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**UNION
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MASTER

**Student Research Activities
in the
Technology Assessments Section
of the
Health and Safety
Research Division**

Summer 1980

R. O. Chester
D. A. Roberts

**OPERATED BY
UNION CARBIDE CORPORATION
FOR THE UNITED STATES
DEPARTMENT OF ENERGY**

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STUDENT RESEARCH ACTIVITIES
IN THE
TECHNOLOGY ASSESSMENTS SECTION
OF THE
HEALTH AND SAFETY RESEARCH DIVISION
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R. O. Chester
D. A. Roberts

Date Published: August 1981

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ABSTRACT

Reports summarizing activities of students assigned to the Technology Assessments Section of the Health and Safety Research Division for the summer 1980 are presented. Unless indicated otherwise, each report was written by the student whose work is being described. For each student, the student's supervisor, the name of the program under which the student was brought to ORNL, the academic level of the student, and the name of the ORNL project to which the student was assigned are tabulated. The reports are presented in alphabetical order of the students' last names.

1. INTRODUCTION

The purpose of this report is to present in a unified collection, a summary of activities of the students assigned to the Technology Assessments Section (TAS) of the Health and Safety Research Division for the summer of 1980. These activity reports, with few exceptions, were written entirely by the students. To preserve the student's style and organization, editing was kept to a minimum.

The section's participation in the University Programs at ORNL provides an opportunity to assist in the training of scientists for energy research and development, while the students contribute to the section's research efforts. The students activities at ORNL are intended to complement their academic endeavors.

As shown in Table 1, eleven students in four different programs participated during the summer quarter. Two students were sponsored by the Union Carbide Corporation Pre-Cooperative Education Program for high school graduates enrolled in engineering at participating academic institutions. Four students were participants in the Union Carbide Corporation Cooperative Education Program for undergraduates in engineering. Two students were associated with the Summer Research Apprenticeship Program for high school students, and there were three graduate students in the ORNL Summer Research Internship Program.

An often neglected aspect of student assignments is the effort and time commitment required of the supervisor. In particular, the first employment period for an undergraduate requires much of the staff supervisor's time and effort to familiarize the student with the organizational structure and types of activities atypical of a research laboratory. At ORNL, the diversity of research activities makes it impossible for the supervisor to acquaint each student with all such activities; therefore, the supervisor must concentrate on those areas of research most likely to be of future interest or applicability to the student's academic goals. Although each student was assigned to a particular project, certain tasks were assigned that necessarily cut across program and/or project lines. This was done in

Table 1. Students assigned to Technology Assessments Section of Health and Safety Research Division for the summer 1980

Name	Age	Degree(s) held/ Prospective	Sponsoring program	College/ University	Academic major	Supervisor	Project assignment
D. J. Crama	22	-/BS	UCC Cooperative Education	Purdue University	Nuclear Engineering	C. A. Little	EPA-Environmental Assessment Modeling for Shallow Land Disposal of Radioactive Waste
P. A. Dawkins	18	-/BS	UCC Pre-Cooperative Education Program	Morehouse (fall 1980)	Engineering	D. E. Fields R. O. Chester M. T. Ryan	EPA-Environmental Assessment Modeling for Shallow Land Disposal of Radioactive Waste
L. J. Farthing	28	BS ^a /BS	UCC Cooperative Education	University of Tennessee	Metallurgical Engineering	C. C. Travis	EPA-Development of a Multi- media Model for Use in Chemical Risk Assessment
S. R. Glandon	20	-/BS	UCC Cooperative Education	Tennessee Technical University	Physics	D. E. Fields	EPA-Environmental Assessment Modeling for Shallow Land Disposal of Radioactive Waste
R. T. Green	16	-/-	Summer Research Apprenticeship			R. O. Chester	Summer Research Apprentice- ship Program for High School Students
R. Grier	18	-/BS	UCC Pre-Cooperative Education Program	Morehouse (fall 1980)	Engineering	D. E. Fields R. O. Chester	EPA-Environmental Assessment Model for Shallow Land Disposal of Radioactive Waste
M. H. Johnson	24	BS,MS	ORNL Summer Research Internship	University of Lowell	Radiological Sciences	M. T. Ryan	NRC-Uncertainties in Assess- ment of Long-Term Collective Dose and Health Effects
P. A. Jones	16	-/-	Summer Research Apprenticeship			R. O. Chester	Summer Research Apprentice- ship Program for High School Students
J. F. King	19	-/BS	UCC Cooperative Education	Georgia Institute of Technology	Nuclear Engineering	M. T. Ryan	NRC-Uncertainties in Assess- ment of Long-term Collective Dose and Health Effects
E. W. McFarland	23	BS/MS	ORNL Summer Research Internship	University of California	Nuclear Engineering	H. W. Dickson	DOE-Beneficial Applications of Radiation Technology
R. R. Smith	22	BS/MS	ORNL Summer Research Internship	Tennessee State University	Electrical Engineering	C. F. Baes III D. E. Fields	EPA-Modeling of Atmospheric Radionuclide Releases

^aDegree held = B.S., Biology.

order to familiarize the student with more than one area of research ongoing in TAS.

This is the first attempt to publish the results of student research activities in TAS. The intent is to recognize the students' and their supervisors' efforts and to give proper credit to each.

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2. ACTIVITY REPORTS BY D. J. CRAMA

Name: D. J. Crama

Age: 22

Academic Background: Undergraduate, B. S. program in Nuclear
Engineering, Purdue University

Sponsor: UCC Cooperative Education

Employment Periods with ORNL: 3 with TAS: 2

Supervisor: C. A. Little

Period of Assignment: 5/19/80 through 8/15/80

Principal Project Assignment: Environmental Protection Agency (EPA)-
Environmental Assessment Modeling
for Shallow Land Disposal of Radio-
active Waste

Description of Project:

This EPA-sponsored project involves the development and assemblage of mathematical models for assessment of the environmental impact and health risk associated with shallow land disposal of low-level radioactive wastes.

The task assigned to Debra Crama was the documentation of computer codes associated with this project.

2.1 Co-op Report

This semester of work with the Technology Assessments Section was most rewarding. Besides working with Craig Little, I had the chance to learn how to use the HP-2647A graphics computer.

Most of my work was with Craig Little. I was working on obtaining documentation for computer codes associated with the EPA Low-Level Radiation Waste Modeling Project. Craig marked about 107 computer codes in "Low-Level Waste Management: A Compilation of Models and Monitoring Techniques" by Science Applications, Inc. I implemented a reference search to locate the documents for the computer codes. I gathered some of the documents at the library and some I found in the Conference Room of Building 7509. The next step was to write letters to the authors of the computer codes. I wrote and sent out 61 letters. Fig. 1 is a copy of one of these letters. I received about 40 answers. Table 2 is a table of the computer codes, showing the ones that letters were sent for and if answers were received.

Like Table 2, many other tables were made for Craig Little for his lecture on low-level waste computer codes for atmospheric, ground water, and surface water modes of transport. Table 3 is a partial example of one of these tables. I made 3 tables, each taking up more than one page of space. The tables were made with the use of the HP-2647A mini-computer. This meant that the pages had to be made one at a time; therefore, I saved a copy of each of the tables' set-ups on tape. This allows Craig to bring the tables back up on the screen and fill in the spaces. The tables were made in the graphics text mode of the computer. This allows one to type words on the CRT while in the graphics mode. This capability has been of great use to me in creating these tables.

Not only did I use the graphics text to make tables, but I also used it to draw a schematic diagram for Craig Little entitled "Schematic of Releases from LLRW Trench to Public." This drawing combined the use of writing a program on the HP-2647A, drawing lines with the graphics cursor, and labeling with the graphics text mode. Figure 2 is a copy of this drawing; it will be used as a visual aid in the EPA project presentations.

OAK RIDGE NATIONAL LABORATORY

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OAK RIDGE, TENNESSEE 37830

June 3, 1980

Mr. J. F. Louis
Department of Astrophysics
University of Colorado
Boulder, CO 80302

Dear Mr. Louis:

In a listing of computer codes by Science Applications, Inc., entitled "Low Level Waste Management: A Compilation of Models and Monitoring Techniques," I saw a description of your model "A Two-Dimensional Transport Model of the Atmosphere." My associates and I feel this model, if codified, could be of use to us in some of our assessment-oriented activities.

If possible, could you please send us a copy of any documentation or a user's manual. If this code is not available or it is proprietary, could you please notify us to that effect at your earliest convenience. We appreciate your cooperation and hope to hear from you soon.

Sincerely,

Debra Crama
Technology Assessments Section
Health and Safety Research Division

DC:vsw

Fig. 1. Letter, Debra Crama to Mr. J. F. Louis, requesting information on computer codes for low-level waste management.

Table 2. Table of computer codes (Crama).

COMPUTER CODES	TYPE	LETTER	RESPONSE	REFERENCE	CONFERENCE RT	LIBRARY	OTHER	AUTHORS
AEOLUS	A ^a	* ^b	3 ^c	* ^d				J. N. Hamawi, and J. Laznow
AIRDOS-EPA	A			*	* ^e	* ^f	* ^g	Robert E. Moore
AIRWAY	A	*	3	*		*		J. L. Rider, S. K. Beal
AMRAW	G			*		*	*	S. E. Logan
AREAC	A	*	2					D. Michlewicz
AREAS	A			*	*	*		Robert E. Moore
ATDL	A			*				S. R. Hanna
ATMAS	A	*				*		D.L. Ermak, R.A. Nyholm, and R. Lange
ATR	A			*				R.J. Harris, J.A. Lonergan, and L. Huszar, Jr.
AT123D	GT					*	*	G. T. Yeh
AQUAMAN	ST				*	*	*	D. L. Shaeffer, and E. L. Etnier
AQUAMOD	ST			*		*	*	R. S. Booth

Table 2. (continued)

COMPUTER CODES	TYPE	LETTER	RESPONSE	REFERENCE	CONFERENCE RM	LIBRARY	OTHER	AUTHORS
BELCH	A	*		*				Rodican P. Reed
BURP	A	*		*				Regis M. Nicoll
CCC	ST	*	3					M. J. Lippman, and D. Mangold
CDM	A	*	1	*				Ellen M. Leonard
CERBERUS	S	*	3	*				William Lai
COLORADO-FD	GT			*				U. Brutsaert
COMO	A	*	2	*				H. W. Church
COOLEY	GT	*	1	*				R. L. Cooley
CRAC	A						* ^h	J. L. Spring
CRITR	F	*	3	*				David A. Baker
DAVIS/FE3D	GT	*	3	*				S.K. Gupta, K.K. Tanji, and J.N. Luthin
DISPER I & II	ST	*						G.C. Christodoulou, J.R. Pagenkopf, B.R. Pearce, and J.J. Connor

Table 2. (continued)

COMPUTER CODES	TYPE	LETTER	RESPONSE	REFERENCE	CONFERENCE RM	LIBRARY	OTHER	AUTHORS
DOSES	A	*		*	*			C. F. Gill
DPRW	GS						*	S.W. Ahlstrom, and H.P. Foote
DPRWGW & DPRWCR	GS						*	S.W. Ahlstrom, and H.P. Foote
ENTRY/RPM-1 & 2	A	*	3	*				Mei-Kao Liu, and Douglas Stewart
FENWASTE	GT					*	*	G.T. Yeh, and D.S. Ward
FETRA & SEPRATRA	ST			*			*	Y. Onishi, P.A. Johanson, F.G. Baca, and E.I. Hilty
FRONT	GT	*	3	*				A. Vandenberg
GAMMA	A	*	3	*	*	*		C. V. Gogolak
GARD	GT	*	2					E.L.J. Rosinger, and K.K.R. Tremaine
GASPAR	A			*			*	K. Eckerman
GETOUT	GT	*		*				G. Jansen and H.C. Burkholder
HANFORD PCP	GT	*	3	*				Dennis Friedrichs

Table 2. (continued)

COMPUTER CODES	TYPE	LETTER	RESPONSE	REFERENCE	CONFERENCE RM	LIBRARY	OTHER	AUTHORS
HERMES	G			*		*		J.F. Fletcher and W.L. Dotson
HN	ST	*						Oceanography Dept, Naval Postgraduate Sch.
HOTSED	ST				*	*	*	D.E. Fields and D.M. Hetrick
HTM	ST					*	*	D. D. Huff
INGDOS	F			*	*	*	*	J. C. Pleasant
INTERA HCTM	GT	*	1	*				INTERA Environmental Consultants Inc
INTERCOMP-GWM	GT	*	3	*				K. H. Coats
ISOQUAD	GT	*	1	*				George Pinder
KANSAS-GREEN	GT	*	1	*				B. W. Green
LADTAP	GS						*	Mike Bell
LIDSR	ST	*	3					P.P. Staneavage and D.G. Abbott
LIRAC 1 & 2	A	*	2	*	*	*		Michael MacCracken and W.H. Duzwer
LODIPS	ST	*				*		M. R. Buckner, and D. W. Hayes

Table 2. (continued)

COMPUTER CODES	TYPE	LETTER	RESPONSE	REFERENCE	CONFERENCE RM	LIBRARY	OTHER	AUTHORS
MAIN: A Model for Calculating Effects of Liquid Waste Disposal in Deep Saline Aquifers	GT	*	2	*				D. B. Grove
MESODIF-II	A	*					*	D.C. Powell, H.L. Wegley, and T.D. Fox
MOC	GS	*	3	*				L. F. Konikow
MSDM	A	*		*				Donald L. Ermak
OAKRIDGE FE	GT	*		*		*		M. Reeves & J.O. Duguid
PABLM	A	*	3	*				Glenn R. Hoenes
PATHS	GT	*		*				R. William Nelson
PERCOL	GWS	*		*				R.C. Routson & R.J. Serne
PREDO	A	*	1	*				Dennis L. Strenge
RAMM	G	*	3	*	*	*	*	R. B. Lyon
RCPIGW	GT	*	1	*				David B. McWhorter & Daniel K. Sunado
RETADD	A	*				*		C.L. Begovich, B.D. Murphy, and C.L. Nappo

Table 2. (continued)

COMPUTER CODES	TYPE	LETTER	RESPONSE	REFERENCE	CONFERENCE RM	LIBRARY	OTHER	AUTHORS
RVRDOS	ST			*	*	*		J. A. Martin Jr.
SEGOL	GS	*		*				G. A. Segol
STM	GT	*	2	*				D.B. Grove, and J. Rubin
SUBPOPA	A	*	1	*				Dennis L. Streng
SWIFT	R	*	3					P.T. Dillon, R.B. Lantz, and S.B. Pahwa
TEHM	GT						*	D.D. Huff, R.J. Luxmoore, J.B. Rankin, and C.L. Begovich
TERMOD II	F	*	3					R. Zach
TIRION	A			*		*		G. D. Kaiser
UDAD	A	*	2	*				Michael H. Momeni
UNAMAP	A	*	1	*				Ellen M. Leonard
VCHFLD	GT	*	1	*				INTERCOMP Resource Development and Engineering, Inc.

Table 2. (continued)

COMPUTER CODES	TYPE	LETTER	RESPONSE	REFERENCE	CONFERENCE RM	LIBRARY	OTHER	AUTHORS
VITTL5	F	*	1	*				D.L. Branchly, J.K. Soldat, J.A. McNeese, and E.C. Watson
WATER	ST	*	3	*				Mark S. Robinson
2BPUFF	AF	*	3	*		*		K. Peterson
A Diffusion Type Model of the Global Carbon Cycle	A			*	*	*	*	G. G. Killough
Analytical Model for Air Pollutant Transport and Deposition from a Point Source	A	*		*		*		Donald L. Ermak
A Model for Evaluation of Airborne Contamination	A					*		J. R. Travis
A Model for Predicting the Redistribution of Particulated Contaminants from Soil Surfaces	S	*	3	*				J. R. Travis
A Model for Redistribution by Wind of Surface Contamination	S	*						A. J. Amato
A Model to Estimate Radiation Dose Commitments to the World Population from the Atmospheric Release of Radionuclides	A	*	3	*		*		J. L. Rider

Table 2. (continued)

COMPUTER CODES	TYPE	LETTER	RESPONSE	REFERENCE	CONFERENCE RM	LIBRARY	OTHER	AUTHORS
Applications of General Computational Model for Composite Environmental Radiation Doses	F	*	3	*				J.K. Soldat, D.A. Baker, and J.P. Corley
A Radionuclide Transport Model for Shallow Land Burial Sites	S	*						Lawrence H. Wight and B. George Kniazewycz
A Regional-Continental Scale Transport, Diffusion and Deposition Model	A			*	*		*	J.L. Heffter, A.D. Taylor, and G.J. Ferber
A Time Dependant Atmospheric Dispersion Model	A	*		*		*		P.E. McGrath and R.M. Blond
A Two-Dimensional Transport Model of the Atmosphere	A	*		*				J.F. Louis
Atmospheric Diffusion and Deposition of Particulate Matter	A	*		*		*		R.W. Cleary, D.D. Adrian, and R.J. Kinch
Atmospheric Transport and Diffusion in the Planetary Boundary Layer	A	*		*				Van Le Hoven I
Calculation of the Gamma-Dose Rate from a Continuously Emitted Plume	A				*	*		W. Hubschmann and D. Papadopolous
Computed-Aided Air Quality Control	A	*	1					L.K. Wang, J. Bergenthal and M.H. Wang

Table 2. (continued)

COMPUTER CODES	TYPE	LETTER	RESPONSE	REFERENCE	CONFERENCE RM	LIBRARY	OTHER	AUTHORS
Computer Simulation of Iodine-131 Transfer from Fallout to Man	F			*		*		B. Sorensen
Effects of Rainstorms and Runoff on Consequences of Nuclear Reactor Accidents	ST	*	2	*				L.T. Ritchie, W.D. Brown, and J.R. Wayland
General Model for Evaluating Transport of Radioactive Products Released to the Environment and its Consequences	G			*	*			E. Hladky, I. Kubik, and J. Moraveck
Integrated Environmental Modeling System for Noble Gas Releases at the Savannah River Plant	A			*	*	*		R. E. Cooper
Land Requirement for a Radioactive Waste Disposal Yard	G			*		*		Y. Inoue and S. Morisawa
Linear Diffusion and Convection of Chemicals in Soils	S	*		*				F. T. Lindstrom
Mathematical Models for the Dispersion of Radionuclides in Aquatic Systems	ST			*		*	*	N.E. Armstrong and E.F. Gloyna
Mathematical Model for the Transport of Radionuclides in Water Surface	ST			*			*	C.S. Shih and E.F. Gloyna

Table 2. (continued)

COMPUTER CODES	TYPE	LETTER	RESPONSE	REFERENCE	CONFERENCE RM	LIBRARY	OTHER	AUTHORS
Modeling of Environmental Pathways and Radiation Doses from Nuclear Facilities	GF	*	3	*				J. K. Soldat
Radioactivity Transport in Water	STF			*	*	*	*	N.E. Armstrong and E.F. Gloyna
Soil Moisture Transport in Arid Site Vadose Zones	S	*		*				R.E. Isaacson, L.E. Brownell, R.W. Nelson, and E.L. Roetman
The Effect of Ground Level Absorption on the Dispersion of Pollutants in the Atmosphere	A	*		*		*		T.S. Heines and L.K. Peters

^a A - Atmospheric Transport, AF - Atmospheric Transport and Food Chain, F - Food Chain, G - General Transport, GF - General Transport and Food Chain, GS - Ground Water and Surface Water Transport, GT - Ground Water Transport, GWS - Ground Water and Soil Transport, R - Risk Assessment, S - Soil Transport, ST - Surface Water Transport, STF - Surface Water Transport and Food Chain

^b A Letter was sent to the author of the Computer Code

^c 1 - Received a letter, 2 - Received a document, 3 - Received a letter and a document

^d Found the reference

^e Found the document in Bld 7509 's Conference Room.

^f Found in Central Library at X-10 or at the Y-12 Library

^g Either the author works at X-10 or Craig Little or someone else in our group had the document

^h CRAC - Can be obtained from the Argonne Code Center

Table 3. A listing of atmospheric transport codes and their characteristics.

CODE	RELEASE TYPE	MODEL TYPE	DEPOSITION		RESUSPENSION	EXTERNAL DOSIMETRY		TERRESTRIAL FOODS	HUMAN BEHAVIOR	INTERNAL DOSIMETRY		COMPUTERIZATION				REFERENCE
			WET	DRY		AIR EXPOSURE	GROUND EXPOSURE			INHALATION	INGESTION	LANGUAGE	COMPUTER	DOCUMENTATION	SAMPLE PROBLEM	
ACRA-II	A ^a	GP ^b	*	*		*				*		F ^c	IBMD	P ^e	*	Stallman and Kam 1973, McGill; et al. 1976
ADPIC	A,R	PC										L	CDC	P		Lange 1973
AIRDOS-EPA	R	GP	*	*		*	*	*	*	*	*	F	IBM	E	*	Moore; et al. 1979
AIREM	R	GP	*	*		*				*		F	IBM	E	*	Martin; et al. 1974
AIRWAY	A,R	GP	*	*	*	*	*	*	*	*	*	F	CDC	E	*	Rider, 1979
ARADS	R	GP				*						F	CDC	S		Plato; et al. 1967,1969
ARCON	A	GP		*										P		Tveten, 1974
AREAC	R	GP	*	*		*	*	*	*	*	*	F	IBM	P	*	Michlewicz, 1976
ATM	R	GP	*	*	*							F	IBM	E	*	Culkowski and Patterson, 1976

Fig. 2. Schematic showing releases from LLRW trench to public (Crama).

The program I wrote in connection with this drawing is listed in Fig. 3. This program draws small circles in a row in a box. These circles were to simulate a trench of canisters filled with radioactive waste. It is possible to change the LOCATE statement in this program in order to draw circles in a larger box or even all across a page.

I wrote another program to digitize with the plotter or even the CRT. When the program is run, it will wait for someone to move the cursor on the CRT or the pen on the plotter to the specified place. Then press any letter on the keyboard of the computer and a solid circle will be drawn. This program was going to be used in drawing the tables for Craig Little. Unfortunately, it took about two minutes to draw the circle. Therefore, I used an asterisk instead. A listing of this program is shown in Fig. 4. These two above programs and the picture I drew are saved on a tape in the terminal room (Room 13, Building 7503, X-10).

Other work I did for Craig Little was to take over where Kathy Kanak left off building up a Low-Level Radioactive Waste Reference Library in the Building 7509 Conference Room. Craig would select articles for the library, then I would assign a number with the first letter of the author's last name as a call number. Next, I cataloged the articles by author, report number, and by subject. I put it on index cards and made a copy for Wilma Minor, IBM Office System-6 operator, to type for the card catalog in the Conference Room.

Also, Craig gave me a U.S. Geological Survey groundwater model computer code on punched cards, and I ran it on the IBM-360/90 computer with sample data to assist in evaluating its utility. The model is now saved in a file called GRODWA.FOR on the PDP-10 computer. Another model I saved in a file on the PDP-10 was the ODMOD model by Nancy Larson and Mark Reeves. The name of that file is DOCMOD.FOR.

Besides all of the tables and pictures I made for Craig, I also made some graphs for Michael Ryan and Marty Johnson on the HP-2647A using Multiplot. Multiplot provides an easy way to plot a graph.

M. L. Randolph also had me make some tables for his "Summary of Docket File Survey." First we made tables listing the companies. Following the companies, we listed the isotopes and the number of

```

GET "L"
R
)LIST
10 PLOTR
20 LOCATE (10.5,49.4,33.2,54)
30 SCALE (-20,20,-10,10)
40 FRAME
50 S=-8
60 FOR M=1 TO 5
70 P=-18
80 FOR N=1 TO 10
90 RESTORE
100 U=P-2
110 MOVE (U,S)
120 L=-1
130 FOR I=1 TO 7
140 READ X
150 X=X+P
160 Y=SQR(4-(X-P)^2)+S
170 PLOT (X,Y,L)
180 DATA -2,-1.7,-1,0,1,1.7,2
190 NEXT I
200 K=-1
210 FOR J=1 TO 7
220 READ T
230 T=T+P
240 R=-(SQR(4-(T-P)^2))+S
250 PLOT (T,R,K)
260 K=+1
270 DATA 2,1.7,1,0,-1,-1.7,-2
280 NEXT J
290 P=P+4
300 NEXT N
310 S=S+4
320 NEXT M
330 END

```

Fig. 3. Computer program to simulate canisters filled with radioactive waste (Crama).


```
R
10 PLOTR
20 LOCATE (0,200,0,100)
30 SCALE (-500,500,-460,460)
40 DIGITIZE (U,S,P)
44 A=1
50 PLOT (U,S,-2)
60 E=1
70 S=4
80 L=-1
90 T=2.25
100 X=-2.25
110 FOR M=1 TO 17
120 S=4
130 S=(SQR(S)*E)^2
140 T=2.25
150 X=-2.25
160 FOR I=1 TO 16
170 X=X+.25
180 C=X*E
190 Y=SQR(S-(C)^2)
200 IPLOT (C,Y,L)
210 NEXT I
220 K=-1
230 FOR J=1 TO 16
240 T=T-.25
250 D=T*E
260 R=-(SQR(S-(D)^2))
270 IPLOT (D,R,K)
280 K=+1
290 NEXT J
300 B=1.05
310 IF M=8 THEN B=1.15
320 IF M=12 THEN B=1.29
321 IF M=15 THEN B=1.57
322 IF M=16 THEN B=2.8
330 E=E/B
340 NEXT M
342 INPUT "ENTER 1 FOR CONTINUE AND 0 FOR STOP",A
344 IF A=1 THEN GOTO 40
350 END
```

Fig. 4. Computer program used to draw solid circles (Crama).

curies the company is allowed to have. Next, we made a table comparing the companies as to what isotopes they can have. Some of the isotopes were listed in number of grams; therefore, I converted them to curies. Some of the information was given for natural uranium, depleted uranium, and enriched uranium as a whole. Therefore, we found each isotope's radioactivity by multiplying by its enrichment percentage. I wrote a couple of paragraphs about our search for the enrichment percentages of ^{235}U and ^{234}U in depleted uranium. I found that in some books they considered ^{234}U negligible. In *Nuclear Fuel Management* (p. 32), I found a table of ^{234}U enrichments versus ^{235}U enrichments showing the ratios of the amounts of the products and the tails with respect to the amount of feed. I am a co-author on the report that includes this information.

I suppose the most demanding job I had was to learn how to use the HP-2647A graphics computer to achieve optimal interface with my other work. I learned how to draw graphs, how to write programs, and how to use the available software, Multiplot. Besides being able to make different types of graphs, Multiplot can be used to make transparencies. This could be very useful for the Technology Assessments Section.

Renée Smith, a graduate student summer employee, and I wrote a program to make budget graphs for Technology Assessments Section projects. This program was designed to draw a graph more suited to specifications required by the data than the standard graph one gets from using Multiplot. The program we wrote has many capabilities and can be changed to suit the style of the user. Renée wrote a paper on how to use the program.

I wrote an introduction for learning how to use the HP-2647A to supplement the User Instruction tapes that are provided by Hewlett-Packard.

Besides all of these jobs, I got to go on some very interesting tours. I went on a tour of the Burial Grounds at X-10 with Dave Fields, Rowena Chester, and Craig Little. The disposal of radioactive waste is the field of study that has captured my attention.

Another tour I went on was a summer tour of X-10.

Overall, my work periods in the Technology Assessments Section have been most rewarding and most interesting. I recommend co-oping to every kind of student. It is a great experience, well-worth the time that it requires.

2.2 Introduction to the Hewlett-Packard 2647A

This report is designed to familiarize one with several features of the Hewlett-Packard 2647A mini-computer. An introduction to the mini-computer can be accomplished through the use of two tapes: "Hewlett-Packard User Instruction Tape 2647A #1" and "Hewlett-Packard User Instruction Tape 2647A #2" that show how to use the alpha-numerics and graphics modes, respectively. This report is not a replacement to the tapes. It is only a supplement which will highlight some important topics.

Load the #1 tape into the left tape drive. The computer will automatically rewind the tape. Then press READ and the instruction tape will lead on into the wonderful world of HP-2647A commands.

First of all, tape #1 introduces the keyboard. Once the operator is familiar with the keyboard, the instruction tape goes on to show one how to control the display with the cursor arrows and other keys such as TAB, TAB CLEAR, etc. These keys are important in learning how to use the computer effectively.

The third section is extremely important because it shows how to use the command keys. There are some points to remember about using these command keys. All of these points are explained in the *User's Manual* from Page 5-1 to 5-6 and 10-1 to 10-15. One important point is to use COPY with everything in the alpha-numerics mode and to use TRANSFER with everything in the graphics mode. For example, if there is a list of data on the screen for which a hard copy is needed, then press "COMMAND, f2 (COPY), f2 (FILE), f3 (DISPLAY), f7 (HP-IB#), 6 (the address of the printer), RETURN." This will copy what is on the screen to the printer. Before the above steps are executed, though, the cursor must be at the top of the data. This data file can be copied onto a tape at the same time, too, by just adding f1 (LTAPE) or f2 (RTAPE) (depending on whether the left tape or the right tape is

needed) after the 6 and before pressing RETURN. If the data is longer than the display on the screen then position the cursor at the top of the data and press "f2 (COPY), f3 (ALL), f3 (DISPLAY), f7 (HP-IB#), 6, RETURN." These commands are not just for data files. Program lines and other alpha-numerics can be copied.

Now, to copy a picture, a graph, or anything in the graphics mode the TRANSFER key must be used. An example is a table that needs to be saved on the right tape; press "COMMAND, f1 (Next), f1 (Next), f3 (TRANSFER), f2 (FILE), f4 (GRAPHICS), f2 (RTAPE), RETURN."

Use of the tape requires many other commands, for instance, the REWIND command. This command is discussed on the instruction tape. Another important command is the marking of a file on tape. After one has copied a file on a tape, the tape must be marked to enable one to copy another file on the same tape; therefore, press "COMMAND, f6 (MARK), f6 (RTAPE), RETURN." If one forgets to mark a file, then the next file copied on the tape will be combined with the first file.

There is another command statement which is quite useful in moving from file to file. This is the FIND statement. For example, one needs to move from File #5 to File #12. There are two ways to do this. One way is to press "COMMAND, f7 (FIND), f7 (FILE), 1, 2, f8 (RTAPE), RETURN," or "COMMAND, f7 (FIND), f7 (FILE), +, 7, f8 (RTAPE), RETURN." Also, if one wants to move from File #12 back to File #5, then either type in a "-7" or just a "5." An absolute number means the number of the file and a number with a + or a - means to skip that number of files either forward or backward, respectively, on the tape.

There is one other thing to remember while working with tapes. If one writes over the first file of a tape, then all the rest of the files are erased from the tape.

The next section on the instruction tape is f4, which discusses text editing. This is helpful in writing programs. Section f5 explains defining the soft-keys, and it brings up the subject of Escape codes. This subject is interesting, but it isn't a requirement in order to use the computer effectively.

Section f6 discusses programming in BASIC. There is a small book titled *Quick Reference Guide*, which has a description for each of the BASIC statements.

Before it is possible to write a program in BASIC, the "BASIC Interpreter" must be loaded into the computer's memory. Once it is loaded, it is always there until the machine is turned off. The instruction tape will explain how to load the BASIC Interpreter.

While writing programs one may want to save them on tape. Instead of using the copy command for which the cursor must be positioned, it is much simpler to SAVE a program. This way all of the program lines are recorded without having to list the program on the screen. While in BASIC, type in SAVE "R" or SAVE "L" depending on which tape one wants it on (the right tape or the left tape). After saving the program, the file must be marked just like any other file. To retrieve the program, simply find the file that the program is saved in by using the FIND Command. Then turn off the COMMAND display and type in GET "R" or GET "L" depending on which tape it is on. This will complete the first instruction tape.

Next, load in the second instruction tape as the first. The first section will cover the keyboard again. The second section discusses controlling the display.

Then the instruction tape will show one how to draw with the cursor on the terminal. This is very useful in drawing diagrams of all sorts. The next section will cover the graphics text mode, which allows one to type in different letter sizes. This is important and useful in creating tables. This text mode is terminated by pressing the STOP key.

The last two sections describe plotting different kinds of graphs.

There are two ways to plot graphs. One way is to use MULTILOT. With MULTILOT, pie charts, bar graphs, and different kinds of linear graphs can be made. All of these types of graphs are described very well on the instruction tape and in the *User's Manual*, starting on page 7-1. It is possible to use the plotter with MULTILOT by entering 4,1 in the menu where it asks "PLOTTER?"

The other way to plot, for the daring and courageous person, is for them to write their own program using AGL (A Graphics Language) statements. The AGL is loaded on the computer memory when the BASIC Interpreter is loaded. These AGL statements are described very well in the *Quick Reference Guide*.

For using the plotter, all one needs to have is: PLOTR (4,1) as the first statement in the program. Also, remember that all program lines must be numbered.

There are many interesting features on the HP-2647A. The plotter or even the CRT can be used as a digitizer by writing a small program. An example of this is in the *Quick Reference Guide* on page 93.

There is also a book titled *Slide Overhead Transparency Preparation Guide*, which allows one to create transparencies on the plotter. A different set of pens must be used for this. The slide menu can be loaded from the MULTILOT tape. The plotter's address in the Slide Menu should be 4.

Hopefully, this report will help to hasten one's learning of the use of the HP-2647A. There are still some functions on the mini-computer that must be conquered by trial and error.

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3. ACTIVITY REPORTS BY P. A. DAWKINS

Name: P. A. Dawkins

Age: 18

Academic Background: Undergraduate, B.S. program in Engineering,
Morehouse College,

Sponsor: UCC Pre-Cooperative Education Program

Employment Periods with ORNL: 1 with TAS: 1

Supervisors: R. O. Chester, D. E. Fields, M. T. Ryan

Period of Assignment: 6/2/80 through 8/15/80

Principal Project Assignment: Environmental Protection Agency (EPA)-
Environmental Assessment Modeling for
Shallow Land Disposal of Radioactive
Waste

Description of Project:

This EPA-sponsored project involves the development and assemblage of mathematical models for assessment of the environmental impact and health risk associated with shallow land disposal of low-level radioactive wastes.

This student's contribution to the project involved library research for project members, compiling computer programs in FORTRAN, and various electronics projects including design and construction of circuit boards.

3.1 Summer Employment 1980

This summer has proved to be a very rewarding and enjoyable one for me. I learned many new things and experienced new encounters.

Upon first reporting to ORNL, I was informed that I would be working with the Health and Safety Research Division. I also learned that I would be working mainly with Dave E. Fields and Michael T. Ryan; Dave Fields especially.

The first thing I began working on was the Decwriter III computer terminal. On this machine, I studied the BASIC language tutorials to learn BASIC language. There are a total of 15 tutorials, which I studied and learned in a period of about one week. Immediately after learning BASIC language, I practiced writing and executing programs using the language. I typed programs for myself and for Dave. The most challenging of these was a program which produced labels when executed on the Decwriter. This program involved a DO loop.

Another of the first things I worked on was the proper and effective use of a technical library. The process involved learning where sections are located, how to use the different files, and how to use the microfilm and microfiche machines. I also learned how to use the various copying machines. During my learning process, I did research for Dave, Mike, Steve Sims, and Mac Randolph. I am grateful for having learned the layout and operation of a technical library. This, I already know, shall be greatly implemented throughout my years of school to come.

As well as learning the layout of the library, I also learned the layout of ORNL itself. This was very well appreciated throughout the summer as I undertook various projects.

I learned, throughout the course of the summer, how to use several of the computers, and computer associated equipment, located in the Health and Safety Research Division. The list of these consists of the Decwriter III, the Radio Shack TRS-80, the keypunch machine of the Batch Station, Room 11, Building 7503, the Tektronics computer graphics terminals, and most recently, the Hewlett-Packard 2647A graphics terminal.

The printer-plotter associated with the TRS-80 used by Dave is better known as "the beast." I learned not only how to operate this machine but how to change the print font. This involved going inside the computer and working with the electronics.

In addition to learning BASIC language, I learned FORTRAN language. Through practicing how to write programs in this language, I learned its implementation. I wrote three programs in FORTRAN which are now included in my user file on the PDP-10 computer.

Through the learning of BASIC and FORTRAN languages, I learned the mechanics of using EDITS. I practiced the EDIT commands while perfecting my computer programs. I had the pleasure of teaching the Health and Safety Research Division's two Summer Research Apprenticeship Program's high school students, Patti Jones and Bob Green, how to use EDITS. I also produced an EDITS manual, designed to instruct other students in the use of EDITS. It is geared toward the newcomer to EDITS and to computers. I am happy to say that I feel the manual meets its purpose.

This summer I also had the pleasure of being introduced to, and of doing, some electronics work. The first experience I had was that of studying circuit board layouts. This was very beneficial when I was given my first electronics project, the construction of a light pen for Dave's TRS-80. This was a project on which I did all of the work. I had to design the layout of the circuit board, attach all of the integrated circuits, and complete all of the necessary wiring. This project took about three days of work and the effort, I am glad to say, was successful.

In order to attach the integrated circuits and the wires, I had to learn to solder. This was done and its use was implemented throughout the summer as I undertook other electronics projects.

The second electronics project I performed was that of attaching a mini-plug to the light pen. This was done to increase the power of the light pen. The mini-plug, then, served as a means of amplification. This was another success.

My third electronics project involved calculators. I was to change the voltage of Dave's HP-41 adapter from 7 volts to 5 volts. This involved going into the adapter case and working with the circuitry. In order to check the end result, I had to use a voltmeter. Consequently, I learned how to operate a voltmeter while doing this project. By the way, another success is reported.

My fourth electronics project had to do with one of the Tektronics computer terminals. I was to introduce an echo device into the circuitry of the computer. This involved going inside the computer case and attaching conductor wires. This device allows the programmer to see everything he types on the keyboard printed on the screen of the computer. This project was another success.

My fifth and final electronics project is the construction of a part for Dave's TRS-80. Steve Glandon is working at my side during this project. The project entails designing the circuit board, attaching the circuits, and completing a great amount of wiring. This is my most challenging project. I shall have completed it before August 15, my termination date. It is a project that will have taken about two weeks to complete.

As well as doing all of the aforementioned things this summer, I also attended a number of seminars and participated in a tour. The seminars were varied and very informative. Most interesting to me were the Love Canal seminar, the Three Mile Island seminar, and Mike's seminar on radiation types. Mike's talk was particularly rewarding for it cleared my mind of some misconceptions that I had and that I'm sure many other people have regarding radiation.

In conclusion, I would like to say again that I have thoroughly enjoyed being involved with the Health and Safety Research Division of the Oak Ridge National Laboratory this summer. I wish to thank everyone with whom I came in contact for making my summer a productive and enjoyable one. Special thanks go to Michael T. Ryan and Dave E. Fields. I am looking forward to returning to ORNL next summer. Thank you all for a wonderful experience and good luck in your future as a team and in your individual futures as far as your separate careers are concerned. Good-bye.

3.2 EDITS

EDITS is a system used to correct, change, erase, etc., any line or number of lines in a computer program. Simply put, EDITS is a system used to perfect a computer program. This can be a program written in any computer language. It is good to note, however, that different languages require slightly different editing procedures.

What this short paper will try to do is to present some fundamental commands used in editing. These can be applied to any computer language, though most widely applied to FORTRAN. These commands belong to the editing system entitled STOPGAP. The commands to be discussed are as follows:

INSERT,
END,
QUALM,
FIND, and
ALTER.

EDITS is also widely used to create a program itself. The programmer places the computer in the edit mode, thus transferring control from the computer to himself. He then creates his program, which is automatically recorded onto his file. He can then correct his program with edit commands.

To place the computer in the edit mode, the programmer must type EIO, followed by the program name, after the computer has printed a period (.) on the screen.

INSERT

The INSERT command is one used mainly to add a line to a computer program.¹ Consequently, this command is used primarily when a programmer is creating a program.

¹There are two insert commands. One is used for intra-program editing. The other is used for intra-line editing.

To activate this command, a programmer simply types I and follows it with a line number. An example is this: I40.¹ The computer reads this command and types back 00040 . Now the programmer writes his line, which is inserted into his program.

END

END is the command used after a programmer has written and/or perfected his program. This tells the computer that the programmer is finished and transfers control back to the computer. END has the same interpretation as exit. END is activated by typing E after the computer has printed *.

QUALM

The QUALM command is the command used to save all edits made within a program. QUALM is activated by typing Q after the computer has printed *. It is noteworthy that although the QUALM command saves all edits, it is best applied when used after each individual edit is made. This is also because, unfortunately, computers shut down at times. If this occurs, all edits previously made, if a programmer is using edits, are forgotten. The programmer then has to go back and start over again. However, if the programmer has utilized the QUALM command after each individual edit is made, and a computer shutdown occurs, the edits made before shutdown occurs are all saved. Obviously, this process can save much time and energy, as it prevents forcing a programmer to start over and to make all necessary edits again.

FIND

The FIND command is used to find a certain word or group of words, called a string, in a computer program. It is executed by typing F, followed by the string, followed by \$ (typed by pressing the alt mode key); and lastly a range of lines. An example is this: F writes \$100:400. The computer reads this as follows: Find the "write" string within lines 100 to 400. The computer searches between lines

¹Every edit instruction, after being typed in, is followed by a return.

100 and 400 for the "write" string. If one is found, the computer prints the line on the screen. If two or more are found, the first is printed on the screen. If none are found, the computer prints * and waits for the next edit command.

The edit commands previously discussed can be considered "intra-program" edit commands. What this means is that they are used within a program, of course, but used to perfect the lines in a program as opposed to the words in the lines of a program. These "intra-line" edit commands are to now be discussed.

ALTER¹

ALTER is the master command used in "intra-line" editing. This is said because the edit commands used in editing program lines form a subset under the term ALTER. The ALTER command is executed by typing A, followed by the number of the line to be altered. It appears as this: A400, which means alter line 400. The computer must print * before the ALTER command can be utilized. The alt mode key is used to escape the ALTER command.

Under ALTER, there are four editing commands which are widely used (S, C, D, and I). The first altering command is S, which is used to search for a character. The S command is executed by typing S, followed by the character being sought, after the computer prints * on the screen. For example, if a programmer wanted to find the g in girl, he would type Sg. The computer would read this command and would move to the g. The programmer would know that this had been done because he would see the cursor appear at the position of the g. If there is more than one g in the line, the programmer must specify which one he is seeking. He does this by typing 1Sg, or 2Sg, or 3Sg, etc. The number before the S specifies which g is being sought. The first g in the line is represented by 1, the second by 2, and so on. No escape is needed when using the S command alone for no change is made. Only

¹ALTER is the master command for altering a line. The four altering commands being a subset, A must be typed to enter the altering mode and to utilize the four commands.

when a character is changed after having been searched for is the escape (alt mode) key used.

The second of these four is C, which means substitute a character. One can more easily familiarize himself with this command if he thinks of it as meaning change a character. The word substitute can be confused with the substitute command, a command used in "intra-program" editing. As stated, the C command is used to "change" a character in a line. For instance, if "lead" were printed in a computer line, and the programmer actually wanted to type "read," he could change the l in "lead" to an r and produce "read." This is done by typing, after the computer prints *, S¹l, which means search for l. The computer will do this, whereupon the programmer types Cr, which means change to r. The programmer then presses the alt mode key to escape the altering mode. He then presses the return key.

The third command under ALTER is D, which is the delete command. It is used very much like the C command, but only to delete characters, not change them. For example, if a programmer types the word "boys" in a line of his program and wanted to type "boy," he could use the delete command to rid the word of the unwanted s. After the computer prints * on the screen, the programmer types Ss, which means search for s. After the computer finds the s, the programmer types D, thus deleting the s from boys and resulting in the word boy. The alt mode key is then pressed to escape the altering mode, and is followed by a RETURN.

The fourth and final altering command is I, which is used to insert characters. It is used similarly to the D command. Let us examine the example, used in describing the delete command, in reverse, to visualize the insert command. A programmer has typed the word "boy" into a program line and wanted to type "boys." He now types, after the computer prints * on the screen, Sy, which means search for y. After the computer has done this, the programmer spaces

¹S is the search command.

over one to pass over the y, and types Is, which instructs the computer to insert an s. Upon completion, the alt mode key, followed by a return, is pressed to escape the altering mode.

This concludes a short description of the commands most often used in editing a program with the STOPGAP editing procedure. Hopes are that this paper can be beneficial to one who happens to read it in the process of either learning about STOPGAP editing or in teaching it. Thank you.

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4. ACTIVITY REPORTS BY L. J. FARTHING

Name: L. J. Farthing

Age: 28

Academic Background: B.S. degree, Biology; Undergraduate, B.S.
program in Metallurgical Engineering,
University of Tennessee

Sponsor: UCC Cooperative Education

Employment Periods with ORNL: 2 with TAS: 2

Supervisor: C. C. Travis

Period of Assignment: 6/9/80 through 9/12/80

Principal Project Assignment: Environmental Protection Agency (EPA)-
Development of a Multi-Media Model for
Use in Chemical Risk Assessment

Description of Project:

This EPA-sponsored project involves Technology Assessments Section members primarily as advisors to Environmental Sciences Division personnel, who are responsible for the project. The project goal is the development of a state-of-the-art, multi-media (atmospheric, terrestrial, and aquatic) environmental model for assessment of the ultimate fate of chemicals released into the environment.

Linda's contribution to the project was compilation of literature surveys on human health effects of "transformation products" (i.e., chemicals derived from primary combustion products such as those formed during fossil fuel combustion).

4.1 Co-op Report

My project for the summer was to do literature surveys on the human health effects of certain "transformation products." Transformation products are chemicals that are derived from primary combustion products. For example, fossil fuel combustion is an anthropogenic source of nitric oxide and nitrogen dioxide; nitric acid, dinitrogen pentoxide, nitrates, peroxyacylnitrates, and N-nitrosamines can be formed from this NO and NO₂ by complex photochemical reactions. In a similar manner, sulfuric acid, ammonium sulfate, and other sulfates can be formed from sulfur dioxide, which occurs both naturally and from fossil fuel combustion.

The surveys will be incorporated into an environmental impact report of the effects of converting gas- and oil-fueled power plants to coal-fueled ones. The Fuel Use Act promotes the use of domestic coal to limit the nation's dependence on foreign oil. It is important to know the health effects of these transformation products (particularly sulfates), since increased use of coal can possibly cause a decrease in ambient air quality.

Information was obtained in several ways. I learned to do literature searches on the RECON system. I made extensive use of the libraries for books, journals, and reports. I telephoned the EPA to request documents. I also received assistance from several people in the Information Division (especially L. W. Rickert).

Section 4.2 is a short summary of the possible health effects of some transformation products. No human health effects could be reported in a few cases, since no studies had been done. For example, ingested N-nitrosamines, but not inhaled, have been studied. Therefore, the effect of atmospheric-N is not known.

One problem I encountered in doing my project was the uncertainty of available information. The major epidemiological studies of atmospheric nitrate and sulfate have been done by the Community Health and Environment Surveillance System (CHESS) of the EPA. The CHESS studies have been widely criticized. Laboratory experiments have their own problems - particularly the small number of participants. It is difficult to determine the significance of two out of six volunteers

showing a particular response. Also, children and the elderly appear to be particularly vulnerable to air pollution; however, most experiments are run with healthy young adults. Both types of studies are open to criticism, but there are obviously very real problems in trying to show cause and effect.

This is my second co-op work period at Union Carbide and also at the Health and Safety Research Division. I did programming and computer simulations most of my first work period, so it was an interesting change to do assessments. My work has made me aware of some of the problems of environmental assessment, including insufficient information and the uncertainty of much of the information. I now understand the difficulty with which standards are set and the susceptibility to change as new data become available. I appreciate the opportunities that Oak Ridge National Laboratory has given me and I especially thank C. C. Travis for his supervision.

4.2 Transformation Products

Dinitrogen pentoxide (N_2O_5)

Chronic exposure to low levels of CO , NH_3 and N_2O_5 has produced relatively high levels of carboxyhemoglobin and methemoglobin in the blood and excessive excretion of vitamin B_6 degradation products.

Peroxybenzoylnitrate (PBzN)

There are no experimental or epidemiological studies on the health effects of PBzN.

Peroxyacetylnitrate (PAN)

Short-term exposures to 1188-1485 $\mu g/m^3$ of peroxyacetylnitrate have produced no adverse health effects in healthy volunteers. No long-term studies have been performed.

N-nitrosamines (NNA)

N-nitrosamines are known to be carcinogenic in animals, but there are no studies on the effects of atmospheric NNA on humans.

Nitric acid

Nitric acid vapor has a threshold limit value (TLV) of 5 $\mu g/m^3$ for industrial exposure. Pulmonary edema, bronchopneumonia, and even death have been reported in workers exposed to vapors resulting from reactions involving metals and nitric acid.

Nitrates

The annual average of nitrate aerosols in non-urban air in the United States is 1.10 $\mu g/m^3$ with 8.9 $\mu g/m^3$ as the 24-hour annual maximum. Short-term exposures of up to 7000 $\mu g/m^3$ of nitrate have had no significant effect on healthy or asthmatic volunteers. A level of 2 $\mu g/m^3$ is viewed as an estimate of the threshold for effects from chronic exposure. This level of exposure may exacerbate pulmonary

symptoms in the elderly. Some studies indicate that respiratory tract irritation may occur at nitrate levels of 3.8-7.2 $\mu\text{g}/\text{m}^3$. Nitrate levels of 8 $\mu\text{g}/\text{m}^3$ are associated with an increased rate of asthma attacks.

Sulfuric acid (H_2SO_4)

Short-term exposures to 100-1000 $\mu\text{g}/\text{m}^3$ of H_2SO_4 have altered bronchial mucociliary clearance in healthy volunteers. Small changes in specific airway conductance have been noted in normal volunteers exposed to 1000 $\mu\text{g}/\text{m}^3$ of sulfuric acid. Coughing, bronchoconstriction, and increased pulmonary resistance have been reported following short-term exposures up to 39 $\mu\text{g}/\text{m}^3$ of sulfuric acid. It has been suggested that exposures to 100 $\mu\text{g}/\text{m}^3$ of H_2SO_4 could exacerbate already existing respiratory disease.

Sulfates

No evidence of respiratory changes has been found in subjects exposed to 100 $\mu\text{g}/\text{m}^3$ of ammonium sulfate, 85 $\mu\text{g}/\text{m}^3$ of ammonium bisulfate, and 75 $\mu\text{g}/\text{m}^3$ of sulfuric acid. Short-term exposures to 1000 $\mu\text{g}/\text{m}^3$ of zinc sulfate, zinc ammonium sulfate, and sodium sulfate have produced no significant changes in healthy adults.

One CHESS study found a 10% increase in the rate of asthma attacks when the minimum temperature was above 50°F and the suspended sulfate (SS) level was greater than 10 $\mu\text{g}/\text{m}^3$. The threshold level was estimated to be 12 $\mu\text{g}/\text{m}^3$ of SS when the minimum temperature was between 30° and 50°F. Another CHESS report estimated the threshold level for effects to be 1.4 $\mu\text{g}/\text{m}^3$ at temperatures greater than 50°F.

The best judgment of the threshold for effects of SS on cardio-pulmonary symptoms in the elderly was estimated to be 6 $\mu\text{g}/\text{m}^3$ (24-hour average). An increase in chronic bronchitis was noted in adults exposed to 4-7 years of 90-95 $\mu\text{g}/\text{m}^3$ of SO_2 , 15 $\mu\text{g}/\text{m}^3$ of SS, and 60 $\mu\text{g}/\text{m}^3$ of TSP (trisodiumphosphate). Another study found an increase in acute lower respiratory disease in children exposed to three or more years of 177 $\mu\text{g}/\text{m}^3$ of SO_2 , 7 $\mu\text{g}/\text{m}^3$ of SS, and 65 $\mu\text{g}/\text{m}^3$ of TSP.

Sulfate levels of 9-15 $\mu\text{g}/\text{m}^3$ were estimated to be the "best judgment" thresholds for increased acute respiratory disease and chronic bronchitis. Concentrations of 6-10 $\mu\text{g}/\text{m}^3$ of SS were estimated to aggravate asthma.

5. ACTIVITY REPORT BY S. R. GLANDON

Name: S. R. Glandon

Age: 20

Academic Background: Undergraduate, B.S. program in Physics,
Tennessee Tech University

Sponsor: UCC Cooperative Education

Employment Periods with ORNL: 1 with TAS: 1

Supervisor: D. E. Fields

Period of Assignment: 6/9/80 through Summer 1981

Principal Project Assignment: Environmental Protection Agency (EPA)-
Environmental Assessment Modeling for
Shallow Land Disposal of Radioactive
Waste

Description of Project:

This EPA-sponsored project involves the development and assemblage of mathematical models for assessment of the environmental impact and health risk associated with shallow land disposal of low-level radioactive wastes.

Steve's contributions to the project included:

- (1) Literature searches;
- (2) Library acquisitions;
- (3) Ordering journal articles; and
- (4) Computer projects for systems modification in TAS.

I am working in the Technology Assessments Section of the Health and Safety Research Division at Oak Ridge National Laboratory. The Technology Assessments Section is unique in that it combines several disciplines but still requires the same in-depth knowledge and experience of each science that pure research demands. These disciplines include physics, biology, computer science, and engineering.

A major portion of our task is keeping abreast of the enormous amount of research that is being published weekly. Information science is a greatly expanding field and I have been given some responsibilities in this area. They include: literature searches on the computer data bases RECON and DIALOG – these provide a rapid means of accessing literature on a large number of subjects; library acquisitions – ordering references for staff members; and taking care of the OATS Order Service – ordering journal articles listed in Current Contents, a magazine listing articles ranging from the physical sciences to agriculture.

Also, I am making computer-produced graphs of the monthly budget of the projects in our section. These visual aids help the section head and group leaders keep better in touch with the expenditures of each project. The graphs show total expenditures for each month of the fiscal year to date for each project in the section and the total for all projects.

I have found that the educational process is greatly accelerated by co-oping. For example, I obtained a working knowledge of the computer language BASIC in two days. I have learned to use many different types of computers – the PDP-10 made by Digital Equipment Corporation, the Hewlett-Packard microcomputer Model 2647A, and the Radio Shack TRS-80 microcomputer. I have completed a small computer project that involved modifying a data preprocessor so that it would be easier for non-computer oriented people to use – this is called "interactive programming."

I have also been assigned a project that includes building, testing, and implementing some computer hardware in the Radio Shack microcomputer. The software consists of a digitization program which would allow map and photographic data to be entered into the computer using

a light pen (a device that picks up the presence of light from a single point) and a cursor-trace (using a moving cursor to trace lines). This data can then be used to find such useful parameters as the area and the perimeter of the figure, in user coordinates. Also, if two maps were digitized, one could find the intersection area and perimeter. This project is nearing completion.

Everyone in the Laboratory, and especially in our section, has been very patient and helpful in answering my many questions. I work with my supervisor every day and meet with our group leader approximately every two weeks. This helps both me and the group work better together - matching goals.

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6. ACTIVITY REPORTS BY R. GRIER

Name: R. Grier

Age: 18

Academic Background: Undergraduate, B.S. program in
Engineering, Morehouse College

Sponsor: UCC Pre-Cooperative Education

Employment Periods with ORNL: 1 with TAS: 1¹

Supervisor: R. O. Chester, D. E. Fields

Period of Assignment: 6/30/80 through 8/15/80

Principal Project Assignment: Environmental Protection Agency (EPA)-
Environmental Assessment Modeling for
Shallow Land Disposal of Radioactive
Waste

Description of Project:

This EPA-sponsored project involves the development and assemblage of mathematical models for assessment of the environmental impacts and health risk associated with shallow land disposal of low-level radioactive wastes.

This student's contribution to the project was the development of flow charts using computer programs.

¹Summer 1980 employment split between Metals and Ceramics and Health and Safety Research Divisions.

6.1 Summer Employment Report

I began working with the Technology Assessments Section of Health and Safety Research Division at the Oak Ridge National Laboratory on June 30, 1980. During that week I went through BASIC language tutorials. I learned a lot about the Dec-System 10. Through the knowledge of the system, I was able to write my own programs. One of the programs converts degrees to radians and then finds the Sine of the angle for the values that were inserted. Another program finds the total resistance of a parallel resistance circuit.

During my second week I went to the library several times. I watched the instructional videotapes on FORTRAN Programming. I discussed with Dave Fields the possibility of writing a program that would compute perfect numbers.

Using the flow charts computer program manual by Stephen Fischer, I have been creating flow charts on the computer. I completed four flow charts: PREREM.FL1 and PREREM.FL2 for the Nuclear Regulatory Commission (NRC) Long-Term Dose Assessment Project, and LOWLEV.FL1 and LOWLEV.FL2 for the EPA Low-Level Radioactive Waste Impacts Modeling Project. It was a very challenging job. Each instruction list has about 125 instructions. I have also been using EDITS to help correct mistakes that I have made on the flow charts. EDITS is a system used to correct, change, erase, etc., any line or number of lines in a computer program.

In addition to projecting flow charts, I have been using the FORTRAN manual by David McCracken. I have also written a few programs in FORTRAN.

I learned a lot about radiation and its effects on certain parts of the body. The seminars that I attended were very interesting. The students here have been very helpful in answering my questions about college. They have helped me on working a few calculus problems.

My summer here has been a valuable experience. Throughout my high school days I had a number of questions about career choices. Some of these questions were answered in school and some were not. This summer I got a lot of those unanswered questions answered.

Coming here to Oak Ridge National Laboratory I got to talk to engineers, mathematicians, a chemist, and other professionals. These conversations helped me to decide which career I would like to pursue. I've really enjoyed being here. I look forward to future employment.

6.2 Flow Charts

This short paper on flow charts is to be used in conjunction with the manual by Steven Fischer.

Before using this program you should try to get some basic knowledge and understanding of the editing programs.

The first thing you should do is develop a file name. When you are ready you should login. After you login you should type "RUN USR: FLOW1," this will get you into the flow chart program. It will then ask if you would like information on FLOW2. The computer will then ask for a file name. You should type your file name. If you have a file created and you want to start where you left off, "OLD FILE" must be entered. If you do have a file created and you want to overwrite what you've written, just give the name of the file.

The computer starts at the top of an $8\frac{1}{2} \times 11$ in. page. You may give your own dimensions if you choose. The command "DIME" should be used as the very first line in your instruction list, if you wish to specify your page size.

You may also tell which position on the paper you want to start. The command "POS1" should be used. Both dimensions and positions are measured in "UNITX" and "UNITY."

There is a list of geometric figures in the manual by Mr. Fischer. Some of these figures can be drawn automatically. Below is an example, the words underlined are the words typed in by the user.

EXAMPLE:

Continue Instruction List

10. A O N

11. I E X I

HOW MANY LINES? 2

LINE 1. C M A L U A T E V A L U E S # \$

LINE 2. M F O R F (X) # \$

Continue Instruction List

12. B O X

Notice in the above example that the type of figure comes after the text. These figures which can be drawn automatically can also have its dimension drawn to a specific size. The figures which can't be drawn automatically have to have their dimension specified also. Here is an example:

EXAMPLE:

Continue Instruction List

10. A O F F

11. U N I I

TYPE THE NEW VALUES OF UNITX AND UNITY 1 5 0 5

Continue Instruction List

12. B O X

13. I E X I

HOW MANY LINES? 1

LINE 1. C M O M P U T E N E W V A L U E S F O R F (X) # \$

Continue Instruction List

For information on how Unit X and Unit Y are measured for each geometric figure, see the Flowcht manual by Steven Fischer.

"ARRO" is used to draw a straight line with the arrowhead pointing in the direction specified. The length is measured in inches.

"CRNN" is used to connect two previously stored points. The type of arrow is determined by the most recent uses of "DOT, DASH, CURV, TWOH, and RSET." If a single arrowhead is used the arrow will point from the first point to the second.

Some of the geometric figure sizes can be determined automatically or they can be specified with Unit X and Unit Y. Other sizes have to be specified. Here is a list of the ones which can be sized automatically. On the left is the command and on the right is the figure that it draws.

OVAL	Oval
PARA	Parallelogram
CARD	Computer card
HEXA	Hexagon
PENT	Pentagon
TRAP	Trapezoid

(top and bottom of TRAP are parallel)

TRP2	Trapezoid
(vertical sides of TRP2 are parallel)	
OUTP	Irregular pentagon
TAPE	Magnetic computer tape
DISK	Disk pack
LIST	Computer listing
SIDE	Pentagon pointing right
TERM	Computer terminal
TUBE	Cathode ray tube

Please note that you may also specify the dimensions on the figures that were previously listed.

The figures below cannot be drawn automatically. Dimensions must be specified by Unit X and Unit Y.

DIAM	Diamond
CIRC	Circle
TRID	Equilateral triangle pointing down
TRIU	Equilateral triangle pointing up
KITE	Kite pointing down
KITU	Kite pointing up

"VIEW" is used to see what has been drawn.

"PRNT" is used to print the coordinates of stored points. It must be used after you view the chart.

To transport the flowchart to the Calcomp plotter, run the flowchart program. When asked whether you want a compressed data set or to plot on the screen, please enter compress, then proceed as usual.

"VIEW" shall be the first command in your instruction list. The program will ignore the command "END" the program and the plot will be returned in a few days (see Table 4 and Fig. 5).

Table 4. Sample command files using FLOW1 (Grier)

```

1. DIME
2. 8.5000
3. 1.1.0000
4. POS1
5. 2.5000
6. 1.1.0000
7. ARRO
8. 0.7500
9. DOWN
10. AON
11. TEXT
LINE 1 3
LINE 2 C@OMPUTE# C@OMPOSITE#$
LINE 3 S F@ACTOR FOR#$
LINE 4 F@ONE# C@OMPARTMENTS#$
12. ROX
13. ARRO
14. 1.0000
15. DOWN
16. AOFF
17. UNIT
18. 1.5000
19. 1.0000
20. DIAM
21. TEXT
LINE 5 3
LINE 6 S@UMMARY#$
LINE 7 @OF# I@NPUT# D@ATA#$
LINE 8 D@ESIRE D?#$
22. STRR
23. DECI
24. RIGH
25. DOWN
LINE 9 1
LINE 10 @NO#$
26. ARRO
27. 0.7500
28. DOWN
29. STOR
30. POS2
31. 1
32. DECI
33. RIGH
34. UP
LINE 11 1
LINE 12 @YES#$
35. ARRO
36. 2.7500
37. RIGH
38. SKIP
39. 0.1500
40. UP
41. SKIP
42. 0.5400
43. RIGH
44. AON

```

Table 4. (continued)

```

45.TEXT
LINE 13 1
LINE 14 C@ALL# OFILE$
46. ROX
47. ARRO
48. 0.4 500
49. DOWN
50.TEXT
LINE 15 1
LINE 16 C@ALL# SUMMRY$
51. BOX
52. CURV
53. ARRO
54. 0.4500
55. DOWN
56. RSET
57. ARRO
58. 4.0600
59. LEFT
60. POS2
61. 2
62. ARRO
63. 0.5000
64. DOWN
65.TEXT
LINE 17 3
LINE 18 S@ELECT# READIONUCLIDE#$
LINE 19 S@UBCHAIN TO BE#$
LINE 20 C@ONSIDERED#$
66. PARA
67. ARRO
68. 1.0000
69. DOWN
70.TEXT
LINE 21 2
LINE 22 U@SER# S@PECIFICATION#$
LINE 23 P@CR# O@UTPUT# FEILE#$
71. PARA
72. ARRO
73. 0.7500
74. DOWN
75.TEXT
LINE 24 1
LINE 25 C@ALL# OFILE$
76. ROX
77. ARRO
78. 1.3000
79. DOWN
80.TEXT
LINE 26 2
LINE 27 O@UTPUT OF# INREM-11$
LINE 28 DeATA# SeET#$
81. PARA
82. PAGE
1. DIME
2. 8.5000
3. 11.0000
4. PCSI
5. 2.0000
6. 10.0000
7. AON
8.TEXT
LINE 1 3
LINE 2 I@NITIALIZE# S@OURCE# @AND#$
LINE 3 T@ARGET# C@RGAN# M@ASSES#$
LINE 4 @AN[* N@AMES#$

```

Table 4. (continued)

```

9. POX
10. ARRO
11. 0.2500
12. DOWN
13. TEXT
LINE 5 2
LINE 6 A@CEPT# P@ARENT#$
LINE 7 R@ADIONUCLIDE# N@AME#$
14. POX
15. ARRO
16. 0.1200
17. DOWN
18. TEXT
LINE 8 2
LINE 9 D@ECAY# C@HAIN# D@ETERMINATION:#$
LINE 10 C@ALL# CHAIN$
19. PARA
20. ARRO
21. 0.1200
22. DOWN
23. STOR
24. AOFF
25. UNIT
26. 1.7500
27. 1.0000
28. DIAM
29. TEXT
LINE 11 3
LINE 12 E@NTER#$
LINE 13 M@ETABOLIC# D@ATA#$
LINE 14 @FROM# F@ILES?#$
30. STRR
31. ARRO
32. 0.1200
33. DOWN
34. AON
35. TEXT
LINE 15 3
LINE 16 U@SER# S@PECIFICATION# @OF#$
LINE 17 M@ETABOLIC# F@ILE#$
LINE 18 S@PECIFICATIONS#$
36. PARA
37. ARRO
38. 0.1300
39. DOWN
40. TEXT
LINE 19 2
LINE 20 C@ALLS# @TO#$
LINE 21 I@FILE$
41. POX
42. ARRO
43. 0.2500
44. DOWN
45. TEXT
LINE 22 3
LINE 23 R@EAD# M@ETABOLIC# D@ATA#$
LINE 24 F@ILE:#$
LINE 25 C@ALL# METAS$
46. PARA
47. ARRO
48. 0.2500
49. DOWN
50. TEXT
LINE 26 2
LINE 27 A@CEPT# S F@ACTOR#$
LINE 28 F@ILE# S@PECIFICATIONS#$

```

Table 4. (continued)

```

51. ROX
52. ARRO
53. 0.3500
54. DOWN
55. TEXT
LINE 29 2
LINE 30 C@ALL#$
LINE 31 IFILE$
56. ROX
57. ARRO
58. 0.1300
59. DOWN
60. TEXT
LINE 32 2
LINE 33 R@EAD# S F@ACTOR#$
LINE 34 F@ILE#$
61. PARA
62. ARRO
63. 1.2000
64. DOWN
65. POS2
66. 1
67. CURV
68. ARRO
69. 5.9300
70. RIGH
71. ARRO
72. 3.3700
73. DOWN
74. RSET
75. POS2
76. 2
77. DECI
78. RIGH
79. UP
LINE 35 1
LINE 36 @NO#$
80. ARRO
81. 1.6200
82. RIGH
83. CURV
84. ARRO
85. 1.7500
86. RIGH
87. ARRO
88. 1.9300
89. DOWN
90. RSET
91. TEXT
LINE 37 2
LINE 38 I@NTERACTIVE# E@NTRY# @OF#$
LINE 39 M@ETAPOLIC# D@ATA#$
92. PARA
93. ARRO
94. 0.1400
95. DOWN
96. AOFF
97. UNIT
98. 1.6500
99. 1.2500
100. DIAM
101. TEXT
LINE 40 2
LINE 41 A@LTER# S@TORED#$
LINE 42 D@ATA?#$

```

Table 4. (continued)

```

102. ST RR
103. ARRO
104.      0.1400
105. DOWN
106. DECI
107. RIGH
108. DOWN
LINE 43      1
LINE 44 @NC#$
109. CURV
110. ARRO
111.      2.0000
112. LEFT
113. ARRO
114.      1.1700
115. IIP
116. ARRO
117.      2.2500
118. LEFT
119. RSET
120. POS 2
121.      3
122. DECI
123. RIGH
124. UP
LINE 45      1
LINE 46 @YES#$
125. ARRO
126.      0.7500
127. RIGH
128. CURV
129. ARRO
130.      0.1100
131. RIGH
132. ARRO
133.      3.0000
134. UP
135. PAGE
136. ACFF
137. UNIT
138.      1.0000
139.      1.5000
140. PAGE

```

```

K/F
Job 80, User: [6642,33] Logged off TTY50 0928 22-Aug-80
Saved all files (240 blocks)
CPU Time = 0.02 Minutes

```

Fig. 5. Flow charts created by use of computer program FLOW1 (Grier).

7. ACTIVITY REPORT BY M. H. JOHNSON

Name: M. H. Johnson

Age: 24

Academic Background: B.S. and M.S. degrees, Radiological
Sciences, University of Lowell

Sponsor: ORNL Summer Research Internship

Employment Periods with ORNL: 1 with TAS: 1

Supervisor: M. T. Ryan

Period of Assignment: 6/18/80 through 8/29/80

Principal Project Assignment: Nuclear Regulatory Commission (NRC)-
Uncertainties in Assessment of Long-
Term Collective Dose and Health Effects

Description of Project:

This project involves identification of sources and magnitudes of uncertainties inherent in current assessment models used for time-dependent estimates of dose and health effects impacts from the release of long-lived radionuclides to the environment.

This student's contribution to the project included:

- (1) Development of single inhalation intake retention functions for determination of fraction of radionuclide remaining at a given time in the lungs and nasopharyngeal region;
- (2) Development of equations yielding instantaneous activity burden of a daughter radionuclide in the lungs at a given time, following single inhalation intake of a pure parent radionuclide; and
- (3) Evaluation of the metabolism and dosimetry of zirconium hydride in man.

I. Developed single inhalation intake retention functions which give the fraction of a single inhalation intake of a radionuclide remaining at time t in the lungs and the nasopharyngeal region

Such functions relate to the inhalation of radioactive aerosols, the most likely route for internal radiation exposure in occupational environments. These formulations are applicable to the respiratory dosimetric model of the International Commission of Radiological Protection (ICRP) Committee 2 in ICRP Publication 30, *Limits for Intakes of Radionuclides by Workers*. Retention functions for each of the three clearance classifications (D, W and Y – see ICRP Publication 30) of inhaled radioactive aerosols were derived. These classifications, appearing in order of decreasing transportability above, describe the retention of the inhaled radioactive materials in the pulmonary region of the lung. More specifically, they refer to a range of clearance half-times for D of less than 10 days, for W from 10-100 days, and for Y greater than 100 days. Table 2 of the ANSI standard (ANSI 1978) furnishes the expected pulmonary clearance classification of inorganic compounds of mixed fission and activation products encountered in the operation of nuclear reactors. It is noted in this standard that the classifications (D, W, or Y) given in Table 2 should be used only as a guide when specific information is unavailable. Deposition of radionuclides in the respiratory system varies with the aerodynamic properties of the inhaled aerosols (i.e., varies with particle size). An Activity Median Aerodynamic Diameter (AMAD) of the aerosol equal to 1 micron was assumed in the development of the single inhalation intake retention functions. A general algebraic equation that generates particle size correction factors for these functions (for an aerosol of AMAD other than 1 micron) was also derived.

Since inhalation is the principal route of intake for radiation workers, in vivo measurements of photon emitters in the respiratory tract may be a useful bioassay procedure for verifying the adequacy of an internal radiation program. Measurements of the activity burdens in the nasopharyngeal region and in the lungs at some time t post a single inhalation intake may be used to estimate the quantity of the

radionuclide(s) inhaled – by application of the single inhalation intake retention functions appropriate for the size and clearance classification of the inhaled particles.

II. Developed equations which yield the instantaneous activity burden of a daughter radionuclide in the lungs at time t , following the single inhalation intake of the pure parent radionuclide at time $t = 0$

Such functions are appropriate for the special case whereby the parent and daughter radionuclides share the same clearance classification D, W or Y, which is the assumption made in ICRP Publication 30 in the establishment of secondary standards for radiation protection [e.g., Annual Limit Intakes (ALI) and Derived Air Concentrations (DAC)]. As were the single inhalation intake retention functions, these formulations are also applicable to the respiratory dosimetric model of ICRP Committee 2 in ICRP Publication 30. Due to their simple mathematical form, they are easily integrated over time to yield the cumulated daughter activity (number of $\mu\text{Ci-days}$) in the lungs at some elapsed time t following the pure parent intake.

III. Evaluated the metabolism and dosimetry of zirconium hydride in man – with the radionuclide tritium making up the hydride form (e.g., Zr^3H_2 and $\text{Zr}^3\text{H}^1\text{H}$, assuming stable zirconium)

The 50-year $\mu\text{Ci-days}$ residence in, and, subsequently, the 50-year dose equivalent commitment to the various tissues and organs of Standard Man were determined for two special cases, following the single inhalation intake of 1 μCi of tritium. In Case I, the 50-year dose equivalent commitment to the j th organ of reference is calculated for an inhalation intake of 1 μCi of tritium (^3H) metabolized as 1 micron zirconium aerosol particulates (for each of the three pulmonary clearance classifications D, W, and Y). The zirconium metabolic model contained in the INREM computer code was used to describe the metabolism of zirconium once it had become systemic contamination. In

Case II, the 50-year dose equivalent commitment to the j th organ of reference is calculated for an inhalation intake of 1 μCi of tritium metabolized as tritiated water vapor (e.g., $^3\text{H}^1\text{HO}$ or $^3\text{H}_2\text{O}$). For this case the assumption was made that 0.5 μCi of tritium is absorbed through the skin for every 1 μCi inhaled. The specific activity model for tritium, developed at ORNL, was employed here. The "Inhalation Ratio" for tritiated zirconium hydride was then calculated for each organ of reference. This ratio represents the quotient of the Case I 50-year dose equivalent commitment divided by the corresponding Case II value. The Inhalation Ratio was thus determined for each of the three pulmonary clearance classifications D, W, and Y, assuming an aerosol of 1 micron AMAD. The magnitude of this Inhalation Ratio for several¹ organs of reference provides one with a feel for the tremendous variability (based on the metabolic models noted above) in the metabolism and, hence, the dosimetry of tritiated zirconium hydride at the extreme ends of the metabolic spectrum. It thus points out the need for research aimed at gaining an understanding of the "true" metabolism of tritiated zirconium hydride residing in Standard Man. Since it is anticipated that zirconium and other transition metals will be used on a large scale as getter materials for tritium in fusion technology, such information must be provided in order to establish meaningful secondary radiation protection standards for these hydride compounds.

¹In particular the lungs, respiratory lymph nodes, mineral bone and endosteal cells.

8. ACTIVITY REPORT BY P. A. JONES

Name: P. A. Jones

Age: 16

Academic Background: High School Student

Sponsor: Summer Research Apprenticeship

Employment Periods with ORNL: 1 with TAS: 1

Supervisor: R. O. Chester

Period of Assignment: 6/17/80 through 8/7/80

Principal Project Assignment: Summer Research Apprenticeship
Program for High School Students

Description of Project:

The Department of Energy's Oak Ridge Summer Research Apprenticeship Program for High School Students is actually a coordinated effort of three organizations: Oak Ridge Associated Universities, Oak Ridge National Laboratory, and Knoxville College (a traditional minority college). The objective of the program is to "motivate academically talented high school students to pursue careers in energy-related fields."¹

Our Section's responsibility in this program was to provide afternoon sessions for the student concerning the types of research and other activities ongoing in the section. Ms. Jones' comments follow.

¹Oak Ridge Summer Research Apprenticeship Program for High School Students, Final Report, September 30, 1980, by Daman S. Walia, ORAU, Oak Ridge, Tennessee.

During my apprenticeship at Knoxville College, I had the opportunity to gain some knowledge from the Health and Safety Research Division of the Oak Ridge National Laboratory. I found these Thursday afternoon sessions the most rewarding part of the program.

I was able to look into many areas of study related to the Health and Safety Research Division.

I thoroughly enjoyed learning about computers from Dave Fields, and then actually being able to work on the computer.

The session learning about the Health Physics Research Reactor activities with H. W. Dickson was informative.

The session devoted to desk calculators and meteorology and assessments was not as informative as it could have been. This session was also rather boring.

Learning to use the RECON Library System, instructed by D. L. Anderson was very informative and also useful. I hope I will have the chance to use this system sometime in the future.

M. T. Ryan gave an interesting talk on Radiation Fingerprints and the misconceptions concerning radiation.

Our last tour was the most interesting one we have had. We toured the Off-Site Pollutants Measurements Laboratory. It was mind-boggling to find out how much radiation is found in parts of Oak Ridge. It was fun riding in the Lab's fully equipped radiation detection van.

In conclusion, I felt that this portion of our Summer Research Program with Knoxville College was the most enjoyable and certainly the most interesting.

I feel a special thank-you should go to all the people who talked to us and let us tour their facilities. I would also like to express my extra special thanks to Ms. Rowena Chester for involving herself in this program and giving a few people a chance to widen their knowledge through the information supplied to us.

9. ACTIVITY REPORT BY J. F. KING

Name: J. F. King

Age: 19

Academic Background: Undergraduate, B.S. program in Nuclear
Engineering, Georgia Institute of Technology

Sponsor: UCC Cooperative Education

Employment Periods with ORNL: 2 with TAS: 2

Supervisor: M. T. Ryan

Period of Assignment: 6/23/80 through 9/5/80

Principal Project Assignment: Nuclear Regulatory Commission (NRC)-
Uncertainties in Assessment of Long-Term
Collective Dose and Health Effects

Description of Project:

This project involves identification of sources and magnitudes of uncertainties inherent in current assessment models used for time-dependent estimates of dose and health effects impacts from the release of long-lived radionuclides to the environment.

John's contribution to the section included the following tasks:

- (1) Various computer-related activities involving graphs and plotting routines,
- (2) Assisting with the annual Nuclear Accident Dosimetry Intercomparison Study,
- (3) Graphing of raw data concerning dose as a function of time in various organs of rats,
- (4) Assisting with M. T. Ryan's experiment concerning transport of plutonium across alveolar membranes of the lung.

After finishing my second work quarter at Union Carbide, I feel I've gained new and useful skills. Once again my scope has been broadened to encompass new aspects of radiation protection and internal and external dosimetry. Following up on the work I did for Mac Randolph on the paper "Estimation of the Probability of Excess Mortality Following Exposure to Low Doses of Ionizing Radiations," I investigated the procedures for having graphs "digitized." This involves taking a smooth curve and breaking it down to several ordered pairs for a more rigorous mathematical treatment. Also this quarter, I started working more with the computer terminals and the automatic plotters. I helped Frank O'Donnell revise a data base, and I made various graphs for others. Thanks to these activities, I feel more comfortable with the computers.

My major contribution this summer has been assisting Howard Dickson with his annual Nuclear Accident Dosimetry Intercomparison Study. Firms from all over the country send representatives to the ORNL Health Physics Research Reactor each year to participate in this study. In preparation for the study, I learned how to use several different radiation detection systems. During the course of the study, I saw the various dosimeters used by industry and other laboratories, while making ORNL reference dosimetry measurements. I also met several interesting people and had many enlightening conversations.

After discussions with G. R. Eisele at the Comparative Animal Research Laboratory, Michael Ryan received some raw data concerning percent dose as a function of time in various organs of serially killed rats. Dr. Eisele thought perhaps Michael could come up with a model describing the transport, removal rates, and dose. I've been graphing the data to see if any assessment will be possible.

Of course, I've continued to assist Ryan with his experiments concerning transport of plutonium across the alveolar membranes of the lung. Moss's procedure for lung fluid preparation has been duplicated successfully.

Once again, I feel as though this work quarter has benefited me in a valuable way. It has given me valuable hands-on experience in many aspects of my field (radiation protection, radiation shielding, and internal and external dosimetry). I greatly appreciate the encouragement that this group has shown me. I would like to thank especially Michael Ryan and Steve Sims for their confidence, time, and their tremendously helpful general discussions. Thank you all very much.

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10. ACTIVITY REPORT BY E. W. McFARLAND

Name: E. W. McFarland

Age: 23

Academic Background: Graduate student, M.S. program in Nuclear Engineering, University of California

Sponsor: ORNL Summer Research Internship

Employment Periods with ORNL: 1 with TAS: 1

Supervisor: H. W. Dickson

Period of Assignment: 6/23/80 through 9/9/80

Principal Project Assignment: Department of Energy (DOE) – Beneficial Applications of Radiation Technology

Description of Project:

This work has previously been performed at the Sandia Irradiator for Dried Sewage Solids. Oak Ridge National Laboratory is taking over the program to extend the application of ^{137}Cs irradiation technology toward commercialization of that technology associated with the radiation preservation of food products and disinfection of sewage sludge.

Eric's contribution was in the form of technical support for this project, including dose and dose distribution calculations in air, water, compost, fruit, and sewage sludge.

This report (ORNL/TM-7637) is in preparation.

DOSIMETRY REPORT FOR THE SANDIA IRRADIATOR FOR DRIED SEWAGE SOLIDS

R. T. Greene
E. W. McFarland
H. W. Dickson

ABSTRACT

Gamma dose measurements were made at the Sandia Irradiator for Dried Sewage Solids. Passive plastic, chemical, and thermoluminescent dosimeters were exposed in the facility under conditions designed to simulate typical plant operation. Absolute dose and dose distribution information was obtained in air, water, compost, fruit, and sewage sludge.

11. ACTIVITY REPORTS BY R. R. SMITH

Name: R. R. Smith

Age: 22

Academic Background: Graduate student, Electrical Engineering,
Tennessee State University

Sponsor: ORNL Summer Research Internship

Employment Periods with ORNL: 1 with TAS: 1

Supervisor: C. F. Baes III, D. E. Fields

Period of Assignment: 5/12/80 through 8/15/80

Principal Project Assignment: Environmental Protection Agency (EPA) -
Modeling of Atmospheric Radionuclide
Releases

Description of Project:

This study is required to develop the environmental transport methodology along with documentation and a user's manual such that it can be employed by EPA to assess facilities emitting radionuclides which could be covered under the Clean Air Act.

Renée's major contribution to this project was a study of food consumption patterns for the U.S. population.

11.1 Summer Internship Report

My summer internship began May 12, 1980, under the supervision of C. F. Baes III, and lasted approximately three months. Assigned to the Technology Assessment Section (TAS) of the Health and Safety Research Division, I undertook two major projects. The first was a study of food consumption patterns for the U.S. population and the second was to write a program that would graphically illustrate the project budgets for the section. In addition to these two projects, I acquainted myself with the Laboratory, its facilities, and a number of useful tools for scientific activities.

Food Consumption Study

This project is still under way.

This study is in conjunction with the AIRDOS-EPA-Clean Air Act Implementation project being done by this section. My assignment was to provide the amount of U.S.-produced food consumed by the American population. The paper required visits to the University of Tennessee's Agricultural Library, conversations with personnel at several federal agencies, and literature searches in order to attain sufficient data for the study.

The parameters used in this study were fruits, vegetables, meats, grains, beverages, and water. The availability of detailed information was limited; however, consumption rates were estimated for most of the commodities. Similar information for beverages and water consumption were not calculated due to lack of time and insufficient information.

The Budget Plotting Program

A simple program was written to draw a graph and illustrate the budget for TAS. The program was written in BASIC computer language for the Hewlett-Packard HP-2647A Graphics Terminal. The graph is a linear plot done on the HP-2647A plotter and shows five parameters in different colors. Two copies of the program have been made and stored

on mini-data cartridge tapes. As a part of writing this program, I made extensive use of the graphics terminal and its peripheral devices; the HP-9872A plotter and the HP-2631G printer.

My background in computer languages was in FORTRAN IV and this made learning BASIC relatively easy. BASIC for the graphics terminal was a little different and more detailed than the conventional BASIC. I found the graphic terminal practical and useful.

Plant Tours and Visits

I visited the Chemical Technology Division to view work going on there. I was interested since most of what I saw pertained to my background and present field of study. I also participated in a day long tour of the X-10 and Y-12 plants that proved enlightening, despite the fact our tour bus encountered mechanical difficulties between the two plants. I was pleased to see first-hand some of the work going on at Oak Ridge National Laboratory. Mike Ryan took a group of us to visit the Dosimetry Applications Research Facility. Dave Fields and Fred Baes gave us a spontaneous tour of the Graphic Arts Department.

Meetings and Seminars

During the summer I attended several seminars that covered such current topics as the Impact Assessment of the Three Mile Island Accident on Reactor Safety. I also attended the weekly TAS group meetings. My advisor and I met with Steve Kaye, Director of the Health and Safety Research Division.

I met with Rowena Chester, Group Leader, and Fred Baes once every two weeks to discuss progress, problems, and other needs. The meetings lasted approximately thirty minutes, in which I gave a progress report. Meetings with my advisor were held as needed to discuss problems, ideas, or seek advice. The summer interns got together for an informal get-acquainted session. It also gave me the opportunity to meet some of the people responsible for my being here.

Acknowledgments

My sincere thanks to C. Fred Baes III, Roberta Shor, and Rowena Chester for guidance in my projects. A special thanks to my colleague, Debra Crama, for assistance in helping me write the Budget Plotting Program.

11.2 Graph Plotting Program

For the utilization of the TAS, I have written a simple program that will graphically illustrate five budget parameters of a given project. The program has been written in BASIC for the HP-2647A Graphics Terminal and stored on Mini-Data Cartridge tape (two copies have been made).

The graph drawn is a line graph that plots labor cost, computing cost, material cost, total cost, and shows the total budget of a project. The program was designed specifically for plotting budget information. Other use outside that purpose would require modification within the program.

While the program is running it will request information in three groups while plotting. First, it will ask for heading, graphic limits, and Y-axis labeling; second, the X-axis labeling; and third, data for plotting. Upon completion of the plotting a legend will be drawn at the left of the graph.

Setting Up Plotter - HP-9872A Plotter

The on/off switch is located on the lower right panel of the HP-9872A Plotter. Press LOAD CHART. Position paper in the lower left corner of the plotter and smooth out any puckers, then press HOLD CHART. The pens should be placed in the following order, starting with Slot 1: Black, Blue, Green, Red. The program has been already instructed for pen and line type.

Using the Budget Plotting Program

Load the Multiplot/Basic Interpreter Tape #02647-13301 into the left tape drive and the Budget Plotting Tape into the right drive. Both tapes will rewind, positioning themselves at the beginning. A beep will be heard and the display screen will show TERMINAL READY. Press the special function key READ. Be certain that the remote key is up (local mode).

The index of the Multiplot/Basic Interpreter Tape will appear on screen. Before any programs can be written or run, the BASIC Interpreter must be loaded into the terminal's memory. This is done by pressing function key "F8." It takes approximately three minutes. The display screen will rerun a prompt, >, and any programming may begin. Check interpreter by pressing the COMMAND key CR (Return). After the prompt type in GET "R" this will now get and load into its memory the Budget Plotting Program (right tape). A prompt appears when the program has been loaded and use may now begin. Listing the program is not necessary, however, if you wish to see it simply type LIST, CR. If your plotter is ready, on, and paper positioned, type RUN, CR (see Tables S-7 and Figs. 6-8).

Running the Basic Multiplot Program

Some of the questions have been programmed to inversevideo. Whenever the program is then over it will be necessary to type those values in. Other information need not be rewritten if you are doing a second plot. Caution: When entering data in, once you press RETURN the information cannot be corrected. However, if you have made a mistake and wish to discontinue plotting you may do so by pressing the RESET TERMINAL key. It will be necessary to check the interpreter by pressing COMMAND KEY and typing BASIC.

Input Information for Budget Graphs Program

<u>Field</u>	<u>Description</u>
Heading	Up to 40 characters may be typed in. This heading will be centered at the top of your graph and screen.
Fiscal Year:	Type in FY 198_.
Max Y?	Use a number larger than your total budget. This will allow for sufficient space to print the total budget and not interfere with the Y axis labeling (e.g., your total budget = \$190000, use 225000; for 10000, use 15000). Interger values must be used. Exponential forms acceptable. Do not use commas.
Increment in Unit of:	Sets and Marks subdivisions along Y-axis. Exponential form acceptable. Do not use commas.
Label in Units of:	Print a major ties and label. Use interger that is divisible by incrementing units. Exponential forms acceptable. Do not use commas.
Number of Months	The program will accept up to 12 months. This also prescribes the number of data values for each parameter. Do not use commas.
Month	Type in the first 3 letters of each month. Twelve months or less depending upon number of months requested. Numerical values are acceptable.
Labor Values: Computing Values: Material Values: Total Cost Values:	Type in interger values one at a time, pressing return after each one. Twelve or less of each will be asked for depending upon number of months. Should you have a project that is under way and there have been no charges for a particular project, enter a very small number (e.g., 1) for those months. This will allow the plot to go from the X-axis to the next point rather than starting at the next point. Entering "0" lifts the pen until another number greater than zero appears.
Total Budget	Type in the amount of your total budget without the use of commas.

Table 5. Computer program used to illustrate section budget in graph form (Smith)

```

LIST
5 PLOTR
10 PLOTR (4,1)
20 GCLR
30 DIM N$(401),Na$(401),X(20),Y(20),L(20)
40 LIMIT (0,265,10,200)
50 LOCATE (35,134,10,85)
60 LINPUT " HEADING?
70 LINPUT "FISCAL YEAR? ",Nfy$
80 INPUT "MAX Y? ",R
90 R=R/1000
100 SCALE (0,29.7,0,R)
110 Cui=0
120 Ratio=-R/55
130 Hratio=R+R/10
140 Fratio=Ratio-(R/55)*6
150 Crd=-Fratio/3
160 INPUT " Increment in Units of ?          ",V1
170 PRINT ""
180 INPUT " Label in Units of ?          ",V
190 V1=V1/1000
200 V=V/1000
210 PRINT ""
220 Vb=V/V1
230 PEN (2)
240 LAXES (0,V1,0,0,0,Vb,1)
250 AXES (2.7,0,0,0,1,0,1)
260 LINE (0)
270 Y1=R+R/55
280 FRAME
290 MOVE (14.5,Hratio)
300 LONG (4)
310 CSIZE (5)
320 Na$=TRIM$(N$)
330 PRINT #0;Na$
340 MOVE (14.5,Fratio)
350 Fy$=TRIM$(Nfy$)
360 PRINT #0;Fy$
370 LONG (6)
380 CSIZE (3)
390 S=-2.7

```

Table 5. (continued)

```
400 INPUT "NUMBER OF MONTHS ",N
410 FOR I=1 TO N
420 INPUT "MONTH: ",T$
430 S=S+2.7
440 MOVE (S,Ratio)
450 PRINT #0;T$
460 NEXT I
470 MOVE (0,0)
480 PEN (1)
490 Za=0
500 PRINT "LABOR VALUES "
510 Cui=0
520 GOTO 640
530 PRINT "COMPUTING VALUES "
540 Crd=Crd-Ratio*2
550 Cui=0
560 GOTO 640
570 PRINT "MATERIALS VALUES "
580 Crd=Crd-Ratio*2
590 Cui=0
600 GOTO 640
610 PRINT "TOTAL COST VALUES "
620 Crd=Crd-Ratio*2
630 Cui=0
640 FOR K=1 TO N
650 READ X(K)
660 DATA 0,2.7,5.4,8.1,10.8,13.5,16.2,18.9,21.6,24.3,27.0,29.7
670 A=X(K)
680 INPUT Y(K)
690 Y(K)=Y(K)/1000
700 W=Y(K)
710 IF W<0 THEN 730
720 IF W>=0 THEN 870
730 IF Cui=1 THEN 850
740 Cui=1
750 LINE (2)
760 PLOT (A,0)
770 LINE (0)
780 MOVE (A,Crd)
```

Table 5: (continued)

```
790 LORG (4)
800 CSIZE (2)
810 PRINT #0;"Credit"
820 MOVE (A,0)
830 PENDN
840 GOTO 890
850 PLOT (A,0)
860 GOTO 890
870 IF W=0 THEN 890
880 PLOT (A,W)
890 NEXT K
900 RESTORE
910 MOVE (0,0)
920 Za=Za+1
930 LINE (0)
940 PEN (Za+1)
950 ON Za GOTO 530,570,610
960 INPUT "TOTAL BUDGET=$",Tb
970 Tb=Tb/1000
980 PEN (1)
990 LINE (4)
1000 MOVE (0,Tb)
1010 PLOT (55,Tb,-1)
1020 MOVE (1.2,Tb)
1030 LORG (1)
1040 CSIZE (3)
1050 PRINT #0;"TOTAL BUDGET=$",Tb;"K"
1060 LORG (8)
1070 CSIZE (3)
1080 La=R-R/15
1090 MOVE (-7.5,La)
1100 PRINT #0;"LEGEND"
1110 LORG (5)
1120 CLIP (-15,0,0,R)
1130 J=0
```

Table 5. (continued)

```
1140 Ly=-8
1150 Lp=-5
1160 J=J+1
1170 Leg=R/6
1180 Ltg=Leg/3
1190 Leg=Leg*J
1200 L(J)=R-Leg
1210 Ld=L(J)
1220 MOVE (-6.5,Ld)
1230 ON J GOTO 1240,1310,1370,1430
1240 PEN (J)
1250 PRINT #0,"LABOR"
1260 LINE (0)
1270 Lt=Ld-Ltg
1280 MOVE (Ly,Lt)
1290 DRAW (Lp,Lt)
1300 GOTO 1160
1310 PEN (J)
1320 PRINT #0,"COMPUTING"
1330 Lt=Ld-Ltg
1340 MOVE (Ly,Lt)
1350 DRAW (Lp,Lt)
1360 GOTO 1160
1370 PEN (J)
1380 PRINT #0,"MATERIALS"
1390 Lt=Ld-Ltg
1400 MOVE (Ly,Lt)
1410 DRAW (Lp,Lt)
1420 GOTO 1160
1430 PEN (J)
1440 PRINT #0,"TOTAL COST"
1450 Lt=Ld-Ltg
1460 MOVE (Ly,Lt)
1470 DRAW (Lp,Lt)
1480 PENUP
1490 PEN (2)
1500 MOVE (0,Y1)
1510 LONG (0)
1520 PRINT #0,"Dollars Spent (K)"
1523 CLIPOFF
1530 MOVE (55,R)
1540 PEN (0)
1550 END
```

Table 6. Example of typical execution of budget graph computer program
(Smith)

RUN

HEADING? EPA-MOD-ATMOS. RADIONUCLIDE (0950)

FISCAL YEAR? FY 1980

MAX Y? 350000

Increment in Units of ? 50000

Label in Units of ? 100000

NUMBER OF MONTHS 12

MONTH: OCT

MONTH: NOV

MONTH: DEC

MONTH: JAN

MONTH: FEB

MONTH: MAR

MONTH: APR

MONTH: MAY

MONTH: JUN

MONTH: JUL

MONTH: AUG

MONTH: SEP

LABOR VALUES

? 18309

? 25168

? 33648

? 53677

? 57693

? 76577

? 76577

? 76577

? 76577

? 79224

? 0

? 0

Table 6. (continued)

COMPUTING VALUES

? 6489
? 12032
? 24481
? 32507
? 44421
? 58854
? 77496
? 78995
? 81650
? 101106
? 0
? 0

MATERIALS VALUES

? 10653
? 19687
? 50002
? 53677
? 66112
? 89149
? 109073
? 118198
? 144966
? 170614
? 0
? 0

TOTAL COST VALUES

? 36924
? 39418
? 111185
? 131332
? 166578
? 226313
? 257206
? 273487
? 304993
? 344124
? 0
? 0

TOTAL BUDGET=\$314000

Table 7. Execution of computer program to graph section budget using negative numbers (Smith)

RUN

HEADING? EPA-MOD-ATMOS. RADIONUCLIDE (0950)

FISCAL YEAR? FY 1980

MAX Y? 350000

Increment in Units of ? 50000

Label in Units of ? 100000

NUMBER OF MONTHS 12

MONTH: OCT

MONTH: NOV

MONTH: DEC

MONTH: JAN

MONTH: FEB

MONTH: MAR

MONTH: APR

MONTH: MAY

MONTH: JUN

MONTH: JUL

MONTH: AUG

MONTH: SEP

LABOR VALUES

? 18309

? 25168

? 33648

? 53677

? 57693

? 76577

? 76577

? 76577

? 76577

? 79224

? 0

? 0

Table 7. (continued)

COMPUTING VALUES

? 6489
? 12032
? -24481
? 32507
? 44421
? 58854
? 77496
? 78995
? 81650
? 101186
? 0
? 0

MATERIALS VALUES

? 10653
? 19687
? 50002
? 53677
? 66112
? 89149
? -109073
? 118198
? 144966

EPA-MOD-ATMOS. RADIONUCLIDE (0950)

Fig. 6. Graph drawn by execution of computer program (Smith).

EPA-MOD-ATMOS. RADIONUCLIDE (0950)

Fig. 7. Graph drawn by computer program using negative numbers as input (Smith).

Fig. 8. Flow chart illustrating computer program used to graph section budget (Smith).

11.3 Food Consumption Study

As national concern focuses on nuclear technologies and their effects on the American citizens, an increasing emphasis has been placed on analysing pathways of environmental exposure. Since terrestrial food crops comprise a large portion of the American food supply, detailed information on food consumption patterns is necessary to evaluate ingestion rates of pollutants and therefore determine health risks.

The intake of radionuclides, carcinogens, and other pollutants by man via ingestion of food is dependent upon the quantity of foods ingested which have been exposed to releases from facilities across the country. Data on food consumption are limited and not detailed enough to obtain individual consumption rates for all foods. However, it is possible to analyse available data to attain an estimate of per capita consumption. This analysis is only an estimate because waste and spoilage during transport and storage is not fully accounted for.

In this paper, foods have been divided into fruits and vegetables, grains, and meats. The fruits and vegetables have been further subdivided into the following categories: leafy vegetables, protected vegetables, and other vegetables. Meats have been divided into pork, beef, and mutton. Categories of vegetables and grains were compiled by the way they intercept airborne deposits and their ultimate distribution. Leafy vegetables have broad flat leaves which can intercept atmospherically deposited material directly. Examples would include lettuce, cabbage, spinach, etc. Protected vegetables such as onions, potatoes, citrus fruits, and lima beans do not intercept depositing material on the edible portion because it is either below the ground or protected by some other tissue. Examples of other vegetables are noncitrus fruits, berries, and snap beans; these intercept as do the leafy vegetables, but the edible portion is generally not made up of broad leaves. The key to the vegetables which make up each category is given in Table 8.

Table 8. Key to crop classification

Leafy vegetables -	artichokes, broccoli, brussel sprouts, cabbage (chinese, mustard, head), cauliflower, celery, lettuce (head, Romaine, other), escarole (escarole, chicory, endive), greens (collards, kale, spinach, mustard greens, turnip greens), green onions (green onions, shallots), mint, watercress.
Other vegetables -	apples (dwarf, standard), apricots, blackberries (blackberries, dewberries), blueberries (tame, wild), boysenberries, cherries (sweet, tart), chinese pea, coffee, cranberries, cucumber, currants, dates, dill oil, eggplant, figs, grapes, gooseberries, guavas, hops, loganberries, mangoes, nectarines, okra, olives, other berries, other fruits and nuts, other noncitrus fruits, papayas, passion fruit, peaches (cling, freestone), pears (bartlett, other) pepper (hot, sweet), pimentos, plums, prunes, raspberries (black, red), rhubarb, sesame, snap beans, squash, strawberries, tomatoes, youngberries.
Protected vegetables -	almonds, avocados, beets, cantalopes, carrots, chufas for nuts, cowpeas, daikon, dasheens, dryland taro, dried lima beans, dry field beans, dry field peas, filberts, garlic, ginger, grapefruit, green peas, honeydew melons, Irish potatoes, kumquats, lemons, lentils, lima beans, limes, lotos, mung beans, muskmelons, mustard seed, naval oranges, onions-dry, other citrus fruit, other nuts, other oranges, peanuts, pecans (improved, wild), pistachios, pomegranates, popcorn, pumpkins, radishes, rapeseed, rice, safflower seed, sugar beets, sugarcane, sunflower seed, sweet corn, sweet potatoes, tangelos, tangerines, temple oranges, turnips, valencia oranges, walnuts-black, walnuts-English, watermelons, wild rice, wetland taro.
Grains -	Barley, corn for grain, cottonseed oil, oats, rye, sorghum, grain, soybeans, wheat.

Method

An analysis has been performed on available data to derive an estimate of the quantity of domestically produced foods consumed by the American population. Most food consumption data in this study are based on production or marketing estimates of farm production, foreign trade, and estimates of spoilage and waste. Per capita consumption usually is derived by the following equation,

$$C_{pi} = \frac{\sum_{j=1968}^{1978} D_{sij}}{\sum_{j=1968}^{1978} P_j}, \quad (1)$$

where

C_{pi} = per capita consumption of food item i ,

D_{sij} = domestic supply of food item i in year j ,

P_j = population of the U.S. on July 1 of year j .

The numerator of Eq. (1) was determined from data from the U.S. Department of Agriculture (USDA).^{1,2} The USDA publishes annually *The Agricultural Statistics*. These references provide detailed information on agricultural production supplies, consumption, facilities, and cost. The statistics represent actual counts done by several federal and non-federal agencies. They were prepared and compiled by the USDA and are official estimates. The U.S. Department of Commerce also supplied information on production, exports, and imports.³ The data are reviewed and supplemented as needed from the Censuses of Agriculture taken every five years. Because the data generated from these sources are averages, they are subject to revision as more information becomes available. Exports were subtracted from the annual total production if the sum of exports was 5% or more of the total production for those years. The fraction of domestically produced food which is exported is given by,

$$C_{pi} = \frac{\sum_{j=1968}^{1978} D_{eij}}{\sum_{j=1968}^{1978} P_{tij}},$$

where

f_{ei} = fraction of food item i which is exported,

D_{eij} = total amount of domestically produced food item i which is exported in year j ,

D_{tij} = total amount of domestically produced food item i in year j .

Annual domestic supply was determined by,

$$D_{si} = \frac{\sum_{j=1968}^{1978}}{10}, 1 - f_e - w_i + s_i,$$

where

w_i = waste of food item i ,

s_i = spoilage of food item i .

Data from 1969 to 1978 were used in order to use the most current information and to account for recent rates of increase in crop production and population. For many food items, data on exports, waste, or spoilage were insufficient. For these items best estimates were made if no other reliable data were found. Some commodities were not produced in sufficient quantities to warrant recordkeeping by the USDA. Rates of consumption for these items are, therefore, determined by incorporating rates for the miscellaneous category. "Preliminary data" were not used in the computation of consumption rates because they often differed by as much as 10% from previous production rates and, therefore, were not considered accurate enough to include in the calculations.

Results

The following tables (9-15) are not based on actual, well-controlled consumption surveys, but rather on production or marketing information. Since they only reflect domestically produced crops and domestically raised livestock, they may appear lower than those cited in other similar literature.⁴ No actual measurement of losses after sales, spoilage waste, cooking losses, unused leftovers, or use as pet food have been used and may therefore affect the reported data.

The relative importance of various categories of food in the American diet is shown in Fig. 9.

Discussion

To attain more accurately individual food consumption rates, disappearance of foods would need to be incorporated into these calculations. Many of the results reported here agree well with values given in other studies, although only domestic production has been considered in this study. It is estimated that 16.6% of the average American's income is spent on food and beverage consumption⁵ (calculated from Table 108 of reference 5). Per capita consumption of different foods between 1970 and 1979 indicate less red meats, fats, and starches are eaten. More poultry, fish, fruits, and vegetables are being consumed. In addition, consumption rates of fruits and vegetables has increased considerably but consumption of sugar is down.^{6,7}

Table 9. Population estimates (United States 1968-1978)^a

	Civilian population (millions)
1968	197.1
1969	199.1
1970	201.7
1971	204.3
1972	206.5
1973	208.1
1974	209.7
1975	211.4
1976	213.0
1977	214.7
1978	216.4

^a Estimates of July 1 as cited in *Statistical Abstract of the United States*, 1978, U.S. Department of Commerce Bureau of the Census.

Table 10. Per capita consumption of leafy vegetables

Vegetables	Consumption (kg/y)
Artichokes	0.02
Broccoli	0.81
Brussel Sprouts	0.14
Cabbage	5.1
Cauliflower	0.67
Celery	3.54
Escarole	0.24
Green Onion	0.06
Kale	0.01
Lettuce	0.02
Mint	2 E-5
Mustard Greens	0.1
Parsley	0.03
Spinach	0.85
Turnip Greens	0.04
Miscellaneous	0.03
TOTAL	11.84

Table 11. Per capita consumption for protected vegetables

Vegetable	Consumption (kg/y)	Vegetable	Consumption (kg/y)
Asparagus	0.01	Popcorn	1.12
Avocado	0.39	Potato	6.3
Beets	0.9	Sugarbeets	11.45
Banana	0.01	Sugarcane	10.73
Blackeyed Peas	0.01	Sunflower Seeds	1.53
Cantaloupe	2.56	Sweet Potato	2.21
Carrots	4.28	Tangelo	1.15
Garlic	0.01	Tangerine	0.97
Grapefruit	10.82	Pumpkin	0.02
Green Pea	1.03	Temple	0.15
Honeydew	0.5	Taro	0.03
Lemon	2.27	Turnips	0.001
Limes		Radishes	0.23
Peas	0.01	Watermelon	5.6
Nuts	0.52		
Parsnips	0.01	TOTAL	87.75
Sweet Corn	9.55		
Onion	0.06		
Orange	3.81		
Peanuts	7.03		
Pomegranates	0.03		

Table 12. Per capita consumption of other vegetables

Vegetable	Consumption (kg/y)	Vegetable	Consumption (kg/y)
Apples	13.88	Snap Beans	3.45
Apricots	0.61	Squash	0.2
Cherries	2.35	Strawberries	1.36
Coffee	0.69	Tomatoes	32.1
Cranberries	0.04	Berries ^a	<u>0.2</u>
Cucumber	3.56	TOTAL ^b	78.2
Currants	0.14		
Dates	0.1		
Eggplant	0.1		
Figs	0.2		
Grapes	1.97		
Hops	0.12		
Nectarines	0.4		
Okra	0.8		
Olives	0.27		
Papayas	0.07		
Peaches	5.6		
Pears	6.13		
Pepper Sweet	2.48		
Plums	0.5		
Prunes	0.86		

^a Frozen only.^b Chinese peas, passion fruit, pimentos, rhubarb, sesame, and mangoes are excluded.

Table 13. Per capita consumption of grains

Grain	Consumption (kg/y)
Barley	68.4
Corn	39.7
Oats	3.1
Rye	0.66
Sorghum	0.94
Soybean	10.2
Wheat	<u>68.0</u>
TOTAL	191.00

Table 14. Per capita consumption of meats

Meat	Consumption (kg/y)
Poultry	22.3
Beef and Veal	54.2
Lamb and Mutton	1.2
Pork	<u>27.8</u>
TOTAL	105.5

Table 15. Total per capita consumption - by food categories

Category	Consumption rate (kg/y)
Leafy vegetables	11.84
Protected vegetables	87.75
Other vegetables	78.2
Grains	191.0
Meats	<u>105.5</u>
TOTAL	474.29

Fig. 9. Graph showing consumption of certain categories of foods per capita in the United States (Smith).

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