

PRNC-3 Health Physics ENVIRONMENTAL SURVEY PROCEDURES MANUAL By J. A. Ferrer Monge Puerto Rico Nuclear Center Operated By University of Puerto Rico For U.S. Atomic Energy Commission Mayagüez, P.R. "JULY 1, 1960." ---Page Break--- RIC = 3, (HEALTH PHYSICS) ENVIRONMENTAL SURVEY PROCEDURES MANUAL by J. A. Ferrer Monge PUERTO RICO NUCLEAR CENTER Operated by UNIVERSITY OF PUERTO RICO for U.S. ATOMIC ENERGY COMMISSION Mayagüez, P.R. July 1, 1960 ---Page Break--- ACKNOWLEDGEMENTS The writer expresses his appreciation to Mr. Pedro Cousins, Mr. Fernando Valdivia, and Ms. Miriam H. Vela of the Health Physics Section for their help in the preparation of the manual. It is a pleasure to especially acknowledge the assistance of Dr. John I. Garley and his staff at the New York Health and Safety Laboratory who read the manuscript, commented and made valuable suggestions. ---Page Break--- INTRODUCTION This manual has been prepared for the purpose of establishing standard procedures to be followed by the Puerto Rico Nuclear Center Health Physics Section, for use in training personnel and trainees in the Health Physics programs and to supply technical information to all persons interested in the field of environmental surveillance. AREA OF STUDY The area to be surveyed is located between latitude 10°00' to 18°25' (North) and longitude 66°57'30" to 67°27'30" (West) with an area of approximately 352 square miles. This is mostly mountainous region being an extension of the Cordillera Central and includes several watersheds, the main ones being the Culebrinas, Grande de Añasco, Yague, Río Cañas, Guayanilla and Rosario Rivers. The lowlands are located in Cabo Rojo, Lajas, Mayagüez, Hormigueros and Aguadilla. Figure 1 presents a map of the island of Puerto Rico indicating the area of study, the cities and towns within that area as well as other large towns (15,000 or more inhabitants) outside the area. Figure 2 presents a map of the area of study and is based on the U.S. Geological Survey topographical maps and includes a plan of the

city of Mayaguez indicating the site of the PRNC and permanent stations where special samples will be collected. To facilitate the identification of the samples, the whole area has been divided into 3. Each one represents 6.1 square miles (2.45 x 2.45). With PRNC as the center, a number of circles with radii of 2.5, 5.0, 7.5, 10.0, and 12.5 miles respectively have been drawn to relate activity measured to distance if this were necessary. ---Page Break--- ACTIVITY TO BE MEASURED The radiological survey involves the measurements of gross alpha and beta-gamma activity. IDENTIFICATION OF SAMPLES Table 1 presents the code to be used in the identification of samples. Samples will have an identification number as follows: RS-1-A-39(EL)W or RS-I-J-354 where: RS - Radiological Survey Program I - indicates Radiological Survey to be carried out A = area in the map where the sample was collected 35 = sample number independently of the area where it was collected (21) = indicates that the sample was collected in a permanent station W = indicates water sample. (A - air, S - sediment, M - milk, S - soil, V - vegetation, W - water) PROCEDURE TO Collection and Identification of Samples A total of four soil samples (from stations W1, W5, W8, and W6) will be collected per month. Additional on a Gimmeter hand auger. The sample will be divided into 2 portions. The 2" top soil will be placed in a polyethylene plastic bag including a tag with the following information: 1. Radiological survey 2. Sample no. 3. Date This number shall correspond with that in Form 631. The remaining 4" of soil will be placed in another bag including BL. Next, Form 651A Field Data sheet shall be completed. The laboratory then: bags will be sealed enclosing the one within the larger. The sample is now ready for analysis. ---Page Break--- Water Drinking Water One sample will be collected every two weeks from station (1) at the mouth of the Yaguez River and one per month at station (E2), five miles upstream of the Yaguez River. One sample will be collected weekly at station.

(E5), Quebrada de Gro, and one per month at station (EM), a dam and (BS), an artesian well. A

weekly sample will be collected from station (35), at PRC. 'Additional samples will be collected whenever necessary from permanent stations or elsewhere. 'ALL water samples shall be collected in duplicate using polyethylene one-liter bottles properly identified (Form fo. 331). Complete Form 6518. (a) Surface water bottles will be filled either by immersion in water or using another container to transfer the liquid to the bottles. (>) Underground water same as 1(a) 'Rain water one sample will be collected each week from the pluviometer installed in the vicinity of PRIC, station (BT) and one per month from the one at the city airport, station (BS). All the water accumulated in the pluviometers during the week will be collected. 'The bottles will be sealed, the samples identified and forms 651 and 651a completed. Each week one air sample will be taken from 2 stations (3) and (85) and one sample four times per year from three other stations. Samples are to be collected in Whatman filter paper No. 1, approximately 4" in diameter using a High-Volume air sampler during 24 hours. After removing the filter paper from the sampler, it shall be enclosed in an envelope with the following information: ---Page Break--- Location: area or station where the sample was collected Date + indicate the time at which collection started and the time at which sampling was finished. + indicate the ft/min at the beginning and end of sampling as indicated by the instrument. (See Manual of Instruments Used in Portable Air Sampler) Signature: signature of the person who took the sample. 'No one-liter samples will be collected per semester. Samples shall be collected in polyethylene bottles sealed and identified. Form 651 and 651a shall be completed. Vegetation One sample per quarter will be collected from 3 stations (1), (5) and (86). Each sample shall consist of approximately 500 grams and it will be enclosed in a cardboard box or

plastic 'bag Properly identified. FA11 Forms 651 and 631a. Sediment sample shall be collected per semester from three stations (E1), (B3) and (B4). The wet weight of each sample shall be no less than 20 grams. Sample will be collected in polyethylene bottles from the middle of the stream or at a point 4 to 6 feet from the shore. The bottles will be sealed and properly identified. Complete Forms 652 and 6518. SAMPLE COLLECTION REPORT Whenever samples are to be collected on private property, the collector shall fill Form 631b. ---Page Break--- I certify that the following listed samples are in storage, have been physically inspected, sealed and in good condition on this day of [date] of storage. SAMPLE PREPARATION 1. Samples low in O.M. content are dried in an oven at 103°C. 2. Sample is pulverized and sieved in a No. 60 sieve (250 microns). 3. Approximately 200 mg. of the sample are spread uniformly in a 2-inch diameter, 1/8" deep, weighed stainless steel planchet. If necessary, water may be added to form a thin paste, then dried under an infrared lamp. 4. Determine sample weight. Samples high in O.H. content are dried at 105°C and then heated. From here on follow the same procedure outlined above. Water Insoluble Solids 1. Filter 1 Liter of water using Whatman filter paper No. 42 (ashless) approximately 5.5 cm in diameter, previously weighed, in a 1500 ml beaker. 2. Dry the filter paper containing the insoluble solids in an oven at 105°C and weigh it. Transfer to a planchet (same type as used for soil samples). Saturate paper with ethyl alcohol and burn using a Meeker burner. Ten to twenty seconds is usually enough. In case of rainwater, this may be less than 1 liter. ---Page Break--- Soluble Solids 1. Evaporate the filtrate in the beaker to a volume of about 10 ml and transfer quantitatively to a previously weighed planchet containing several drops of nitric acid. Wash beaker with 6M nitric and transfer to planchet. 2. Dry in an oven at 103°C or under an infrared lamp. 3.

Determine weight of soluble solids. Air samples do not require any preparation. The filter paper is removed from the air sampler and counted directly (See Air Counting & Accuracy). Sediment: 1. Decant and remove excess water. 2. Transfer to a weighed planchet an amount of sediment such that when dry it is approximately 200 mg. 3. Evaporate to dryness: A. Determine weight of sediment. 2. Shake sample well. Pour 20 cc in a 100 ml beaker. 2. Add approximately 5 ml. of

concentrated HNO₃ (e.g., gr. 1-42). Wait 1 hour or longer until the solid separates completely from the soluble portion. 3. Carefully place the beaker on a hot plate and evaporate slowly almost to dryness (80°-95°C). 4. Remove the beaker from the hot plate and add 10 ml. concentrated HNO₃. Swirl until the solids are dissolved. 3. Evaporate to dryness. Cool for 5 minutes. 6. Repeat a second and third digestion adding each time 5 ml. of HNO₃ and evaporating to dryness. 7. Add 10 ml. concentrated HNO₃, and 2 ml. of a 30% solution of H₂O₂. 8. Remove acidity by adding carefully distilled water down the sides of the beaker and evaporating to dryness. Repeat this top step. 9. Add about 10 µl. of distilled water and transfer carefully to a previously weighed planchet. 30. Evaporate to dryness and count. ---Page Break---

Activity of a sample by direct counting unless the emitter is known. Reference standards are used to counteract this difficulty. AL Alpha Standards 2. Soil and Sediment: Pulverize a quantity of quartz and pass through a 0.60 sieve. D. Add to a known weight of quartz a known amount of uranyl nitrate in solution. Mix thoroughly and evaporate to dryness. @. Transfer 50, 100, 150, 200, 300, 500, 750, 1000 mg. approximately of the mixture of quartz and uranyl nitrate to previously weighed planchets and count. Find the efficiency of the instrument by dividing the counting rate of the sample by the disintegration rate obtained by the amount of uranyl nitrate present. f. Plot a curve of percent efficiency versus weight of sample. (Graph 1). Water 8 Evaporate enough.

water to obtain weights of 25, 50, 0.5, 100 ngs. of soluble solids. b. Transfer these solids to previously weighed planchets. c. Add a volume of uranyl nitrate solution having an activity of approximately 1000 disintegrations per minute to each sample. 4. Dry under an infrared lamp and weigh the planchet to find the weight of the samples. e. Count the sample and find the efficiency of the instrument in each case by dividing the counting rate obtained by the disintegration rate of the sample. f. Plot a graph of percent efficiency of the instrument versus weight of sample (Graph 2): B. Both Standards 1. Soak a Rulyerdze the HEL in mortar and pass it through a 60 sieve. b. Transfer 50, 100, 150, 200, 300, 400, 500, 750, and 2000 mgs. of KCl to previously weighed planchets. c. Find the counting rate for each sample. 4. Determine the efficiency of the instrument by dividing the counting rate by the disintegration rate of the isotope present in each sample of KCl. e. Plot a graph of percent efficiency versus weight of sample (Graph 5). Water s. Prepare a saturated solution of KCl. 9 ---Page Break---

a. Plot a curve of percent efficiency of the instrument versus weight of sample (Graph 4). For air samples, the portable air sampler is assumed to have a collecting efficiency of 1 (100%) and the filter paper an absorption efficiency of 0.7 for alphas (0.3 or 30% is lost) and 1.0 for betas (no loss). COMING AND INTERPRETATION I. Soil, Vegetation, Milk, Sediment and Water Accuracy Samples shall be counted for a period of time not less than 55 minutes. Thirty minutes counts for background shall be taken at least twice a day. The counting rate of samples will be reported with a 0.9 statistical error. This error (E) is calculated from: $E = x + 1.65 (\text{counting rate of sample (background included)} - \text{counting rate of background}) / (\text{time in minutes the sample was counted}) - (\text{time in minutes the background was counted})$ counting rate, M, will be given as $(N_s - M_y) + E$ A soil sample is counted for 55 minutes and the total count obtained was

6916. The background obtained for 30 minutes was 2550 counts. What is the net counting rate of the sample? ---Page Break---

Mes Qe 25 of aed = 85 cfm ty = 95 min. F t= min, Te 0.9 statistical error is $z_g \times (\text{---h---} + b_v?)$ 26 (igs Ee = 1.65 (2.29 + 2.05)² 1.55 (5.12)? = 1.65 (2.25) Bo = 37 e/a The net counting rate of the samples is therefore: Hoos Me-m + B= (15-05) 4 5.7 Kos We57 of whenever greater accuracy is desired the sample and background can be counted for a longer period of time thus making the 0.9 error smaller. This is true especially in cases where the counting rate of sample (ig) is very close to background's (li). In such cases it is desirable to distribute the

counting periods of sample and background in such a way as to reduce the error to a minimum. This can be done applying the formula () ---Page Break--- Since H, and Np have been previously determined (in the first run) the counting time of the sample and the counting time of the background (ts) can be obtained. A. Counting and Accuracy 1. Count the sample until a minimum of 500 total counts is obtained or for 55 minutes, whichever is shorter; this gives approximately Tf error at 90% CL. 2. For immediate alpha or beta activity, count sample as soon as removed from sampler. 3. For alpha activity due to long-lived radioisotopes take one count (Cy) at least four hours after collecting the sample. 4. Take a second count (C2) at least 20 hours after taking the first count. 5. For beta activity due to long-lived radioisotopes take one count (Cy) after removing the filter from the sampler. 6. Take count (Cp) at least twenty hours after the first count. 7. Between first and second counting return filter paper to its appropriate envelope. 8. Determine activity due to alpha and/or beta as instructed in Form PRNC-HP5(iS) 652. 9. Save all samples until calculations and reports have been made. REPORT OF 3 The final result of sample analyses shall be reported in microcuries per gram or whichever the case may be. An individual report shall be made for each.

explo ustag the following 'orm PRIC-HPS(75)632 - Data sheet - Civil, Vegetation, Ik, Sediment and water. Form PRNC-HPS(RS)632a - Data Sheet - for analysis using Form (5) for samples in one ---Page Break--- ; (CALCULATIONS 'Some calculations and examples are given under Counting and Interpretation. As reference other calculations are presented herein. I. Activity in Air Samples 'the general equation to use is: ° ucfec = net cfe py fox A Rerxtexk = efficiency of counter. This value is obtained from the efficiency curves of the corresponding standards. absorption of activity by the filter paper. = 0.47 for alphas (June 30\$ activity is absorbed). = 1.0 for betas (assume no absorption) = | air row co/minute. = sampling time interval in minutes. fe = filter paper efficiency for collecting particles in the air Assume fp = 1. K = a constant to convert a/a/ec to uc/ecs K = 2.22 x 10^4/mue 'Substituting in equation (1) for alphas @ where * a tet ae Oe x OTR TRIXEX 'which can be simplified to @) uuc/ee = Bet o/m 5.4 x 10 ie Ag the equation in Form 652a for air samples. For betas the equation is similar, but f, is assumed to be 0.5 and A=, thus ---Page Break--- uc/ec = —pet c/n x 0.9 x 10^6 O) wef = This equation also appears in Form 6328. To determine activity in 'str due to long-lived radioisotopes the general equation to use is: © wc 07: 0595lt2 = ty) = 22% « ow, 1 -OBHeg Gy fe Cy, = counts/minute due to long-lived radioisotopes ©, = counts/minute 4 hours or more after collecting 'the sample counts/minute 24 hours after Cy 1) = correction factor due to disintegration rate of Thoron, , the lapse between ϕ) ax cp (in hours). 2t (to - t.) Se Rept constant, for example 20 hours, equation (5) can be substituted by: Cy f= 6 (21) a, - = Lb (co = -27 cy) of u 0.73 @ * once Cy, counts/minute corrected has been determined for a and p activity Value is substituted in equations (3) and (4) to calculate 'the alpha and beta activity in the sample co that Cp, x Selb x 10^S (1) sefee alpha = — He (8) wofee beta» X09 210° ae TL. Activity

in Goll, Water, Milk, Vegetation and Sediment Samples A, Alpha activity of the samples will be expressed in µC relative to natural uranium. The activity in natural uranium is due to its isotopes 238, 235 and 234 and it is determined as follows. ---Page Break--- 3 Arora = EM Where 14% is the activity of each one of the isotopes The activity due to = 4.88 x 10 where T 1/2 is the half-life of U or 4.49 x 10^9 years ¥ = number of atoms per g of Uranyl Nitrate = 8.16 x 10^-3 x 2 x 0.993 for the abundance of the 238 isotope 6.025 x 10^23 Avogadro's number is the number of Uranyl Nitrate A ot = 468 x 10^7 x 10 = 3810 a/sec/g of Uranyl Nitrate The activity of = 3.08 x 10^7 ge a ZH + exw where Ty = 7.13 x 10^10 years t w = 00a x 6.02 x 10^23 x 6.60 x 10^19 atoms of U per gram of Uranyl Nitrate Where 0.00715 is the abundance of U-234 isotope a: A = am = (5.08 x 10^6) (8.60 x 10^6) = 260 a/s/en. ---Page Break--- The activity of U-238 isotope is the same as the activity of the U-234 because they are in secular equilibrium. The calculation for grams of Uranyl Nitrate is

therefore $A_{\text{total}} = 9810 + 5810 + 260 = 11900$ a/sec. The beta activity of the samples will be expressed in μC relative to the activity in KCl due to x is determined as follows: Percent of K-40 in natural K = 0.0119% half-life of K-40 ($n = 3/2$) = 1.3×10^9 years Therefore: $d_s R_s T_{1/2} = 13 \times 10 \times 365 \times 24 \times 60 = 101 \times 10^7$ min. Molecular weight of KCl = 74.557 g/m = number of K-40 atoms/g of KCl $B = 20009 \times 6.02 \times 10^{23}$ $T_s = 55T$ $N = 9.6 \times 10^{-2}$ atoms $A =$ activity of K-40 in a/g = $1.01 \times 10^{10} \times 9.6 \times 10^{17} = 970$ a/g of K. The basic equation to convert activity of sample in a/m to $\mu\text{C/cm}$ or $\mu\text{C/g}$ is: $(9) > w_o/e_s$ or $g = \text{---Bet } c/a \text{ ox } t_{gk}$ for efficiency factor $f_g =$ sample weight in cm or g $K =$ constant to convert a to μC $K = 2.22 \times 10^8 \mu\text{C}$ ---Page Break--- cg ---Page Break--- was NVagaElyuvo J9VSSVd VNOW NV390 SDILNVILV OOld OLYANd JO GNVIS! SHL 40 dVW ---Page Break--- Free, From "to 38" ao orw or zoo ao or 30° w a oe or a0 qo oe 30" o ao er og oe 30" a0 6 ot so er

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