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File  
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UNITED STATES  
ATOMIC ENERGY COMMISSION  
OAK RIDGE OPERATIONS  
P.O. BOX E  
OAK RIDGE, TENNESSEE 37830

AREA CODE 615  
TELEPHONE 483-3611

NOV 9 1970

Ralph Elson, Director Contract Division

REQUEST FOR CONTRACT ACTION

It is requested that you take the necessary steps to process the following described contract action (CA):

1. Nature of Action Requested:

- Selection of New Contractor and/or Negotiation of Contract  
Number:  
Contractor:
- Modification of Contract  
Number: AT-(11-1)-490  
Contractor: University of Texas

2. Nature of Services To Be Covered by Contract: Research

Title: "Transport of Radionuclides in Water (Model River and Ecological System)"

3. Type of Contract:

- Support Agreement
- Cost Type
- Other

4. Amount of AEC Funds To Be Obligated by this CA: \$18,000

5. AEC Percentage of Est. Total Cost To Be Shown by This CA: 100%

6. Description of Other Changes To Be Covered by This CA:

Provide for the performance of additional research during the period October 1, 1970 through September 30, 1971. AEC Support Ceiling will be increased from \$60,000 to \$78,000. Title to equipment shall vest in the contractor under authority of PL-85-934.

7. Authority:

Memo from Milton Shaw, HQ, to S. R. Sapirle  
dtd 8-28-70

*Herman M. Roth*  
Herman M. Roth, Director  
Laboratory and University Division  
CONTRACTS - 490 (Texas)

OLE:LM

*Medley*  
11-5-70

REPOSITORY  
2. *Copy kept in Operations*  
3. *Records kept in area*  
COLLECTION  
4. *1074-97*  
5. *2714-H*  
6. *2714-H*  
7. *2714-H*  
EX NO. *A-78-3 Bldg. 2714-H*  
FOUNDER *Contract 490 - Texas*  
*CA 11-9-70*

1138690

*CA*

## APPENDIX "A"

For the Contract Period October 1, 1970 through September 30, 1971.

ARTICLE-I RESEARCH TO BE PERFORMED BY CONTRACTOR

The Contractor will continue investigations to develop techniques for distinguishing and predicting biological changes resulting from release of heated waters as compared with effects caused by other wastewaters, and to study transport systems and characteristics related to tritium movement in flowing and non-flowing ecosystem, to include (1) use of a flume system, (2) effects of heated water on productivity and respiration in the ecosystem, (3) effects of various stresses, (4) the characteristics of instantaneous and continuous release of tritium, and (5) equilibrium concentrations and interchanges of tritium between sediment, biomass, and water.

Dr. E. F. Gloyna, Principal Investigator, expects to devote approximately 5% of his time or effort to the project.

ARTICLE-II WAYS AND MEANS OF PERFORMANCE(a) Items Included in Total Estimated Cost:

(1) <u>Salaries and Wages:</u>	\$16,600.00
Research Associate	
2 Research Assistants	
Research Analyst	
(2) <u>Employee Benefits:</u>	500.00
(3) <u>Materials and Supplies:</u>	1,000.00
Chemicals and Glassware	
(4) <u>Equipment to be Purchased or Fabricated by Contractor:</u>	0
<u>a</u> Equipment Estimated to Cost Less than \$1,000:	
None	
<u>b</u> Equipment Estimated to Cost in Excess of \$1,000:	
None	
(5) <u>Computer Time:</u>	400.00
(6) <u>Travel:</u>	665.00

- (7) Indirect Costs (Fixed at 20% of direct costs): \$ 3,835.00
- (b) Items, if any, Significant to the Performance of this Contract, but Excluded from Computation of Support Cost and from Consideration in Proportioning Costs:
- (1) Items to be Contributed by the Contractor:
- Research Assistant including indirect costs and fringe benefits.
- (2) Items to be Contributed by the Government:
- None
- (c) Time or Effort of Principal Investigator(s) Contributed by Contractor, but Excluded from Computation of Support Cost and from Consideration in Proportioning Costs:

Approximately 5%

ICLE-III The total estimated cost of items under A-II (a) above for the contract period stated in this Appendix "A" is \$23,000; the Commission will pay 100% of the actual costs of these items incurred during the contract period stated in this Appendix "A", subject to the provisions of Article III and Article B-XXVII. The estimated AEC Support Cost for the contract period stated in this Appendix "A" is \$23,000.

The estimated AEC Support Cost in the preceding paragraph includes \$5,000 as estimated unexpended funds from the previous period. For the purpose of calculating the payments under Article B-XI for the current period only, \$18,000 will be used as the estimated Support Cost.



UNITED STATES  
ATOMIC ENERGY COMMISSION  
WASHINGTON, D.C. 20545

AUG 28 1970

5339

S. R. Sapirie, Manager, Oak Ridge Operations Office

SUM 1031 1970

UNIVERSITY OF TEXAS - CONTRACT AT(11-1)-490  
(TRANSPORT OF RADIONUCLIDES IN WATER - MODEL RIVER AND ECOLOGICAL  
SYSTEM)

This is in response to H. M. Roth's memo to me dated July 1, 1970  
concerning extension of the subject contract.

We have completed our review of the University's renewal proposal (thru  
9-30-71) and concluded that further extension cannot be supported. This  
decision is based upon our judgment of the relative importance of the  
proposed study when compared with other more critical reactor development  
and technology programs that must be supported within our very limited  
resources.

Accordingly, it is requested that Contract AT(11-1)-490 be brought to an  
orderly close by December 31, 1970 including the performance of the  
following work:

1. Complete and prepare a report on the flume studies now underway  
which are designed to test the previously developed mathematical  
model of radionuclide transport.
2. Complete the work and report the results of the aquaria studies  
underway which are designed to investigate the uptake and reten-  
tion of tritium.
3. Prepare a final summary technical report.

For performance of such work, additional funding in the amount of  
\$18,000 will be made available to OR. Budget Activity 04 60 40 01.

*EE Sinclair acting*

Milton Shaw, Director  
Division of Reactor Development  
and Technology

cc: RDT Sr. Site Rep., ORNL

B 7477

AUG 31 1970

1138893



THE UNIVERSITY OF TEXAS AT AUSTIN  
OFFICE OF SPONSORED PROJECTS  
AUSTIN, TEXAS 78712

Post Office Box 7726  
AC 512, 471-1353

October 26, 1970

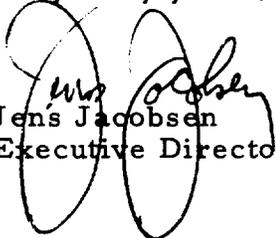
United States Atomic Energy Commission  
Oak Ridge Operations  
P. O. Box E  
Oak Ridge, Tennessee 37830

Subject: Proposal entitled "Transport of Radionuclides  
In Water (Model River and Ecological Studies)  
Submitted by Dr. Earnest F. Gloyna, May 20, 1970

Gentlemen:

At Dr. Gloyna's request, we are submitting herewith two  
copies of a revised budget for use with the subject proposal.

Very truly yours,

  
Jens Jacobsen  
Executive Director

JJ/gg

Enclosures: 2

cc: Dr. Earnest F. Gloyna

CONTRACTS - 490 (Tela)

B 9252  
OCT 30 1970

1138894

BUDGET

The estimated costs are \$23,000.00 under a lump-sum contract. The duration of this particular project and funding period is estimated at one year, October 1, 1970, to September 30, 1971, inclusive.

Total

SALARIES AND WAGES . . . . . \$16,600.00

(Salaries paid from Government contract funds at The University of Texas at Austin conform to the rates approved by the Board of Regents for salaries paid from regular University funds.)

Principal Investigator <i>(5% of time)</i>	None
Research Associate (50% of time)	\$ 3,200.00
2 Graduate Research Assistants (50% of time each)	7,000.00
Research Analyst, Typist, etc. (50% of time each)	6,400.00

MATERIALS, SERVICE, AND ~~SERVICES~~ *SUPPLIES* . . . . . 1,400.00

~~(This item includes the operation of the flame, purchase of test equipment, expendable materials, minor equipment items, and occasional services of others not included in Salaries and Wages.)~~

Computer <i>Time</i>	400.00
Chemicals and Glassware	1,000.00

TRAVEL . . . . . 665.00

(Transportation expense of persons engaged in the work, including transportation by plane or rail and Pullman, or by private car at an allowance of not to exceed 10¢ per mile in lieu of actual expense, plus per diem on the quarter-day basis.)

INSURANCE . . . . . 500.00

(Workmen's Compensation Insurance coverage, as may be required by University regulations under the University's self-insuring plan; plus Federal Social Security.)

BUDGET (Continued)

	Total
INSTITUTIONAL OVERHEAD AND INDIRECT COSTS** . . . . .	3,835.00
(Shared rate of 20% of all costs exclusive of overhead.)	
TOTAL REQUESTED FROM AEC . . . . .	<u>\$23,000.00</u>

~~\*Estimated Project Director for nine months is about \$2,500.00. Also, graduate students who are on traineeships are not included in the cost contribution because the amount is not known presently. In the past, one or more such students have made contributions to the project. These efforts are equivalent to about one full time employee.~~

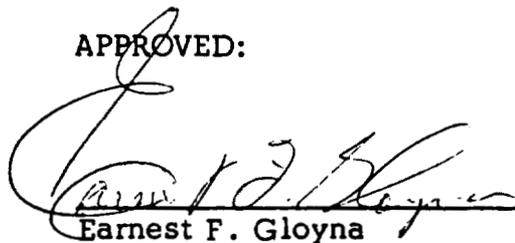
\*\*The University provides space, facilities, supplies, etc. for graduate students. In addition, salaries for faculty will be met by University. Actual University contribution cannot be estimated.

ADMINISTRATIVE INFORMATION

The University of Texas represents: (a) that it has not employed or retained any company or person (other than a full-time bona fide employee working solely for The University of Texas) to solicit or secure this contract and (b) that it has not paid or agreed to pay to any agency or person (other than a full-time bona fide employee working solely for The University of Texas) any fee, commission, percentage or brokerage fee, contingent upon or resulting from the award of this contract; and agrees to furnish information relating thereto as may be requested by the Contracting Officer.

Further information relating to the technical portions of this proposal may be obtained from Dr. E. F. Gloyna, Dean, College of Engineering, Taylor Hall 167, The University of Texas at Austin, Austin, Texas 78712, telephone GREENWOOD 1-1166. Non-technical administrative and contractual matters should be referred to the University's Office of Sponsored Projects, Post Office Box 7726, Austin, Texas 78712, telephone GREENWOOD 1-1353.

APPROVED:

  
 Earnest F. Gloyna  
 Project Director

APPROVED:

Original Signed by

\_\_\_\_\_  
 Bryce Jordan  
 Ad Interim President

*Above changes made per telecon with Dr. Gloyna.*

1138896

11-2-70

OCT 12 1970

Dr. Earnest F. Gloyna, Dean  
College of Engineering  
University of Texas  
Austin, Texas 78712

CONTRACT NO. AT-(11-1)-490

Dear Dr. Gloyna:

Reference is made to your letter of September 15, 1970, with respect to the extension, financing, and completion of work under Contract No. AT-(11-1)-490.

Based on your request, we propose to extend Contract No. AT-(11-1)-490 through September 30, 1971, and authorize the use of estimated unexpended prior period funds up to \$5,000 in addition to \$18,000 new funding authorized. The renewal period will run from January 1, 1971 through September 30, 1971. Please submit a budget for this proposed renewal period based on the approved financing. The information submitted should be endorsed by an appropriate administrative official of the University.

Sincerely,

C. S. Shoup, Chief  
Research Contracts Branch  
Laboratory and University Division

OLE:LH

CC: J. M. Jacobsen, Univ. of Texas  
Norman Hackerman, Univ. of Texas

OCT 15 5 52 PM '70

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DIC 15 1970

CONTRACTS - 490 (Tel. av)

OFFICE	Adm. Ser. Br.	Res. Cont. Br.			
SURNAME	Medley	C. S. Shoup			
DATE	10-8-70	10-12-70			

1138897



THE UNIVERSITY OF TEXAS AT AUSTIN  
COLLEGE OF ENGINEERING  
AUSTIN, TEXAS 78712

Office of the Dean

September 15, 1970

Dr. Herman Ross  
U. S. Atomic Energy Commission  
P.O. Box E  
Oak Ridge, Tennessee 37830

Dear Sir:

Reference is made to our telephone conversation of September 11, 1970. It is my understanding that my present AEC contract number AT(11-1)-490 will be renewed for an amount of about \$18,000.

I would like to request that this grant be made for the period October 1, 1970, through September 30, 1971. Also, I would like to request permission to carry over the unexpended funds in the present contract and add these to the new grant. I estimate that I might be able to carry over about \$4,000 to \$5,000.

I base my request on the fact that most of the projected work will be undertaken by graduate students who are working on either Masters or PhD degrees. Better projects can be defined and reports can be completed in a more efficient manner if overall effort can be related to specific assignments. I have gone over my budgets and by combining the new grant with the projected carry over it will be possible for me to phase out this project in an efficient manner. Also it will be possible for me to complete the graduate student efforts now involved in this project and thereby do a better job than if I were requested to complete the project by January 1, 1970.

Hopefully this request meets with your approval.

Sincerely,

Earnest F. Gloyna  
Project Director

EFG:jm  
cc: Mr. Craig Roberts

CONTRACTS - 4-11 (Tera)

*Craig Roberts says OK  
in 10-9-70 telecon  
K. W.*

SEP 17 1970

B 1939

1138898

SEP 15 1970

Milton Shaw, Director, Division of Reactor Development  
and Technology, Headquarters

CONTRACT NO. AT-(11-1)-490 - UNIVERSITY OF TEXAS

The information contained in your memorandum dated August 28, 1970, on the extension, funding, and completion of work under Contract No. AT-(11-1)-490 was relayed to the contractor by a letter from this office.

On September 10, Earnest F. Gloyna, Principal Investigator on Contract No. AT-(11-1)-490, telephoned this office and requested that (1) the contract be extended through June 30, 1971, the end of the school year and (2) he be authorized to utilize between \$3,000 to \$5,000 in estimated unexpended prior period funds in addition to the \$18,000 new funding authorized. I talked to Craig Roberts of your office concerning the contractor's request and he offered no objection to the proposed change in extending the period to June 30, 1971, and allowing the University to use the unexpended funds. Therefore, we propose to modify the contract accordingly.

ORIGINAL SIGNED BY  
RICHARD B. MARTIN

Herman M. Roth, Director  
Laboratory and University Division  
Oak Ridge Operations

OLE:LM

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AT-(11-1)-490 (Texas)

10 OFFICE ▶ SURNAME ▶ DATE ▶	Adm. Ser. Br. & U. Division <i>Medley</i> Medley:oc	<i>9/15</i> <i>Martin</i>				
	<i>9-11-70</i>	<i>9-15</i>				

1138899

SEP 10 1970

Dr. Earnest F. Gloyna, Dean  
College of Engineering  
University of Texas  
Austin, Texas 78712

CONTRACT NO. AT-(11-1)-490

Dear Dr. Gloyna:

We have authorization to extend Contract No. AT-(11-1)-490 through December 31, 1970, with new AEC funds in the amount of \$18,000. Please submit a revised budget as soon as possible based on the approved financing. Please have the revised budget endorsed by an appropriate administrative official of the University.

Your renewal proposal for extension of Contract No. AT-(11-1)-490 was forwarded to our Headquarters office for review and consideration. AEC Headquarters comments and instructions concerning the extension and completion of the contract are as follows:

We have completed our review of the University's renewal proposal (thru 9-30-71) and concluded that further extension cannot be supported. This decision is based upon our judgment of the relative importance of the proposed study when compared with other more critical reactor development and technology programs that must be supported within our very limited resources.

Accordingly, it is requested that Contract No. AT-(11-1)-490 be brought to an orderly close by December 31, 1970, including the performance of the following work:

1. Complete and prepare a report on the flume studies now underway which are designed to test the previously developed mathematical model of radionuclide transport.

CONTRACTS-490-721001

Dr. Earnest F. Gloyna

2

SEP 10 1970

- 2. Complete the work and report the results of the aquaria studies underway which are designed to investigate the uptake and retention of tritium.
- 3. Prepare a final summary technical report.

The additional funding of \$18,000 is being made available for the performance of the above work.

Your cooperation in this matter will be appreciated.

Sincerely,

ORIGINAL SIGNED BY

C. S. SHOUP

C. S. Shoup, Chief  
Research Contracts Branch  
Laboratory and University Division

OLE:LM

CC: <sup>05</sup> J. M. Jacobsen, Univ. of Texas  
Norman Hackerman, Univ. of Texas

OFFICE ▶	Adm. Ser. Br.	Res. Cont. Br.				
SURNAME ▶	Medley Medley:00	C. S. Shoup				
DATE ▶	9-10-70	9-16-70				

1138901

JUL 2 1970

Mr. J. M. Jacobsen  
Executive Director  
Office of Sponsored Projects  
Post Office Box 7726  
University of Texas  
Austin, Texas 78712

CONTRACT NO. AT-(11-1)-490

Dear Mr. Jacobsen:

In addition to the renewal proposal and related material which has been received on Contract No. AT-(11-1)-490, we need a report number (URO-490- ) for the progress report portion of the renewal proposal and a completed Form AEC-427 on the recommended disposition of the report. We are enclosing a supply of Form AEC-427.

Your attention is invited to the enclosed copy of our letter dated June 1, 1970, on renewal of Contract No. AT-(11-1)-490, and our June 16, 1970 letter on the renewal documents required. Both letters request that the progress report be numbered and that a completed Form AEC-427 be submitted.

Your cooperation in furnishing us with the above requested information as soon as possible will be appreciated.

Sincerely,  
ORIGINAL SIGNED BY  
C. S. SHOUP

C. S. Shoup, Chief  
Research Contracts Branch  
Laboratory and University Division

OLE:LM

Enclosures:  
As stated above

cc: Earnest F. Gloyna, Univ. of Texas

CONTRACTS - 490 (Texas)

OFFICE ▶	Adm. Serv. Br.	Res. Cont. Br.			
SURNAME ▶	MEDLEY:ijt	CS Shoup			
DATE ▶	7-2-70	7-2-70			

1138902

JUN 16 1970

Dr. Ernest F. Gloyna  
Dean  
College of Engineering  
University of Texas  
Austin, Texas 78712

CONTRACT NO. AT-(11-1)-490

Dear Dr. Gloyna:

Thank you for the proposal which was submitted with the completed Form 189a under Contract No. AT-(11-1)-490.

In addition to the renewal proposal document which we received, we should like to point out that we will also need the other related material which is requested in our letter of June 1, 1970, on renewal of the contract. When we receive the remainder of the required renewal material; viz, (1) progress report appropriately numbered with completed Form AEC-427, (2) financial statement, and (3) 200-word summary, we will forward the complete renewal package to AEC Headquarters for their review and decision on renewal. We will then advise you as soon as we receive our Headquarters' decision.

We note that the proposal does not provide for any time to be devoted to the project by you. Do you plan to devote any time to the project? If so, approximately what percentage?

We shall also appreciate receiving an itemized listing of the materials, services and equipment to be acquired with the \$13,000 budgeted for these expenses.

Your cooperation is appreciated.

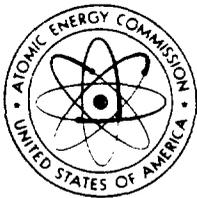
700 17  
Sincerely,  
F. CLARK HUFFMAN

700 17  
D125  
Clark Huffman, Acting Chief  
Reactor Contracts Branch  
Laboratory and University Division

7 0812  
OLE:LM

OFFICE ▶	Adm. Ser.Br.	Res.Cont.Br.	Reactor Cont.Br.		
SURNAME ▶	Medley:mgg				CONTRACTS - 490 (Texas)
DATE ▶	6-15-70				

1138903



UNITED STATES  
ATOMIC ENERGY COMMISSION

OAK RIDGE OPERATIONS  
P.O. BOX E  
OAK RIDGE, TENNESSEE 37830

AREA CODE 615  
TELEPHONE 483-8611

*File*

July 1, 1970

**Milton Shaw, Director, Division of Reactor Development and Technology, HQ**

**RENEWAL OF CONTRACT NO. AT-~~600000~~ (11-1)-490 WITH THE UNIVERSITY OF TEXAS**

We are submitting for your review and appropriate action the following information concerning the contract which will expire on **September 30, 1970**:

- 1. Renewal Proposal (4)
- 2. Progress Report (4)
- 3. Financial Statement (4)
- 4. 200-Word Summary (3)

We shall appreciate your advising us of your decision so that we may proceed with the necessary contract action at the earliest possible date.

*Herman M. Roth*  
Herman M. Roth, Director  
Laboratory and University Division  
Oak Ridge Operations

OLE:LM *Milly*

Enclosures:  
As Listed Above

BC: D. S. Zachry, w/cy <sup>2</sup>Progress Report and Form AEC-427  
C. S. Shoup, w/cy encls  
Alice Brown

7 4223

CONTRACTS - 490 (Texas)

1138904



THE UNIVERSITY OF TEXAS AT AUSTIN  
COLLEGE OF ENGINEERING  
AUSTIN, TEXAS 78712

*Department of Civil Engineering  
Environmental Health Engineering  
Engineering Laboratories Building 305*

June 16, 1970

U. S. Atomic Energy Commission  
Laboratory and University Division  
Post Office Box E  
Oak Ridge, Tennessee 37830

Dear Sir:

Transmitted herewith are four copies of the "Notice of Research Project" for Renewal of Contract No. AT-(11-1)-490.

This is in compliance to the letter of June 1, 1970 from Mr. Herman M. Roth, Director of the Laboratory and University Division, Oak Ridge Operations.

Sincerely,

Ernest F. Gloyna  
Environmental Health Engineering

st

ck Enclosure: 4 copies of "Notice of Research Project"

CONTRACTS - 490 (Texas)

JUN 19 1970

1138905



THE UNIVERSITY OF TEXAS AT AUSTIN  
OFFICE OF THE PRESIDENT  
AUSTIN, TEXAS 78712

President

June 20, 1970

Laboratory and University Division  
Oak Ridge Operations  
U. S. Atomic Energy Commission  
P. O. Box E  
Oak Ridge, Tennessee 37830

Attention: Mr. F. Clark Huffman, Acting Chief  
Reactor Contracts Branch

Gentlemen:

We are pleased to transmit a copy of a proposal prepared by Earnest F. Gloyna, of our Department of Civil Engineering. This proposal has the approval of cognizant officials of the University.

Further information relating to the technical portions of this proposal may be obtained from Dr. Earnest F. Gloyna, Department of Civil Engineering, The University of Texas at Austin. Contractual matters should be referred to Mr. Jens Jacobsen, Executive Director, Office of Sponsored Projects, The University of Texas at Austin, Post Office Box 7726, Austin, Texas 78712.

Very truly yours,

Norman Hackerman

NH/cv

Enclosures: 1 cy proposal  
20 cys Financial Statement

cc: Dr. Earnest F. Gloyna

CONTRACTS - 490 (Texas)

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1138906

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THE UNIVERSITY OF TEXAS AT AUSTIN  
OFFICE OF SPONSORED PROJECTS  
AUSTIN, TEXAS 78712

Post Office Box 7726  
AC 512, 471-1353

July 7, 1970

United States Atomic Energy Commission  
Oak Ridge Operations  
P. O. Box E  
Oak Ridge, Tennessee 37830

Attention: C. S. Shoup, Chief  
Research Contracts Branch  
Laboratory and University Division

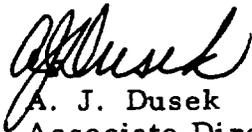
Subject: AEC Contract No. AT-(11-1)-490

Gentlemen:

We are in receipt of your letter dated July 2, 1970, in regard to information which was not included in the renewal proposal for continuation of AEC Contract No. AT-(11-1)-490.

Copies of Form AEC-427 are being forwarded to Dr. Gloyna. By copy of this letter, we are asking Dr. Gloyna to complete the form and return it directly to you with the required progress report number.

Very truly yours,

  
A. J. Dusek  
Associate Director

AJD/cv

cc: Dr. Earnest F. Gloyna

JUL 9 1970

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CONTRACTS - 490 (Texas)

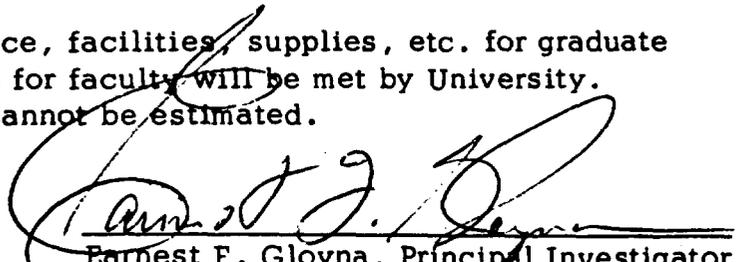
1138907

## FINANCIAL STATEMENT

	Total Project Allowances	Expenditures to Date	Estimated Expenditure	Expected Balance at Expiration of Contract
Personnel	42,624.00	24,420.28	18,203.72	-0-
Travel	1,000.00	79.75	920.25	-0-
OASI and WCO	1,076.00	510.47	565.53	-0-
Other Expenses	5,300.00	2,580.34	2,719.66	-0-
Indirect	10,000.00	5,518.17	4,481.83	-0-

1. Estimated Project Director for nine months is about \$2,500.00. Also, graduate students who are on traineeships are not included in the cost contribution because the amount is not known presently. In the past, one or more such students have made contributions to the project. These efforts are equivalent to about one full time employee.

2. The University provides space, facilities, supplies, etc. for graduate students. In addition, salaries for faculty will be met by University. Actual University contribution cannot be estimated.

  
 Ernest F. Gloyna, Principal Investigator  
 The University of Texas at Austin

ORIGINAL SIGNED BY  
 NORMAN HACKERMAN

Norman Hackerman, President  
 The University of Texas at Austin

PUBLICATION BY AEC AUTHORIZED

NOTICE OF RESEARCH PROJECT SCIENCE INFORMATION EXCHANGE SMITHSONIAN INSTITUTION

U.S. ATOMIC ENERGY COMMISSION

SIE NO.

AEC CONTRACT NO.

SUPPORTING DIV. OR OFFICE:

NAME & ADDRESS OF CONTRACTOR OR INSTITUTION: (State the division, department, or professional school, medical, graduate or other, with which this project should be identified.)

The University of Texas at Austin Department of Civil Engineering Environmental Health Engineering Engineering Labs. Building 307 Austin, Texas 78712

TITLE OF PROJECT:

Transport of Radionuclides in Water (Model River and Ecological System)

NAMES, DEPARTMENT, AND OFFICIAL TITLES OF PRINCIPAL INVESTIGATORS AND OTHER PROFESSIONAL SCIENTIFIC PERSONNEL: (not including graduate students) engaged on the project, and fraction of man-year devoted to the project by each person.

- Dr. Earnest F. Gloyna, Dean, College of Engineering and Professor, Department of Civil Engineering (10% academic year and 100% for two summer months). Dr. E. Gus Fruh, Assistant Professor (10% academic year and 100% for one summer month). Dr. Y. A. Yousef, Assistant Project Investigator (100% of time).

NO. OF GRADUATE STUDENTS ON PROJECT: 4 NO. OF GRADUATE STUDENT MAN-YEARS: 2

SUMMARY OF PROPOSED WORK: (200-300 words, omit Confidential Data). Summaries are exchanged with government and private agencies supporting research, are supplied to investigators upon request, and may be published in AEC documents. Make summaries substantive, giving initially and for each annual revision the following: OBJECTIVE; SCIENTIFIC BACKGROUND FOR STUDY; PROPOSED PROCEDURE; TEST OBJECTS AND AGENTS. It is the purpose of this investigation to develop techniques for distinguishing and predicting biological changes resulting from release of heated waters as compared to those effects caused by other wastewaters. Also, the transport characteristics of different forms of tritium in flowing and non-flowing ecosystems will be investigated.

Experiments will be conducted as follows:

- 1. A research flume (200 ft. long, 2.5 ft. wide and 2.0 ft. deep, and partitioned at mid-width) will be insulated. Heat exchangers will be installed to provide desired temperature levels. 2. The effect of heated water on diversity index and changes in productivity over respiration of the ecosystem will be investigated. 3. The system will be subjected to various stresses such as temperature, low dissolved oxygen and toxic material and the effect of these stresses on the bio-physical characteristics of the ecological systems will be evaluated. 4. The transport characteristics of instantaneous and continuous releases of tritium in the ecosystem will be modeled. 5. The equilibrium concentrations and interchangeable tritium between sediment, biomass and water will be investigated.

RESULTS TO DATE: A prediction model which describes the transport characteristics of radionuclides in ecological system has been developed and verified in the research flume. Mass transfer coefficients and concentration coefficients for plants and bed sediments have been developed for various radionuclides.

CONTRACTS - 490 (Texas)

Signature of Principal Investigator (handwritten signature) JUN 19 1970

Table with 2 columns: BUDGET, PROGRAM CATEGORY NO. Rows: PRIMARY, SECONDARY

DATE: June 17, 1970

INVESTIGATOR - DO NOT USE THIS SPACE

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A Proposal to  
The United States Atomic Energy Commission

TRANSPORT OF RADIONUCLIDES  
IN WATER  
(MODEL RIVER AND ECOLOGICAL STUDIES)

The University of Texas at Austin  
Department of Civil Engineering  
ENVIRONMENTAL HEALTH ENGINEERING  
Austin, Texas 78712

Submitted by

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Professor, Department of Civil Engineering

E. Gus Fruh, Assistant Professor  
Y. A. Yousef, Assistant Project Investigator  
Department of Civil Engineering

May 20, 1970

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Proposal to the Atomic Energy Commission  
From The University of Texas at Austin  
For Funds to Support Research on  
Transport of Radionuclides in Water  
(Model River and Ecological Studies)  
for the period  
October 1, 1970 - September 30, 1971

ABSTRACT

This is a request from The University of Texas at Austin for a cooperative lump-sum contract in the amount of \$60,000.00 for the period October 1, 1970 - September 30, 1971, inclusive. Present contract No. AT (11-1)-490 expires September 30, 1970.

The most recent topical report and papers have described the simulation of sustained releases to selected river environments, effects of organic pollution and the role of organic pollution and oxygen balance in transport.

An overall evaluation study and summary report was released in February, 1970, which summarizes the previously issued topical reports and research efforts has been completed. A mathematical model for routing a radionuclide through a model river system has been developed.

Future studies proposed include: (1) measurements of the species diversity and changes in productivity resulting from thermal stresses, (2) effect of added toxic materials on species diversity, (3) effects of thermal pollution on life stages of fish, (4) transport characteristics of tritium in model river system (research flume), (5) influence of diurnal changes on interchangeable tritium between biomass, sediment and water, and (6) measurement of equilibrium concentrations and mass transfer coefficients for tritium.

## SUMMARY OF RESEARCH THROUGH FY 1969

Extensive research has been undertaken on the behavior of radionuclides in rivers. Experiments have involved both the development of physical and mathematical models. Analytical and numerical solutions to differential equations have been developed which assist in predicting the transport of pulses (unsteady state) of radionuclides through a model river. This, combined with a thorough study of a real river system involving Sr and Cs led to the development of a conceptual model which illustrates the importance of various environmental stresses on the transport and detention of radionuclides. Through these studies and model development considerable insight has been gained regarding the possible behavior of radionuclides in river systems. The expense and effort has certainly been much less than that required to conduct full-scale river experiments.

Quarterly reports were submitted regularly. Technical reports were submitted as specific phases of the project were completed. Since most of the phases of this project were associated with either master's or doctoral research projects, reports were published as the faculty approved the thesis or dissertation.

Titles of reports exclusive of those released during FY 1970 are listed below:

1. Reynolds T. D. and E. F. Gloyna, Radioactivity Transport in Water--  
Transport of Strontium and Cesium by Stream and Estuarine Sedi-  
ments, Technical Report No. 1 to the U. S. Atomic Energy Commis-  
sion, 117 pp., (June, 1963).

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2. Patterson, C. C. and E. F. Gloyna, Radioactivity Transport in Water--  
The Dispersion of Radionuclides in Open Channel Flow, Technical  
Report No. 2 to the U. S. Atomic Energy Commission, 87 pp.,  
(June, 1963).
3. Story, A. H. and E. F. Gloyna, Radioactivity Transport in Water--  
Environmental Behavior of Nitrosylruthenium, Technical Report No. 3  
to the U. S. Atomic Energy Commission, 89 pp., (June, 1963).
4. Bolch, W. E. and E. F. Gloyna, Radioactivity Transport in Water--  
Behavior of Ruthenium in Algal Environments, Technical Report No. 4  
to the U. S. Atomic Energy Commission, 55 pp., (September, 1963).
5. Rowe, D. R. and E. F. Gloyna, Radioactivity Transport in Water --  
The Transport of Zn<sup>65</sup> in an Aqueous Environment, EHE-09-6403,  
Technical Report No. 5 to the U. S. Atomic Energy Commission,  
010 pp., (September, 1964).
6. Clanton, U. S. and E. F. Gloyna, Radioactivity Transport in Water--  
Sorption and Release of Radionuclides by Sediments of the Guadalupe  
River, EHE-10-6404, Technical Report No. 6 to the U. S. Atomic  
Energy Commission, 64 pp., (July, 1964).
7. Yousef, Y. A. and E. F. Gloyna, Radioactivity Transport in Water--  
The Transport of CO<sup>14</sup> in an Aqueous Environment, EHE-12-6405,  
Technical Report No. 7 to the U. S. Atomic Energy Commission,  
121 pp., (December, 1964).
8. Copeland, B. J. and E. F. Gloyna, Radioactivity Transport in Water--  
Structure and Metabolism of a Lotic Community, Part I (April-July,  
1964)., EHE-02-6501, Technical Report No.-8 to the U. S. Atomic  
Energy Commission, 51 pp., (February, 1965).
9. Bhagat, S. K. and E. F. Gloyna, Radioactivity Transport in Water--  
Transport of Nitrosylruthenium in an Aquatic Environment, EHE-11-6502,  
Technical Report No. 9, to the U. S. Atomic Energy Commission,  
144 pp., (November, 1965).
10. Shih, C. S. and E. F. Gloyna, Radioactivity Transport in Water--  
Transport of Sr<sup>85</sup> and Cs-137 in an Aquatic Environment, EHE-01-6602,  
Technical Report No. 10 to the U. S. Atomic Energy Commission, 97 pp.,  
(January, 1966).
11. Canter, L. W. and E. F. Gloyna, Radioactivity Transport in Water--  
Transport of CR-51 in an Aqueous Environment, EHE-04-6701, Technical  
Report No. 11 to the U. S. Atomic Energy Commission, 241 pp., (May,  
1967).
12. Shih, C. S. and E. F. Gloyna, Radioactivity Transport in Water--  
Mathematical Model for the Transport of Radionuclides, EHE-04-6702,  
Technical Report No. 12 to the U. S. Atomic Energy Commission,  
179 pp., (June, 1967).

13. Purushothaman, K. and E. F. Gloyna, Radioactivity Transport in Water -- Transport of <sup>85</sup>Sr and <sup>137</sup>Cs Under Induced Clay Suspensions, EHE-12-6701, Technical Report No. 13 to the U. S. Atomic Energy Commission, 120 pp., (January, 1968).
14. Armstrong, N. E. and E. F. Gloyna, Radioactivity Transport in Water-- Numerical Solutions of Radionuclide Transport Equations and Role of Plants in SR-85 Transport, EHE-12-6703, Technical Report 14 to the U. S. Atomic Energy Commission, 139 pp., (December, 1967).
15. Shull, R. D. and E. F. Gloyna, Radioactivity Transport in Water-- Simulation of Sustained Releases to Selected River Environments, EHE-04-6801, Technical Report No. 15 to the U. S. Atomic Energy Commission, 237 pp., (May, 1968).
16. Futagawa, K. and E. F. Gloyna, Radioactivity Transport in Water-- Effects of Organic Pollution on Radionuclide Transport, EHE-04-6803, Technical Report No. 16 to the U. S. Atomic Energy Commission, 61 pp., (May, 1968).
17. Kudo, Akira and E. F. Gloyna, Radioactivity Transport in Water-- Interaction Between Flowing Water and Bed Sediment, EHE-69-03 CRWR-36, Technical Report No. 17 to the U. S. Atomic Energy Commission, 152 pp., (January, 1969).
18. Patterson, C. C., Kudo, Akira, Eller, J. M. and E. F. Gloyna, Radioactivity in Water --The Role of Organic Pollution and Oxygen in Transport, EHE-69-09, CRWR-42, Technical Report No. 18 to the U. S. Atomic Energy Commission, 49 pp., (May, 1969).

SUMMARY OF RESEARCH UNDER  
TRANSPORT OF RADIONUCLIDES IN WATER SERIES  
FY 1969 - FY 1970

- 1. White, A. and E. F. Gloyna, Radioactivity Transport in Water--Mathematical Simulation, EHE-70-04, CRWR-52, Technical Report No. 19 to the U. S. Atomic Energy Commission, (Feb, 1970).

A mathematical model has been developed for routing a radionuclide through a model river system. The capabilities of this simulation model include the following characteristics:

- 1. It distributes radionuclide activity by advective and dispersive mechanisms along the longitudinal axis of the system.
- 2. It may be discretized into any number of segments (vertical planes normal to the longitudinal axis) as may be appropriate to describe spatial variations in radionuclide activity.
- 3. It is capable of treating instantaneous, continuous, or time-varying releases of radionuclide activity.
- 4. It provides for a temporal description of radionuclide activity throughout the system.
- 5. It provides for sorption and desorption by both plants and bottom sediments.

- 2. Yousef, Y. A., Akire Kudo and E. F. Gloyna, Radioactivity Transport in Water--Summary Report, EHE-70-05, CRWR-53, Technical Report No. 20 to the U. S. Atomic Energy Commission, 80 pp., (Feb, 1970).

A transport model is presented which describes the behavior of radionuclide movement in an ecological system, and considers hydraulic transport, sediment sorption and desorption, and biomass uptake and release. Solutions of the transport model are programmed and verified using data obtained from the laboratory ecosystem and the research flume. The limitations and relative importance of environmental factors affecting transport were evaluated. Recommendations for the use of this prediction model are discussed.

Flume experiments limited to fresh water systems and slow moving streams were conducted. In general, radionuclide movement followed the same pattern as Rhodamine B dye releases. However, discrepancies were observed due to interactions of radionuclides with sediments, biomass and organic debris. Therefore, before tests were conducted in the fully instrumented flume (model river), laboratory experiments with small ecosystems (aquaria) were conducted to help evaluate the functional form and factors involved in prediction models.

The effects of specific environmental factors such as pH, temperature, dissolved oxygen, oxidation-reduction potential sunlight were studied to estimate the uptake and release rates of radionuclides. The radionuclides investigated included  $^{65}\text{Zn}$ ,  $^{58}\text{Co}$ ,  $^{103}\text{Ru}$ ,  $^{137}\text{Cs}$ ,  $^{85}\text{Sr}$ , and  $^{51}\text{Cr}$ .

SCIENTIFIC SCOPE AND OBJECTIVES

It is the purpose of this investigation to develop techniques to distinguish and predict the biological changes resulting from the release of heated waters from those effects caused by other wastewaters in the stream ecosystems. It is also required to study the transport characteristics of different forms of tritium in flowing and non-flowing ecosystems.

To achieve the objectives, certain continuation experiments and evaluation techniques will be conducted (FY 1971).

1. The research flume will be insulated and heat exchangers will be installed to provide constant heated water flowing through the flume from a storage tank rich in phytoplankton.
2. The effect of heated water on diversity index and changes in productivity over respiration of the ecosystem will be investigated.
3. The system will be subjected to various stresses such as temperature, low dissolved oxygen and toxic material and the effects of these stresses on the biophysical characteristics of the ecological systems will be evaluated.
4. The transport characteristics of instantaneous and continuous releases of tritium in the ecosystem will be modeled.
5. The equilibrium concentrations and interchangeable tritium between sediment, biomass and water will be investigated.

The major effect is outlined above and at least two topical reports will be developed for FY 1971.

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## PERSONNEL

The Principal Investigators will be Dr. E. F. Gloyna and Dr. E. Gus Fruh; Assistant Project Investigator will be Dr. Y. A. Yousef.

Advisors from areas other than those actively participating in the Environmental Health Engineering Program will be consulted.

Research Assistants will be part-time faculty and graduate students. Additional staff will include electronics repairman, programmers and general help.

Complete biographical information is included for Dr. E. F. Gloyna, Dr. E. Gus Fruh, and Dr. Y. A. Yousef (see attachments 1 - 3).

## OTHER FINANCIAL ASSISTANCE

Students holding fellowships supported by U. S. Public Health Service, National Science Foundation, Federal Water Pollution Control Administration, etc., may participate in this project, and their thesis or dissertation research may be included in various reports. Otherwise, no other agency except The University of Texas at Austin is contributing to the support of this research project.

## MATERIALS, EQUIPMENT, AND FACILITIES

By June 15, 1970 a \$500,000.00 addition to the Water Resources Research Facility will be completed. It is located adjacent to the present radionuclide transport project.

All of the research centers and research laboratories at The University of Texas are part of the graduate program. These laboratories and facilities are, in part, made available for acquainting science and engineering students with radiochemical techniques and the problems of radioactive waste treatment and disposal.

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Most of the laboratory equipment, as well as utilities, will be furnished by The University of Texas.

Some of the available equipment consists of data acquisition units, spectrophotometers, electron microscopes, X-ray diffraction machines, a 512-channel gamma spectrometer, an electrometer for counting gaseous and liquid samples, a variety of window and windowless proportional flow counters, a gas flow proportional counting system, and an automatic low-level beta counter.

A flume has been constructed at the Balcones Research Center Laboratories that is being used as a model for evaluating radionuclide movement. This site was chosen because there are several large existing tanks that can be made available for this study. These tanks were formerly used as settling tanks. They vary in size from 50 feet to 150 feet in diameter and are about 8 feet deep.

ANNEX I

WORK PLAN

Radioactivity Transport in Water -- MODEL RIVER  
AND ECOLOGICAL SYSTEM STUDIES

Previous	Proposed
<p><u>Development and Verification of Prediction Model</u></p>	<p>Biophysical Changes Resulting From Pollutational Stresses (Thermal and Tritium)</p>
<p>AT(11-1)-490</p> <p>Total of 20 Topical Reports</p> <ol style="list-style-type: none"> <li>1. Dispersion Studies</li> <li>2. Uptake and release of Sr, Co, Zn, Cs, Ru, Cr on Biomass and Sediments</li> <li>3. Lab., Ecosystem and Model River Performance</li> <li>4. Development and Verification of Prediction model</li> </ol>	<p>FY 1971</p> <pre> graph TD     A[Effect of Heated Wastes on Diversity Index and Changes in P/R Ratio] --&gt; B[Initial]     A --&gt; C[Acclimatized]     C --&gt; D[Pollutational Stress (a) Low D.O. (b) Toxic Materials (c) Tritium]     D --&gt; E[Topical Report]     D --&gt; F[Transport Characteristics of Tritium in Model River]     F --&gt; G[Retention and Release Coefficients]     F --&gt; H[Equilibrium and Mass Transfer Coefficients]     G --&gt; I[Topical Report]     H --&gt; J[Transport Model]     J --&gt; I     </pre>
	<p>FY 1972</p> <p>Effect of Heated Wastes on Various Stages of Fish</p> <p>Continuous Releases of Tritium and Verification of Prediction Model</p>

Sept 30, 1970  
Oct 1, 1970

Oct 1, 1971

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## BUDGET

The estimated costs are \$60,000.00 under a lump-sum contract. The duration of this particular project and funding period is estimated at one year, October 1, 1970, to September 30, 1971, inclusive.

	Total
SALARIES AND WAGES . . . . .	\$36,000.00
(Salaries paid from Government contract funds at The University of Texas conform to the rates approved by the Board of Regents for salaries paid from regular University funds.)	
Dr. E. Gus Fruh, Co-Principal Investigator (10% Academic year and 100% for one summer month)	\$ 3,000.00
Dr. Y. A. Yousef, Assistant Project Director and Research Engr.-Sci. (100% of time)	13,200.00
Biologist (50% time)	4,000.00
Technician (100% time)	4,800.00
Two graduate Research Assistants (50% each)	6,000.00
Electronic Repairman (25% time)	2,000.00
Typist (50% time)	2,000.00
Employee benefits	1,000.00
MATERIALS, SERVICE, AND EQUIPMENT . . . . .	13,000.00
(This item includes the operation of the flume, purchase of test equipment, expendable materials, minor equipment items, and occasional services of others not included in Salaries and Wages.)	
TRAVEL . . . . .	1,000.00
(Transportation expense of persons engaged in the work, including transportation by plane or rail and Pullman, or by private car at an allowance of not to exceed 10¢ per mile in lieu of actual expense, plus per diem on the quarter-day basis.)	
Total Direct Cost . . . . .	50,000.00
Indirect Cost . . . . .	<u>10,000.00</u>
	\$60,000.00

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## ECOSYSTEM RESPONSE TO THERMAL STRESS

### Objective and Scope

The purpose of this investigation is to develop techniques to distinguish and predict the biological changes resulting from the release of heated waters from those effects caused by other wastewaters in the stream ecosystem. The scope of the project will include measurement of the species diversity and changes in the productivity to respiration ratio of similar environments subjected to long term singular and interacting stresses such as temperature, low dissolved oxygen, and toxic materials. These measurements will be undertaken at various time intervals starting with the initiation of the stress(es) to the "acclimation" of the ecosystem to the stress(es). Other biological measurements such as change in standing crop will be obtained as required.

Because of the undefined characteristics and uncontrollable environmental changes which occur in a natural stream, flumes with the capability of controlling flow, velocity, temperature and other inputs will be utilized for the basic aquatic environments.

### Introduction

Discharge of heated waters generally affects the entire aquatic ecosystem - the interrelated biological, chemical, and physical system. A number of investigations have been undertaken to solve this problem (which are summarized by Parker and Krenkel, 1969; FWPCA, 1968). However, except for overall principles and concepts, this wealth of information generally has not helped the design engineer or his counterpart in the water pollution control agency in their attempts to solve the problem. The main reason for the failure of research to give an answer is that most of the investigators

have considered the temperature problem in isolation from other problems. Thus, if the engineer desires to know if a specific temperature increase will affect a particular ecosystem, he must know not only the temperature requirements of the organisms present, but also must be able to assess the stress placed on the organisms by low dissolved oxygen, toxic materials, silt loads, etc. To do this, our engineering estimating techniques (and soon, hopefully, our water pollution control regulations) need to be based on assessing the ecological effects of each waste collectively rather than individually.

One characteristic of a natural community which lends itself to such a quantitative assessment is the relationship between the number of different species of organisms present and the number of individuals representing each species. This relationship, called the species diversity, is correlated with community stability. The structure of a community is a complex of energy flow pathways. Energy enters via the lower trophic levels and travels via multiple pathways to the top carnivore level. The forces and flow of energy (which are of unidirectional character through the community as required by the second law of thermodynamics) interconnect all species in all possible combinations. Some of the species have specific "job" responsibilities other than direct energy transfer. These particular species maintain diversification of organisms in each trophic level so that a large number of energy pathways are kept open.

If an ecosystem is subjected to an energy-requiring stress, the energy required to survive that added cost will be removed from the energy pool utilized for specific "job" responsibilities; e.g. diversification. In other words, the several species that were supported by the overall energy systems

to perform a specifically restricted task such as maintaining the diversification of that system, will be replaced by a smaller number of species, each capable of fulfilling wider job responsibilities. Thus when the energetic cost of supporting diverse populations is switched to survival, the resulting characteristic is a less diverse population designed to be more adaptable and capable of surviving. Moreover, the additional energy required to survive pollutional stresses such as low dissolved oxygen and toxicity also leaves less of an energy reserve for meeting any additional requirements of naturally occurring stresses such as unusual temperature fluctuations. With species living closer to their physiologically adapted limits in polluted waters, these limits are more readily exceeded causing the elimination of the species.

Literature Review

Maximum diversity exists if each individual belongs to a different species and maximum diversity exists if all individuals belong to the same species (Wilhm, 1967; Wilhm and Dorris, 1966; Storrs et al, 1969). Thus, a community that contains only a few species with large numbers of individuals will have a low diversity and, conversely, one with a great number of species each represented by a few individuals will have a high diversity. There have been several different mathematical interpretations of the species diversity concept, with most investigators presenting the data as a diversity index (Odum, et al, 1960; Menhinick, 1964; and Wilhm, 1967). The advantages of applying diversity indices derived from information theory is that they express the relative importance of each species, are dimensionless, and are independent of sample size (Wilhm and Dorris, 1968). Pielou (1966) has classified sample collections into five different types, each type having a different

method for determining the sample's information content. Wilhm (1968) substituted biomass units for numbers, more closely relating diversity to energy distributions among species. He concluded that energy flow units would be preferable to biomass units in a diversity index, but that measurements were difficult to attain.

Several earlier workers analyzing the effects of pollution recognized the relationship between the species diversity of the aquatic organisms in the area being studied and its water quality (Tarzwell and Gaufin 1953; Katz and Gaufin 1953; Gaufin and Tarzwell 1956; Doudoroff and Warren 1957; Bartsch and Ingram 1959). Although they did not specifically present their data in the form of a diversity index, the relationship between number of species and number of individuals was discussed and in some cases diagrammed. The results show that in polluted streams the number of organisms are distributed among more species the greater the distance from the pollution source.

The occurrence of bottom community types in estuarine areas has been used to indicate varying degrees of water quality (Filice 1954, 1958; Reish 1960; McNulty 1961). The most polluted areas contained few or no organisms while the less polluted areas had different associations than did the unpolluted waters.

Patrick et al. (1954), Hohn (1959) and Williams (1964) found that diatom counts also provided a measure of water quality. The diatom populations were reduced in polluted areas and their diversity was correspondingly lower.

Several workers have computed an actual diversity index in examining the effects of pollution on aquatic organisms. Using the number of species of zooplankton per 1000 individuals in a sample as an index of diversity,

Odum et al. (1963), Copeland (1966) and Copeland and Wohlschlag (1968) showed that species diversity increased as distance from a known pollution source increased.

Diversity indices derived from information theory have been applied to plankton and benthic macroinvertebrate samples collected during water pollution studies. Patten (1962) described the annual diversity cycle of phytoplankton in Raritan Bay and showed a progressively decreasing diversity from Lower Bay to the mouth of the Raritan River.

Wilhm and Dorris (1966) studied benthic macroinvertebrates in Skeleton Creek, Oklahoma, a stream polluted with domestic and industrial wastes. The diversity indices showed an increase as distance from the sources of pollution increased. Storrs et al. (1969) found that benthic macroinvertebrates indices for San Francisco Bay were lowest in those areas under the greatest environmental and polluttional stresses.

The literature indicates that in theory and with actual data, species diversity indices can be used to indicate environmental and polluttional stress. Little work has been accomplished with fish diversity in this regard, although studies using fish have provided information about water quality for many years. The complete absence of fish from areas receiving domestic and industrial wastes was used as an indication of grossly polluted waters by Katz and Gaufin (1953). Tsai (1968) studied the effects of chlorinated sewage effluents on fishes in the Patuxent River. The results indicate that diversity was seriously reduced immediately below the effluent outfalls and increased as distance from the source increased, with a species shift occurring downstream.

Various diversity concepts have been utilized to determine the effects of thermal pollution on an ecosystem. Wurtz and Dolan (1960) reported that a hot water discharge reduced the diversity of the community on a reach of the Schuylkill River. By suspending microscopic slides a few inches under the stream surface above and below a source of heated water and counting the species and individuals, Trembley (1960) reported that the periphyton was considerably altered by the power plant discharge. A return to normal conditions occurred approximately a mile downstream. Trembley (1960) also studied the bottom fauna above and below hot water discharges. In the zone of maximum temperature rise just below the outfall, there was a significant reduction of species and individuals. In the cool water unaffected by the thermal overflow, there was no reduction in macroinvertebrates. During the cooler seasons of the year, there was repopulation of the areas affected during the hot months by the thermal discharge. Coutant (1962) followed Trembley and reported that the tolerance limit for a normal benthic population was approximately 90°F and further rise in temperature was accompanied by extensive loss in numbers and diversity of organisms. Coutant (1962) observed an increase in both variety and number of organisms as he progressed from hot to cool water. From July to October in particular there was a substantial reduction in the number, diversity and biomass of benthic organisms in the path of the heated water. Trembley (1960) made a detailed survey of the rooted vegetation and found little difference in above and below the heated discharge.

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Trembley (1960) also reported on four years data for fish distribution at a heated water discharge site. (Although no specific diversity indices were calculated, his data are pertinent to the experimental procedure of this project). With the exception of one species, all the fish normally inhabiting the unheated section of the river were found living in the heated section at some time during the year. During the warm months of the year, most fish species almost completely avoided the zone of maximum heat. Repopulation of the zone of maximum heat occurs in other months and during the cold months there was a congregation and extended period of feeding activity of many species in the heated zone.

It is apparent from a review of the literature that a major emphasis has to be placed on the fish of commercial and sports fisheries importance. Temperature effects on each life stage (egg, fry, fingerling, yearling and adult) need to be determined for each species of fish. Particular emphasis is needed on the following subject categories:

1. lethal and optimum temperatures and the effects (lethal and sub-lethal) of temperature on reproduction and development;
2. movement and activity (including migration);
3. feeding and growth;
4. acclimation;
5. disease;
6. physiological responses more or less on the cellular level; and
7. compound stress (changes in conjunction with limiting conditions such as oxygen).

An excellent review for salmon is presented in Krenkel and Parker (1969).

Some studies have utilized multivariate techniques in assessing associated environmental factors on fish. An excellent example is Alderdice (1963) who conducted studies on the mean resistance times of juvenile coho salmon acclimated at 12°C (53.6°F) to 3 mg/l of sodium pentachlorophenate at various combinations of salinity, temperature, and dissolved oxygen.

Similar studies have not been conducted on the effect of multiple stresses on a stream ecosystem. One of the main difficulties is the inability to utilize natural streams because of the uncontrollable variables which exist. Based on the great amount of knowledge gained on biological systems from work on the transport of radionuclides in a controlled flume environment, funds are requested for similar studies on modeling ecosystem changes resulting from hot water discharges with and without other stresses. The results from this study in conjunction with the results from an overwhelming number of investigations being conducted specifically on the singular temperature effects of hot water discharges on important fish should aid the Atomic Energy Commission significantly in their planning and site evaluation for new nuclear thermal plants.

#### Experimental Procedure

The 200 foot long flume has been divided in two major sections and will be insulated. Both sections of the flume will receive water from a 0.5 million gallon storage tank containing ground water. Water entering one of the sections will be raised in temperature by a heat exchanger. At the upper end of each flume section, three 40 foot long sub-flumes will be added. The first of the sub-flumes in each section will receive a low dissolved oxygen

stress; the second chromium (common in cooling waters to prevent algal growth); and the third will function as a control. The effluents from each sub-flume will mix and the ecosystem in the remainder of the flume will be receiving a multitude of stresses.

The above set of experiments will be conducted in winter and summer until the ecosystem acclimates to the stresses.

A data acquisition system is available to record continuously the responses from a number of temperature and dissolved oxygen probes which will be placed at different positions in the sub-flumes and sections of the flume. The dissolved oxygen probes will be utilized to determine productivity to respiration ratios. Diurnal pH measurements will be intermittently conducted as a check. Benthos samples will be obtained for species, number and mass determinations. Microscopic slides will be placed in the flume to obtain the same information on the periphyton. The changes in rooted vegetation (planted in cans to prevent the expansion of roots throughout the sediments) will also be measured.

In order to evaluate the effect of each individual factor (season, temperature, dissolved oxygen concentration and chromium concentration) as well as the way each effect depends on the other factors, the experiments will be conducted according to a factorial design (Davis, 1963) so that each factor is varied in a regular way. This makes it possible to obtain a more complete picture of what is happening than would be obtained by varying each of the factors one at a time while keeping the other constant. Designs of this sort, moreover, lend themselves well to statistical analysis and can provide their own estimates of experimental error. This is particularly useful in this type of biological research in which the experimental errors are usually large

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compared with the effects being investigated, the cost of the individual observations is not great, and extensive replication cannot be accomplished.

During the spring as the temperature of the ground water in the storage tank slowly warms, the temperature, dissolved oxygen and chromium stresses will be fluctuated in both flume sections. Once again, a detailed factorial design will be utilized to distinguish these short-term responses.

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REFERENCES - THERMAL

- Alderdice, D. F. 1963. "Some Effects of Simultaneous Variation in Salinity, Temperature and Dissolved Oxygen on the Resistance of Young Coho Salmon to a Toxic Substance." *Journal of Fisheries Research Board of Canada*, 20, 525.
- Bartsch, A. F. and W. M. Ingram. 1959. "Stream Life and the Pollution Environment." *Public Works*, 90, 104-110.
- Copeland, B. J. 1966. "Effects of Industrial Waste on the Marine Environment." *Journal Water Pollution Control Federation*, 38, 1,000-1,010.
- Copeland, B. J. and D. E. Wohlschlag. 1968. "Biological Responses to Nutrients - Eutrophication: Saline Water Considerations." In E. F. Gloyna and W. W. Eckenfelder (eds.), Advances in Water Quality Improvement, University of Texas Press, Austin, Texas, pp. 65-82.
- Coutant, C. C. 1962. "The Effect of a Heated Water Effluent Upon the Macroinvertebrate Riffle Fauna of the Delaware River." *Penn. Acad. Science*, 37, 58.
- Davis, O. L. 1963. Design and Analysis of Industrial Experiments. Hafner Publishing Co., N. Y.
- Dickman, M. 1968. "Some Indices of Diversity." *Ecology*, 49, 1,191-1,193.
- Doudoroff, P. and C. E. Warren. 1957. "Biological Indices of Water Pollution with Special Reference to Fish Populations." In Biological Problems in Water Pollution, 1st Seminar, R. A. Taft Sanitary Engineering Center, Cincinnati, Ohio, pp. 144-163.
- Filice, F. P. 1954. "A Study of Some Factors Affecting the Bottom Fauna of a Portion of the San Francisco Bay Estuary." *Wasmann J. Biol.*, 12, 257-292.
- Filice, F. P. 1958. "Invertebrates from the Estuarine Portion of San Francisco Bay and Some Factors Influencing their Distributions." *Wasmann J. Biol.*, 16, 159-211.
- Federal Water Pollution Control Administration. 1968. "Industrial Waste Guide on Thermal Pollution." Pacific Northwest Water Laboratory, Corvallis, Oregon.
- Gaufin, A. R. and C. M. Tarzwell. 1956. "Aquatic Macro-invertebrate Communities as Indicators of Organic Pollution in Lytle Creek." *Sewage and Industrial Wastes*, 28, 906-924.

1138932

- Hohn, M. 1959. "The Use of Diatom Populations as a Measure of Water Quality in Selected Areas of Galveston and Chocolate Bays." Texas Publ. Inst. Mar. Sci., University of Texas, Austin, Texas, 6, 206-212.
- Katz, M. and A. R. Gaufin. 1953. "The Effects of Sewage Pollution on the Fish Population of a Midwestern Stream." Trans. Am. Fish. Soc., 82, 156-165.
- Menhinick, E. F. 1964. "A Comparison of Some Species - Individuals Diversity Indices Applied to Samples of Field Insects." Ecology, 45, 859-861.
- McNulty, J. K. 1961. "Ecological Effects of Sewage Pollution in Biscayne Bay, Florida; Sediments and the Distribution of Benthic and Fouling Macro-Organisms." Bull. Mar. Sci., 11, 394-447.
- Odum, H. T., J. E. Cantlon and L. S. Kornicker. 1960. "An Organizational Hierarchy Postulate for the Interpretation of Species - Individual Distributions, Species Entropy, Ecosystem Evolution, and the Meaning of a Species - Variety Index." Ecology, 41, 395-399.
- Odum, H. T., R. P. Cuzon du Rest, R. J. Beyers and C. Allbaugh. 1963. "Diurnal Metabolism, Total Phosphorus, Ohle Anomaly, and Zooplankton Diversity of Abnormal Marine Ecosystems of Texas." Publs. Inst. Mar. Sci., University of Texas, Austin, Texas, 9, 404-453.
- Parker, F. L. and P. A. Krenkel. 1969. "Thermal Pollution: Status of the Art." Report No. 3., Department of Environmental and Water Resources Engineering, Vanderbilt University, Nashville, Tennessee.
- Patrick, R., M. H. Hohn and J. H. Wallace. 1954. "A New Method for Determining the Pattern of the Diatom Flora." Notulae Naturae of Acad. Nat. Sci. Phila., 259, 1-12.
- Pattern, B. C. 1962. "Species Diversity in Net Phytoplankton of Raritan Bay." J. Mar. Res., 20, 57-75.
- Pielou, E. C. 1966a. "Species - Diversity and Pattern - Diversity in the Study of Ecological Succession." J. Theoret. Biol., 10, 370-383.
- Pielou, E. C. 1966b. "Shannon's Formula as a Measure of Specific Diversity: Its Use and Misuse." Am. Nat., 100, 463-465.
- Pielou, E. C. 1966c. "The Measurement of Diversity in Different Types of Biological Collections." J. Theoret. Biol., 13, 131-144.

- Reish, D. J. 1960. "The Use of Marine Invertebrates as Indicators of Water Quality." In E. A. Pearson (ed.), Waste Disposal in the Marine Environment, Pergamon Press, New York, pp. 92-103.
- Storrs, P. N., E. A. Pearson, H. F. Ludwig, R. Walsh and E. J. Stann. 1969. "Estuarine Water Quality and Biologic Population Indices." Proceedings 4th Inter. Conf. Water Poll. Res., Prague, Czechoslovakia.
- Tarzwel, C. M. and A. R. Gauvin. 1953. "Some Important Biological Effects of Pollution Often Disregarded in Stream Surveys." Purdue University Engineering Bulletin - Proceedings 8th Industrial Waste Conference, 316 pp.
- Trembley, F. J. 1960. "Research Project on Effects of Condenser Discharge Water on Aquatic Life." Progress Report, 1956-59, The Institute of Research, Lehigh University.
- Tsai, Chu-Fa. 1968. "Effects of Chlorinated Sewage Effluents on Fishes in Upper Patuxent River, Maryland." Ches. Sci., 9, 83-93.
- Wilhm, J. L. 1967. "Comparison of Some Diversity Indices Applied to Populations of Benthic Macroinvertebrates in a Stream Receiving Organic Wastes." Journal Water Pollution Control Federation, 39, 1,673-1,683.
- Wilhm, J. L. 1968. "Use of Biomass Units in Shannon's Formula." Ecology, 49, 153-156.
- Wilhm, J. L. and T. C. Dorris. 1966. "Species Diversity of Benthic Macroinvertebrates in a Stream Receiving Domestic and Oil Refinery Effluents." Am. Midl. Nat., 75, 427-449.
- Wilhm, J. L. and T. C. Dorris. 1968. "Biological Parameters for Water Quality Criteria." Bioscience, 18, 477-481.
- Williams, L. G. 1964. "Possible Relationships Between Plankton-diatom Species Numbers and Water Quality Estimates." Ecology, 45, 809-823.
- Wurtz, C. B. and T. Dolan. 1960. "A Biological Method Used in the Evaluation of Effects of Thermal Discharge in the Schuylkill River." Proceedings 15th Industrial Waste Conference, Purdue University, Lafayette, Indiana.

## TRANSPORT OF TRITIUM IN AQUATIC SYSTEMS

### Objective and Scope

It is the purpose of this research to study the transport characteristics of tritiated water and organically bound tritium and its related effects in small scale ecosystems (Research Flume). Retention and release of tritium by biomass and bottom sediments will be investigated using slug and continuous discharges of tritium. Development or verification of prediction models for transport of tritium will be undertaken after establishing all the necessary coefficients.

Laboratory studies along with the model river studies will be conducted to investigate the related effects and mechanisms responsible for the retention and release of tritium by biomass and sediments and the environmental factors that influence the movement of tritium.

### Introduction

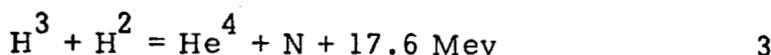
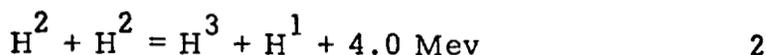
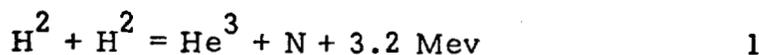
Tritium, a radioactive isotope of Hydrogen, is produced by numerous nuclear reactions and is released through operating heavy-water reactors, light-water reactors, Tritium production plants and Thermonuclear reactions.

Jacobs (1970) stated that most tritium problems are encountered at heavy-water reactors where the tritium hazard is as important as all other radionuclide hazards combined under normal operating conditions.

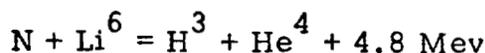
Tritium is also formed from several fusion interactions of cosmic rays with gases of the upper atmosphere which exits principally in the form of water vapor and precipitates in rain and snow. Previous studies indicated that the concentration of Tritium in rain, ranged from 17 to 28 T. U. (1 T. U. is one Tritium atom per  $10^{18}$  hydrogen atoms) and the natural concentration of Tritium in rivers was estimated to be 5 T. U.

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The fusion of light elements, Hydrogen ( $H^1$ ) with its two other isotopes, Deuterium ( $H^2$ ) and Tritium ( $H^3$ ), to form heavier and more tightly bound nuclei can result in the release of significant amounts of nuclear energy. Hydrogen is the most abundant, Deuterium occurs in nature with an abundance of about one part in six thousands of hydrogen. Tritium, however, is a radioactive isotope which must be manufactured. These later isotopes are of great interest as fusion fuel. In order to make the nuclear fusion reactions take place, temperature of the order of several million degrees are necessary and they are referred to as "Thermonuclear Reactions" as follows:



If an equal mixture of  $H^2$  and  $H^3$  is used as fusion fuel (Reaction 3), the great majority (80%) of the released energy appears as kinetic energy of the neutrons. To recover it, the neutrons must be slowed down in a moderator. Since Tritium does not occur in nature, the neutrons must be used to generate the Tritium from Lithium.



As a result the heat generated in the moderator can be removed by a suitable coolant and used to generate electrical power through a heat cycle.

Tritium has one of the highest maximum permissible body burden, 1 mc, recommended by the ICRP because of its emission of extremely low energy beta radiation during decay. However since Morgan (1964) stated that it can be taken through the skin as fast as inhalation and because of its long

half-life (12.26 y), it poses a potential hazard.

### Tritium in the Environment

Tritium is usually released to the atmosphere in the form of water vapor or tritiated hydrogen gas. Chamberlain and Eggleton (1964) estimated that 1,000 curries/day of tritiated water vapor would be permissible from a 60-meter stack. Jacobs (1970) indicated that the continuous release of 1,000 curries/day would be about an order of magnitude lower than the estimated 10,000 to 20,000 curries/day of natural tritium production. This tritium will be deposited over continental areas or oceanic areas through rainfall or downward diffusion of the released plume. Once tritium is deposited it will follow several pathways through evaporation, seepage through the soil, run-off and transpiration. In general, tritiated water is expected to behave the same as ordinary water except for the slight difference in vapor pressure which is caused by the larger mass of tritium atoms. After tritium is condensed it evaporates less than ordinary water. Tritium is found exclusively in water molecules as  ${}^3\text{H}_2\text{O}$  or  ${}^3\text{H}_1\text{HO}$  which indicates that the elemental fission product atoms replace normal hydrogen atoms on the water molecules.

Smith (1965) and Blomeke (1967) indicated that Tritium has not been monitored routinely at most reactors, but has been measured in primary coolants in several reactors and found to be about 0.5 to 5.0  $\mu\text{c}/\text{cc}$  in PWR's and about 0.005 to 0.05  $\mu\text{c}/\text{cc}$  in BWR's. As a "rule of thumb" figure for future tritium discharge estimates, an annual average value of roughly 0.4 curries per electrical megawatt has been used. Analysis of water samples from the Savannah River (1963-1966) indicated that the tritium concentration has averaged about 0.3 to 0.4% of the maximum permissible concentration of

0.003  $\mu\text{c}/\text{ml}$ . The tritium concentration in the Clinch River averaged  $1.1 \times 10^{-4}$   $\mu\text{c}/\text{ml}$ . Practically all the tritium released to surface water would be expected eventually to enter oceans and seas.

Tritium of higher concentrations was detected in ground water, soil and vegetation of Nuclear testing sites. Mason (1969) reported that the levels of tritium in the Nevada test site Corps ranged from 2.0 to 3.0  $\mu\text{ci}/\text{gm}$  of dry tissue or 3.00 to 4.87  $\mu\text{ci}/\text{ml}$  of tissue water of plants, radish, potatoes, corn, beans, and onions. Tritium was noticed to be available over considerable periods of time and does not leave the environment via evaporation as suggested. Tritium profile in the soil indicates a maximum concentration at a depth of approximately 70 cm, which is closely correlated with the depth of the maximum desert rainfall penetration of this area.

#### Transport Characteristics of Tritium

Tritium water is expected to behave the same as ordinary water in ecological systems except it exhibits a lower vapor pressure resulting from its higher mass. It is interchangeable with the free and bound water of the sediments and with tissue water in biota. Nir (1964) indicated that in saturated soil, all the tritiated water will be free water in macropores and its velocity of movement will vary due to the diffusion characteristics into the sediments.

Whenever Tritium-labelled water is employed as a test solute or tracer in biological systems, an appreciable exchange between tritium and labile hydrogen atoms occur that frequently affects the productivity of biological systems. The position of tritium within the cell is important. For example,

Person and Sclair (1968) have considered the loss of colony forming ability and the degradation of DNA by tritium incorporated into either DNA, RNA or protein in E. coli.

Predictions by Parker, et al. (1966) of downstream concentrations resulting from slug discharge of tritium in the Clinch River were made possible by assuming complete mixing. However, their prediction was based only on dilution and no attempt was made to account for detention and release of tritium by bottom sediments, biomass and dead zones. Struxness, et al. (1967) indicated that full vertical and traverse mixing of tritium occurred in the Clinch River within 4 to 6 miles downstream from the mouth of White Oak Creek, the discharge point. Brown (1963) reported that lateral mixing was complete in the Ottawa River after 2.5 miles of flow. An adequate prediction model for transport of radionuclides was developed by Gloyna and Associates (1967) which followed the form:

$$\frac{\partial c}{\partial t} = D_x \frac{\partial^2 c}{\partial x^2} - U \frac{\partial c}{\partial x} - \sum_{i=1}^n f_i K_i [G_i(c) - C_i]$$

where

- $f_i$  = mass of i-th sorbent affecting a unit volume of the flow zone
- $K_i$  = the mass transfer coefficients for phase "i"
- $D_x$  = diffusion coefficient in the x-direction
- $U$  = mean velocity
- $G_i(c)$  = a transfer function relating the concentration of activity in the water to the equilibrium level in the phase "i"
- $C_i$  = the specific activity in the i-th position of the N-sorption phases

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The first two terms of this equation define the mixing characteristics and dilution while the third term established the retention and release by various aquatic surfaces. Retention of tritium by biomass and soil is dependent on its form whether organically bound or tritium oxides. Estimates of the capacities of surface water for tritium acceptance can be made with less errors if a better understanding of the transport characteristics of tritium in the ecological system exists. It is necessary to adequately establish the concentration factors and transfer coefficients for tritium in the system and the influence of pollutional stresses such as temperature and organic load on the transport characteristics should be understood.

REFERENCES - TRITIUM

- Bishop, Amasa S. 1958. "Project Sherwood, The U. S. Program in Controlled Fusion." Prepared for the U. S. A. E. C., Addison - Wesley Publishing Company, Inc., Reeding, Massachusetts.
- Blomeke, J. O. May 4, 1964. "Management of Fission Product Tritium in Fuel Processing Wastes." U. S. A. E. C. Report ORNL - TM - 851, Oak Ridge National Laboratory.
- Bond, V. P. and L. E. Feinendegen. 1966. "Intranuclear <sup>3</sup>H Thymidine: Dosimetric, Radiobiological and Radiation Protection Aspects." Health Physics, 12, 1,007-1,020.
- Brown, D. A. 1957. "Tritium Separation Factor in the Calcium - Water Reaction." U. S. A. E. C. Report DP-217, Savannah River Laboratory.
- Butler, H. L. and J. H. Leroy. 1965. "Observation of Biological Half-life of Tritium." Health Physics, 11, 283-285.
- Chamberlain, A. C. and A. E. J. Eggleton. February 1964. "Washout of Tritiated Water Vapour by Rain." Int. J. Air Water Pollution, 8, 135-149.
- Drobinski, J. C., Jr., D. P. Lagatta, A. S. Goldin, and J. O. Terrill, Jr. 1965. "Analysis of Environmental Samples for Carbon-14 and Tritium." Health Physics, 11, 385-395.
- Eisenbud, Merrill. 1963. Environmental Radioactivity, McGraw-Hill Book Company, Inc., New York.
- Glasstone, Samuel. April 1962. Editor The Effects of Nuclear Weapons. Prepared by the U. S. Department of Defense, published by the U. S. A. E. C.
- Hawkins, D. B. and B. L. Schmeltz. August 1965. "Environment Tritium Studies at the National Reactor Testing Station." U. S. A. E. C. Report IDO-12043, Idaho Operations Office.
- International Atomic Energy Agency. 1962. Tritium in the Physical and Biological Sciences. Proceedings of the Symposium on the Detection and Use of Tritium in the Physical and Biological Sciences, Vols. 1 and 2, held in Vienna, Austria May 3-10, 1961.
- International Commission on Radiological Protection. 1964. "Recommendations of JCRP, International Commission on Radiological." Commission Publication No. 6, Pergamon Press, Inc., New York.

- Jacobs, D. G. 1968. "Sources of Tritium and Its Behavior Upon Release to the Environment." TID-24635, U. S. A. E. C.
- Johns, T. F. 1962. Prospects for Thermo-nuclear Power. George C. Harrap and Company, Ltd., London, England.
- Koranda, John J. 1965. "Preliminary Studies of the Persistence of Tritium and  $^{14}\text{C}$  in the Pacific Proving Ground." *Health Physics*, 11, 1,445-1,457.
- Lambert, B. E. 1969. "Cytological Damage Produced in the Mouse Tests by Tritiated Thymidine, Tritiated Water and X-Rays." *Health Physics*, 17, 547-557.
- Mason, B. J., W. J. Whipper and V. D. Leavitt. 1969. "Tritium Uptake Following a Thermonuclear Test." STJ-PUB-226 Conf-690317, Symposium Proceedings on Environmental Contamination by Radioactive Materials, pp. 167-174, Vienna, Austria.
- McConnon, D. January 15, 1967. "Tritium Experience at Pacific Northwest Laboratory." U. S. A. E. C. Report BNWL-SA-1026, Battelle Memorial Institute, Pacific Northwest Laboratory.
- Nakayama, F. S. and R. D. Jackson. May-June 1963. "Diffusion of Tritiated Water in Soils." *Soil Sci. Soc. American Proc.*, 27, 255-258.
- Parker, F. L., et al. 1966. "Dilution, Dispersion and Mass Transport of Radionuclides in the Clinch and Tennessee Rivers." STJ-PIB-126, Symposium Proceedings on Disposal of Radioactive Wastes into Seas, Oceans, and Surface Waters, pp. 33-55, International Atomic Energy Agency, Vienna, Austria.
- Parker, F. L. and D. J. Rose. March 22, 1968. "Wastes from Fusion Reactors." *Science*, 159, 1,376.
- Price, A. H. January 25, 1958. "Vapor Pressure of Tritiated Water." *Nature*, 181, 262.
- Ray, J. W., R. O. Wooten, and R. H. Barns. October 31, 1966. "Investigation of Tritium Generation and Release in Nuclear Power Plants." U. S. A. E. C. Report BMJ-1787, Battelle Memorial Institute.
- Rothchild, Seymour. 1965. Editor Advances in Tracer Methodology. Vols. 1, 2, and 3. Plenum Press, New York.
- Savannah River Laboratory. February 1966. "Effect of the Savannah River Plant on Environmental Radioactivity." Semiannual Report, July-December, 1965, U. S. A. E. C. Report DPST-66-30-1.

Struxness, E. G., et al. April 1967. "Comprehensive Report of the Clinch River Study." U. S. A. E. C. Report ORNL-4035, Oak Ridge National Laboratory.

Vennart, J. 1969. "Radiotoxicology of Tritium and <sup>14</sup>C Compounds." Health Physics, 16, 429-440.

Vukmirovic, Z. 1965. "Determination of the Tritium Build-up in a Heavy-Water-Moderated Reactor." Proceedings of the Third International Conference on the Peaceful Uses of Atomic Energy, Geneva, 1964, Vol. 3., pp. 307-413, United Nations, New York.

Woods, F. W. and D. O'Neal. January 8, 1965. "Tritiated Water as a Tool for Ecological Field Studies." Science, 147, 148-149.

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## ATTACHMENT 1

## BIOGRAPHICAL DATA SKETCH

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Membership in Professional Organizations:  
National Society of Professional Engineers  
American Institute of Chemical Engineers  
American Society of Civil Engineers  
American Association of Professors in Sanitary Engineering  
American Water Works Association  
Water Pollution Control Federation  
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 Associate Professor, The University of Texas, 1953 - 1959  
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 Assistant Professor, The University of Texas, 1949 - 1953  
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 Water Quality Improvement  
 Advanced Laboratory, Water Quality  
 Measurement and Process Control  
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 Wastewater Systems  
 Advanced Municipal Sanitation  
 Vector-Borne Disease Control  
 Radiological Health  
 Administration of Municipal Public  
 Works  
 Research Seminar - Water Resources,  
 Air Resources, and Environmental  
 Health  
 Thesis  
 Dissertation

Undergraduate

Water Supply and Wastewater  
 Disposal  
 Water Resources: Hydraulics  
 Water Resources: Industrial Waste  
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1138945

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PUBLICATIONS

1. "Flow Measurements in a Sewage Disposal Plant," Proc., 31st Texas Water and Sewage Works Short Course, 150-52 (February 1949).
2. "Laboratory-Size Pump Developed," with K.W. Cosens, Industrial Hygiene Newsletter, 9, 13 (March 1949).
3. "Treatment of Controlled Dairy Waste in the Milk Plant," Southern Products J., 46, 84-91 (October 1949).
4. "Sanitation-Treatment of Controlled Dairy Wastes in the Plant," The Beacon, 26-28, 36-40 (1950 Edition).
5. "Milk Waste Treatment on an Experimental Trickling Filter," Water and Sewage Works, 97, 11, 473-478 (November 1950).
6. "Radioactive-Contaminated Laundry Waste and Its Treatment," with J.C. Geyer, Office of Tech. Services, U.S. Department of Commerce, Research Report No. NYO 4514, 9-24 (September 11, 1952).
7. "Laboratory Contact Filters," Proc., 5th Annual Gulf Coast Regional Conf. on Industrial Health (September 1952).
8. "Rotary Tubes as Experimental Trickling Filters," with R.F. Comstock and C.E. Renn, Sewage and Industrial Wastes, 24, 11, 1355-57 (November 1952).
9. "Reduction of Radioactivity in Water," J. American Water Works Assn., 46, 66-78 (January 1954).
10. "Oxidation Ponds," with E. W. Steel, Office of Tech. Services, U.S. Department of Commerce, Bull. Wash-275, 10-35 (April 15, 1954).
11. "Opportunities for the Civil Engineer in the Atomic Energy Industry and the Resultant Challenge," J. of Engineering Education, 44, 590-92 (June 1954).
12. "Vertical Separators Aid in Experimental Trickling Filters," with M. Smith, Public Works Magazine, 85, 75-76 (June 1954).

1138946

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13. "Radioactive Contaminated Laundry Waste and Its Treatment, Part I, Preliminary Experiments," Sewage and Industrial Wastes, 26, 6, 777-789 (June 1954).
14. "Radioactive Contaminated Laundry Waste and Its Treatment, Part II, Treatment by Continuous Flow Over Slime," Sewage and Industrial Wastes, 26, 7, 869-886 (July 1954).
15. "Recent Developments in Radioactive Waste Treatment," (Four Parts), ASCE, The Texas Engineer, Part I, 24, 6-12 (September 1954); Part II, 24, 9-10 (October 1954; Part III, 24, 8-11 (November 1954); Part IV, 24, 5-6 (December 1954).
16. "Detergents-Classification," Public Works Magazine, 85, 85-86, 118-119 (December 1954).
17. "Detergents-The Effect of Detergent Containing Wastes on Biological Forms and Water Uses," Public Works Magazine, 86, 95-96, 133-137 (January 1955).
18. "Concentration of Radioactivity in Oxidation Ponds," with E. W. Steel, Sewage and Industrial Wastes, 27, 8, 941-56 (August 1955).
19. "Nuclear Notes," with ASCE Comm. on Sanitary Engineering Aspects of Nuclear Energy, Civil Engineering (Monthly Column, May 1954 - June 1956).
20. "Graphite Ore as a Filter Material," with L. Hirsch, Southwest Water Works J., 38, 15-20 (June 1956). Reprinted in Tank Topics, National Tank Co., Tulsa (June 1956).
21. "Some Design Considerations for Oxidation Ponds," with E. R. Hermann, Proc., Sanitary Engineering Div., ASCE, 82, SA4, 1047-1-20 (August 1956).
22. "Summary of Investigations on the Removal of Radioisotopes from Waste Water by Oxidation Ponds," with E. R. Hermann, Office of Tech. Services, U.S. Department of Commerce, Research Report No. TID-7517 (Pt. 1-a), 26-46 (October 1956).
23. "Radiation Protection," with J. C. Rude, M.D., Texas State J. of Medicine, 52, 853-60 (December 1956).

1138947

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24. "Design of Oxidation Ponds," with E. R. Hermann, Assn. Interamericana de Ingenieria Sanitaria - Organo Oficial, Mexico (1957).
25. "Uranium Recovery from Saline Solutions by Biological Slimes," with B. B. Ewing, Nucleonics, 15, 78-81 (January 1957).
26. "Discussion on Algae in Waste Treatment," with E. R. Hermann, Sewage and Industrial Wastes, 29, 455-57 (April 1957).
27. "Radioactive Waste Treatment," Proc., Oklahoma Industrial Wastes Conf. (September 1957).
28. "Development of Design Criteria for Waste Stabilization Ponds," with E. R. Hermann, Office of Tech. Services, U.S. Department of Commerce, AECU-3481, 153 pp. (1957).
29. "Storage of Reactor Fuel Wastes in Salt Formations, Fixation of Radioactivity in Stable, Solid Media," with R. S. Schechter and S. Serata, Office of Tech. Services, U.S. Department of Commerce, TID-7550, 70-84 (March 1958).
30. "Waste Stabilization Ponds, Part I. Experimental Investigations," with E. R. Hermann, Sewage and Industrial Wastes, 30, 511-538 (April 1958).
31. "Waste Stabilization Ponds, Part II. Field Practices," with E. R. Hermann, Sewage and Industrial Wastes, 30, 646-651 (May 1958).
32. "Waste Stabilization Ponds, Part III. Formulation of Design Equations," with E. R. Hermann, Sewage and Industrial Wastes, 30, 963-975 (August 1958).
33. "Developing a Water Re-Use Program," The Municipal South, 6, 22-26 (May 1959).
34. "Oxidation-Reduction Potential Measurements in Waste Treatment Systems," with W. R. Drynan, Southwest Water Works J., 41, 3, 28-40 (June 1959).
35. "Water Re-Use in Texas," with E. R. Hermann and W. R. Drynan, J. American Water Works Assn., 51, 768-780 (June 1959).

1138948

36. "Temperature Rise in Underground Storage Sites for Radioactive Wastes," with R. S. Schechter, Chemical Engineering Progress Symposium Series, J. Nuclear Engineering, 55, 303-310 (1959); also reproduced in Nuclear Engineering, Part VII, American Institute of Chemical Engineers, 55, 27, 117-124 (1959).
37. "Thermal Considerations in the Storage of Radioactive Wastes in Salt Formations," with R. S. Schechter, Sewage and Industrial Wastes, 31, 1165-1174 (October 1959); Engineers Joint Council, New York (1959).
38. "Design Principles for Underground Salt Cavities," with S. Serata, Proc., Sanitary Engineering Div., ASCE, SA3, 86, 2468, 1-21 (May 1960); Engineers Joint Council, New York (1959).
39. "Radiological Health in Engineering," University Curricula in Radiological Health, Symposium held at Princeton, N.J. (August 2-4, 1960), U.S. Public Health Service, U.S. Govt. Printing Office: 1961, 0-581667, 57-60 (1960).
40. "Radioactivity in Texas Streams," with W. R. Drynan and D. F. Smallhorst, Proc., Second Sanitary Engineering Conf., 28-33 (January 1960).
41. "Reactor Fuel Waste Disposal Project," et al., Industrial Radioactive Waste Disposal, Hearings before the Special Committee on Radiation of the Joint Committee on Atomic Energy, Congress of the U.S., 86th Congress, First Session on Industrial Waste Disposal, 3, 2223-2279 (January-February 1960).
42. "Present and Prospective Means for Improved Re-Use of Water," with J. B. Wolff, J. C. Geyer, and A. Wolman, U.S. Senate Select Committee on National Water Resources, Comm. Print No. 30, 54 pp. (March 1960).
43. "Water Quality Evaluation," with R. S. Schechter, Public Works, 91, 108-112 (April 1960).
44. "Monitoring of Water Samples and Contamination," Radiological Sciences Conference Final Report, Denton, Texas (April 1960).
45. "Computational Aids for Forecasting Water Quality," with R. S. Schechter, J. Water Pollution Control Federation, 32, 514-520 (May 1960).

46. "Underground Waste Disposal and Ground Water Contamination," et al., J. American Water Works Assn., 52, 619-622 (May 1960).
47. "Sanitary Engineering Aspects of Nuclear Energy," et al., Proc., Sanitary Engineering Div., ASCE, SA3, 86, 2476, 87-110 (May 1960).
48. "Oxygen Depletion in Streams," Electronic Computers in Engineering Education, Annual Report, The Ford Foundation Project, Cushing-Malloy, Inc., Ann Arbor, E536-E541 (August 1960).
49. "Survey of Ground Water Contamination and Waste Disposal Practices," et al., J. American Water Works Assn., 52, 1211-1219 (September 1960).
50. "Principles of Structural Stability of Underground Salt Cavities," with S. Serata, J. Geophysical Research, 65, 9, 2979-2987 (September 1960).
51. "Creep Measurements in Salt Mines," with T. D. Reynolds, Proc., Fourth Symposium on Rock Mechanics, Mining Engineering Series, Pennsylvania State University, No. 76, 11-17 (November 1961).
52. "Must Water Treatment be High Priced?" Proc., Water Resources Conf., U.S. Public Health Service, Dallas (May 1961).
53. "Radioactivity in the Surface Waters of Texas," with W. R. Drynan and D. F. Smallhorst, Southwest Water Works J., 43, 31-35 (August 1961).
54. "Versatility of Electrometers for Low Level Radioactivity Measurements," with J. O. Ledbetter, Public Works Magazine, 93, 11, 87-90 (May-June 1962).
55. "Petrochemical Wastes Effects on Water," Four Parts, with J. F. Malina, Jr., Industrial Water and Wastes, Part I, 7, 5, 134-138 (September-October 1962); Part II, 7, 6, 157-161 (November-December 1962); Part III, 8, 1, 14-22 (January-February 1963); Part IV, 8, 2, 33-36 (March-April 1963). Water and Sewage Works Reference Number 110, R-262-285 (October 1963).

Dr. E. F. Gloyna

January, 1970

56. "Discussion of Paper No. 12, Sec. 1--'Determination and Charting of the Waste Load in a Flowing Stream,'--G. Muller-Neuhaus," Advances in Water Pollution Research Proc. of the First International Conference on Water Pollution Research, London (1962), 1, 254-259.
57. "Radiological Health," Proc., First Seminar, Urban Planning for Environmental Health, Austin (January 24-25, 1963).
58. "Low Cost Waste Treatment--Waste Stabilization Ponds," Proc., United Nations Conference on the Application of Science and Technology for the Benefit of Less Developed Areas, Geneva, Switzerland (1963). Natural Resources--Energy, Water, and River Basin Development, 1, 282-291 (February 1963).
59. "Predicting Inorganic Quality of Water for Industry," with J. O. Ledbetter, Proc., Third Annual Industrial Water and Waste Conf., Rice University, Houston, 23-24 (June 1963).
60. "The Use of X-Ray Fluorescence in Determining Strontium and Calcium," with S. K. Bhagat and W. A. Felsing, Jr., J. Water Pollution Control Federation, 35, 7, 893-902 (July 1963).
61. "Environmental Radionuclides in Municipal Wastewater," with S. K. Bhagat, Water and Sewage Works, 110, 6, 205-209 (June 1963); Environmental Health (India), V, 3 (July 1963).
62. "Environmental Radionuclides in a Water Supply," with W. A. Felsing, Jr., Water and Sewage Works, 110, 7, 245-250 (July 1963).
63. "Temperature Effects on Waste Stabilization Ponds Treatment," with V. Suwannakarn, Symposium, Waste Treatment by Oxidation Ponds, Central Public Health Engineering Research Institute, Nagpur, India, 1-14 (October 29-30, 1963).
64. "Chapter 10, Problems in Water Re-Use," Official Bulletin, Arizona Water and Pollution Control Assn., XXIII, 1, 64-77 (1963).
65. "Heat Generation by Radioactive Wastes," with H. J. Longley and C. W. Christenson, Proc., Sanitary Engineering Div., ASCE, SA1, 90, 43-66 (February 1964).
66. "Predictive Techniques for Water Quality--Inorganics," with J. O. Ledbetter, Proc., Sanitary Engineering Div., ASCE, SA1, 90, 127-151 (February 1964).

1138951

67. "Efecto de la temperatura en el tratamiento de aguas residuales mediante estonques de estabilizacion," with V. Suwannakarn, Boletin de la Oficina Sanitaria Panamericana, Año 43, LVI, 2, 128-139 (February 1964).
68. "Abstract, Uptake and Release of Radionuclides by Stream Sediments," with T. D. Reynolds, J. Water Pollution Control Federation, 36, 3, 279-280 (March 1964).
69. "Radioactive Waste Disposal, Part I," with S. D. Stoddard and C. W. Christenson, Ceramic Age, 80, 6, 63-72 (June 1964); Part II, 80, 7 (July 1964); Part II, 80, 8 (August 1964).
70. "Uptake and Release of Radionuclides by Stream Sediments," with T. D. Reynolds, Advances in Water Pollution Research Proc., 2nd International Conference on Water Pollution Research, Tokyo, Japan, 1, 151-164 (August 1964).
71. "Discussion of Power Dissipation in Biological Flocculation," Proc., 2nd International Conference on Water Pollution Research, Tokyo, Japan, 2, 212-214 (August 1964).
72. "New Aspects of Biological Waste Treatment Design," with W. W. Eckenfelder, Jr., Proc., 35th International Congress of Industrial Chemistry, Warsaw, Poland, 26 pp. (September 15-19, 1964). Translated into Polish.
73. "What Exploration Geologists Should Know About Pollution," Proc., A Symposium--Oil and Water, Southwestern Federation of Geological Societies, Austin (January 29, 1965). Southwest Water Works Journal, 47, 7, 30-34 (October 1965).
74. "Dispersion Measurements in Open Channels," with C. C. Patterson, Proc., Sanitary Engineering Div., ASCE, SA3, 91, 4347, 17-29 (June 1965); Transactions ASCE, 131, 46 (1966).
75. "Treatment of Activated Sludge in Stabilization Ponds," with C. P. Fisher, J. Water Pollution Control Federation, 37, 11, 1511-1520 (November 1965).
76. "Correlating Coliform Bacteria with E. Coli Bacteriophages in Shellfish," with Y. Kott, Water & Sewage Works, 22, 11, 424-426 (November 1965).

Dr. E. F. Gloyna

January, 1970

77. "Transport of Radionuclides in a Model River," with S. K. Bhagat, Y. Yousef, and C. Shih, Proc., International Atomic Energy Agency Symposium on the Disposal of Radioactive Wastes into Seas, Oceans, and Surface Waters, Vienna, Austria (May 16-20, 1966), pp. 11-32.
78. "Waste Stabilization Pond Concepts and Experiences," World Health Organization, Water Disposal, 1.65 Rev. 66.1, 65 pp. (1966).
79. "Bassins De Stabilisation Des Dechets Notions Theoriques et Donnees D'Experience," Document prepare pour le Service de l'Evacuation des Dechets, Division de l'Hygiene du Milieu, Organisation Mondiale de la Sante, 65 pp. (1966). Translated into Yugoslavian.
80. "Formal Discussion - Paper I-6 'Algal Cultures as a Means to Assess the Fertilizing Influence of Pollution,'" with E. Espino de la O, Proc., Third International Conference on Water Pollution Research, Munich, Germany (September 5-9, 1966); Copyright Water Pollution Control Federation, Washington, D. C., pp. 1-8 (1966).
81. "Estimating the Effect of Return Flows," with Dan M. Wells, American Water Works Assn. Annual Conference, Bal Harbour, Florida (May 22-27, 1966). J. American Water Works Assn., 59, 7, 805-814 (July 1967).
82. "Major Research Problems in Water Quality," Water Research, presented at the Seminar in Water Resources Research, Colorado State University, 479-493 (1966).
83. "Diseno de Lagunas de Estabilizacion de Aguas Negras," Tema IV, Lagunas de Estabilizacion, Universidad Nacional Autonoma de Mexico, Mexico, D. F., 104 pp. (June 1966).
84. "Environmental Control--Waste Management," Proc., 41st Conference of State Sanitary Engineers, Washington, D. C., 17-20 (June 6-10, 1966).
85. "Water Resources and Conservation," with W. W. Eckenfelder, Master Brewers' Association Tech. Quarterly, 4, 1, 85-93 (January 1967).
86. "Suppression of Photosynthetic Oxygenation," with D. Thirumurthi, Water and Sewage Works, 114, 3, 83-88 (March 1967).

87. "Nitrosylruthenium - Nitro Complexes in an Aqueous Environment," with S. K. Bhagat, J. Water Pollution Control Federation, 39, 3, 334-345 (March 1967).
88. "Transport of Organic and Radioactive Wastes," with Neal E. Armstrong and Larry W. Canter, Water and Wastes Engineering, 5, 7, pp. 54-56 (July 1968).
89. "Development of Biological Treatment Data for Chemical Wastes," with D. L. Ford, Engineering Bulletin of Purdue Univ., Proc. of the 22nd Industrial Waste Conference, Lafayette, Indiana, Part One, 292-309 (May 1967).
90. "Mathematical Models for the Dispersion of Radionuclides in Aquatic Systems," with Neal E. Armstrong, Proc. of the 2nd National Symposium on Radioecology, Ann Arbor, Michigan, pp. 329-335 (May 15-17, 1967).
91. "Effect of Organic Compounds on Photosynthetic Oxygenation, Part I. Chlorophyll Destruction and Suppression of Photosynthetic Oxygen Production," with Ju-Chang Huang, Journal of Water Research, 2, 5, pp. 347-366, Birmingham, England (July 1968).
92. "Effects of Organics on Photosynthetic Reoxygenation, Part II. Design Modification for Waste Stabilization Ponds," with Ju-Chang Huang, Journal of Water Research, 2, 6, 459-469, Birmingham, England (August 1968).
93. "Mathematical Model for the Transport of Radionuclides in Stream System," with Chia Shun Shih, Presented at the Health Physics Society Midyear Topical Symposium, Environmental Surveillance in Vicinity of Nuclear Facilities, Augusta, Georgia (January 24-25, 1968). Pub. Pending in Symposium Proc.
94. "Numerical Solutions of Radionuclide Transport Equations," with Neal Armstrong, Water - 1968, Chem. Engineering Progress Symposium Series, 64, 90, pp. 47-58, New York, N. Y. (1968).
95. "Transport of Chromium-51 in an Organically Polluted Environment," with Larry W. Canter, Presented at the 23rd Annual Purdue Industrial Waste Conference, Lafayette, Indiana (May 7-9, 1968).
96. "A Few Unsolved Engineering Problems in Water Quality Management," Presented at the Banff Conference on Pollution, Banff, Canada (May 16-17, 1968). Pub. Pending in Proc. of the Banff Conference on Pollution.

Dr. E. F. Gloyna

January, 1970

97. "Ecological Aspects of Stream Pollution," with Neal E. Armstrong and B. J. Copeland, Advances in Water Quality Improvement, The University of Texas Press, Austin, 85-95 (1968).
98. "Basis for Waste Stabilization Pond Designs," Advances in Water Quality Improvement, The University of Texas Press, Austin, 397-408 (1968).
99. "The Role of Algae in Degrading Detergent Surface Active Agents," with Ernst Davis, J. Water Pollution Control Federation, 41, 8, 1494-1504 (August 1969).
100. "Transport of Dissolved Wastes in Rivers," with Roger Don Shull, Proc., Sanitary Engineering Division, ASCE, 95, SA6, 995-1012 (December 1969).
101. "Use of Aerated Lagoons and Ponds in Refinery and Chemical Waste Treatment," with S. O. Brady and H. Lyles, Journal Water Pollution Control Federation, 41, pp. 429-439 (March 1969).
102. "Formal Discussion - Paper II-16, 'Microbiology of Waste Stabilization Pond,' " presented at the Fourth International Conference on Water Pollution Research, Prague, Czechoslovakia (April 1969). Pub. pending in Proc. 4th International Conf. on Water Pollution Research.
103. "A Review of Water Reuse and Recycling in Industry," with D. Ford and J. Eller, Presented at the American Water Works Association Meeting, San Diego, California (May 19-22, 1969). Pub. pending.
104. "Sulfide Production in Waste Stabilization Ponds," with Ernesto Espino, Proc., Sanitary Engineering Division, ASCE, 95, SA3, 607-628 (June 1969).
105. "Influence of Sediments on the Transport of Solutes," with Chia Shun Shih, Proc., Hydraulics Division, ASCE, 95, HY4, 1347-1467 (July 1969).
106. "Anionic and Nonionic Surfactant Sorption and Degradation by Algal Cultures," with Ernst M. Davis. Pub. pending in Journal of the American Oil Chemists' Society.

1138955

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107. "Transport of Radionuclides in a Model Aquatic System," Presented at Symposium de Radioecologie Continentale, Cadarache, France (September 8-11, 1969). Pub. pending.
108. "Water Reuse in Industry," with D. L. Ford and J. Eller, Presented at the 42nd Annual Conference of the Water Pollution Control Federation, Dallas, Texas (October 6, 1969). Pub. pending in J. Water Pollution Control Federation.
109. "Petrochemicals and Waste Treatment," with Davis L. Ford, Presented at the 19th Canadian Chemical Engineering Conference and 3rd Symposium on Catalysis, Edmonton, Alberta, Canada (October 19-20, 1969). Pub. pending.
110. "The Effect of Colored Organics on Iron Removal," with William K. Oldham, J. American Water Works Assn., 61, 11, 610-614 (November 1969).
111. "A Least-Cost Analysis for the Houston Ship Channel," with A. J. Hays, Jr., Presented at the ASCE Specialty Conference in Ocean Engineering, Miami, Florida (December 10-12, 1969). Pub. pending.

Dr. E. F. Gloyna

PARTIAL LIST OF PROFESSIONAL REPORTS

A. Public Agencies

1. Oxidation Ponds--Radioactivity Uptake and Algae Concentration, with E. W. Steel, San. Eng. Labs. Tech. Report No. 1 to the Atomic Energy Commission, 75 pp. (February 28, 1954).
2. Oxidation Ponds--Waste Treatment Studies, Radioisotope Uptake, and Algae Concentration, with E. R. Hermann and W. R. Drynan, San. Eng. Labs. Tech. Report No. 2 to the Atomic Energy Commission, 90 pp. (June 1, 1955).
3. Development of Design Criteria for Waste Stabilization Ponds, with E. R. Hermann, San. Eng. Labs. Final Report to the Atomic Energy Commission, 154 pp. (March 1, 1957).
4. Water Re-Use in Texas, with E. R. Hermann and W. R. Drynan, Report to the U. S. Department of Interior, The Bureau of Reclamation, Area Planning Office, Austin, 149 pp. (June 1957).
5. Reactor Fuel Waste Disposal--Geology of Salt Domes and Storage Possibilities, with W. R. Muehlberger and E. L. Trice, San. Eng. Res. Lab. Tech. Report to the U. S. Atomic Energy Commission, 29 pp. (November 1, 1958).
6. Background Radioactivity in Texas Waters--Evaluation of the Vibrating Condenser Electrometer for Measuring Radioactivity in Water, with J. O. Ledbetter, San. Eng. Res. Lab. Tech. Report to the Texas State Dept. of Health, 53 pp. (November 1958).
7. Background Radioactivity in Texas Waters--Water Treatment Sludges, with H. E. Emig, San. Eng. Res. Lab. Tech. Report to the Texas State Dept. of Health, 53 pp. (1958).
8. Reactor Fuel Waste Disposal Project--Development of Design Principle for Disposal into Underground Salt Cavities, with S. Serata, San. Eng. Res. Lab. Tech. Report to the U. S. Atomic Energy Commission, 173 pp. (January 1959); Office of Tech. Services, U. S. Dept. of Commerce, Research Report No. TID 6317.

1138957

Dr. E. F. Gloyna

9. Reactor Fuel Waste Disposal Project--Pressure Temperature Effects on Salt Cavities and Survey of Liquefied Petroleum Gas Storage, with K. E. Brown and F. W. Jessen, San. Eng. Res. Lab. Tech. Report to the U. S. Atomic Energy Commission, 114 pp. (January 1959); Office of Tech. Services, U. S. Dept. of Commerce, Research Report No. TID 5718.
10. A Report Upon Present and Prospective Means for Improved Re-Use of Water, with J. B. Wolff, J. C. Geyer, and A. Wolman, Report to Select Committee on National Water Resources, U. S. Senate, 195 pp. (February 15, 1960).
11. Reactor Fuel Waste Disposal Project--Thermal Considerations in the Storage of Radioactive Wastes in Salt Formations, with R. S. Schechter, San. Eng. Res. Lab. Tech. Report to the U. S. Atomic Energy Commission, 61 pp. (June 1, 1960).
12. Radioactivity--Levels in Surface Waters, 1958-1960, with W. R. Drynan, San. Eng. Res. Lab. Tech. Report to Texas State Dept. of Health, 251 pp. (June 20, 1960).
13. Reactor Fuel Waste Disposal Project--Permeability of Rock Salt and Creep of Underground Salt Cavities, with T. D. Reynolds, San. Eng. Res. Lab. Tech. Report to the U. S. Atomic Energy Commission, 121 pp. (December 30, 1960); Office of Tech. Services, U. S. Dept. of Commerce, Research Report No. TID 12383.
14. Environmental Radioactivity--2--Food, with J. A. Eure, Environmental Health Eng. Lab. Tech. Report to the U. S. Public Health Service, 69 pp. (July 31, 1961).
15. Environmental Radioactivity--3--Waste Waters, with S. K. Bhagat, Environmental Health Eng. Lab. Tech. Report to the U. S. Public Health Service, 98 pp. (January 31, 1962).
16. Heat Generation in the Disposal of High Level Radioactive Wastes, with H. J. Longley and C. W. Christenson, Los Alamos Scientific Lab. Report to the U. S. Atomic Energy Commission, 84 pp. (January 1962); Office of Tech. Services, U. S. Dept. of Commerce, Report No. TID 4500.

1138958

Dr. E. F. Gloyna

17. Environmental Radioactivity--4--Summary, with S. K. Bhagat, W. R. Drynan, W. A. Felsing, Jr., and J. A. Eure, Environmental Health Eng. Lab. Tech. Report to the U. S. Public Health Service, 26 pp. (March 30, 1962).
18. Environmental Radioactivity--1--Water, with W. A. Felsing, Jr., Environmental Health Eng. Lab. Tech. Report to the U. S. Public Health Service, 82 pp. (August 1, 1962).
19. Predictive Techniques for Water Quality--Inorganics, with J. O. Ledbetter, Environmental Health Eng. Lab. Tech. Report to the U. S. Public Health Service, 72 pp. (December 1962).
20. Radioactivity Transport in Water--Transport of Strontium and Cesium by Stream and Estuarine Sediments, with T. D. Reynolds, Environmental Health Eng. Lab. Tech. Report to the U. S. Atomic Energy Commission, 117 pp. (June 1, 1963).
21. Radioactivity Transport in Water--The Dispersion of Radionuclides in Open Channel Flow, with C. C. Patterson, Environmental Health Eng. Lab. Tech. Report to the U. S. Atomic Energy Commission, 87 pp. (June 1, 1963).
22. Radioactivity Transport in Water--Environmental Behavior of Nitrosylruthenium, with A. H. Story, Environmental Health Eng. Lab. Tech. Report to the U. S. Atomic Energy Commission, 89 pp. (June 1, 1963).
23. Safe Use of Radioisotopes and Ionizing Radiation, with R. N. Little and W. H. Wade, Prepared for use within The University of Texas (June 1, 1963).
24. Radioactivity Transport in Water--Behavior of Ruthenium in Algal Environments, with W. E. Bolch, Environmental Health Eng. Lab. Tech. Report to the U. S. Atomic Energy Commission, 56 pp. (September 1, 1963).
25. Galveston Bay Water Quality Study--Historical and Recent Data, with J. F. Malina, Jr., Center for Research in Water Resources and Environmental Health Eng. Lab. Tech. Report to the Texas Water Pollution Control Board (March 1, 1964).

1138959

Dr. E. F. Gloyna

26. Radioactivity Transport in Water--Sorption and Release of Radionuclides by Sediments of the Guadalupe River, with U. Clanton, Environmental Health Eng. Lab. Tech. Report to the U. S. Atomic Energy Commission, 64 pp. (July 1, 1964).
27. Radioactivity Transport in Water--The Transport of Zn<sup>65</sup> in an Aqueous Environment, with D. R. Rowe, Environmental Health Eng. Lab. Tech. Report to the U. S. Atomic Energy Commission, 101 pp. (September 1, 1964).
28. Radioactivity Transport in Water--The Transport of Co<sup>58</sup> in an Aqueous Environment, with Y. A. Yousef, Environmental Health Eng. Lab. Tech. Report to the U. S. Atomic Energy Commission, 116 pp. (December 1, 1964).
29. Radioactivity Transport in Water--Structure and Metabolism of a Lotic Community, Part I (April-July 1964), with B. J. Copeland, Environmental Health Eng. Lab. Tech. Report to the U. S. Atomic Energy Commission, 51 pp. (February 1, 1965).
30. Relative Toxicity of Organics to Chlorella Pyrenoidosa, with D. Thirumurthi, Technical Report to the Water Supply and Pollution Control Division, U. S. Public Health Service, 97 pp. (November 1, 1965).
31. Radioactivity Transport in Water--Transport of Nitrosylruthenium in an Aquatic Environment, with S. K. Bhagat, Technical Report to the Atomic Energy Commission, 144 pp. (November 1965).
32. The Interactions of Iron with Soil Organic Acids, with W. K. Oldham, Technical Report to the Engineering Foundation, 85 pp. (December 1965).
33. Return Flows in Texas--Quality and Quantity of Municipal and Industrial Wastewater Streams, with Dan M. Wells, Technical Report to the Texas Water Development Board (January 20, 1966).
34. Radioactivity Transport in Water--Transport of Sr-85 and Cs-137 in an Aquatic Environment, with Chia-Shun Shih, Technical Report to the Atomic Energy Commission, 97 pp. (January 20, 1966).
35. Return Flows--Impact on Texas Bay Systems, with H. S. Curington, Dan M. Wells, Frank D. Masch, and B. J. Copeland, Technical Report to the Texas Water Development Board (January 31, 1966).

1138960

Dr. E. F. Gloyna

36. Management of Return Flows in Texas, with Dan M. Wells, Technical Report to the U. S. Public Health Service (August 1966).
37. Radioactivity Transport in Water--Mathematical Model for the Transport of Radionuclides, with Chia-Shun Shih, Technical Report to the Atomic Energy Commission, 179 pp. (May 1967).
38. Radioactivity Transport in Water--Transport of Cr-51 in an Aqueous Environment, with Larry W. Canter, Technical Report to the Atomic Energy Commission, 263 pp. (May 1967).
39. Nitrification and Denitrification in a Model Waste Stabilization Pond, with Jorge Aguirre, Technical Report to the Federal Water Pollution Control Administration, 83 pp. (May 1967).
40. Effects of Toxic Organics on Photosynthetic Reoxygenation, with Ju-Chang Huang, Technical Report to the Federal Water Pollution Control Administration, 192 pp. (August 1967).
41. The Role of the Sanitary Engineer in Environmental Engineering, et al, Report presented to the Second National Conference on Environmental and Sanitary Engineering Graduate Education, Evanston, Illinois (August 28-30, 1967). Published in Proceedings Environmental and Sanitary Engineering Graduate Education Report, Chapter 1, 1-13 (1967).
42. Environmental Contamination by Radioactive Substances, with Environmental Radiation Exposure Advisory Committee, Technical Report to U. S. Public Health Service (December 1967).
43. Radioactivity Transport in Water--Transport of 85-Sr and 137-Cs Under Induced Clay Suspensions, with Krishnier Purushothaman, Technical Report to the U. S. Atomic Energy Commission (January 1968).
44. Radioactivity Transport in Water--Numerical Solutions of Radionuclide Transport Equations and Role of Plants in 85-Sr Transport, with Neal Armstrong, Technical Report to the U. S. Atomic Energy Commission (January 1968).

1138961

Dr. E. F. Gloyna

45. Radioactivity Transport in Water--Simulation of Sustained Releases to Selected River Environments, with Roger Shull, Technical Report to the U. S. Atomic Energy Commission (May 1968).
46. Sulfide Production in Waste Stabilization Ponds, with Ernesto Espino, Technical Report to the Federal Water Pollution Control Administration (May 1968).
47. Radioactivity Transport in Water--Effects of Organic Pollution on Radionuclide Transport, with Kazuhiro Futagawa, Technical Report to the U. S. Atomic Energy Commission (May 1968).
48. Radioactivity Transport in Water--Interaction Between Flowing Water and Bed Sediments, with Akira Kudo, Technical Report to the U. S. Atomic Energy Commission (January 1969).
49. Radioactivity Transport in Water--The Role of Organic Pollution and Oxygen Balance in Transport, with C. C. Patterson, A. Kudo, and J. M. Eller, Technical Report to the U. S. Atomic Energy Commission (March 1969).
50. Oxygen Production and Loss in a Model River, with James Eller, Technical Report to Office of Water Resources Research (January 1969).
51. Concentration of Cobalt Solutions by Reverse Osmosis, with Dave Goff, Technical Report to U. S. Army Nuclear Defense Laboratory (April 1969); Report No. 1449 published by the U. S. Army Aberdeen Research and Development Center, Ballistic Research Laboratories, Aberdeen Proving Ground, Maryland (September 1969).
52. Radioactivity Transport in Water--Summary Contractual Report, with Y. A. Yousef and Akira Kudo, Technical Report to the U. S. Atomic Energy Commission (January 1970).
53. Bactericidal Effects of Algae on Enteric Organisms, with Ernst M. Davis, Technical Report to the Federal Water Pollution Control Administration (January 1970).

Dr. E. F. Gloyna

BOOKS

1. Advances in Water Quality Improvement, Edited with W. Wesley Eckenfelder, Jr., The University of Texas Press, Austin and London (1968).
2. Principles of Radiological Health, with Joe O. Ledbetter, Marcel Dekker, Inc., N. Y., 488 pp. (1969).
3. Water Quality Improvement by Physical and Chemical Processes, Edited with W. Wesley Eckenfelder, Jr., The University of Texas Press, Austin and London (In Press, to be released January 1970).
4. Waste Stabilization Ponds--Basis for Wastewater Treatment, Current Practices, Selected Designs and Operating Suggestions, World Health Organization, Geneva, Switzerland (In Press, to be released 1970).

1138963

Dr. E. F. Gloyna

B. Private Groups

1. Evaluation of Graphilter as a Substitute for Sand in Water Filtration Plants, with L. Hirsch, Progress Report to Graphilter Corp., 36 pp. (July 1, 1955).
2. The Effects of Treated Sewage on the Mountain Creek Reservoir System, Report to Dallas Power and Light Co., Dallas, 13 pp. (September 13, 1955).
3. The Water Quality of the San Antonio River, Report to Forrest and Cotton, Consulting Engineers, Dallas, 53 pp. (June 1956).
4. Investigation into the Failure of the Amarillo Sewage Treatment Plant, Report to City of Amarillo, 14 pp. (February 26, 1957).
5. The Treatment of Acid Wastes, Report to Southwestern Graphite Company, Burnet, Texas, 21 pp. (May 1957).
6. Treatment of Sewage for Water Injection, San. Eng. Res. Lab. Report to Magnolia Petroleum Co., 48 pp. (September 25, 1957).
7. The Permeability of Rock Salt, Report to Olson, Mecklenburger, von Holst, Pendleton, and Neuman, Pan-American Oil Co. Project, Chicago, 22 pp. (February 1960).
8. Report on Wildlife and Recreational Resources of Chocolate Bayou, Report to Monsanto Chemical Co., St. Louis, 39 pp. (March 30, 1962).
9. A Report on Waste Treatment, Environmental Health Eng. Lab. Tech. Report for Jefferson Chemical Co., Inc., Port Neches, Texas, 66 pp. (July 1962).
10. Cavity Spacing Studies for Solution Mining of Potash 5000 Feet Below the Ground Surface, with E. A. Ripperger, Report Prepared for Pittsburgh Plate Glass Co. (August 1, 1962).
11. Report on Biological Waste Treatment, Report to Humble Oil and Refining Company, Baytown, Texas, 37 pp. (May 20, 1966).

1138964

Dr. E. F. Gloyna

12. Report on Biological Waste Treatment, with D. L. Ford, Report to Thompson Chemical Company, St. Louis, Missouri, 41 pp. (January 1967).
13. Report on Biological Waste Treatment, with D. L. Ford, Report to Jefferson Chemical Company, Conroe, Texas, 38 pp. (February 1967).
14. Results of Wastewater Treatment Survey, Report to Stagecoach Inn, Salado, Texas, 17 pp. (April 1967).
15. Report on Biological Waste Treatment, with D. L. Ford, Report to the Pure Oil Company, Smiths Bluff Refinery, Nederland, Texas, 52 pp. (March 1967).
16. Report on Biological Waste Treatment, with D. L. Ford, Report to Atlantic-Richfield Company, Atreco Refinery, Port Arthur, Texas, 58 pp. (May 1967).
17. A Survey of Waste Disposal, with A. H. Ullrich, Report to Copropiedad Electrica Grupo Guimico, Monterrey, Nuevo Leon, Mexico, 66 pp. (July 1967).
18. A Report on Biological Waste Treatment for the Merichem Company, Houston, Texas, with D. L. Ford and N. K. Burleson, Center for Research in Water Resources, The University of Texas at Austin (1968).
19. Results of Waste Stabilization Pond Analysis, with Jorge Aguirre, Report to Planidro--Consultories de Engenharia Hidraulica E Sanitaria Ltda., Sao Paulo, Brazil, 25 pp. (November 20, 1968).
20. Survey of Aerated Lagoon, Report to Humble Oil and Refining Company, Baytown, Texas, 50 pp. (January 16, 1969).
21. Preliminary Survey of Wastewater Treatment and Water Quality Management Practices, Report to The Government of Jamaica and Pan American Sanitary Bureau/WHO, Kingston, Jamaica, 27 pp. (June 1969).

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22. The Petrochemical Industry--A Profile of Wastewater Treatment, with Engineering-Science, Inc., Report to Robert S. Kerr Water Research Center, Federal Water Pollution Control Administration (In press, to be released in 1970).

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PARTIAL LIST OF CONSULTANTSHIPS

1. The Aluminum Company of America
2. Amarillo, City of
3. Army Chemical Center, Nuclear Defense Laboratory
4. Atlantic Richfield
5. Brackenridge Hospital, Austin
6. Bryant-Curington Consulting Engineers
7. Convair (General Dynamics Corporation)
8. Dallas Power and Light Company
9. El Paso Products
10. Engineering-Science, Inc.
11. Esso Research & Engineering
12. Fluor Corporation
13. Forrest and Cotton Consulting Engineers
14. Goodrich-Gulf Chemicals, Inc.
15. Goodyear Rubber Company
16. Graphite Corporation of America
17. Guadalupe - Blanco River Authority
18. Gulf Oil Corporation
19. Humble Oil and Refining Company
20. Hundley and Halff Engineers
21. International Paper Company
22. Jefferson Chemical Company
23. Los Alamos Scientific Laboratory
24. Magnolia Petroleum Company
25. The Merichem Company
26. Monsanto Chemical Company
27. Morton Salt Company
28. Neches Butane
29. Northern Natural Gas
30. Pan American Oil
31. Pan American Sanitary Bureau, World Health Organization
32. Pittsburg Plate Glass Company
33. Pure Oil Company
34. Reichhold Chemicals, Inc.
35. San Jacinto River Authority
36. San Marcos, City of
37. Shell Oil Company
38. Shreveport, City of
39. Southwestern Graphite
40. State Hospital, Austin
41. Sun Oil Company
42. Texas-U.S. Chemicals Company
43. Tracor, Inc.

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- 44. Turner, Collie & Braden
- 45. U. S. Public Health Service, Radiological Health Division
- 46. U. S. Public Health Service, Water Resources Division
- 47. U. S. Senate
- 48. World Health Organization
- 49. Zurn

## ATTACHMENT 2

BIOGRAPHICAL DATA

NAME: E. Gus Fruh

## PRESENT POSITION:

Assistant Professor  
Environmental Health Engineering Program  
Civil Engineering Department  
The University of Texas

## BUSINESS ADDRESS:

Engineering Laboratories Building 305  
The University of Texas  
Austin, Texas 78712  
Telephone: GR1-5602

## RESIDENCE ADDRESS:

[REDACTED]

## PERSONAL DATA:

Birthdate: [REDACTED]  
Birth Place: [REDACTED] New York  
Marital Status: [REDACTED]  
Children: [REDACTED]

## EDUCATION:

[REDACTED]

## ORGANIZATIONS:

AWWA, ASCE, Water Pollution Control Federation,  
Chi Epsilon, Sigma Xi, Texas Academy of Science,  
American Chemical Society, Limnology and Oceanography

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EXPERIENCE:

Research

Project Director - "Enzymatic Technique for Detection of Surplus Phosphorus Uptake by Activated Sludge," Federal Water Pollution Control Administration.

Project Director - "Limnological Investigations on Texas Impoundments for Water Quality Management Purposes," Office of Water Resources Research.

Project Director - "Selective Withdrawal at Lake Livingston," Office of Water Resources Research.

Project Director - "Colorado River - Highland Lakes Study," Texas Water Quality Board.

Co-Director - "Ecological and Biological Studies on Galveston Bay," Texas Water Quality Board.

Other

Project Consultant: "Pollution Control and Water Quality Management Study," The West Central Texas Council of Governments (present).

Project Consultant: Spring Creek Auxiliary Water Pollution Control Project, Development of Scientific Parameters for the Control of Pollution from Combined Sewer Overflows and the Quantitative Assessment of the Ecology of Jamaica Bay, New York (present).

Colleague Reviewer: U.S. Geological Survey Investigation, Brazos River Reservoirs Studies on the Quality of Water and Stratification of Possum Kingdom, Whitney, Hubbard Creek, Proctor and Belton Reservoirs (Sept, 1967).

Committee Consultant: Biological and Ecological Studies for Galveston Bay, Texas Inter-University Water Resources Research Agreement (June - Sept, 1966).

Post-doctoral Research Fellow, University of Wisconsin, Project - "Effect of Eutrophication on the Water Resources of the Yahara River Basin," (Jan, 1965 - Jan, 1966).

Consultant, City of Madison Technical Committee on Lake Mendota Problems (Jan, 1965 - Jan, 1967).

Engineer, "Raritan Bay and Bathing Beach Investigation," New York Department of Health (June - Sept, 1961).

TOTAL PUBLICATIONS:

(Chapter of Books)

1. "Urban Effects on Quality Streamflow" in The Effects of Watershed Changes on Streamflow, University of Texas Press, Austin (1969).
2. "Biological Response to Nutrients - Eutrophication Problems in Freshwater" in Advances in Water Quality Improvement, edited by E.F. Gloyna and W.W. Eckenfelder, University of Texas Press (1968).
3. (With Krenkel, P.A., Eckenfelder, W.W., and Gloyna, E.F.) "Eutrophication" in Stream Analysis and Thermal Pollution Training Manual, Volume II. Prepared for Poland Project - 26, World Health Organization, University of Texas Press, Austin (1968).
4. (With G.F. Lee) "Sorption of Cesium on Stratified Mica," in Principles and Applications of Water Chemistry, edited by S. Faust and J. Hunter, John Wiley and Sons (1967).

(Referred Articles)

1. (With R.B. Higgins) "Relationship between the Chemical Limnology and Raw Water Quality of a Subtropical Texas Impoundment," Texas Journal of Science, XX, 1, 13-32 (1968).
2. "The Overall Picture of Eutrophication" Journal Water Pollution Control Federation, 39, 9, 1449-1463 (1967).
3. (With G. F. Lee) "The Aging of a Lake" Industrial Water Engineering, 3, 26 (1966).
4. (With K.M. Stewart, G.F. Lee, and G.A. Rohlich) "Measurement of Eutrophication and Trends" Journal Water Pollution Control Federation, 38, 1237 (1966).

(Reports)

1. (With H.G. Moore) "Surplus Phosphorus Uptake by Microorganisms - Algae" (1969).
2. (With H.G. Moore and R.B. Higgins) "Surplus Phosphorus Uptake by Microorganisms - Batch Tests With Dilute Activated Sludge Cultures" (1969).

TOTAL PUBLICATIONS (continued)

(Reports...)

3. (With E.M. Davis) "Water Quality of the Highland Lakes - Determination of the Effect of Urbanization on Impoundment Water Quality" (1969).
4. (With D.L. Pittman and E.M. Davis) "Water Quality of the Highland Lakes - Determination of the Effect of Shoreline Development on Impoundment Water Quality" (1969).
5. (With A.C. Gravel and E.M. Davis) "Limnological Investigations of Texas Impoundments for Water Quality Management Purposes - The Distribution of Coliform Bacteria in Stratified Impoundments" (1969).
6. (With E.M. Davis) "Limnological Investigations of Texas Impoundments for Water Quality Management Purposes - Limnological and Water Quality Data for the Highland Lakes, 1968" (1969).
7. (With B.A. Floyd and E.M. Davis) "Limnological Investigations of Texas Impoundments for Water Quality Management Purposes - The Use of Algal Cultures to Assess the Effects of Nutrient Enrichment on the Highland Lakes of the Colorado River, Texas" (1968).
8. Consulting Report (With Lee, Beatty, Corey, Holt, Hunter, Lawton, Peterson, Schraufnagel, and Young) "Report on the Nutrient Sources of Lake Mendota," Lake Mendota Problems Committee, Madison, Wisconsin, August (1967).
9. (With Mackum, Wohlschlag, B.J. Copeland, Ray) "Biology and Ecology Studies for Galveston Bay" Texas Inter-University Water Resources Research Agreement, September, 1966.
10. Colleague Reviewer, U.S. Geological Survey. "Brazos River Reservoir Studies Progress Report 1965, Quality of Water and Stratification of Possum Kingdom, Whitney, Hubbard, Creek, Proctor and Belton Reservoirs," September 1966.

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TOTAL PUBLICATIONS (continued)

(Short Courses for Continuing Education)

1. Director - "Analysis and Control of Water Resource Systems" College of Engineering and Engineering Foundation, The University of Texas at Austin (June 1969).
2. Participant Lecturer - "Water Quality of Reservoirs" Bureau of Reclamation Short School, Texas A & M University, College Station (Oct. 1968).
3. Participant Lecturer - "Water Quality of Texas Reservoirs" U.S. Army Corps of Engineers Short School, Texas A & M University, College Station, February (1968).
4. MCA Courses, Participant Lecturer - "Ecological Effects of Pollution" Manufacturers-Chemists Association Short Course (Bi-annual, 1966 - present).

(Other)

1. "The University of Texas and Water Production Engineering" in Proceedings of the Symposium on Water Production Engineering in Texas, Center for Research in Water Resources, University of Texas, (1967).
2. "Cesium Sorption of Hydrobiotite," Water Pollution Abstracts, 39 178 (1966).
3. "Cesium Sorption by Hydrobiotite," Dissertation Abstracts, 25 Civil Engineering Department, University of Wisconsin (1965).

## ATTACHMENT 3

## BIOGRAPHICAL DATA SKETCH

Name: Yousef A. Yousef

Title: Research Scientist Associate V, Environmental Health Engineering,  
The University of Texas at Austin, Austin, Texas 78712

Born: [REDACTED] Egypt, U.A.R.

Education: [REDACTED]

Affiliations: Member of the U.A.R. Engineering Syndicate, Sigma Xi, and Chi Epsilon

References: Dr. Earnest F. Gloyna, Professor, Environmental Health Engineering and Director, Center for Research in Water Resources, The University of Texas at Austin, Austin, Texas  
Dr. O. I. Ghazzaly, Associate Professor, Civil Engineering, The University of Houston, Houston, Texas  
Dr. D. R. Rowe, Professor, Department of Agronomy and Physics, Western Kentucky State University, Bowling Green, Kentucky.

Publications:

Co-author in:

1. "Coliform in Waste Stabilization Ponds", Thesis, The University of Texas at Austin, January, 1962
2. "Fate of Coliform Organisms in Waste Stabilization Ponds", J.W.P.C.F., Vol. 36, No. 11, November, 1964
3. "The Transport of <sup>58</sup>Co in an Aqueous Environment", EHE-12-6405, Technical Report No. 7 to the U.S. Atomic Energy Commission, 121 pp., December, 1964
4. "United Arab Republic Programme for Management and Treatment of Low and Intermediate Level Radioactive Waste", Symposium on Practices in the Treatment of Low and Intermediate-Level Radioactive Wastes, SM-71/67., I.A.E.A., Vienna, December 5-10, 1965
5. "Transport of Radionuclides In a Model River", Symposium on Radioactive Wastes Into Seas, Oceans and Surface Waters, SM-72/2, I.A.E.A., Vienna, 1966
6. "Behaviour of Certain Radionuclides in the Aquatic Ecology of Ismailia Canal", Annual Report Submitted to I.A.E.A., Research Contract No. 422/RB, October 1, 1966-September 30, 1967

7. Ibid, Research Contract No. 422/R1/RB, October 1, 1967-September 30, 1968
8. "Affinity of Ismailia Canal Bottom Sediments For Certain Radionuclides", J. of Isotope and Radiation Research, Vol. 1, No. 1, Published by Middle Eastern Regional Radioisotope Center, Cairo, U.A.R., 1968
9. "Behaviour of Certain Radionuclides in the Aquatic Ecology of Ismailia Canal", Presented before the American Society of Civil Engineering, New Orleans, Louisiana, February 3-7, 1969
10. "Transport of Organic and Inorganic Materials in Small Scale Ecosystems", Presented before the Division of Water, Air and Waste Chemistry, American Chemical Society, Houston, Texas, February 22-27, 1970
11. "Radionuclide Transport and Responses to Organic Stress in a Research Flume", Presented before the International Conference on Water Pollution Research, San Francisco, California, July, 1970
12. "Radioactivity Transport in Water - Summary Report", Technical Report No. 20 to the U.S. Atomic Energy Commission, In Print

Experience: February, 1969 - Present, Research Engineer, studying transport of organic and inorganic material in streams  
April, 1965 - January, 1969, Teaching in Alexandria and Assuit Universities in Egypt, U.A.R., Head of Radiation Protection Engineering Division, U.A.R. Atomic Energy Establishment, Cairo, Egypt  
September, 1960 - March 1965, Working for my Ph.D. degree and research assistant in The University of Texas at Austin, Austin, Texas  
June, 1952 - August, 1960, Civil Engineer in the U.A.R. Ministry of Irrigation in charge of surveying, leveling, planning, designing and excuting irrigation projects such as canals, barrages and bridges