Ca}$  and a *Dscryodes excelsa*

was injected with 0.19 mci of  $^{45}\text{Ca}$ , 0.34 mci of Mn and 17.69 mci of  $^{32}\text{P}$ .

Also during 1968 another experiment using tritiated water was

reported but the amounts of the radioisotope are not mentioned.

The next reference to the use of radioisotopes was reported in June

1968, p. 73, 65,

1970, In this report,  $^{45}\text{Ca}$  and  $^{32}\text{P}$  are mentioned as the

radioisotopes used to study nutrient pathways and depth of nutrient uptake. This experiment apparently was carried out in plastic trays in

the Laboratory. (11).

Another reference to the tagging of trees using  $^{22}\text{P}$  does not specify the date of the experiment but it is mentioned that a Ci of the

isotope was used

and *Dacryodes*

used for injecting two trees of species *Sloanea berteriana*

*icelsa*, Reference to this study is made in "A Tropical

---Page Break---

Sain Forest, (10) Since this book was published in 1670, it is assumed that this experiment was performed in 1969 or before.

After 1970, the Terrestrial Ecology Division reported only one

involving the use of radioisotopes, i.e., the tagging of # Giant

Tree Fern, Cyathes

atboree. The tree was tagged during

3p,

in June 197: with

radioisotopes of

Based on these data, Table 1 has been prepared. It is a summary of

the radioisotopes used, amounts used and date and location of the

experiment.

ISOTOPE (S) DATE AND AREA ai ontotsan,

\_ ACTIVITY

Jan, 6 19673 Area 2 (Fig.#) ? 20mck Laat

Os May 1968 Area 3 (Fig-10) 50 ech 12s

3p y903 1 act, 357.07

3p we 46 mci 280.57

\$e

137çq Sept.18,1968 Area 4 (Fig.l) 0.46 nCt 0.5

86,0 came) 17.69 acs 293-41

ask : 0119 mcs 84162

54 no 0134 nce 1743,

Bee fug-10, 1967 agea 5 (Figs12) 1 act v0.26

es ?oe 0.8 mee 7.77

en

&

an fag. 95 1967 Area 7 (g.13) 3 acs 16.99

eee

tee dams 6y 1946 area 8 CE 1 ct 5.25

Bee eo ag ist 98:30

"on im i

SSS

Table 1 - Summary of radioisotope usage in El Verde Rain Forest

---Page Break---

1e tust be nontioned thuty asociated with the

id activ

there ie Leberatery building that wus constructed in 1965.

aocher

horctory, adjacent to thy first one, was constructed sn

There 4s x0 record of radioisotope usaye in the new leboratery.

other hang, it ie assuncé thst sone scmple preparation

inveivine the use of radiotracers was performed in the old laborstery.

Figu:

3 hows the

## SOBUAY OF THE RADIOLOGICAL SURVEY

A Radiological Survey was planned and performed in order to

determine the status of the Verde facilities and research areas from

the radiological contamination standpoint. The survey included a survey of

the radiation levels and radiological contamination in the old laboratory building and a walk-through survey of the forest. Also, soil and vegetation samples were collected and analyzed.

Survey in the Laboratory Building:

The radiation levels within the laboratory were measured using

Portable Geiger Muller and Scintillation survey meters. The benches,

tables, drawers, instruments, floors,

11s, materials and other sur-

faces were scanned on contact and at 1 meter high.

Since the laboratory building is included in NRC License Ko.

52-1994-02, and at the time of the survey there were plans for the use

of radioisotopes such as Tritium, no efforts were made to survey the

Grains, hoods exhaust system, sink traps, etc.

The survey for removable contamination was done using the  
standard smear technique, Figures 4, 5 and 6 show the areas where the

smears were taken.

---Page Break---



4 walk-through survey was done in the forest, starting from the

Jaberutory ares through the trails up te the rad.

fen center where the

Se was Anstailed on IS64, The survey was extended to three,

ond twelve m4

fs from the trails. The area with

he 10. radius

scrveyed in a grid of epproximately one peters

This pare of the survey vas performed at ground level, and 1

seter high, using earphones in crder to wore precisely detect variation

in radiation levels in spite of rhe

wequality of the ground.

Der

ing the walk-through survey, six areas were found fenced

With chicken wire seroens and marked tt!

radiation safety signs.

These areas were marked as follows: areas 2,

12, based on

already existing within the fenced plots. For the purpose of this report, these areas will be called hereinafter, areas as numbered. Figure 7 shows the approximate location of these areas. Each

was thoroughly surveyed, and a detailed map of the radiation levels

was done. Also, soil and vegetation

samples were collected in the areas.

In order to have a complete idea of the status of the surrounding grounds, soil samples were also collected outside of the fenced areas, beyond the radiation safety signs. All soil samples were col-

lected from surface 6 inches and from next 6 inches deep in the ground.

Soil and vegetation samples, representative of each rca vere

analyzed for radionuclide content in a Germanium Lithium drifted  
detector, Also, other portions were oven dried, grinded and an aliquot

of 200 mg was counted in a Gas Flow Proportional Counter, for gross

---Page Break---

sipha ond betacgsama coutarsuation, Mierocurfes per gram vere

colculated veing the following formal

+ eps where Am anount of sanple analysed (g)

ifs ???\_\_\_\_,

(7)  $2.22 \times 10^5$  efficiency ractor = 507

## VEY REVORE DrCOSTANENATION

The initial Kediological survey for EL Verde Research Areas was carried out during different intervals of time in FY 1978 through FY 1979.

The background radiation level varies from 2 uR/hr to 6 uR/hr in the Laboratory area and in the forest. Figure 8 shows the detailed radiation levels in the Laboratory area.

Each one of the areas was surveyed in detail. Figures 9, 10, 11,

12, 13, and 14 show the radiation levels and location of the samples

taken inside and beyond the fence of each area. Samples taken beyond

the fence are identified as control samples

Based on the description and clues found in each area

spectro

netric analysis of some

ples and the descriptions found in the

- Literature searched, the isotopes used in each seopling zone vere

identified as follovs:

area 2 -th

- Area 3 Fu, 3p

Area & - Mes, se, Ata, Spy

Area 5 - Bsr, Mes

. Area 7 - Sc9

1g g, gp, 54

Area 8 ~ Mes, ?Me

---Page Break---

Appendix 1 ts a summary of

Results of the samples analyzed for

arose betarganas and gross alpha centaninstion.

Appendix 2 is a summary of the saeples analyzed in the Gelt

Three of the ureas vere f

wad vith radiatien Jevele higher than

background: Areas 4, 5 and £. Sex Figures 1, 12 and 16.

No contusination vas found in the laboratory building.

Appendix 14 shows the results of all the spears taken in this

buslding. Ko sauples vere taken {n the nev laboratory constructed in

1976,

Sc 1 samples fron ar ares where no radioisotopes have been used,

were taxen and onciyzed in order te establish @ background level for

comperiscn purpose. The results of these cof} samples are included tn

Appendix 3.

---Page Break---

TRIMENTS UST

1, Ludtun tleasurerents, Inc.

Model 3, Pa

Git 1.8 up/ee window

Sweetwater, Texas

2. Sesueciintion

jacna Rateneter Type 13974

Pector Control biveion



Eliot Process Automation Limited

Levisham, London, S.E. 13

3. Nuclear Measurements Corporation

Gas Flow Proportional Counter

et PCO=LIT-DS-IT Combination

50% ELL, Ave. efficiency for gamma energies from 0.500 Mev to 1.3

Mev.

WNC Indianapolis, Indiana

4, Nuclear Data 4410 Spectrometer

with @ GeLi Detector

Nuclear Data Inc.

5. Liquid Scintillation Counter

Beckman Model LS 31337

Beckman Inc., California

30% Eff. for Tritium

---Page Break---

Efforts were concentrated to two of the areas

(and 8, The contaminated soil in area 5 was readily removed.

Total amount of soil was removed until

Juniper tray was found

about 1000 Geep in area by Bes:

nd this level no contaminat: 2m was

Found. about 1,600 1b (453 ke)

soil were rem

4, placed tn plestic

bags and transyorted to CELE Novagues for proper disposal.

At the present time the rediation levels in area 8 vary from 2  
uR/sz to 10 uR/br. See figure 15 for a diagan of the radiation levels.

Teo trees were found contaninated in area 4. The resin of the

Free, a5 well ue some pieces of cortex, were

ed in the epestro

neter and /\*7cs was found os the contuninant. Ko attempt was cade to

Quantify the remaining dose. Soil contaminated with cesium under  
the tree, was removed. Even though about 100 lb (43 kg) of soil  
were removed, the radiation level under the tree is still higher than  
background, i.e. about 200 uR/hr. Figure 16 shows the present status of  
this area.

The contaminated tree remains in place and the Forest Service  
concurred with CEFR that the El Verde Research area should be licensed for

the use of radiotracers. A license application was submitted to the  
Nuclear Regulatory Commission and License No. 52-1934-02 was granted on  
March 9, 1962.

Area 4 will remain fenced and with radiation safety signs. ALL  
other radiation safety signs have been removed.

Of the radioisotopes used in El Verde, (Table 1), tritium is the  
one of more concern because it could be incorporated into the human body  
following ingestion of HTO, by passing through skin or inhalation either

---Page Break---

as liquid or in aqueous form. However, this concern is lessened in

view of the relatively short biological half-lives of the chemicals involved.

For example, NCIP Report No. 62 indicates that:

© seems reasonable to

conclude that one pool of residues in exposed individuals

in the form

free body water. It has been reported © and 18

a)

We conclude on the basis of the observations (Jordan 1970) that any

tritium used in the areas has been dissipated in the atmosphere as water

spor.

Jordan estimated the half residence time ( $t_{1/2}$ ) for tritium in the

+ in the vegetation and in the air  $d = 9$  tropical ecosystems such as

Verde, (2)

According to Jordan, tritium moves into the air through evaporation

of the water in the litter, in such a way that, the half-residence time of the  $^3\text{H}$  in the soil and litter, necessarily controls concentration in the water vapor above the spiked soil. The results in his experiments indicated that: "29 days probably is @ good estimate for the th of

tritium in the soil as a whole.?" (2)

He found that for trees growing in soil spiked with tritium, the th is between 41 and 55 days. For those trees (*Dactyodes excelsa*) where the isotope was injected, the t of tritium was 6.6 days (2)

If one Curie (1 Ci) of tritium bought in 1965 was used during 1969

and experienced @ half-residence time of 55 days, the amount remaining

in 1983 would be  $1,95 \times 10^7 \text{Ci}$ ,

ee

\* Half residence time = is the length of time that it takes for half the activity in a compartment to be removed.

\*\* Biological half-life = is the time required for the body to eliminate  
by regular process of elimination one half of @  
dose received of any substance

---Page Break---

1s

Based on the above observation, then we conclude that biological

elimination and the ro

of a pesticide in a tropical ecosystem as El verde

is such

that the pesticide used in the research area has been dispersed to



sphere in very low levels not dangerous to either the publ

ph

© persone orking \$a the area,

---Page Break---

3

%

10.

a

2.

+ Carl F. and Drees, George E. The Kain Forese Project  
annual Report. Puerto Rico Nuclear Center, Phic= 129, (June  
1977) a7.

Koranda, 3. Jey Eline, 2. Ry and Mare:  
In a tropical ecosystem

3.

histo}.

<0, 807,

Kine, Jerry R. Terrestrial ecology Program = The Rain Forest  
Project, Puerto Rico Nuclear Center annual Report 1966.

PR

102, (Sept. 1967) 146,

Jerry R. and Staff. The Rain Forest Project Annual Report  
FY1967. Puerto Rico Nuclear Center, PRSCA-13, 22) 23+

by Jerry R. Kine, Carl T. Drew, George E. The Rain  
Forest Project. Reports Puerto Rico Nuclear Centers  
PRIC-11Y, (June 1962), 200, 220. Tees

KCRP (1979) Natdenet Council on Kediation Protection and  
Heasurements, Tsitiun in the Environment, NCAP Report No. 62  
(National Counei1 on Radiation Protection and Measurements,  
Washington).

Puerto Rico Nuclear Center, Annual Report 1967, PRNC-121, 170, 173.

Oguz, Howard T. The Rain Forest Project Annual Report FY-1965.

Puerto Rico Nuclear Center, PRIC-6I (March 1, 1963) 3. 4.

Odun, Yoward T. A Tropical Rain Forest, A Study of Irradiation and  
Ecology at £1 Verde, Puerto Rico, washington DC.

a

}, Howard T. The Rain Forzst Project. Puerto Rico Nuclear  
Center, PRNCH34 (Aprél 1, 1964) 34.

Odve, Howard T. A Tropical Rain Forest, A Study of Irradiation and  
Ecology at £1 Verde, Puerto Rico. washington DC: Division of  
?Technical Inforaation, 1970.

Stark, Nellie, The Rain Forest Project Annual Report. Puerto Rico  
Nuclear Center, PRNC-147 (June 1970) 130-140.

---Page Break---

APPENDIX 1,

---Page Break---

CENTER FOR ENERGY AND ENVIRONMENT RESEARCH.  
WEALTH AND SAFETY OFFICE

ENVIRONMENTAL. SAMPLES Sunecay ALPORT

Instruments used KEC 217

environmental samples 8 TO

Sampling route Wn 22

se

t

b Jole jols

?F

zesyy

450 yet

ae

kus oye

245 x0

Jeu. 50 wo"

| 72 vie?



226 | yos wo"

MAI 4 00 yo

4.50 v0

o'o

Rey: # Net Results » uCi/g sample ~ uw Ci/9 background Error range + 2.3 x 10<sup>0</sup>, Ci/g

Ve vegetation c= control

Ae soit surface 6 in, Be seit sub-surface 6 im.

ngieates activity below detection 11

Counters

£5 of the Gat Flow Proportional

---Page Break---

?CENTER FOR ENERGY AND EXVIRONMENT RESEARCH

WEALTH AND SAFETY oFFice

ENVIRONMENTAL SAMPLES SUMARY REPORT

tare Ape! "72 Instrument used\_Ds<1T

ay, elgrosns 8 Goa TE

Technician omg, Pree d

Background @

Sample. Vo!

We bemq

Sampling zone Ayes #3 Type of sample Sei"

swe Wo. siya py ulfe ey

Bl%y o sawue no. utile a

B.c.h | ay.se xo \*

Keys \* Net Results =  $u_{\text{Ci/g sample}} \sim u_{\text{Ci/g background}}$  Error range #  $2.3 \times 10^5 \text{ y Ci/a}$

Vs vegetation c= control

S= 201 Ae soil surface 6 In. Be so) sub-surface 6 ine

sazero (0)

ts of the Gas Flow Proportional

---Page Break---

CENTER FOR ENERGY AND ENVIRONMENT RESEARCH

WEALTH AND SAFETY OFFICE

ENVIRONMENTAL SAMPLES SUMMARY REPORT

vote Zp Ja) "78 rument verd DIT

= ground By Gad am 270

Teermician Raman Peer es around :

rie Vola" or We 3a6- 5





Sanpting zone Aven #3. Type of soaphe

Wa ty Ble swmeno, yey lew

Wie? id oO 3-10 Dea o

135 4707 o 3-18 leusyey?] 0



9.0 un @ o | a2 [ery] 0

ea o || x22 °

zrsya 7] 0 || ssa ©

a i °

os °

2 | °

ol asa -Sovn'4 0

o 3-36 fasove\*| 2

sox? 2 °

9.0 410% ° aust? | 0

4.8 yuo-\* ° Bon zest | 0

U5 9ser0~% ° Lasys07 2

fe-3-8a | dos we? | 0 308 ary? | o

6-398 | 1-35 xo" ° 398 wasvet| oO

crt a | aroyioe | 0

on 98 [as cred 6

oy: Wet Results = uCi/a sample ~ u Ci/g background Error range + 2.3 x 10°Sy Ci/9

We vesetation + control

s s0Ht As soit surface © In, Be soil sub-surface 6 ine

ero (0) indicates activity bellow detection limits of the Gax Flow Proportional

Counters

---Page Break---

CENTER FOR ENERGY AND ENVIRONMENT RESEARCH  
WEALTH AND SAFETY OFFICE

[ENVIRONMENTAL SAMPLES. SUMMARY REPORT

te Wag 78 lostranent vied ReclIT, D SIF

bate Re. ckground By Sedgm £10

Tectmician amen Peter ctsreund @? Segatins eo ?

Simple Vol. or Wee Game





Seopting sone Oven pb ¥ Type of sample Sg

sworn, Se ey Mle a sine no, tthe ay whee

pre? | oT CL

wrest 2 \_ \_

ieeues | 0 \_

aes wi? 2

1s p07 2 \_

eusonw oi [

west | oo

13s ¥Q > x

usth zesu? | o \_

use | 1ovw® | o | i}

Hoy! © Net Results = uCi/9 sample ~ » Ci/a background Error range + 2.3 x 10°Sy ci/g

Ye veseta c= controt

ss0it Ae soil surface 6 ime Be soft sub-surface 6 In.

?ter0 (0) indicates activity bellow detection Vimits of the Gas Flow Proportional

---Page Break---

CENTER FOR ENERGY AND ENVIRONMENT RESEARCH  
HEALTH AND SAFETY OFFICE

ENVIRONMENTAL SAMPLES SUMMARY REPORT

note Na 72 Instrument used\_Dg

note WY r bs-it







Tecnician Ramon Paver Bectgrownd « =  
sonoting zone Aves U Type ef suaphe ta,  
sire no, sive ey ele «sammie yo. ufos y ation  
ku.sowe? oe ficea size | async} 0  
o flew-r28 | wsoxs'| 2  
\* 0 fevasne | usovet 2  
useyro? | 0 dieu [ews 0  
eusy/ oe? eo ficu-wa | gos] o  
o fieww8 Jeusy st] 0  
2 | ç-4-1F em a o

oe wiza | 8 o

\_ ol cu ese °

goo xn? | \_o c-u-100 °

tasyo? | \_o de-w-na | °

1.Bo £70"? o 6-4 =198 | 9.00 y 10" °

<u 50 ¥e o C-4- ign seve] o

135 x0" o c-u-iga| users] 6

[c-u-wa| ox | 0 cue tan [easonm?| 0

1oB | 135x209 o ¢-4-19p | uses? | 0

cou-ua | ' Boye"? ° c-4- on [eu-sovnt] 0

ne £u.soxso7® ° C-4- 0G ? )

Key: \* Net Results = uCi/a sample - u Ci/g background Error range + 2.3 x 10°Sy Ci/g

Ve vegetation C= control

s\* soit Ae soil surface 6 lm, 8 soll sub-surface 6 in.

sezero (0) Indicates activity bellow detection limits of the Gas Flow Proportional

Counters

bs

---Page Break---

CENTER FOR ENERGY AND CITIRONNENT RESEARCH.

WEALTH AND SAFETY OFFICE

ENVIRONMENTAL SAMPLES SUMMARY REPORT

pare Sept 1472 fnstrument used PCE =l

ee

7 Background By

Techaician we Background &

Sompie Vol. or Bee

Type of Semple Sac Veg

Tele « smicro. vio ey tilee

o? || 5-38 | vizoni] oe

2 s-x@ | ey °

2 aan wos | a

2 S46 ? 2

2 veg A | saves °

2 vn [wsovet]

°

2 ?

| o



- 
- 
- 

M9560" ◦

b-s0w0-? | 0

wore? | o

S218 | is we" 2

s.2h | zero? | o

5.28 | seuwr | o

Key: \* Net Results =  $\mu\text{Ci/a sample} \sim y \text{ Ci/g background Error range} + 2.3 \times 10^5 y \text{ Ci/g}$

Ve vegetation C= control

S= soil surface 6 in Be soil sub-surface 6 in

ero (0) indicates activity below detection limit

Counters

[type of the Gas Flow Proportional

6

---Page Break---

CENTER FOR ENERGY AND ENVIRONMENT RESEARCH

HEALTH AND SAFETY OFFICE

date: August 1978

technician Ramon Poser

ENVIRONMENTAL SAMPLES SUMMARY REPORT

Instrument used: Deuterium Tritium (DT)

Background: 8 y <sup>232</sup>Th dea ETD









Background a" gga SER

sisting tne Bessa at

Ula ty Mle eo seme. to ay

2.26 ie? 3? g- th lewnyn's} oo

? ° 718 | gous] 0

zrowo? | > g- 2h | us0406\*| 9

Pow? |\_o q- 28 | Vases] 0

a 7 2 Te 3D} 1G0x,07{ 0

6.0. 3b | 1 B04 197 ° 7-38 | unvwil o

276 yn? | 7. 4a | erorw3] 0

b box 10"? ab | gay °

Zev | o ne sa lees? | oo

zt0¥07 | 0 158 | susiW °

400 ws" | oo zasis?| 0

? ° 7-06 |ircwd®| 0

[c-7- 7A | euso yet | o

C-7- 7a] °

- | ¢-7- @A | 270x077 ° \_

6-7-28 | 1-9 x/0°F °

C-1- 9h Jeursovser® | oo

1-98 | asovie?] o

~ Heys \* Met Results = uCi/9 sample = y Ci/g background Error range + 2.3 X 10°Sy CI/p

Ye vegetation c= control

= 20 Ae soll surface 6 In, 4011 sub-surface 6 ine

Counters

oa

\*\*zero (0) indicates activity bellow detection limits of the Gas Flow Proportional

---Page Break---

CENTER FOR ENERGY AND EXVEROSMENT RESEARCH

WEALTH AND SAFETY OFFICE

[ENVIRONMENTAL SAMPLES SUNRARY REPORT

bore Vovomber 1978 instrument used Pec - IT

Se Background Gm 76,

Technicisn Bamen. Peve Background ?el pm



sampling tone Bee. ¥ @ Tye of seme eee

3 Belle 0 same no. sto sy Weide e

NW B-cod fey suys' °

° Bees. ®

2 Qai®

2 ga18

1 o4s0"7 ° 2A

9-094107% ° B-7B

Btoure® ° |

BIS var 2 a

eusoy o

was yn O J

eusows?}| 0 .

2.20 x70" o

w9s vet o

gc ae Oo =

2:70 49077 o

a u °

a 5h | pve °

2-58 jeu.sovsoee °

\* Net Results  $\text{uCi/g sample} = \text{w Ci/g background Error range} + 2.3 \times 10^{-5} \text{Sy Ci/g}$

Ve vegetation C= conte

S= soit Ae \$011 surface 6 Ine Be sol) sub-surface 6 in.

\*Azero (0) indicates activity bellow detection limits of the Gas Flow Proportional

Counters



---Page Break---

APPENDIX 1A,

---Page Break---

Identification of Samples:

Area A- Lab TE E] verde

---Page Break---

# HEALTH PHYSICS ASSAY REPORT

bis LL dngetoo L& DIT Cnr

El Verde

Area Anta TL

---Page Break---

Identification of Saeples:

El Verde

Avea A- Lah IE

---Page Break---

El Verde Leboradery

Ave B

---Page Break---

---Page Break---

## PHYSICS ASSAY REPORT

elm Gooner,

erro DS-2

achground\_2.9"/e Geometry 27

fF leation of Samples:

El Vere Labocetery

Avea-B

---Page Break---

---Page Break---

HEALTH PHYSICS ASSAY REPORT

El Vevcte

Storage Room

---Page Break---

HEALTH PHYSICS ASSAY REPORT

ere CD Crmority on ext. ?To be counted for



vate

ofr Tei Cisse

copy of report to Pechground\_\_ cfm Geometry

Cy Send coor me Code, GAMMA, os-tT

a Sen 30!tin teametry 2

phe Identification of Samples:

TV E/ Verde Lol Bly

Avea @ ond Sheps °

---Page Break---

Ht H PHYSICS ASSAY REPORT

nies fLfasteroonfrer CD Qwerty on ent

To be counted for

of results

Background\_\_\_/m Geanetry,

Wseraccama OS =

Da ertyrune\_2.92"e/m teontey 29°

Ident ifeatton of Samples:

El Vewde bel building

Avia C om Shops

rato

---Page Break---

os for

/m Geometry,

DSB

2 e/m Geometry 2 I

Identification of Samples:

Smears El Verde Leb Bling

Aven @ and Shops

tat

---Page Break---

HEALTH PHYSICS ASSAY REPORT

To be counted for

Clatrna

fackground\_\_e/m Geometry,

pera-cama | DS IT

Background\_3.0\*/m Geometry Ir

dent ifcation of Samples:

BI Verh Leb Building

Aves © ond Sheps

WZ

---Page Break---

## HEALTH PHYSICS ASSAY REPORT

dent iFleation of Samples:

El Vareke habe building

Aven C and Shops

---Page Break---

APPENDIX 2.

---Page Break---

APPENDIX 2



Soll Samples Analyzed in the Germanium Lithium Spectromete- \*

VEGETATION

AREA SAMPLE NO CONTAMINATED NOT CONTAMINATED

4 3 5-137

2 ? x

2 5 x

8 ? x

son

2 6Ase x

2 5AsB x

3 Ace

4 Base of tree Cs-137

4 Resin of tree Cs-137

5 SAG x

5 6Ace x

7 7AeB x

7 BACB x

6 1AcB x

8 2AcB x

8 6AcB x

® Control A B x

\*Spectrometric analysis was made with the only

Purpose of detecting radioactive contaminants.

No attempt was made to quantify any contaminant.

---Page Break---

- APPENDIX 3.

---Page Break---

APPENDIX 3

Soil Samples taken at the Experimental Station in order to

establish background levels for comparison purposes.

Samples counted in the Sas Flow Proportional Counter

?SAMPLE NO. wCi/gm + 2.3 K 10<sup>5</sup>

1 2.70 x 10<sup>5</sup>

2 5.40 x 10<sup>5</sup>

3 4.05 x 10<sup>7</sup>

4 1.80 x 10<sup>5</sup>

---Page Break---

APPENDIX 4,

---Page Break---

wot Ls NUCLEAR REGULATORY COMMISSION PAGEL or. 3 nae

fom: Sc ENN SN en Sere Ree EC

i This Co Wo Your Files MATERIALS LICENSE

Pras the Atomic Ene Act of 1984 amended he Enea Reviganiction Act of 1971 (Pubic Law 93-438)

and Tie

j Case of toler! Pequaions, Chapter 1, Parts30,31, 32, 33,34. 35,3640 nd 90,and i ela on slatemens

and opr

leteofors aie + the Hee, alent is hereby issued authorizing the eerie to recive sie, poses an wer

Byprodl

source nt specs malar material enigated Wow to use such aril fo the pupusa a the pact) Sesighted

elon

sive ans such mate to persons authorized to recive iin avordance wth the veg ation ofthe spplicable

Pa) aed to

prt sich hyp let and soc materi. This Tere stall be Geri to contain the canon specified In Section 189  
of the  
Atoiiic eng 1 of 1954. a anended, and subject to a apple vl elation sd nde ofthe Nacht Reqalstony  
Comsat Never effet an to any estan pei stow

j Tien T oe

"university of muerte Rico 8 Ueememamber 519434-02

| Gantoe for Shergy and ?sivionmental |

? Lo

2capaeaa Fnishts Station bapa

Sui doin, Puerta Rico 00935 feptiondite Ngee 92, 1987

Ticker

Ho \_ a Relevance No.

ipl se andor 7 entmiansir pyseat

spi ack teal fmm po yon ne

nde th iee

AL tydrosan 9 Ay A. 4 caries

Conia 137 BL hy BLT nllicurie

iderlad we

A. api B. For use in field experinenta,

OTTERS

10, Licensed mterial chal be wood only at Caribiean ational forest, Lugutllo

Forest, El Verde Research Station, Puerto Rico

21. The Licensee shall comply with the provisions of Title 10, Chapter 1, code of Federal Regulations, Part 19, "Notices, Instructions and Reports to Workers: Inspections" and Part 20, "Standards for Protection Against Radiation."

32. Licensed material shall be used by, or under the supervision of, Jeffrey Carl Luvall.

Senneterre

---Page Break---

(C22 Es ame SERENE Bees eee

\_ Us NUCLEAR REGULATORY COMMISSION 2 3

nes or

MATERIALS LICENSE

?Can

"Sensitized material shall not be used in or on human beings or in products distributed to the public.

A. Individuals involved in operations which utilize, at any one time, more than 100 millicuries of Hydrogen 3 in a non-contained form, other than metallic foil, shall have bioassays performed within one week following each operation and at weekly intervals for continuing operations.

(0) Tritium shall not be used in such a manner as to cause any individual to receive a radiation exposure such that urinary excretion rates exceed 28 microcuries of tritium per liter then averaged over a calendar quarter.

(2) Urinalysis shall be performed at weekly intervals on all individuals who work in the restricted areas of facilities in which tritium is used. If the average concentration of tritium in urine for any single individual during a calendar quarter is less than 10 microcuries per liter, urinalysis may be performed on that individual at monthly intervals for the following calendar quarter and may continue at monthly intervals so long as the average concentration in the

calendar quarter remain below 10 microcuries per liter. The urine specimen shall be collected on the same day of the week insofar as possible.

if an average concentration in excess of the limit specified in B(L) above for any individual shall be filed, in writing, within thirty (30) days of the end of the calendar quarter with the Office of Inspection and Enforcement, U. S. Nuclear Regulatory Commission, Washington, D. C. 20555, with a copy to the Regional Office of Inspection and Enforcement. The report shall contain the results of all urinalyses for the individual during the calendar quarter, the cause of the excessive concentrations, and the corrective steps taken or planned to assure against a recurrence.

(4) Any single urinalysis which discloses a concentration of greater than 50 microcuries per liter shall be reported, in writing, within seven

(7) days of the licensee's receipt of the results, to the Office of Inspection and Enforcement, U.S. Nuclear Regulatory Commission, Washington, D. C. 20555, with a copy to the U.S. Nuclear Regulatory Commission, Region III, office of Inspection and Enforcement, 101 Marietta Street, Suite 3100, Atlanta, Georgia 20303.

---Page Break---



E

3

§

&

:

S62 oR Se SR aS RRR TEE

MATERIALS LICEN: h

}

cuore

Not as specifically provided otherwise by this License, the licensee shall  
comply with the License material described in Articles 6, 7, and 8 of this  
License in accordance with the conditions, representations, and procedures

set forth in letter dated December 20, 1961, to the Nuclear Regulatory Commission.  
The provisions shall govern the licensee's obligations in applications or hearings  
unless the provisions are more restrictive than the regulations,

Bees Kies, &

Bi B

Washington DC 20555, E

---Page Break---

MATERIALS LICENSE

SUPPLEMENTARY SHEET

miuevelty of Puerto Rico.

Contes for Shergy and Enviromental

Paerareh

ch Helite Station

Dein, Biesta Rico 00995

oA material shall be use? only at Caries National F

rest, Lagat?

1 EL Verde Research Station, Puerto Fico.

&

&

|

i. rene

wansyn be 2538

|

A material shall be used by; or under the supervision of, taurenee J. TiLly,

Ammo weseon prema ew mn nage ean Rae LRM UIE ESR ARAL

es

eee

---Page Break---

FIGURES,

---Page Break---

fete

WSU ERS

Fig. 1, Map of Puerto Rico Showing the Location of Luquillo Forest

and El Verde Research Area.

---Page Break---

long term growth plots

(1964-1970)

Fig. nA. Approximate boundary of the 156 acres under DOE-

Forest Service Agreement

---Page Break---

---Page Break---

Fig. 3. Laboratory Area, El Verde Research Station.

---Page Break---

Fig. 4. Detail of Old Laboratory Building, Ares A. Numbers Indicate



i cael

Je a \*

| zy

@ ~

Le = 20

AveaA tabs L-IE

---Page Break---

Survey Points. See Appendix 1A

caeed

8. Numbers Indicate

Results.

STORAGE

a6

nee

@ 2

One,

rrps

Anca

---Page Break---

Building, Area C and Shops. Numbers

?See Appendix 4 for Results.



ser @

@ ay. Bilis

nfo @ ce

i |

Syl] 2 Ju e

30 @|,

@

aoe |\*® wy 8 |O ve

o

a @\s H

cf Ae

'0 @ |e" t

of 2 23

G 48 ?

snor @

@

---Page Break---

---Page Break---

22

22

32

Qadonardm]? 3 FF?

2322 2 2 2 2 2 2

---Page Break---



Fig. 9. Radiation Levels and Sampling Locations in Area 2. See Appendix 1 for Results of Samples Analyzed.

E/ Verde Rein Forest ?Lazn Area #2 ? Back Ground ? 2.04R

Bab onl

cont. 2-3V 204K

ce4sy 20KR nropk

ces 2.OKR ABH est,

zolees

2235 Comb

%

(2

ve A

prea Diameter

oy

BAYS Cob

ov onh

Tree ttl Coons

Tree AE

Soil LSAR

)

aie

', ?

---Page Break---

Fig. 18, Radiation Levels and Sampling Locations in Area 3,

See Appendix 1 for Results

Aven #3 El Verde Ri

wast

F10

33 Hone

?oowa WiLL

Aap fan,

---Page Break---

Fig. 11. Radiation Levels and Sampling Locations in Ares

See Appendix 1 for Results of Samples Analyzed

AREA #ç# ?I VERDE

AREA DIAMETER

espe S

Tree af

note

PE ese

ane i

Le-wst

wecin

Fs he

A doy to,

---Page Break---

SI 50pR

SYS 30K,

SLs TAR

SY 1SHk

SAYS Dope

S319 D0pk

cou ty 207k

5-6 08 5 xF

5-6 vs LSA

S718 20K

Avegt bay

Avea #5 El Verde

st

a

Area Drameber

s7

ey

Fig. 12, Radiat

Jevels and Sampling Locations in Area #.

See Appendix 1 for Results of Samples Analyzed

---Page Break---

Area #7 El Vevde

ls

Zope yng

2-4 2h The

Dead Trunks

Fig. 13. Radiation Levels and Sampling Locations in Area 7.

See Appendix 1 for Results of Samples Analyzed.

A tip beny

---Page Break---

Fig. 18. Radiation Le

?See Appendix 1

AREA #8 &1 Verde.

ty NSS

. f

3

wu ;

er

Arca Diameter)

B--sv coens

a All hres dease

DEAD ratonuco

TREGTRUNE

8-4 So

Ot Fege Bon,

---Page Break---

Fig. 15. Radiation Levels After Decontamination of Area 8.

AREA #8 &1 Verde hesea Lona mee-S)

a yy

eBu So

A gt bny

---Page Break---

Fig. 16. Radiation Levels, at the present time, in Area 8

AREA #+ EI VERDE

oe AREA (DIAMETER

eR Ys Hpk \

5 5 OAR

cnet 20nR °

Tree #f ot IMbeialt 7 AK

& .

?ie :

SAR ot tm from tree #Z AA. .

Tree #2 of twbeinlt, Hk oe



Tree te 3k adbese, 28

ab tiysrvend level

Oe Ok ewer

At TERS copes wae

oun) wa)

ree Mepra bors

TS ach ace

Aga bs

---Page Break---