PULSTAR ANNUAL REPORT TO
UNITED STATES NUCLEAR REGULATORY COMMISSION

for the

Period of 1 July 1978 - 30 June 1979

Submitted by J. R. Bohannon, Jr.
Nuclear Operations Administrator
NCSU NUCLEAR REACTOR PROGRAM

Compiled by Thomas C. Bray
PULSTAR Reactor Supervisor

Reference: PULSTAR Technical Specifications
Section 6.7.5

Docket No. 50-297

Department of Nuclear Engineering
North Carolina State University
Raleigh, North Carolina
27650

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DEPARTMENT OF NUCLEAR ENGINEERING

PULSTAR REACTOR ANNUAL REPORT

For the Period: 1 July 1978 - 30 June 1979

The following report is submitted in accordance with Section 6.7.5 of the PULSTAR Technical Specifications:

6.7.5.(a): Reactor Operating Experience

(1) The NCSU PULSTAR reactor has been utilized for the following:

a.	Teaching and Short Courses	110.76 hours
b.	Graduate Research	15.16 hours
c.	Isotope Production	503.84 hours
d.	Neutron Activation Analysis	1005.52 hours
e.	NPP Reactor Operator Training	947.73 hours
f.	PULSTAR Reactor Operator Training	25.02 hours
g.	Reactor Calibrations and Measurements	159.77 hours
h.	Reactor Health Physics Surveillance	18.63 hours
i.	Tours and Visitors	25.98 hours
j.	Faculty Research	29.72 hours
	Total Hours	2842.13*
Same reporting period 1977-1978		2623.30

A cross section of experiments performed relate to these areas:

a. Development of Prompt Gamma Facility in Beam Tube No. 2.

b. Ball Milling and other flow/tracer studies.

c. Development of Neutron Radiography Unit in Beam Tube.

d. Reactor Noise Measurements Using Fuel assembly shaker and reactivity oscillator in Beam Tube No. 1.

e. Physics Tests of 5 x 5 Reflected Core No. 3.

f. Absolute Flux measurements in the PULSTAR core.

g. Neutron Activation for Analysis of Coal, Petroleum Products, Fly Ash, Animal Tissue and Rain/River water.

h. NAA of Liquid Effluents from fuel fabrication plant.

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* This applied to total hours reactor operating time devoted to the areas a-j. Multiple irradiation capability ("piggybacking") enables us to provide service to several different users simultaneously, hence the reactor utilization hours (* above) is higher by a factor of ~ 2.5 than actual operating hours.

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(2) Design Changes Accomplished:

79-1 Installation and Routine Operation of the 5 x 5 Reflected Core No. 3 --- Allows routine operation of the 5 x 5 Core reflected on two sides by graphite and equipped with rotating vertical exposure ports.

79-2 Modification to Pneumatic Transfer System for Nitrogen Injection When Operating Reactor --- Provides for reduced ^{41}Argon production when reactor is operating at full power level.

79-4 Add Check Valves to Raw Water System to Prevent Possible Cross-Contamination --- a change made to assure separation of reactor service water system and domestic water supply as described in IE Circular #77-14.

79-5 Reposition Linear Power Channel Automatic Control Energize Switch --- Authorized adjustment of auto channel energize switch as a result of D.C. 79-1.

79-6 Modification to Fission Chamber Drive Support Tube --- Provided for proper channel overlap between source range and intermediate range power measuring channels as a result of D.C. 79-1.

79-7 Reposition Low Shutdown Margin Alarm Switch --- Made necessary by shift in physical position of fuel as described in D.C. 79-1.

(3) Changes in Performance Characteristics and Operating Procedures Related to Reactor Safety:

a. Addition of 5 graphite reflector assemblies to 5 x 5 Reflected Core #1 (D.C. 79-1) altered the nuclear characteristics of the reactor core in the following manner: increased negative moderator temperature coefficient, increased excess reactivity, reduced shutdown margin and lower radial peaking factor which reduced the total peaking factor.

b. Procedure to allow adjustment of Log N Channel compensation voltage prior to reactor startup (Operations Manual change AC-145) increased Log N/Startup Channel overlap by one decade.

(4) Results of Surveillance Tests and Inspections:

The reactor surveillance program has revealed no significant or unexpected trends in reactor systems performance during the past year.

All inspections conducted of reactor systems have yielded routine results with no singularities observed.

6.7.5.(b): Total Energy Output:

742.83 MW-Hours (EFMH)
30.95 MW-Days (EFMH)

: Pulse Operations:

0

: Reactor was critical:

1176.06 Hours

: Total Cumulative Energy Output Since Initial Criticality:

3922.91 MW-Hours
163.45 MW-Days

6.7.5.(c): Number of Emergency and Unscheduled Shutdowns:

One emergency shutdown was initiated on 11 August 1978 when the Regulating Rod drive switch did not return to the neutral "off" position after rod drive. Reactor was shut down by manual scram function. See 18 August 1978 report to NRC Region II office.

: Number of Inadvertant Scrams:

39

Reasons:	(1)	Operator error	31
	(2)	Loss of campus power	2
	(3)	Linear Power Channel range switch	2
	(4)	Low Primary Flow setpoint drift	1
	(5)	Safety Flapper position switch	3

Explanation of (1) above:

Nuclear Power Plant Operator training (27)
NRP Staff operators (4)

Explanation of (2) above:

Loss of campus and hence building power normally results in a reactor shutdown.

Explanation of (3) above:

The range selector switch on the Linear Level power measuring channel had developed faulty contact make-and-break characteristics. Conventional switch contact cleaning operation provided correction.

Explanation of (4) above:

Primary coolant flow rate trip switch activated at a conservative 490 gpm rather than 475 gpm, the adjusted setpoint. Small indicated fluctuations of brief time duration are normal in the primary cooling system flow.

Explanation of (5) above:

Operator error. After having conducted reactor operator training involving routine flapper valve opening and closing, a licensed operator made a "key-on" startup and upon reaching 150 kw in his approach to rated power, the reactor tripped (as per RSS design should the flapper be open). Operator in training did not pull flapper-close handle with enough force to properly close the position switch.

6.7.5.(d): Major Maintenance Operations

None during this reporting period.

6.7.5.(e): Changes in the Facility, Procedures, Tests and Experiments

(1) Design Change 79-1, "5 x 5 Reflected Core No. 3, Installation and Routine Operation" was proposed to extend reactor fuel lifetime, optimize burnup and included the use of rotating vertical exposure ports designed to more uniformly irradiate target material.

Safety evaluation summary: "...the 5 x 5 Reflected Core No. 3 can be operated within the analytical envelope developed in the PULSTAR FSAR and the present Technical Specifications. Further it is concluded that there are no unreviewed safety questions pursuant to 10CFR 50.59, and therefore no NRC approval required."

(2) Design Change 79-2, "Modification to Pneumatic Transfer System for Nitrogen Injection when Operating Reactor" was method utilized to reduce Argon-41 production and release in and from the PULSTAR reactor facility. Earlier attempts to reduce leakage air flow through P-N system, and hence curtail ^{41}Ar production, had not been effective. Keeping system purged with nitrogen has proven to be the only reliable ^{41}Ar reduction technique.

Safety evaluation summary: "This design change does not involve an unreviewed safety question since the nitrogen injection fitting (nozzle) will not affect the operation of the reactor or the RSS."

(3) Design Change 79-4, "Add Check Valves to PULSTAR Raw Water System to Prevent Possible Cross-contamination" was made in response to IE Circular 77-14. Two series check valves and a gate valve were installed in the raw (domestic) water supply line to the reactor facility to satisfy guidelines of the NRC Circular.

Safety evaluation summary concludes: "...thus installed, the check valves addition does not constitute an unreviewed safety question since operation of the reactor will not be affected and there will be no impact on the Reactor Safety System."

(4) Design Change 79-5, "Reposition Auto Control Channel Energize Switch for use with 5 x 5 Reflected Core #3" was necessary as a result of a new ganged control rods critical position for Core #3. 5 x 5 Reflected Core #1 auto energize switch position was 14.5" but Core #3 requires the switch be moved to 13.5" due to lower ganged rods critical position -- a result of Core #3's greater k-excess.

Safety evaluation summary concludes that operation of the 5 x 5 Reflected Core #3 with the ganged Reg Rod in automatic, at a position >13.25", would not adversely alter the flux distribution in regard to the safety analysis performed for allowing operation of the 5 x 5 R.C. #3.

(5) Design Change 79-6, "Modification to Fission Chamber Drive Support Tube" was necessary for routine operation with the 5 x 5 Reflected Core #3 due to a shift in core flux produced by fuel repositioning and the relative proximity of the startup channel detector to the shifted fuel. The change raised the detector ~ two inches which yielded the desired initial count rate and enabled reactor startups with the fission chamber in the "0" position per standard operating procedure.

Safety evaluation summary, "This change does not alter the operation of the Startup Channel or its RSS inhibit functions but provides for greater safety by increasing the amount of overlap between the Startup and Log N channels."

(6) Design Change 79-7, "Reposition Low Shutdown Margin Alarm Microswitch for use with 5 x 5 Reflected Core #3" provided for repositioning the LSDM alarm microswitch at the control rods position corresponding to a 0.4% $\Delta k/k$ shutdown margin because of increased k-excess of new core.

Safety evaluation summary, "...in accordance with PULSTAR Final Safety Analysis Report, section 7.4.2., 'A microswitch is located at a pre-selected position on all control rods and if rods are not out beyond this position when the reactor power reaches 4 watts, a LSDM alarm is generated'."

(7) Procedure Change 3-78, "Emergency Plan for the NCSU PULSTAR Reactor". Rewritten to conform to ANS 15.16, Standard for Emergency Planning for Research Reactors and to include experience corrections from past drills and training.

No safety evaluation appropriate. Change made to conform to ANS standard.

(8) Procedure Change 4-78, "Revision to Calibration of Pool Level Measuring Channel procedure, PS-2-02-5:S1". Made to add precautions to decrease likelihood of damaging bubbler hose and to tighten acceptance criteria of calibration.

Safety evaluation not required. Proposed revision is more conservative than current procedure with respect to safety.

(9) Procedure Change 5-78, "Emergency Procedures for the NCSU PULSTAR Reactor". Rewritten to conform to ANS 15.16 Standard for Emergency Planning for Research Reactors.

No safety evaluation appropriate. Change made to conform to ANS standard.

(10) Procedure Change 6-78, "Revision No. 1 to Special Procedure 3.2, Fuel Handling Procedures. This change revised procedure format in conformance to SP2.1., added definitions, limitations, guidelines and precautions not detailed in original version of SP3.2.

Safety evaluation summary, "Original safety related procedural steps content has not been altered. This revision represents a more comprehensive version of the original.

(11) Procedure Change 1-79, "Revision of H. P.-20-9 and H. P.-20-10". The test instruments utilized to conduct these Health Physics procedures were replaced by improved equipment allowing increased accuracy in the measurement of pH and resistivity.

No safety evaluation appropriate.

(12) Procedure Change 2-79, "H. P.-20-14, Radiation and Contamination Survey of PULSTAR Bay" is a new formal procedure designed to comply with the requirements of 10 CFR 20.201. Technical Specification 6.7.5.g. and 10 CFR 20.201 requirements for accomplishing said surveys were being met prior to the institution of HP-20-14 and resulting data was and is being recorded and filed.

No safety evaluation is appropriate for this new procedure.

(13) Procedure Change 3-79, "Administrative Procedure 2.0, Procedure for Evaluating and Reporting Defects and Non-compliance in Accordance with 10 CFR 21". A new procedure addressing the issue of reporting possible substantial safety hazards produced by the facility, a component within the facility or some activity of the facility. Reporting procedures are therein presented to the public as well as members of the staff.

No safety evaluation is appropriate for this new administrative procedure.

(14) PULSTAR Project P-15, "Reactor Noise Experiment", describes a design to mechanically vibrate a fuel assembly in the reactor core and to measure the effect of the fuel movement on the measured reactor transfer function.

Safety evaluation summary:

(a) Reactivity worth of experiment proposed will be less than T.S. limiting value for moveable experiments.
(b) The experiment integrity will not be adversely affected by temperature change and there is no anticipated change in chemical composition or likelihood of radiolytic decomposition of the experimental equipment.
(c) Materials selection for construction of the vibrator device will be made to preclude chemical interaction with reactor components.
(d) Activation of the fuel vibrating apparatus . . . will be minimized

by separation from the core and at the proposed operating level of ~1 kw the radiation hazard to experimenting personnel will be minimal.

(15) PULSTAR Project P-16, "Preliminary Tests for Prompt Capture Gamma-Ray Research on the PULSTAR Reactor Tangential Beam Tube (No. 2)", describes an experiment to determine the effect on the reactor core of collimator and shield placement in B.T. #2 and to measure neutron and gamma-ray flux inside and outside the beam tube with and without target samples inserted near the core.

Safety evaluation summary:

(a) The reactivity effect of placing lead and graphite collimators near the core in beam tube #2 will be less than 0.6% $\Delta k/k$.
(b) The shielding and collimators in the beam tube will not be exposed to water and these materials can easily withstand the range of temperatures that exist in the beam tube.
(c) The lead and concrete collimators will be enclosed in aluminum or cadmium or will be painted with a sealer and samples introduced will be doubly encapsulated in plastic vials. Hence, interaction of physical or chemical nature will not occur between experimental and reactor components.
(d) Radiation levels generated during the course of this experiment will not be significant and will originate primarily from scattering or activation from target materials inside the beam tube.

6.7.5.(f): Radioactive Effluents

Liquid Wastes (by Quarter)

1. Radioactivity Released During the Reporting Period

(a) No. Batches	(b) Total Activity μCi/ml	(c) Volume Released liters	(d) Diluent Volume liters	(e) Tritium Activity μCi	(Period)
27	76.58	93,300	1.372E7	126.68	1 July - 30 Sept 1978
15	39.11	47,070	1.372E7	0.00	1 Oct - 31 Dec 1978
18	16.73	57,410	1.372E7	71.53	1 Jan - 31 March 1979
12	33.06	38,100	1.176E7	0.00	1 April - 30 June 1979

(f) 165.48 μCi total activity released

(g) 198.21 μCi total Tritium activity released.

2. Identification of Fission and Activation Products

The radioactive concentration in any batch released this past year did not exceed 4 E-5 μCi/ml. Therefore, fission and/or activation products were not identified.

3. Disposition of Liquid Effluents Not Released to the Sanitary Sewer System.

The concentration of radioactivity in each batch of liquid waste at this facility during the past year was less than 4 E-7 μCi/ml when the authorized daily dilution factor was considered. Therefore, all batches could be and were released to the sanitary sewer system. This paragraph was not applicable during the year 1978-1979.

Gaseous Wastes

1. Radioactivity Discharged During the Reporting Period (in curies) for:

(a) Gases

	Period	μCi/ml	Time hrs.	Ci
1978:	1 May - 17 July	4.32E-8	1855.30	2.72
	17 July - 21 Sept	5.63E-8	1583.18	3.03
	21 Sept - 20 Oct	5.39E-8	696.75	1.28
	20 Oct - 20 Nov	4.56E-8	775.42	1.20
	20 Nov - 19 Dec	4.81E-8	707.00	1.16

Period	µCi/ml	Time hrs.	Ci
1979: 19 Dec - 15 Jan	2.01E-8	639.92	0.44
15 Jan - 14 Feb	4.03E-8	717.83	0.98
14 Feb - 19 Mar	2.90E-8	791.42	0.78
19 Mar - 17 Apr	1.85E-8	728.30	0.46

The following two (2) periods are reported so that the next "year" over which the gaseous effluent may average more nearly conforms to the annual reporting period:

1979: 17 Apr - 16 May	2.06E-8	795.62	0.56
16 May - 18 Jun	2.88E-8	779.92	0.76

(b) Neither the Constant Air Monitor in the Bay nor the Particulate Monitor in the exhaust stack evidenced any particulate released having a half life in excess of eight (8) days.

2. The gaseous activity released during this past year was A-41 in the amount of 12.05 Ci or 4.17E-8 µCi/ml averaged over 8495.12 Hrs.

A nitrogen purge of the experimental facility the Pneumatic System (P-N) was installed in March, 1979, to reduce the production of A-41. This purge is to be turned on during periods of reactor operation when the P-N System is not to be used. The effectiveness of this purging can be seen by comparing the periods.

1979: 19 Mar - 17 Apr	1.85E-8	728.30	0.46
17 Apr - 16 May	2.06E-8	795.62	0.56
16 May - 18 Jun	2.88E-8	779.92	0.76

with the other periods during the past year.

The MPC for A-41 in an unrestricted area is 4E-8 µCi/ml.

Solid Waste

1. Total Volume of solid waste -- 35 $ft.^3$.

2. Total Activity -- 0.007667 curies

3. Dates of shipments and disposition:

11 July 1978	Burial by Chem-Nuclear
15 September 1978	Burial by Chem-Nuclear
17 October 1978	Burial by Chem-Nuclear
22 November 1978	Burial by Chem-Nuclear
20 December 1978	Burial by Chem-Nuclear
6 February 1979	Burial by Chem-Nuclear
27 June 1979	Burial by Chem-Nuclear

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6.7.5.(g): Personnel Radiation Exposure Report (Reporting Period - 1 June 1978 - 31 May 1979)

Name	Total dose (rem)
Staff	
Bilyj, Stephen J.	0.222
Bohannon, Jr., James R.	0.098
Brackin, Thomas L.	0.077
Bray, Thomas C.	0.177
Cross, Robert D.	0.098
Douglas, William G.	0.130
Dunn, William L.	0.103
Eudy, Lucille P.	0.119
Gant, D. Michael	0.150
Gurkin, Louis M. (6/1/78-11/30/78)	0.067
Lewis, Luther E.	0.019
Miller, Garry D.	0.158
Price, Leslie F. (5/1/79-5/31/79)	0.013
Rhiner, Glenda D.	0.0
Thorsen, Leigh A. (6/1/78-9/30/78)	0.025
Weaver, Jack N.	0.036
Faculty	
Elleman, Thomas S.	0.130
Gardner, Robin P.	0.080
Kohl, Jerome	0.119
Murray, Raymond L.	0.392
Saxe, Raymond F.	0.056
Stam, Ephraim	0.088
Verghese, Kuruvilla	0.066
Zumwalt, Lloyd R.	0.072
Radiation Protection Office Personnel	
Ball, Arthur C.	0.056
Caruthers, L. Thomas	0.0
Clark, Samuel T. (6/1/78-2/28/79)	0.012
Corbett, E. Marcelle	0.038
Debnam, Joshua	0.014
Freeman, Ralph M.	0.012
Grady, Stanley M.	0.148
Howard, Suzanne M.	0.0
Mangum, Royelle O.	0.123
Morgan D. William	0.0
Custodians	
Dunn, Johnnie J.	0.040
Jones, Arthur	0.037
Sanders, Joseph	0.051

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Students

79 film badges were issued to Nuclear Engineering Department students during the reporting period. No significant radiation exposures were reported. The majority of the radiation exposures were in the 'no measurable exposure' range.

Visitors and Short Courses

804 film badges were issued to visitors and participants in short courses during the reporting period. No significant radiation exposures were reported. The majority of the radiation exposures were in the 'no measurable exposure' range.

The shield for the Neutron Radiography Unit (NRU) has been improved with each iteration. Thus, the radiation levels in the PULSTAR Bay have been significantly reduced. Routine work can be undertaken in the Bay with only normal precautions applicable to any Radiation Area. Plans are being formulated to further refine and improve the NRU shield.

Summary of Radiation and Contamination Surveys

Routine contamination surveys in the Bay by the RPO have not disclosed any contaminated spots. Special contamination surveys made upon completion of RWP's have found evidence of unsuccessful clean-up after the work under the RWP. These spots were subsequently cleaned. This surveillance has maintained a clean Bay working area.

The Radiation and Contamination Surveys, giving due consideration to the influence of the NRU shielding, do not show any indication of change of radiation levels in the Bay.

ENVIRONMENTAL RADIATION SURVEILLANCE REPORT
AND ANALYSIS PROCEDURES

APRIL 1, 1978 TO SEPTEMBER 30, 1978

Arthur C. Ball, Environmental Health Physicist
Joshua Debnam, Environmental Chemist

Radiation Protection Council
L. T. Caruthers, Radiation Protection Officer
D. W. Morgan, Associate Radiation Protection Officer
North Carolina State University
Raleigh, North Carolina

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1. INTRODUCTION

The Environmental Radiation Surveillance (ERS) program at North Carolina State University has been in operation on a limited basis since August 1970 and as a funded program since July 1973. During these first five years as a funded operation, the program has grown to maturity. Local analyses now include gross alpha and beta counting of air, water, soil, vegetation, and sewage. Gamma analysis is performed on air, water, soil, vegetation, and milk. Strontium-90 analysis is performed on water, milk, sewage, and waste water.

In order to perform the large and still growing number of analyses, the ERS staff of two full time persons and one part time student assistant utilize a well equipped laboratory. In addition to chemicals and chemistry apparatus, the laboratory includes a Beckman Widebeta II Low Background Alpha and Beta Counter and a Nuclear Data ND-100, 4096 Channel Gamma Analyzer used with a Ge(Li) Detector and NaI(Tl) Compton Suppression Unit on one half of the memory, and a 4" x 4" NaI(Tl) Detector Crystal with a 1" x 2" Well on the second half.

The Ge(Li) system, having high resolution (but low efficiency), is used to identify specific radionuclides in air, water, vegetation, and soil samples. Counting times are necessarily long as activities are low.

The NaI Well Crystal is used for detection of specific radionuclides where identification is known and higher efficiency is required. Iodine-131 detection in air and milk samples is the primary function of this system.

Gamma spectra from samples counted on both detectors are stored on magnetic tape and analyzed on the IBM-370 Model 165 computer at the Triangle Universities Computer Center (TUCC). NaI(Tl) spectra are first examined on the Cathode Ray Tube (CRT) on the ND-100 by means of overlaying a background spectrum of similar counting time. Any photopeaks observed are then analyzed by means of the Gauss analysis program. Ge(Li) spectra are analyzed for all gamma photopeaks by means of the MONSTR Program which was made available by Oak Ridge National Laboratories in late 1975.

Calculations for specific activities for all samples are accomplished on a Wang Model 462 Programmable Electronic Calculator.

2. AIR MONITORING

Airborne particles are collected with high volume samplers equipped with 6" x 9" glass fiber filters and millipore pumps equipped with 47 mm millipore filters and activated charcoal cartridges.

These samplers are located in five sampling stations on the NCSU campus (see Table 2.1) and operate for six hours a day, Monday through Friday of each week. Samplers are turned on and off by a seven-day clock switch with actual time of run recorded on an electric timer which is switched on and off simultaneously with the samplers.

After a ten-day decay period to eliminate naturally occurring radon and thoron daughters, the 6" x 9" glass fiber filters are combined for a composite sample and analyzed with the Ge(Li) Detector and ND-100 Gamma Analyzer. The spectra are then put on magnetic tape and gamma activity is determined by use of the MONSTR Program on TUCC IBM 370 Computer.

The millipore filters are counted for 100 minutes each for gross alpha and beta activity (also after a ten-day decay period) with the Widebeta II. The charcoal cartridges are analyzed immediately as a composite sample for halogen activity by means of a long count (over the weekend following Friday collection) on the 4" x 4" NaI(Tl) Crystal and ND-100 Gamma Analyzer.

Determination of halogen activity in gaseous form is accomplished by means of the overlay feature of the CRT on the ND-100. The sample spectrum is displayed simultaneously with a background spectrum of similar counting time. Gamma peaks above background which are observed in the sample spectrum may then be measured to determine specific activity by means of the computer program "GAUSS" and the TUCC Computer. To date, no gaseous halogen has been detected in air samples. Iodine activity which has been reported following atmospheric nuclear detonations in the Peoples Republic of China has been measured on the glass fiber filters indicating that the halogen has attached itself to dust particles and is no longer in gaseous form.

Gross alpha and beta activity is calculated from the Widebeta II printout and reported as Specific Activity in femto Curies per Cubic Meter (SA fCi/M^3).

$$SA = \frac{C - B}{U} \pm \frac{1}{U}\sqrt{C + B + .0025\,(C - B)^2}$$

where C = Sample counts per 100 min

B = Background counts per 100 min

$$U = \left(.222\ \frac{\text{dis}}{(100\ \text{min})(\text{fCi})}\right)(\text{Volume})(\text{Efficiency})$$

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For a sample collection time of 30 hours at a flow rate of 30 liters per minute:

$$\text{Volume} = \left(30 \frac{\text{liters}}{\text{min}} \right)(30 \text{ hrs})(60 \text{ min/hr})\left(\frac{M^3}{1000 \text{ liters}} \right) = 54 \ M^3$$

Efficiency = .278 for alpha in the millipore configuration

.380 for beta in the millipore configuration

therefore, U = 3.33 for alpha

4.56 for beta

This problem is solved on the Wang Calculator with program "Gross α and $\beta \pm 1 \sigma$" Verification No. 234 or "SA Beta Air" Verification No. 309.

Specific Activity for gamma emitters is calculated from the computer printout for the spectrum and is also reported as Specific Activity in fCi/M^3. The fission products reported as present in air samples do not normally appear in background speccra; thus, it is not necessary to substract background peaks from sample peaks.

$$SA = \gamma/\text{sec} \left(\frac{\text{sec fCi}}{3.7 \times 10^{-5} \ \gamma} \right) \left(\frac{1}{IV} \right) 2^{10/T_{\frac{1}{2}}} \pm SA \sqrt{\sigma_\gamma^{\ 2} + .0025}$$

where γ/sec is taken from the MONSTR printout or converted from the area of the peak as determined from the GAUSS printout

I = Intensity (or abundance) of the gamma

V = Volume of sample

$T_{\frac{1}{2}}$ = Half-life of nuclide in days

σ_γ = Standard deviation of counts per sec taken from MONSTR printout or converted to decimal from GAUSS printout.

This problem is solved on the Wang Calculator with program "γ Specific Activity" Verification No. 413.

During the period of this report, airborne activity has generally been declining following the last atmospheric test at the Lop Nor test site in March 1978. Typical lung hazard fission products are reported in Table 2.3 and other fission products associated with the Chinese testing are reported in Table 2.4. Gross beta activity is reported in Table 2.2. No significant alpha activity has been detected.

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Table 2.1 Air Particle Sampling Locations

Designation	Direction[1]	Distance[2]	Elevation[3]
Broughton	Southwest	410 ft.	- 55 ft.
David Clark Lab (DCL)	West		
Library	Northwest	629 ft.	+ 36 ft.
Riddick	Southeast	325 ft.	- 46 ft.
Withers	Northeast	270 ft.	- 19 ft.

[1]Direction - Direction from Reactor Stack

[2]Distance - Distance from Reactor Stack

[3]Elevation - Elevation with respect to top of Reactor Stack

- -

Table 2.2 Airborne Gross Beta Activity ($fCi/M^3 \pm 1\sigma$)

Date	Broughton	DCL	Library	Riddick	Withers
1978					
4/3-4/7	264.6 ± 15.7	233.4 ± 14.1	130.1 ± 9.1	221.3 ± 13.5	219.8 ± 13.5
4/10-4/14	334.5 ± 19.1	307.9 ± 17.8	280.9 ± 16.4	315.8 ± 18.1	330.5 ± 18.9
4/17-4/21	59.6 ± 5.7	48.6 ± 5.2	36.3 ± 4.7	57.6 ± 5.6	45.1 ± 5.1
4/24-4/28	170.5 ± 11.0	166.6 ± 10.8	145.7 ± 9.8	181.3 ± 11.5	27.0 ± 4.4
5/1-5/5	142.4 ± 9.6	125.5 ± 8.8	81.3 ± 6.7	149.9 ± 9.9	132.2 ± 9.1
5/8-5/12	108.6 ± 7.9	107.5 ± 7.8	103.5 ± 7.7	90.8 ± 7.1	118.5 ± 8.4
5/15-5/19	44.6 ± 4.9	46.7 ± 5.2	27.3 ± 4.2	52.7 ± 5.3	49.5 ± 5.2
5/22-5/26	120.7 ± 8.6	130.5 ± 9.0	118.9 ± 8.5	89.9 ± 7.1	156.3 ± 10.3
5/29-6/2	129.2 ± 8.9	101.9 ± 7.6	118.7 ± 8.4	3.7 ± 3.3	97.8 ± 7.4
6/5-6/9	78.7 ± 6.7	65.7 ± 6.1	63.5 ± 5.9	79.6 ± 6.7	82.6 ± 6.8
6/12-6/16	165.9 ± 10.8	151.9 ± 10.1	127.9 ± 8.9	165.0 ± 10.7	146.1 ± 9.8
6/19-6/23	163.9 ± 10.7	152.9 ± 10.21	138.9 ± 9.5	146.6 ± 9.9	175.2 ± 11.3
6/26-6/30	148.8 ± 9.9	111.8 ± 8.2	108.1 ± 8.0	113.8 ± 8.3	101.5 ± 7.7
7/3-7/7	83.7 ± 6.8	85.5 ± 6.9	72.3 ± 6.3	73.8 ± 6.3	Not Operational
7/10-7/14	117.6 ± 8.4	108.4 ± 7.9	104.2 ± 7.7	103.1 ± 7.7	90.5 ± 7.1
7/17-7/21	146.8 ± 9.9	129.0 ± 8.9	123.5 ± 8.7	130.5 ± 9.1	141.9 ± 9.6
7/24-7/28	49.2 ± 5.1	44.6 ± 4.9	35.4 ± 4.5	42.9 ± 4.8	43.3 ± 4.9
7/31-8/4	64.6 ± 5.8	53.7 ± 5.5	52.5 ± 5.2	66.4 ± 5.8	62.9 ± 5.7
8/7-8/11	48.6 ± 5.3	58.0 ± 5.6	38.9 ± 4.9	44.4 ± 5.1	41.5 ± 4.9
8/14-8/18	60.0 ± 5.7	54.7 ± 5.4	48.1 ± 5.1	54.[illegible] ± 5.4	61.5 ± 5.7
8/21-8/25	96.3 ± 7.4	104.4 ± 7.7	80.2 ± 6.6	105.3 ± 7.8	90.3 ± 7.1
8/28-9/1	48.6 ± 5.1	49.5 ± 5.1	42.2 ± 4.8	44.6 ± 4.9	61.3 ± 5.7
9/4-9/8	65.9 ± 5.9	85.9 ± 6.8	80.4 ± 6.6	88.1 ± 6.9	86.4 ± 6.8
9/11-9/15	95.0 ± 9.3	91.4 ± 9.1	88.1 ± 8.9	92.1 ± 9.1	109.4 ± 9.9
9/18-9/22	80.2 ± 8.4	75.2 ± 8.2	69.8 ± 7.9	63.3 ± 7.7	92.8 ± 9.0
9/25-9/29	96.4 ± 9.1	78.1 ± 8.3	70.1 ± 7.9	91.7 ± 8.9	80.2 ± 8.4

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Table 2.3 Airborne Particulate Specific Activity (γ emitters)
(Campus Average fCi/M^3 $\pm$ 1 σ)

Date 1978	^{144}Ce	^{141}Ce	^{103}Ru	^{106}Ru	^{95}Zr	^{95}Nb
4/3-4/7	64.3 ± 3.7	5.5 ± 0.5	8.6 ± 0.6	11.9 ± 1.4	6.8 ± 0.8	13.1 ± 0.8
4/10-4/14	79.4 ± 4.4	8.2 ± 0.7	14.7 ± 0.7	14.3 ± 3.1	9.2 ± 1.0	16.2 ± 1.0
4/17-4/21	15.2 ± 1.6	0.96 ± .3	< 0.5	< 5.0	< 1.0	4.6 ± 0.5
4/24-4/28	55.8 ± 3.2	< 1.0	1.7 ± 0.3	14.6 ± 2.4	4.3 ± 0.7	9.6 ± 0.7
5/1-5/5	46.5 ± 2.9	1.6 ± 0.4	1.5 ± 0.3	13.8 ± 2.7	4.4 ± 0.7	8.7 ± 0.6
5/8-5/12	32.3 ± 2.7	< 1.0	< 0.5	< 5.0	3.3 ± 0.9	11.5 ± 1.2
5/15-5/19	12.4 ± 1.6	< 1.0	< 0.5	< 5.0	2.0 ± 0.6	< 0.5
5/22-5/26	47.6 ± 3.0	< 1.0	< 0.5	6.3 ± 1.5	< 1.0	7.2 ± 0.6
5/29-6/2	42.4 ± 2.8	< 1.0	< 0.5	8.4 ± 2.0	3.7 ± 1.0	6.5 ± 0.6
6/5-6/9	24.6 ± 2.1	< 1.0	< 0.5	9.5 ± 2.9	2.7 ± 0.6	5.4 ± 0.6
6/12-6/16	49.8 ± 3.0	< 1.0	< 0.5	< 5.0	3.1 ± 0.6	6.9 ± 0.6
6/19-6/23	61.9 ± 3.6	< 1.0	< 0.5	14.5 ± 2.8	2.9 ± 0.6	6.9 ± 0.6
6/26-6/30	31.4 ± 2.4	< 1.0	< 0.5	< 5.0	< 1.0	1.4 ± 0.5
7/3-7/7	25.4 ± 2.0	< 1.0	< 0.5	< 5.0	0.8 ± 0.3	3.3 ± 0.5
7/10-7/14	30.6 ± 2.4	< 1.0	< 0.5	10.9 ± 2.9	1.4 ± 0.5	3.5 ± 0.6
7/17-7/21	36.3 ± 2.6	< 1.0	< 0.5	12.5 ± 2.9	< 1.0	3.8 ± 0.6
7/24-7/28	11.7 ± 1.7	< 1.0	< 0.5	< 5.0	< 1.0	< 0.5
7/31-8/4	11.5 ± 1.8	< 1.0	< 0.5	< 5.0	< 1.0	< 0.5
8/7-8/11	7.3 ± 1.7	< 1.0	< 0.5	< 5.0	< 1.0	< 0.5
8/14-8/18	9.2 ± 2.2	< 1.0	< 0.5	< 5.0	< 1.0	1.2 ± 0.6
8/21-8/25	26.8 ± 2.4	< 1.0	< 0.5	< 5.0	< 1.0	2.6 ± 0.7
8/28-9/1		< 1.0	< 0.5	< 5.0	< 1.0	< 0.5
9/4-9/8	12.9 ± 1.7	< 1.0	< 0.5	< 5.0	< 1.0	1.7 ± 0.7
9/11-9/15	13.6 ± 1.6	< 1.0	< 0.5	< 5.0	< 1.0	1.4 ± 0.6
9/18-9/22	5.9 ± 1.5	< 1.0	< 0.5	< 5.0	< 1.0	< 0.5
9/25-9/29	8.5 ± 1.7	< 1.0	< 0.5	< 5.0	< 1.0	< 0.5

Table 2.4 Other Fission Products Detected in Air Samples (fCi/M^3 ± 1 σ)

Isotope	4/3 - 4/7	4/10-4/14	4/17 - 4/21
^{131}I	6.1 ± 0.7	< 1.0	< 1.0
^{137}Cs	8.0 ± 0.6	9.6 ± 0.7	1.4 ± 0.4
^{140}Ba	7.6 ± 0.8	13.9 ± 1.8	< 1.0
^{140}La	8.3 ± 2.5	11.6 ± 3.6	< 1.0

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3. MILK

Milk is collected from the NCSU Dairy on a monthly basis. Samples are analyzed for Strontium-90 activity according to the procedures in Appendix A. Milk is also analyzed for Iodine-131 activity as follows:

> 500 ml of milk is put into a 1000 ml beaker. 20 gm of Dowex 1-X8, 200-400 mesh anion exchange resin is added and the sample is stirred on a magnetic stirrer for thirty minutes. The resin is allowed to settle, transferred to a 20 ml vial and counted for gamma activity in the well of the 4" x 4" NaI(Tl) Crystal for 99,000 sec. The spectrum is then examined on the ND-100 CRT display and compared to a background spectrum with the use of the overlap feature of the ND-100. If an Iodine peak were observed, it would be evaluated with the use of the GAUSS Program and the TUCC Computer.

To date no Iodine-131 has been detected in the milk from the NCSU Dairy. This may be attributed to the fact that the cattle producing this milk are primarily silage fed, and therefore, would not generally ingest substantial quantities of the short lived nuclide Iodine-131 (half-life = 8.041 days).

Tests conducted on spiked samples of milk have shown the Iodine procedure to be approximately 95% efficient and the NaI(Tl) Crystal has a 51% efficiency for the 364.5 KeV gamma emitted by Iodine-131 in a sample counted in the well of the crystal. The intensity (or abundance) of the 364.5 KeV gamma is 82% giving a 40% total efficiency for this procedure.

Table 3.1 Milk Specific Activity (pCi/l ± 1 σ)

Date	^{90}Sr	^{131}I
4/78	5.19 ± 0.61	< 2.0
5/78	4.26 ± 0.54	< 2.0
6/78	3.37 ± 0.47	< 2.0
7/78	5.87 ± 0.49	< 2.0
8/78	3.14 ± 0.48	< 2.0
9/78	3.20 ± 0.70	< 2.0

4. SURFACE WATER

Surface water is collected from Rocky Branch Creek at two locations: ON - where the creek flows onto NCSU campus and OFF - where the creek flows off of NCSU campus. Samples are collected in five-gallon Nalgene containers. (These containers hold 19 liters when filled to the top.) Care is taken when filling the containers to avoid floating debris and bottom sediment.

Surface water is analyzed for gross alpha and beta activity according to the procedures in Appendix B and for gamma activity according to the procedures in Appendix C. Following gamma analysis, the condensed 18-liter sample is diluted to 500 ml and analyzed for Strontium-90 activity according to procedures in Appendix A.

Specific Activities for surface water samples are reported in Table 4.1. No unusually high readings of Strontium-90 were noted during this reporting period; hence, the hypothesis of a delay in fallout from atmospheric nuclear tests being washed into Rocky Branch Creek remains unverified at this time.

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Table 4.1 Surface Water Specific Activity (pCi/l $\pm 1\sigma$)

Date	Location*	^{137}Cs	^{58}Co	^{60}Co	^{40}K	^{90}Sr	Gross Beta
April	ON	< 0.1	< 0.2	< 0.2	17.98 ± 24.01	0.26 ± 0.02	6.01 ± 0.49
1978	OFF	< 0.1	< 0.2	< 0.2	8.89 ± 23.97	0.51 ± 0.04	8.08 ± 0.59
May	ON	< 0.1	< 0.2	< 0.2	6.13 ± 26.31	0.51 ± 0.04	5.49 ± 0.45
1978	OFF	0.68 ± 0.55	< 0.2	< 0.2	< 2.0	0.75 ± 0.05	5.90 ± 0.47
June	ON	1.35 ± 0.33	< 0.2	< 0.2	< 2.0	0.21 ± 0.02	3.55 ± 0.36
1978	OFF	1.49 ± 0.37	< 0.2	< 0.2	14.97 ± 27.85	0.35 ± 0.03	3.67 ± 0.37
July	ON	< 0.1	< 0.2	< 0.2	< 2.0	0.37 ± 0.03	3.23 ± 0.37
1978	OFF	< 0.1	< 0.2	< 0.2	23.70 ± 22.32	0.29 ± 0.03	6.18 ± 0.50
Aug	ON	< 0.1	< 0.2	< 0.2	< 2.0	0.64 ± 0.04	5.40 ± 0.46
1978	OFF	0.10 ± 0.42	< 0.2	< 0.2	< 2.0	0.59 ± 0.04	5.78 ± 0.48
Sept	ON	< 0.1	< 0.2	< 0.2	< 2.0	0.50 ± 0.04	3.91 ± 0.38
1978	OFF	< 0.1	< 0.2	< 0.2	< 2.0	0.52 ± 0.04	3.86 ± 0.38

*ON - Denotes Rocky Branch Creek as it enters NCSU campus

OFF - Denotes Rocky Branch Creek as it leaves NCSU campus

5. SOIL

Soil samples are collected in January and July of each year. Surface samples are taken at four sites on or near campus and deep samples (4.5 feet below surface) are taken outside of the radioactive materials burial ground. An additional deep sample was taken this reporting period in the vicinity of the West sample for comparison purposes.

The locations of the four surface samples are: North - near Bell Tower; South - between Morrill Drive and Western Blvd.; East - next to Rocky Branch Creek as it flows off of NCSU campus; West - next to Rocky Branch Creek as it flows onto NCSU campus.

Soil samples are screened to remove rocks and vegetation matter, then ashed in a muffle furnace at 520°C for 96 hours. Approximately 0.1 gram from each sample is transferred to an aluminum planchet and counted for gross alpha and beta activity and approximately 50 grams are transferred to a plastic dish and analyzed on the Ge(Li) Crystal for gamma activity.

Following 100 minute counts each for alpha and beta activity, gross specific activities are calculated as follows:

$$SA = \frac{C - B}{U} \pm \frac{1}{U}\sqrt{C + B + .0025(C - B)^2}$$

where C = Sample counts per 100 min

B = Background counts per 100 min

$U = (\text{Efficiency})(\text{Mass})(222\ \frac{\text{dis/100 min}}{\text{pCi}})$

Efficiency = .278 for α

.380 for β

This problem is solved on the Wang Calculator with program "Gross α or $\beta \pm 1\sigma$" Verification No 234.

Soil samples to be scanned for gamma activity are weighed in small plastic dishes, placed in the Compton Suppression Well above the Ge(Li) Detector, and counted for 100,000 seconds each. The spectra are transferred to magnetic tape and sent to TUCC for analysis by the MONSTR program on the TUCC Computer.

Specific Activity for gamma emitters is calculated from the computer print-out for the spectrum and is reported in Table 5.1 in picoCuries per gram.

The gamma energies from nuclides normally found in soil samples do occur in background spectra and are long-lived so they do not require decay time correction.

$$SA = \frac{C - B}{U} \pm \frac{1}{U} \sqrt{\sigma_C^2 + \sigma_B^2 + .0025\ (C - B)^2}$$

where C = γs per sec from sample spectrum

B = γs per sec from background spectrum

$U = (.037\ \frac{\text{dis per sec}}{\text{picoCurie}})(\text{Intensity})(\text{Mass})$

σ_C = Sample error from printout

σ_B = Background error from printout

This problem is solved on the Wang Calculator with program "Sp Act γ with Bkg" Verification No. 359.

Table 5.1 Soil Specific Activity (pCi/gm ± 1 σ)

Location*	Gross α	Gross β	^{228}Th	^{226}Ra	^{137}Cs	^{40}K
North	4.86±0.98	9.72±2.08	0.707±0.487	0.650±0.408	1.078±0.197	< 0.4
South	4.05±0.90	17.31±2.39	0.303±0.466	0.804±0.378	4.007±0.286	< 0.4
East	6.48±1.12	34.26±3.15	1.530±0.462	1.556±0.377	0.872±0.177	34.811±8.561
West	4.05±0.90	21.10±2.60	1.231±0.454	1.105±0.362	0.141±0.161	9.032±8.233
W(4.5')	1.94±0.66	13.63±2.21				
OBG(4.5')	3.06±0.84	15.39±2.47				
NBG(4.5')	5.20±1.06	28.06±3.01				

*Location - Denotes direction from reactor
Burial Ground samples are in near proximity to fence
NBG denotes New Burial Ground
OBG denotes Old Burial Ground (not presently in use)
4.5' denotes depth of sample; others are at surface

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6. VEGETATION

Edible crops (corn and soy beans) are collected from the NCSU Farm at harvest time and analyzed for gross alpha and beta activity and specific gamma emitters. Pine needles and grass samples are collected in January and July and are also analyzed for gross alpha and beta and specific gamma activities.

During this reporting period, only one pine needle sample and one grass sample were taken. These were in the vicinity of the South soil sample. Specific Activities are reported in Table 6.1.

Procedures for preparation and analysis of vegetation samples are reported in Appendix D.

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Table 6.1 Vegetation Specific Activity (pCi/gm ± 1 σ)

Sample	Gross α	Gross β	^{137}Cs	^{40}K
Pine	0.064 ± .014	4.784 ± 0.258	< 0.02	5.17 ± 1.73
Grass	0.058 ± .021	9.686 ± 0.525	< 0.03	10.70 ± 4.32

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7. REACTOR WASTE TANKS AND SEWAGE

Reactor waste tank monitoring has never been considered a part of Environmental Radiation Surveillance (ERS); however, gross alpha and beta determinations have been carried out by Radiation Survey Technicians prior to release of tank contents into the Raleigh sewage system. The ERS personnel have developed a procedure for the determination of Strontium-90 in waste tank water and the specific activities determined are reported in Table 7.1 along with the gross alpha and beta activities for the same samples.

Sewage water from the Raleigh treatment plant is being analyzed for gross alpha and beta and Strontium-90 activity as an addition to the ERS program. These specific activities are reported in Table 7.1 along with the reactor waste tank specific activities.

Procedures for gross alpha and beta analysis of sewage water and Strontium-90 analysis of both sewage water and waste tank water are in Appendices E and F respectively.

Table 7.1 Waste Tank and Sewage Specific Activity (pCi/l ± 1 σ)

Sample	Gross α	Gross β	^{90}Sr
WT #1 June	< 0.5	587.1 ± 30.6	1.23 ± 0.25
WT #2 June	< 0.5	667.9 ± 34.6	1.38 ± 0.26
WT #2 July	< 0.5	332.0 ± 18.6	0.77 ± 0.22
WT #3 July	< 0.5	352.6 ± 19.6	0.88 ± 0.23
WT #2 Aug	< 0.5	65.2 ± 5.6	0.96 ± 0.22
WT #3 Aug	< 0.5	< 5.0	0.45 ± 0.21
WT #1 Sept	< 0.5	57.9 ± 5.2	1.44 ± 0.25
WT #3 Sept	< 0.5	39.4 ± 4.5	2.40 ± 0.29
May Sewage	< 0.1	10.45 ± 0.88	1.16 ± 0.45
July Sewage	< 0.1	10.48 ± 1.33	1.73 ± 0.58
Sept Sewage	< 0.1	15.44 ± 1.47	1.69 ± 0.65

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8. THERMOLUMINESCENT DOSIMETERS (TLDs)

TLD packages of two LiF chips and one $CaSO_4$:Dy dosimeter are located at the five air sampling stations on the NCSU campus and at six reactor monitoring stations. A control package is also kept in Room 214 David Clark Laboratories away from ionizing radiation sources. Locations of all TLD stations are indicated in Table 8.1.

LiF TLDs are exchanged monthly and read locally for exposure. $CaSO_4$:Dy TLDs are also exchanged monthly and sent to Teledyne Isotopes for analysis. Transit dosimeters accompany those shipped to Teledyne so that exposure accumulated during transit may be subtracted from exposure received on station.

Abnormally high readings for the locally analyzed dosimeters located on the West Wall of the PULSTAR Reactor Bay for August and September may be attributed to open beamport work conducted during those months. Low readings for corresponding contracted dosimeters are unexplained.

TLD exposure is reported in Table 8.2 as average weekly exposure (mR/wk).

$$mR/wk = \left(\frac{E - T}{D} \right) 7$$

where E = Exposure Reading for TLD

T = Transit Reading (if applicable)

D = Time on Station for TLD (in days)

7 = days in week

This problem is solved on the Wang Calculator with program "TLD Weekly Avg" Verification No. 184.

Table 8.1 Thermoluminescent Dosimeter (TLD) Locations

Designation	Location
Broughton	410 ft. southwest of and 55 ft. below top of Reactor Stack
DCL	Roof of David Clark Laboratories
Library	629 ft. northwest of and 36 ft. above top of Reactor Stack
Riddick	325 ft. southeast of and 46 ft. below top of Reactor Stack
Withers	270 ft. northeast of and 19 ft. below top of Reactor Stack
Control	Room 214 David Clark Laboratories
R-3	Entrance to NCSUR-3 Reactor Bay from Control Room
PULSTAR	PULSTAR Reactor Bay, West Wall
Equipment Room	PULSTAR Equipment Room East of PULSTAR Bay
Control Room	PULSTAR Control Room
Pool	Over PULSTAR Reactor Pool
Stack	Top of PULSTAR Reactor Stack

Table 8.2 Thermoluminescent Dosimeter Readings (Average mR/wk based on Co-60 Standard)

Area Monitors	*	4-78	5-78	6-78	7-78	8-78	9-78
Broughton	L	2.3	2.6	2.3	1.9	1.9	1.9
Broughton	C	2.7	1.3	1.9	X	0.3	2.9
DCL	L	1.6	1.9	1.1	1.3	1.3	1.3
DCL	C	2.0	1.0	1.1	X	0.5	2.1
Library	L	2.6	2.7	2.1	2.2	2.1	2.2
Library	C	1.8	1.4	1.7	X	0.8	2.3
Riddick	L	2.9	2.7	2.3	2.2	2.2	2.1
Riddick	C	2.5	1.6	2.0	X	0.2	3.2
Withers	L	1.9	2.3	1.9	1.8	1.6	1.9
Withers	C	1.6	1.1	1.7	X	0	2.8
Control	L	2.5	2.0	2.5	1.8	1.4	1.8
Control	C	2.0	1.3	1.4	X	1.6	1.9
Reactor Monitors							
R-3	L	5.1	5.4	4.7	4.7	4.2	4.4
R-3	C	3.6	2.2	3.2	X	1.4	4.1
PULSTAR	L	26.4	35.0	86.3	129.0	299.1	150.2
PULSTAR	C	13.7	12.7	14.1	X	21.3	15.4
Equipment Room	L	25.4	29.1	22.0	21.0	25.6	23.1
Equipment Room	C	19.4	13.8	17.2	X	18.8	17.5
Control Room	L	6.4	7.3	9.4	10.4	23.5	13.0
Control Room	C	4.4	3.5	3.9	X	3.5	4.7
Pool	L	36.2	41.0	38.4	42.5	71.9	51.8
Pool	C	26.2	22.6	24.3	X	28.7	26.3
Stack	L	3.8	3.0	2.1	1.8	2.6	2.6
Stack	C	2.0	1.3	1.5	X	0.7	2.5

* L Denotes Locally Evaluated LiF Dosimeters

* C Denotes $CaSO_4$:Dy Dosimeters Contracted to Teledyne Isotopes for analysis

X Teledyne reports that Contracted dosimeter readings for July were lost during a company relocation

APPENDIX A

^{90}Sr PROCEDURE FOR MILK AND WATER

Phase 1

1. Put 500 ml milk into 1000 ml beaker, or dilute water sample to 500 ml in 1000 ml beaker.
2. Add 30 gm Dowex 50W-X8 200-400 mesh resin and stir for one (1) minute on magnetic stirrer.
3. Adjust pH to 6.0 with pH Meter using 6 M NaOH while stirring. Continue stirring for 30 minutes after pH adjustment. (DO NOT ADJUST pH OF WATER SAMPLES.)
4. Allow resin to settle, then aspirate milk or water from above resin and discard.
5. Add 200 ml distilled water (washing beaker sides) and stir.
6. Allow resin to settle again; then aspirate milk-water from above resin and discard. Repeat washing if necessary to remove milk solid particles.
7. Add 200 ml 8N HNO_3 and stir on magnetic stirrer for 30 minutes.
8. Filter resin-acid mixture through Whatman-42 (or equivalent) filter paper in Buchner funnel.
9. Wash beaker with 50 ml 8N HNO_3 and continue filtering. Repeat washing two more times allowing each wash to filter completely. Discard resin. Save filtrate.
10. Add the 350 ml solution to a 500 ml beaker containing several glass beads and evaporate to dryness.
11. Add 50 ml 30% H_2O_2 and evaporate to dryness.
12. Add 20 ml 8N HNO_3 and evaporate to dryness.
13. Add 20 ml 30% H_2O_2 and evaporate to dryness.
14. Add 10 ml 0.08 N HCl and warm.
15. Add to 125 ml separatory funnel containing 20 ml 20% HDEHP.
16. Rinse beaker with 5 ml 0.08 N HCl and add to separatory funnel.
17. Repeat Step 16 and shake for two (2) minutes.
18. Allow phases to separate and drain off bottom aqueous layer into clean 100 ml beaker.
19. Add 20 ml of fresh 20% HDEHP to second clean separatory funnel.
20. Add contents of beaker to second separatory funnel. Shake for two (2) minutes and allow to settle.
21. Drain off bottom aqueous layer into 20 ml vial for storage. Record time and date as T_1.

Phase II (after at least 14-day ingrowth period)

1. Pour sample into 125 ml separatory funnel containing 20 ml 20% HDEHP.
2. Rinse vial with one or two ml 0.08N HCl and add to separatory funnel. Shake for two (2) minutes and allow to settle.
3. Drain off bottom aqueous phase into its 20 ml vial. Record time and date as T_2.
4. Add 20 ml 0.08N HCl and shake for two (2) minutes. Drain off bottom aqueous phase and discard.
5. Add 20 ml 8N HNO_3 and shake for two (2) minutes. Drain off bottom aqueous phase into clean 100 ml beaker.
6. Repeat Step 5. (Add to same beaker.)
7. Evaporate contents of beaker to a few ml.
8. Transfer solution to flamed and cooled 2" planchet.
9. Wash beaker with a few ml 8N HNO_3 and add to planchet. Continue washing until beaker is clean.
10. Evaporate solution in planchet to dryness under infrared lamp.
11. Count planchet in low background beta counter for 100 minutes and record midpoint of counting time as T_3.

Milk samples are normally processed in pairs of spiked and unspiked one-half liter samples from each collection. Yttrium-90 ingrowth which occurs between T_1 and T_2 becomes important only when $T_2 - T_1$ is substantially different between spiked and unspiked samples. Percent of ingrowth ($\frac{^{90}Y}{^{90}Sr}$) may be found by solving the equation $\frac{\lambda_y Y}{\lambda_s S} \approx 1 - 2^{-T/64\ hr}$

This equation is solved on the Wang Calculator with program "^{90}Y Ingrowth" Verification No. 207. If $\frac{\%\ \text{ingrowth spiked}}{\%\ \text{ingrowth unspiked}}$ is less than .99 or greater than 1.01, multiply this fraction by the actual spike added for use in calculating ^{90}Sr Specific Activity. Specific Activity $\pm 1\ \sigma$ (PicoCuries per liter) is calculated as follows:

$$SA = \frac{C - B}{C' - C} \left(\frac{Sp}{\frac{1}{2}l} \right) 2^{-T/64}$$

where C = Counts per 100 min (unspiked sample)

C' = Counts per 100 min (spiked sample)

B = Counts per 100 min (Background)

Sp = Quantity of ^{90}Sr spike in picoCuries (corrected for ingrowth if necessary)

$T = (T_3 - T_2)spk - (T_3 - T_2)unspk$ (in hours)

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$$\sigma = \left[\frac{B(C' - C)^2 + C(C' - B)^2 + C'(C - B)^2}{(C' - C)^4} \right]^{\frac{1}{2}}$$

This problem (Specific Activity with Standard Deviation) is solved on the Wang Calculator with program "^{90}Sr SA Milk" Verification No. 609.

Specific Activity for water is determined as follows:

$$SA = \frac{C - B}{U} 2^{T/64 \text{ hr}} \pm \frac{2^{T/64}}{U} \sqrt{C + B + .0025(C - B)^2}$$

where C = Counts per 100 min (sample)

B = Counts per 100 min (background)

$T = T_3 - T_2$ (in hours)

$U = (18 \text{ liters})(222 \frac{\text{dis/100 min}}{\text{pCi}})(E)(I)$

E = .265 = Total efficiency for water procedure

I = Ingrowth percentage as explained earlier

= .974 after 14 days; .980 after 15 days, etc.

therefore, $1031 < U < 1059$ (depending on ingrowth time).

Specific Activity for water is solved on the Wang Calculator with program "Sp. Act. with Decay ^{90}Sr" Verification No. 397.

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APPENDIX B

GROSS ALPHA AND BETA DETERMINATION IN WATER

1. Transfer one (1) liter of water to a 1000 ml or 1500 ml beaker and evaporate to approximately 50 ml on hot plate in hood.
2. Transfer sample to 100 ml beaker using distilled water and rubber policeman as necessary to insure complete transfer. (See Note.)
3. Evaporate sample to less than 10 ml.
4. Transfer sample to flamed and cooled 2" stainless steel planchet using distilled water and rubber policeman as necessary to insure complete transfer. (See Note.)
5. Evaporate sample to dryness under heat lamp.
6. Count sample for alpha and beta activity for 100 minutes each in low background alpha and beta counter.

Note: 8N HNO_3 may be used if necessary to insure quantitative transfer of sample.

Calculations:

Specific Activity (SA) pCi/1.

$$SA = \frac{C - B}{U} \pm \frac{1}{U}\sqrt{C + B + .0025(C - B)^2}$$

where C = Sample counts per 100 min

B = Background counts per 100 min

U = (222)(Volume)(Efficiency)

= (222 disintegrations/100 min/pCi)(1 liter)(E)

E = .287 for beta, .210 for alpha

U = 15.93 for beta, 11.655 for alpha

This problem is solved on the Wang Calculator with program "Gross α or $\beta \pm 1\sigma$" Verification No. 234.

APPENDIX C

GAMMA ISOTOPIC ANALYSIS OF SURFACE WATER

1. Transfer approximately three (3) liters of 18-liter water sample into five liter boiling flask and boil at reduced pressure. (.7 atmosphere vacuum is maintained in evaporation system to reduce boiling temperature and decrease possibility of volatilizing dissolved solids.)
2. As volume in boiling flask is decreased, periodically add water from 18-liter sample and continue boiling until entire sample has been reduced to approximately 200 ml. (As sample approaches final volume, reduce flame to prevent evaporation to dryness and reduce possibility of breaking flask.)
3. Transfer sample to 400 ml beaker rinsing flask several times with distilled water to insure quantitative transfer.
4. Evaporate sample on hot plate in hood to approximately 25 ml.
5. Transfer sample to 50 ml covered plastic dish rinsing beaker with distilled water as necessary to insure complete transfer.
6. Place dish containing sample in Compton Suppression Well of GeLi Detector system and count gamma activity for 100,000 seconds.
7. Analyze gamma spectra for Specific Activity using MONSTR Program on the TUCC Computer.

Specific Activity for gamma emitters is calculated in picoCuries per liter as follows:

$$SA = \frac{C - B}{IV(.037 \frac{dis/sec}{pCi})} \pm \frac{1}{.037\ IV} \sqrt{\sigma_C^2 + \sigma_B^2 + .0025(C - B)^2}$$

where C = γ/sec from IBM Printout for sample

B = γ/sec from IBM Printout for background

σ_C = Sample error converted from Printout

σ_B = Background error converted from Printout

I = Intensity (or abundance) of gamma

V = Volume of sample = 18 liters

This problem is solved on the Wang Calculator with program "Sp Act γ with Bkg" Verification No. 359.

If peak does not appear in Bkg Spectrum, 0 may be entered for B and σ_B.

APPENDIX D

PREPARATION AND ANALYSIS OF VEGETATION SAMPLES

1. Weigh out 100 gm of sample in drying dish and heat in drying oven for one day at 100°C.
2. Weigh and record weight of ceramic crucible, then transfer sample to crucible for ashing.

Note: Grass and Pine Needle samples should be pulverized in blender before ashing to reduce volume so they will fit in crucible.

3. Ash sample in muffle furnace for 96 hours at 520°C.
4. Weigh crucible with ashed sample in it to determine reduction factor (R)

$$R = \frac{100 \text{ gm}}{\text{net wt after ashing}}$$

5. Weigh approximately 100 mg of sample in 2" aluminum planchet and count in Widebeta II for alpha and beta activity for 100 minutes each.

Calculations for gross alpha or beta Specific Activity (SA)

$$SA = \frac{C - B}{U} \pm \frac{1}{U}\sqrt{C + B + .0025(C - B)^2}$$

where: C = Sample counts per 100 min

B = Background counts per 100 min

$$U = (\text{Efficiency})(\text{Mass})(R)\left(\frac{222 \text{ dis/100 min}}{\text{picoCurie}}\right)$$

This problem is solved on the Wang Calculator with program "Gross α or $\beta \pm 1 \sigma$" Verification No. 234.

The remainder of the ashed sample is transferred to a plastic dish and analyzed for gamma activity in the Compton Suppression Well of the Ge(Li) Detector for 100,000 seconds. The spectrum is then put on magnetic tape and sent to TUCC for analysis on the TUCC Computer with the MONSTR program. Specific gamma activity is determined from the computer printout with the same calculations and Wang Program as is used for soil samples using mass of sample times reduction factor in place of mass.

APPENDIX E

ANALYSIS OF SEWAGE WATER FOR GROSS ALPHA AND BETA ACTIVITY

1. Place 250 ml sewage water in 400 ml beak- and evaporate in hood to a few ml.
2. Transfer evaporated sewage water to 2" stainless steel planchet using 8N HNO_3 to wash beaker and insure all of sample is transferred.
3. Evaporate sewage water to dryness on planchet under infrared lamp.
4. Count evaporated sample for gross alpha and beta activity in Widebeta II for 100 minutes each.

Specific Activity (SA) calculation:

$$SA = \frac{C - B}{U} \pm \frac{1}{U} \sqrt{C + B + .0025\ (C - B)^2}$$

where C = Sample counts/100 min

B = Background counts/100 min

U = 222 VE = 222(.25)(Efficiency)

Efficiency = .278 for beta, .210 for alpha in this configuration

U = 15.93 for beta, 11.655 for alpha

This problem is solved on the Wang Calculator with program "Gross α or $\beta \pm 1\ \sigma$" Verification No. 234.

APPENDIX F

STRONTIUM-90 ANALYSIS OF WASTE TANK AND SEWAGE WATER

1. Dissolve sample by placing planchet in approximately 200 ml of 8N HNO_3 in 250 ml or 400 ml beaker.
2. Heat to boiling on hot plate in hood and remove planchet with hemostat, washing planchet and hemostat jaws with 8N HNO_3 from squeeze bottle.
3. Add a few glass beads to beaker to prevent bumping and evaporate sample to dryness.
4. Add 50 ml 30% H_2O_2 and evaporate to dryness.
5. Add 20 ml 8N HNO_3 and evaporate to dryness.
6. Add 20 ml 30% H_2O_2 and evaporate to dryness.
7. Add 10 ml 0.08N HCl and warm solution to insure sample is dissolved.
8. Transfer solution to 125 ml separatory funnel containing 20 ml 20% HDEHP.
9. Shake sample for two minutes and allow phases to separate.
10. Drain off bottom aqueous phase into 20 ml vial. Note: Ingrowth period for Yttrium-90 is not required in this procedure since strontium and yttrium have not been separated until this point and are considered to be in equilibrium. The aqueous phase is saved only as a precaution and tests have shown that subsequent extraction of Yttrium-90 after an ingrowth period (See Milk Strontium-90 Procedure) produces the same results; however, efficiency is lower if ingrowth and extraction is used rather than direct extraction.

    (Total efficiency = .265 with resin and ingrowth.
    Total efficiency = .332 with direct extraction.)
11. Add 20 ml 0.08N HCl and shake for two minutes.
12. Allow phases to separate, drain off bottom aqueous phase and discard.
13. Add 20 ml 8N HNO_3 and shake for two minutes.
14. Allow phases to separate and drain off bottom aqueous phase into 100 ml beaker.
15. Repeat Steps 13 and 14. (Add to same beaker.)
16. Evaporate acid solution to a few ml on hotplate in fume hood.
17. Transfer sample to flamed and cooled 2" stainless steel planchet using 8N HNO_3 from squeeze bottle to wash beaker and insure complete transfer.

18. Evaporate sample to dryness under infrared lamp.
19. Count sample for Yttrium-90 beta activity for 100 minutes in Widebeta II.

^{90}Sr Specific Activity (SA) calculations:

$$SA = \frac{C - B}{U} 2^{T/T_{\frac{1}{2}}} \pm \frac{T/T_{\frac{1}{2}}}{U} \sqrt{C + B + .0025 (C - B)^2}$$

where C = Sample counts per 100 minutes

B = Background counts per 100 minutes

T = Decay time from extraction to midpoint of count

$T_{\frac{1}{2}}$ = Half-life of Yttrium-90 = 64 hours

$U = (222 \frac{\text{dis per 100 min}}{\text{picoCurie}})(\text{Volume})(\text{Efficiency})$

U = (222)(.25)(.332) = 18.426 for 250 ml sample

U = (222)(1)(.332) = 73.704 for one liter sample

This problem is solved on the Wang Calculator with program "Sp. Act. with Decay ^{90}Sr" Verification No. 397.

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6.7.5.(h) Part 2

ENVIRONMENTAL RADIATION SURVEILLANCE REPORT
FOR THE PERIOD
OCTOBER 1, 1978 TO MARCH 31, 1979

Arthur C. Ball, Environmental Health Physicist
Joshua Debnam, Environmental Chemist

Radiation Protection Council
L. T. Caruthers, Radiation Protection Officer
D. W. Morgan, Associate Radiation Protection Officer
North Carolina State University
Raleigh, North Carolina

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1. INTRODUCTION

Environmental radioactivity in the vicinity of North Carolina State University has been markedly low throughout the current reporting period. No increases have been detected subsequent to low level releases reported by nuclear power plants in other states or from any other sources.

Contracted analysis has been performed on Thermoluminescent Dosimeters but not on other samples. This analysis provides the only readings for the TLD stations for January and February 1979 as the reader used for local evaluation was not operational.

2. AIR MONITORING

No significant alpha or halogen activity was detected in any air samples taken during this reporting period. Gross beta activity is reported in Table 2.2 and specific activities for gamma emitters is reported in Table 2.3.

3. MILK

No iodine activity was detected in any milk samples analyzed during this period. Strontium-90 activity is reported in Table 3.1. The reading for December is higher than normal, but is still well within safety limits. No attributable cause is known for the abnormal December reading.

4. SURFACE WATER

Gross alpha and beta and Strontium-90 activities are reported in Table 4.1 along with gamma emitters Cesium-137 and Potassium-40 (which were detected in only a few of the twelve samples reported).

5. SOIL

Gross alpha and beta and specific gamma emitter activities are reported for the various soil samples in Table 5.1.

6. VEGETATION

Specific activities for corn, soy beans, and pine needles are reported in Table 6.1.

7. REACTOR WASTE TANKS AND SEWAGE

Gross alpha and beta activities for the PULSTAR reactor waste tanks and for Raleigh sewage water are reported in Table 7.1. Strontium-90 activity is also reported for the sewage samples.

8. THERMOLUMINESCENT DOSIMETERS (TLDs)

TLD average weekly exposure readings are reported in Table 8.2. Local evaluations were not performed during January and February of 1979 due to the non-operational status of the TLD reader. Repairs have now been completed and local evaluation of TLDs resumed in March 1979.

Table 2.1 Air Particle Sampling Locations

Designation	Direction[1]	Distance[2]	Elevation[3]
Broughton	Southwest	410 ft.	- 55 ft.
David Clark Lab (DCL)	West		
Library	Northwest	629 ft.	+ 36 ft.
Riddick	Southeast	325 ft.	- 46 ft.
Withers	Northeast	270 ft.	- 19 ft.

[1]Direction - Direction from Reactor Stack
[2]Distance - Distance from Reactor Stack
[3]Elevation - Elevation with respect to top of Reactor Stack

- -

Table 2.2 Airborne Gross Beta Activity ($fCi/M^3 \pm 1\sigma$)

Date	Broughton	DCL	Library	Riddick	Withers
1978					
10/2-10/6	69.1 ± 6.1	59.2 ± 5.6	49.3 ± 5.2	50.7 ± 5.2	66.4 ± 5.9
10/9-10/13	42.3 ± 4.9	39.7 ± 4.8	43.7 ± 5.0	52.2 ± 5.3	33.1 ± 4.5
10/16-10/20	46.5 ± 5.0	41.0 ± 4.8	42.8 ± 4.9	39.7 ± 4.7	40.1 ± 4.7
10/23-10/27	42.1 ± 4.8	45.4 ± 5.0	41.7 ± 4.8	40.1 ± 4.7	39.7 ± 4.7
10/30-11/3	60.3 ± 5.7	62.5 ± 5.8	55.5 ± 5.4	56.8 ± 5.5	58.3 ± 5.6
11/6-11/10	74.6 ± 6.3	87.9 ± 6.9	53.3 ± 5.3	66.9 ± 5.9	76.8 ± 6.4
11/13-11/17	43.6 ± 4.8	40.1 ± 4.7	46.3 ± 5.0	10.1 ± 3.4	67.3 ± 5.9
11/20-11/24	77.9 ± 6.5	55.9 ± 5.5	60.4 ± 6.1	63.4 ± 5.8	93.3 ± 7.3
11/27-12/1	34.9 ± 4.4	33.8 ± 4.3	21.3 ± 3.4	29.4 ± 4.1	30.7 ± 4.2
12/4-12/8	29.8 ± 4.2	34.6 ± 4.2	28.7 ± 4.1	19.5 ± 3.7	35.7 ± 4.4
12/11-12/15	19.0 ± 3.6	34.9 ± 4.3	37.3 ± 4.4	38.8 ± 4.5	47.1 ± 4.9
12/18-12/22	31.1 ± 4.4	46.5 ± 5.1	37.1 ± 4.7	76.8 ± 6.5	35.1 ± 4.6
12/25-12/29	70.1 ± 6.2	83.7 ± 6.8	81.1 ± 6.7	66.4 ± 6.0	75.6 ± 6.3
1979					
1/1-1/5	45.4 ± 5.0	44.3 ± 4.9	42.5 ± 4.8	43.4 ± 4.9	42.3 ± 4.8
1/8-1/12	46.3 ± 4.8	60.5 ± 5.5	51.8 ± 5.1	47.4 ± 4.9	56.6 ± 5.3
1/15-1/19	47.8 ± 5.1	54.6 ± 5.2	48.9 ± 5.1	52.4 ± 5.3	53.0 ± 5.3
1/22-1/26	27.6 ± 4.1	23.5 ± 3.9	29.8 ± 4.2	40.4 ± 4.6	38.6 ± 4.6
1/29-2/2	25.7 ± 4.1	39.7 ± 4.7	37.5 ± 4.6	36.0 ± 4.5	31.8 ± 4.3
2/5-2/9	30.5 ± 4.2	50.2 ± 5.1	43.9 ± 4.8	41.4 ± 4.7	46.2 ± 5.0
2/12-2/16	67.5 ± 5.9	65.8 ± 5.9	50.9 ± 5.2	27.9 ± 4.1	53.7 ± 5.3
2/19-2/23	10.7 ± 3.4	28.1 ± 4.2	39.3 ± 4.6	32.9 ± 4.4	36.2 ± 4.5
2/26-3/2	11.8 ± 3.5	20.2 ± 3.8	32.7 ± 4.4	29.8 ± 4.2	32.9 ± 4.4
3/5-3/9	18.2 ± 3.7	49.3 ± 5.0	39.7 ± 4.6	44.3 ± 4.8	46.3 ± 4.9
3/12-3/16	18.0 ± 3.7	52.4 ± 5.2	45.8 ± 4.9	26.1 ± 4.0	41.9 ± 4.7
3/19-3/23	33.6 ± 4.6	32.9 ± 4.4	34.2 ± 4.5	21.9 ± 4.0	32.9 ± 4.4
3/26-3/30	55.5 ± 5.4	59.4 ± 5.6	50.2 ± 5.2	41.0 ± 4.7	45.4 ± 4.9

Table 2.3 Airborne Particulate Specific Activity (γ Emitters)
(Campus Average $fCi/M^3 \pm 1\ \sigma$)

Date	^{144}Ce	^{141}Ce	^{103}Ru	^{106}Ru	^{95}Zr	^{95}Nb
1978						
10/2-10/6	6.8 ± 1.4	< 1.0	< 0.5	< 5.0	< 1.0	< 0.5
10/9-10/13	8.3 ± 1.6	< 1.0	< 0.5	< 5.0	< 1.0	< 0.5
10/16-10/20	< 5.0	< 1.0	< 0.5	< 5.0	< 1.0	< 0.5
10/23-10/27	6.5 ± 1.7	0.9 ± 0.3	< 0.5	< 5.0	< 1.0	< 0.5
10/30-11/3	5.1 ± 1.4	< 1.0	< 0.5	< 5.0	< 1.0	< 0.5
11/6-11/10	< 5.0	< 1.0	< 0.5	< 5.0	< 1.0	< 0.5
11/13-11/17	13.6 ± 3.3	< 1.0	< 0.5	< 5.0	< 1.0	< 0.5
11/20-11/24	< 5.0	< 1.0	< 0.5	< 5.0	< 1.0	< 0.5
11/27-12/1	< 5.0	< 1.0	< 0.5	< 5.0	< 1.0	< 0.5
12/4-12/8	9.0 ± 2.4	< 1.0	< 0.5	< 5.0	< 1.0	< 0.5
12/11-12/15	7.9 ± 2.2	< 1.0	< 0.5	< 5.0	< 1.0	< 0.5
12/18-12/22	< 5.0	3.6 ± 1.0	< 0.5	< 5.0	< 1.0	< 0.5
12/25-12/29	10.6 ± 2.8	12.9 ± 0.9	6.4 ± 0.5	< 5.0	< 1.0	< 0.5
1979						
1/1-1/5	< 5.0	4.1 ± 0.7	1.7 ± 0.4	< 5.0	< 1.0	< 0.5
1/8-1/12	< 5.0	< 1.0	1.8 ± 0.4	< 5.0	< 1.0	< 0.5
1/15-1/19	9.4 ± 2.2	< 1.0	< 0.5	< 5.0	< 1.0	< 0.5
1/22-1/26	< 5.0	< 1.0	< 0.5	< 5.0	< 1.0	< 0.5
1/29-2/2	< 5.0	< 1.0	< 0.5	< 5.0	< 1.0	< 0.5
2/5-2/9	7.6 ± 1.8	< 1.0	< 0.5	< 5.0	< 1.0	< 0.5
2/12-2/16	10.5 ± 2.8	< 1.0	< 0.5	< 5.0	< 1.0	< 0.5
2/19-2/23	6.7 ± 2.7	< 1.0	< 0.5	< 5.0	< 1.0	< 0.5
2/26-3/2	< 5.0	< 1.0	< 0.5	< 5.0	< 1.0	< 0.5
3/5-3/9	5.9 ± 2.0	< 1.0	< 0.5	< 5.0	< 1.0	< 0.5
3/12-3/16	12.9 ± 3.2	< 1.0	< 0.5	< 5.0	< 1.0	< 0.5
3/19-3/23	9.6 ± 2.6	< 1.0	< 0.5	< 5.0	< 1.0	< 0.5
3/26-3/30	8.9 ± 2.1	< 1.0	< 0.5	< 5.0	< 1.0	< 0.5

Table 3.1 Milk Specific Activity (pCi/l ± 1 σ)

Date	^{90}Sr	^{131}I
10/78	3.28 ± 0.43	< 2.0
11/78	3.69 ± 0.59	< 2.0
12/78	10.45 ± 0.62	< 2.0
1/79	3.93 ± 0.48	< 2.0
2/79	2.43 ± 0.51	< 2.0
3/79	2.93 ± 0.37	< 2.0

Table 4.1 Surface Water Specific Activity (pCi/l ± 1 σ)

Date	Location*	^{137}Cs	^{40}K	^{90}Sr	Gross Alpha	Gross Beta
1978						
Oct	ON	< 0.1	< 2.0	0.22 ± 0.02	0.23 ± 0.07	2.86 ± 0.35
	OFF	< 0.1	< 2.0	0.23 ± 0.02	0.20 ± 0.07	4.44 ± 0.42
Nov	ON	< 0.1	< 2.0	0.05 ± 0.02	0.28 ± 0.08	4.69 ± 0.41
	OFF	< 0.1	< 2.0	0.09 ± 0.02	0.16 ± 0.06	5.38 ± 0.44
Dec	ON	< 0.1	< 2.0	0.37 ± 0.03	0.44 ± 0.09	6.21 ± 0.49
	OFF	< 0.1	< 2.0	0.38 ± 0.03	0.23 ± 0.07	5.19 ± 0.44
1979						
Jan	ON	< 0.1	< 2.0	0.36 ± 0.03	0.36 ± 0.09	4.03 ± 0.38
	OFF	0.25 ± 0.71	39.59±42.05	0.33 ± 0.03	0.30 ± 0.08	8.33 ± 0.59
Feb	ON	0.33 ± 0.71	18.29±41.95	0.31 ± 0.03	1.02 ± 0.14	7.95 ± 0.57
	OFF	0.33 ± 0.71	< 2.0	0.82 ± 0.06	0.43 ± 0.09	7.73 ± 0.56
Mar	ON	< 0.1	< 2.0	0.40 ± 0.03		
	OFF	< 0.1	< 2.0	0.30 ± 0.03		

* ON - Denotes Rocky Branch Creek as it enters NCSU Campus
OFF - Denotes Rocky Branch Creek as it leaves NCSU Campus

Table 5.1 Soil Specific Activity (pCi/gm ± 1 σ)

Location*	Gross α	Gross β	^{228}Th	^{226}Ra	^{137}Cs	^{40}K
North	1.11±0.43	10.32±1.73	0.37±0.35	0.91±0.36	4.48±0.36	< 0.4
South	1.07±0.36	9.75±1.46	0.45±0.41	0.94±0.41	4.05±0.38	< 0.4
East	1.33±0.37	10.36±1.43	1.32±0.61	1.28±0.47	2.99±0.36	< 0.4
West	2.38±0.71	19.93±2.81	1.63±0.59	1.25±0.46	3.20±0.36	42.09±17.96
W (4.5')	1.62±0.30	12.52±2.07	0.63±0.32	1.11±0.21	0.19±0.15	19.73±9.63
OBG(4.5')	2.27±0.43	26.55±2.36	2.30±0.46	0.81±0.35	0.26±0.22	48.09±13.89
NBG(4.5')	4.88±0.79	18.31±2.33	0.92±0.32	4.40±0.45	0.39±0.25	19.49±15.66

*Location - Denotes direction from reactor
Burial ground samples are in near proximity to fence
NBG denotes New Burial Ground
OBG denotes Old Burial Ground (Not presently in use)
4.5' denotes depth of sample. Others are at surface

Table 6.1 Vegetation Specific Activity (pCi/gm ± 1 σ)

Sample	Gross Alpha	Gross Beta	^{137}Cs	^{40}K
Corn	< 0.01	3.20 ± 0.18	0.051 ± 0.044	7.07 ± 2.78
Soy Beans	0.15 ± 0.03	14.81 ± 0.79	0.109 ± 0.028	53.76 ± 3.28
Reactor Pine	0.05 ± 0.03	2.87 ± 0.23	0.012 ± 0.057	4.85 ± 3.71
South Pine	0.09 ± 0.03	2.49 ± 0.22	0.083 ± 0.061	9.03 ± 3.76

Table 7.1 Tank and Sewage Specific Activity (pCi/l ± 1 σ)

Sample	Gross Alpha	Gross Beta	^{90}Sr
WT #2 Oct	< 0.5	3267 ± 175	
WT #3 Oct	< 0.5	3376 ± 180	
WT #1 Nov	< 0.5	613 ± 42	
WT #3 Nov	< 0.5	371 ± 30	
WT #1 Dec	< 0.5	211 ± 22	
WT #3 Dec	< 0.5	349 ± 29	
WT #1 Jan	< 0.5	523 ± 37	
WT #3 Jan	< 0.5	497 ± 36	
WT #1 Feb	< 0.5	704 ± 47	
WT #3 Feb	< 0.5	330 ± 28	
WT #2 Mar	< 0.5	868 ± 54	
WT #3 Mar	< 0.5	1191 ± 71	
Oct Sewage	0.20 ± 0.14	11.55 ± 1.03	1.53 ± 0.41
Dec Sewage	< 0.1	9.66 ± 0.95	1.33 ± 0.41
Feb Sewage	< 0.1	17.44 ± 1.32	0.56 ± 0.22

Table 8.1 Thermoluminescent Dosimeter (TLD) Locations

Designation	Location
Broughton	410 ft. southwest of and 55 ft. below top of Reactor Stack
DCL	Roof of David Clark Laboratories
Library	629 ft. northwest of and 36 ft. above top of Reactor Stack
Riddick	325 ft. southeast of and 46 ft. below top of Reactor Stack
Withers	270 ft. northeast of and 19 ft. below top of Reactor Stack
Control	Room 214 David Clark Labs
R-3	Entrance to NCSUR-3 Reactor Bay from Control Room
PULSTAR	PULSTAR Reactor Bay, West Wall
Equipment Room	PULSTAR Equipment Room East of PULSTAR Bay
Control Room	PULSTAR Control Room
Pool	Over PULSTAR Reactor Pool
Stack	Top of PULSTAR Reactor Stack

Table 8.2 Thermoluminescent Dosimeter Readings
(Average mR/wk based on Co-60 Standard)

Area Monitors	*	10/78	11/78	12/78	1/79	2/79	3/79
Broughton	L	3.2	3.8	3.7	X	X	3.7
Broughton	C	0.7	2.8	2.0	2.0	1.8	1.8
DCL	L	2.3	3.1	2.4	X	X	2.8
DCL	C	< 0.1	2.2	1.6	1.3	1.0	0.7
Library	L	3.2	3.8	3.6	X	X	3.6
Library	C	0.5	2.9	2.0	1.9	1.8	1.8
Riddick	L	3.4	3.8	3.9	X	X	4.2
Riddick	C	1.0	3.0	2.2	2.0	2.0	2.6
Withers	L	3.0	3.0	3.0	X	X	3.0
Withers	C	0.4	2.7	1.4	1.6	1.3	1.8
Control	L	3.0	3.0	1.3	X	X	2.8
Control	C	0.3	2.3	2.0	1.4	1.8	1.4
Reactor Monitors							
R-3	L	6.0	5.9	6.4	X	X	6.0
R-3	C	6.3	3.6	3.4	3.1	2.9	3.1
PULSTAR	L	97.4	87.0	14.5	X	X	53.8
PULSTAR	C	13.3	12.2	8.3	8.8	11.4	26.8
Equipment Room	L	30.0	19.9	27.9	X	X	32.3
Equipment Room	C	23.8	17.7	18.3	21.4	21.3	24.2
Control Room	L	10.2	9.6	6.0	X	X	8.6
Control Room	C	3.0	4.0	3.5	3.4	3.8	3.7
Pool	L	50.8	47.9	40.0	X	X	48.9
Pool	C	32.8	30.1	23.8	30.2	28.6	21.2
Stack	L	2.8	3.8	4.0	X	X	4.9
Stack	C	0.2	2.5	1.6	1.7	1.5	2.2

*L - Denotes Locally Evaluated LiF Dosimeters
C - Denotes $CaSO_4$:Dy Dosimeters Contracted to Teledyne Isotopes for analysis
X - TLD Reader used for local evaluations was not operational and in repair status for January and February 1979