Proj 931/133 (3)
PD- PD-AAD-279-A1

Project Authorization and Request for Allotment of Funds

56p

Part II

Entity : TA Bureau

Project : Water Projects Effects

Project Number: 931-1133

This authorization provides the twelve-month AID funding needed to carry out the work necessary to confirm a methodology for predicting the adverse environmental health impact of water development projects on the transmission of schistosomiasis. This project was endorsed by the RAC at its meeting of July 14-15, 1977, subject to the condition that:

> "during the period of applying the model to the Tanzanian data the Principal Investigator direct some effort to the specification and trial of additional variables and/or stochastic characteristics of the two variables which might improve prediction of infection."

This condition is acceptable to TAB.

Signature: M S Belcher for C Farrar
Curtis Farrar
Assistant Administrator
for Technical Assistance

Date: AUG 23

Clearance: TA/PPU, J. N. Gunning

Reference: Howard to Farrar Action Memorandum dated July 22, 1977

Attachments: 1. Research Project Statement - Socio-economic Analysis of Impact of Water Projects on Schistosomiasis

July 22, 1977

ACTION MEMORANDUM FOR THE ASSISTANT ADMINISTRATOR, TAB

FROM: TA/H, Lee M. Howard, M.D. [illegible]

Problem: Your approval of the attached Research Project Statement for the project Socio-economic Analysis of Impact of Water Projects on Schistosomiasis (Water Projects Effects) is requested.

Background: One common environmental health problem resulting from water resource projects is the increased spread of schistosomiasis. Several models have been developed to predict the impact of such projects on the transmission of the infection, but the complexities and data requirements of most of these models limit their general applicability. In 1975, AID, as a part of its Graduate Work Study Program, sponsored the development of a model which is believed to have better prospects for use. That model was designed to permit the prediction of the future course of schistosomiasis transmission in water resource projects, to permit the analysis of transmission under existing conditions and to provide a basis for estimating the cost effectiveness of available interventions. This project proposes to test that model against another set of data to confirm its validity and usefulness.

Utilization: The results of this project are expected to provide another tool for the assessment of the environmental impact of development projects and to improve the implementation of Agency policy on development and the environment. It will also provide an improved tool for selecting the most appropriate means of controlling schistosomiasis transmission under locally prevailing conditions.

The proposal has been reviewed and endorsed by the R&DC. The RAC, at its July 1977 meeting, considered the proposal and endorsed it with the condition that "during the period of applying the model to the Tanzanian data the Principal Investigator direct some effort to the specification and trial of additional variables and/or stochastic characteristics of the two variables which might improve prediction of infection."

The proposal from Dr. Rosenfield of Resources for the Future has been reviewed by the Office of Health and meets the requirements of an unsolicited proposal contained under AID PR 7-4.5301 (e).

Recommendations: It is recommended that you:

1. Indicate your approval of the project by signing the attached Project Authorization and Request for Allotment of Funds form which authorizes one-year funding in the amount of $77,000.

Attachments:
1. Project Authorization and Request for Allotment of Funds
2. Research Project Statement

Clearances:
DAA/TA:CDMcGraw CDM Date 8/9/77
AAA/TA:TSchwarzwalder MWX Date 8/10/77
TA/RES:MRechcigl s/ Date 8/5/77
TA/PPU:RSimpson Date

TA/H?EH:JTThomason:jss:7/21/77:X-59020

5/25/76

RESEARCH PROJECT STATEMENT

(13) 1133

Project Title: Socio-economic Analysis of Environmental Health Problems (Short title: Water Project Effects)

New or Extension: New

Time Period: Twelve months

Estimated Total Cost: $75,581

Principal Investigator:

Patricia L. Rosenfield, Ph.D.
Resources for the Future
1755 Massachusetts Avenue, NW.
Washington, D.C. 20036

Project Manager: James F. Thomson, TA/H

Narrative Summary:

Project evaluation and feasibility studies of water resource projects currently being prepared tend to concentrate on the direct economic costs and benefits of the proposed project, i.e., costs of construction and operation and benefits from increased employment and agricultural production. Virtually no considerations are given to possible adverse environmental impacts occasioned by the project which result in decreased human productivity and increased medical care costs.

One common example of environmental health impacts resulting from water resource projects is the increased spread of schistosomiasis. Schistosomiasis is a disease intimately associated with the introduction or increase in water availability in places as diverse as Brazil, Tanzania, Egypt, Iran, Philippines, and the People's Republic of China. Schistosomiasis also thrives at low levels of development in the presence of inadequate domestic water supplies, inadequate waste disposal facilities, lack of formal education, and malnutrition. The dual association of water and poverty makes schistosomiasis representative of the varied environmental health impacts from development projects.

Narrative Summary: (Cont'd.) This study proposes to use schistosomiasis as an indicator of environmental health impacts from water resource projects to confirm a method of predicting the intensity of the impact and to determine the costs and effectiveness of strategies to prevent those detrimental effects.

SOCIO-ECONOMIC ANALYSIS OF
ENVIRONMENTAL HEALTH PROBLEMS

A. The Research Goal

1. Goal Statement

The goal of this research project is to improve the quality of life of the some 700 million rural people living in areas of endemic schistosomiasis, 200 million of whom are afflicted by the disease, through more effective disease control programs.

2. Measurement of Goal Achievement

Progress toward accomplishment of this goal can be measured inter-alia by:

a. Reductions in morbidity and mortality rates.

b. Increased production of food and fiber.

c. Improved scale of living.

d. Enhanced dietary intake

3. Assumption of Goal Achievement

Pre-requisites for goal achievement all of which are believed to be present are:

a. LDC Governments have a sincere desire to improve quality of life of their rural poor.

b. LDC planners would allocate available resources in a more optimal cost-effective manner if they possessed an appropriate analytical tool.

c. LDC resources, although limited, are adequate to initiate optimally planned long range programs.

B. The Project Purpose

1. The Project Purpose is Two-fold:

a. To expand a previously developed schistosomiasis transmission simulation (STS) model into a methodology which will permit national planners in schistosomiasis infected countries to determine the environmental health impacts of water resource development projects and choose most effective control measures.

b. To provide AID with a tested tool to use in the preparation, for water resource projects, of environmental analyses acceptable to the Council for Environmental Quality under the legal requirement of Section 102B of the National Environmental Policy Act.

2. End of Project Status

Two categories of conditions are foreseen as marking the project end point:

a. The methodology is determined to be appropriate or inappropriate for accomplishing the stated purposes.

b. Methodology, if appropriate, has been published and circulated, to donor agencies and governments interested in schistosomiasis control.

3. Basic assumptions at this level are three:

a. There is a relationship between health benefits and socio-economic development projects which can be demonstrated quantitatively and qualitatively.

b. Both the costs and effectiveness of each component of various mixes of preventive and curative schistosomiasis abatement control programs can be identified; and

c. A methodology derived from b, above, would constitute a useful planning tool.

C. Statement of Project Outputs

1. Outputs and Output Indicators

The paramount output will be a methodology of determining cost and effectiveness associated with alternative schistosomiasis control strategies. This output will result from collecting, analyzing and synthesizing three types of data: epidemiological (including but not limited to prevalence, incidence, and intensity of infection); monetary costs (project capital costs and disease control costs); and effectiveness of the various control methods.

Output	Indicator	Target Date
1. Confirmation of ability of model to predict level of schisto prevalence.	1. Report of Confirmation	1. 9 mos. after initiation of project.
2. Ability to determine cost-effectiveness of various disease control strategies.	1. Milestone report ranking alternatives in terms of cost-effectiveness.	1. 11 mos. after beginning.
3. Methodology for predicting environmental health impacts and for analyzing cost-effectiveness of strategies to reduce adverse impacts of water resource projects.	1. Final report on Methodology	1. 12 mos. after start.

2. Basic Assumptions

Basic assumptions include the following:

a. Data from the Tanzanian project include record of intensity of infection, costs of control measures, infection reduction, and are sufficiently comprehensive to show a cause effect relationship.

b. The present STS model can be modified to provide a sequential expenditure cost-effectiveness curve.

c. Established patterns of behavior, e.g., unhygienic habits, can and will be modified by health education and sanitation programs if those programs are designed in keeping with the customs, past experiences and present needs of the people and if they perceive individual benefits of the new way.

D. Project Inputs

1. The contractor's inputs will include but not necessarily be limited to:

a. The STS mathematical relationship formula.

b. General supervision of entire project.

c. Provision of requisite technical manpower.

d. Consultants.

e. Analysis and modeling capability.

f. Backstopping facilities (computer time, libraries, printing facilities, laboratories, etc.) as required.

2. Cooperating Agency inputs include:

a. Access to data of study site.

b. Collaboration of the Cooperating Agency officials responsible for the Tanzanian schistosomiasis control program. This includes reviewing and commenting on developed methodology.

3. AID/W inputs:

a. Life of project funding.

b. Project monitoring.

c. Liaison with cooperating agency.

d. Reproduction and dissemination of final report.

E. Significance and Rationale of Research

The purpose of the project is subsumed under the Agency's overall objective of improving the quality of life of the some 700 million rural people living in areas of endemic schistosomiasis. Favorable quality of life indicators include inter-alia; low mortality and morbidity rates; improved production of food and fiber; improved housing and environmental surroundings; and improved dietary intake. Improvements in these areas can be made as costs of schistosomiasis control programs are decreased. The project, therefore, seeks to consider each point of intervention in a schistosomiasis abatement program and to determine which control method results in minimum costs in cost-effectiveness terms. The project may be considered completed when the methodology developed is regarded by AID and other donor agencies, such as the International Bank for Reconstruction and Development (IBRD), as a management tool for incorporating into original project analyses the effectiveness and costs of preventing potentially adverse environmental health impacts resulting from water resource development projects.

The importance of schistosomiasis as a deterrent to social and economic progress in many developing countries has been recognized for many years. While the disease has been known for centuries, calcified parasitic ova having been found in two Egyptian mummies 1250-1000 B.C. circa, it has become of increasing concern during the last two decades as water resources development projects have proliferated and spread the snail vector into new areas. Today the disease undoubtedly is a costly burden contributing to inefficiency and waste in the use of natural

resources, to needless consumption of food energy, and hindering cultivation of irrigated land. It remains a pervasive foe of the "Well-being of people" which is central to the objectives of U.S. foreign assistance.

A quarter of a century ago an estimated 200 million persons were infected (Stoll, 1947), but as the world population doubled between 1935 and 1970, and with 50% of the population in many areas being under 15 (the age group most prone to schistosome infection), the population now infected may be in the region of 300 million. There is little sign that the number is being reduced. In fact, evidence shows that the building of dams and in many areas the irrigation schemes that follow (frequent components of the foreign aid programs of the United States and other donor countries), cause an increase in prevalence and intensity of infection and spread it to previously uninfected areas. It is estimated that the disease is endemic in 70 countries or island territories which in 1972 had an estimated population of 1600 million.

AID for several years has recognized schistosomiasis as a disease of growing importance because of the close association between increased transmission, development of new water projects (particularly irrigation systems and water impoundments), low levels of sanitation, malnutrition and illiteracy. More recently, the Agency's Near East and Africa Bureaus are showing evidence of growing interest. Specifically, the Near East North Africa Bureau is considering the schistosomiasis risk of an irrigation scheme being planned for Morocco and is anticipating requests for assistance from Egypt and a number of other countries. The Africa Bureau has recruited technical consultants for Swaziland and is considering incorporation of plans for control in new development projects such as Volta and Senegal River Basin projects.

The International Bank for Reconstruction and Development now routinely requires the incorporation of plans for schistosomiasis control in new water management schemes which it supports if they are situated in an area where schistosomiasis is a threat. The Rockefeller Foundation is supporting an extensive control project in St. Lucia, West Indies. The Edna McConnell Clark Foundation provides support for the testing of anti-schistosomal drugs. The World Health Organization is engaged in a number of abatement programs. All such programs require a heavy expenditure of funds--expenditures which might be materially reduced if workers had an acceptable methodology of calculating the cost-effectiveness of each of the various experimental interventions tried. This project is designed to provide that methodology. Numerous workers have developed models to analyze the dynamics of transmission. A joint AID/WHO "Symposium on the Future of Schistosomiasis Control" in 1972 recommended that economic impact studies of schistosomiasis be conducted. To this objective, therefore, AID sponsored research on a transmission simulation model which for the first time considered the man-water-snail-water-man interaction as modified by the dynamics of environmental change, and control and/or treatment measures.

In September 1974, the U.S. Secretary of State announced to the United Nations that the U.S. within the next few months would present its proposals for a concerted effort to control schistosomiasis. The following study is therefore seen as being responsive to the Secretary's initiative.

The study proposes to use schistosomiasis as an indicator of environmental health impacts from water resource projects to predict the impacts of increased water availability on schistosomiasis transmission and to determine the costs and effectiveness of strategies associated with preventing those detrimental effects.

In the past, project evaluations and feasibility studies of water resource projects have concentrated on the direct economic costs and benefits of the proposed project, i.e., costs of construction and operation, plus benefits from increased employment and agricultural production. Virtually no consideration has been given to possible adverse environmental impacts occasioned by the project which have resulted in decreased human productivity and increased medical care costs. Examples of these studies are the guidelines for analyzing the costs and benefits of water resource development projects issued by UNIDO (1972) and OECD (1968). These along with more detailed works by Maass (1962) and Eckstein (1958), concentrate on the economic problems involved: choice of appropriate discount rates, time horizons, direct and indirect monetary costs and benefits, allocation of joint costs and benefits, and other aspects of public investment criteria. Indirect costs due to adverse environmental health effects were not included nor were the benefits of preventing adverse effects through alternative project designs or protective measures.

On the other hand, the economic effects of schistosomiasis have been studied by Wright (1972), Farooq (1964), Fenwick (1972), Weisbrod (1973) and Jobin (1972), et. al. Wright and Farooq estimated costs of the disease on a national basis, considering in each case the total costs of medical care, unemployment, and decrease in labor productivity. The others have each taken a specific project area to estimate the costs and benefits of control programs on the economic effects of the disease.

Only Jobin has attempted to develop a more generalized methodology for cost-benefit analysis of control measures based on a model that simulates transmission of the disease in populations and snails. Despite these works and others concerning health resources planning and health economics there are few, if any, analyses of environmental health impacts resulting from development projects wherein the environmental health impacts have been quantitatively included in the original economic analysis of the project.

The increased spread of schistosomiasis is a common example of an adverse environmental impact resulting from water resource projects. Schistosomiasis is a disease intimately associated with the introduction or augmentation of water availability in places as diverse as Brazil, Tanzania, Iran, Philippines and the People's Republic of China. Numerous water resource development schemes located in endemic schistosomiasis areas have been financially assisted by AID. The disease thrives at low levels of development in the presence of inadequate domestic water supplies, inadequate waste disposal facilities, lack of formal education, and malnutrition. The dual association of water and poverty makes schistosomiasis representative of the varied environmental health impacts from development projects.

In summary, to analyze the environmental health impacts of development projects and to determine the costs and effectiveness of preventing these impacts in developing countries, it is necessary to 1) predict the environmental health impact, 2) estimate costs of preventing the impact, and 3) develop the methodology within the

same framework as that used in the traditional project analysis. The purpose of this study is to confirm a methodology developed for environmental health analysis of an existing water resources project and, if time permits, to apply the methodology to an area of new water resource development.

F. Plan to Facilitate Utilization of Research Results

As stated before numerous organizations are concerned over the spreading of schistosomiasis. The World Bank, WHO, PAHO, UNEP and others are united on the desirability of identifying effective control measures. All are eager to obtain a method of developing economically sound and environmentally sensible development strategies, and to identify those which are most cost-effective.

The results of this study will be disseminated through those agencies and by the scientific and medical press. Within AID, the work should affect projects handled by TA/AGR, TA/H, TA/RD, SER/ENGR and each of the Regional Bureaus.

G. Management Considerations

1. This is expected to be a sole source procurement based upon the rights of the proposed principal investigator in the STS model and her employment by RFF.

2. The proposed contractor, Resources for the Future, Inc., is a non-profit organization partially funded by the Ford Foundation. It is capable of providing both administrative and technical supervision plus clerical, accounting, library etc., as required.

Administrative supervision will be provided by Dr. Emory Castle, Vice-president RFF and by Dr. Lincoln Gordon, former Ambassador to Brazil, Assistant Secretary of State and President of Johns Hopkins University. Technical supervision will come through Dr. Clifford Russell, well known economist and environmentalist with expertise in modeling for environmental quality. The Contractor will provide office space, secretarial assistance, computer facilities and overall guidance. In addition, the Schistosomiasis Unit of WHO has offered their services as reviewers of the research at all stages.

3. The method for project evaluation will be developed jointly by the Agency's project manager and external expert advisors.

H. Technical Review

An earlier proposal to apply the model to additional data to be developed in Iran was presented in early 1976. Technical and RAC review confirmed the desirability of testing and modifying the model and developing the methodology. There were, however, reservations concerning the proposal to attempt cost-benefit analysis, the use of Iranian data and the high cost of the project. The consensus was that limited funds be provided to apply the schistosomiasis transmission simulation model to data available through WHO. The project as presented herein is responsive to that consensus.

I. Research Project Design, Methods and Work Plan

1. Implementation Plan

The objectives of this study which will lead to a practical methodology for environmental health impacts analyses of water resource projects are based on a knowledge of the epidemiology of the environmental

health impact under study, i.e., schistosomiasis, the design of the water resources project or the knowledge of human water contact sites, and the costs and effectiveness of the alternative strategies for controlling/preventing the disease from spreading. The study will be based on the STS model developed by the proposed investigator. This newest model is based on environmentally sensitive parameters of disease transmission, i.e., meters of snail habitat, number of people sick, and the data requirements are few. Through the use of this model, verified with data from an irrigated area in Iran, it will be possible to predict the impact of a planned water resources project on the spread of schistosomiasis. By using and expanding the cost-effectiveness analysis associated with the predictive STS model, the costs and benefits of alternative control strategies for preventing the spread of the disease may be estimated. Basic improvements in living conditions that will further assist in controlling the disease, e.g., improvements in domestic water supply and waste disposal, and health education programs will be included in the economic analysis of preventing the spread of the disease. The multiplicity of control strategies and the unknown cost-effectiveness of each is clearly wasting funds each year. The proposed study will permit the development of a methodology which will permit planners from LDCs or international agencies to 1) utilize environmentally sound strategies of development, 2) analyze economic and social effects of environmental health problems associated with water resource projects, and 3) utilize realized savings in provision of amenities and improvements in the standard of living. Such a methodology has not been developed and is clearly needed. To develop the methodology, the model will be applied to data from a

schistosomiasis control program in Tanzania which is available and lends itself to study using the model. Overall time schedule and cost data are attached hereto.

As indicated above the complete study consists of three phases or objectives.

a. Objective 1 - Confirmation of model for predicting level of prevalence of schistosomiasis.

This objective will be reached through appropriate modification of the STS model which has been verified with data from an irrigated area in Iran. Prior to conception of the STS model it was known that the two fundamental processes of infection and de-infection of schistosomiasis may be expressed as one simple rate process by the following equation (Muench, 1959):

$$dY / dt = A(1-Y) - BY \qquad (1)$$

where Y is the fraction of the population infected with schistosomiasis, A is the force of infection, B is the force of de-infection. Equation 1 states that the rate of change in schistosomiasis prevalence is a function of the rate at which healthy people become infected and infected people lose the infection. An important assumption in the equation is that as infected individuals lose the infection, they join the pool of susceptible individuals. In contrast to previous models (Hairston, 1965b), immunity to re-infection is not considered in this model. With S. haematobium infections there is reason to think that changing exposure to snail habitats (as would happen with a new water resource project) plays a more significant role than immunity in the transmission cycle.

A solution for Equation 1 for the boundary conditions $Y = 0$ at $t = 0$ has been given by Muench (1959):

$$Y = \frac{A}{A+B} \left(1-e^{-(A+B)t} \right) \qquad (2)$$

The new STS model is based on three equations derived from the basic transmission Equations 1 and 2. These equations and their components are shown in Table 1 attached. In the STS model, the numerical values for the infection rate A, have been determined for several villages from 1964 through 1973 from data collected by the Bilharziasis Control Project (BCP) staff through annual examination of a selected group of 0 to 10 year olds initially diagnosed as negative on the basis of 3-day urine tests. These field values of A are directly related in the model to transmission factors of the disease, snail habitats and number of people infected, by regression analysis. After several different trial regressions, the most successful equation for estimating A was found to be the interaction of meters of accessible snail habitats (H) and number of people infected (P):

$$A = b_0 \left(H^{b_1} \times p^{b_2}\right) \qquad (3)$$

where b_0, b_1, and b_2 are determined in the regression analysis.

The force of de-infection, B, is the natural loss rate of the disease. The value used in the model was estimated from steady-state data to be 0.2, and is considered constant over all ages and years in the model. The value agrees closely with values estimated by Hairston (1965b) for S. haematobium in Syria and Egypt.

Estimates of the forces of infection and de-infection are used in the simulation of changes in prevalence over time. The time unit for the model is one year because that is the unit of time the BCP used for their data collections. Simulation of prevalence is accomplished with iterative use of the following equation:

$$Y_{t+1} = I\ (1-Y_t) - BY_t + Y_t \qquad (4)$$

where Y_t is the fraction positive in the beginning of year t, B is the force of de-infection, and Y_{t+1} is the fraction positive predicted for the end of year t or beginning of year t+1. I is the fraction of uninfected people who become positive at the end of one year. I can be expressed as a function of A and B by solving Equation 2 for Y_t when t = 1:

$$I = Y_1 - Y_0 = \frac{A}{A+B}\ (1 - e^{-(A+B)}) \qquad (5)$$

The STS model simulates changes in levels of prevalence over time. A flow diagram which schematically represents use of the model is given in Figure 1. With values of A, B, I, and Y_0 a model run is accomplished by solving for Y_1, Y_2, ..., Y_T, where T is the number of years in the planning period, by seccessive application of Equation 4.

Data on prevalence (Y_0) are required for the initial year of operation. Data required for each year include meters of accessible snail habitats (H) and total population. The data used in the model are corrected to account for actual events that occurred during the year of analysis. For this reason, only meters of accessible snail habitats not molluscicided nor improved by engineering measures are included. A chemotherapy correction factor, (Q), the fraction of total number of infected people treated over total number infected, is applied when appropriate.

TABLE 1 - STS EQUATIONS AND NOTATION

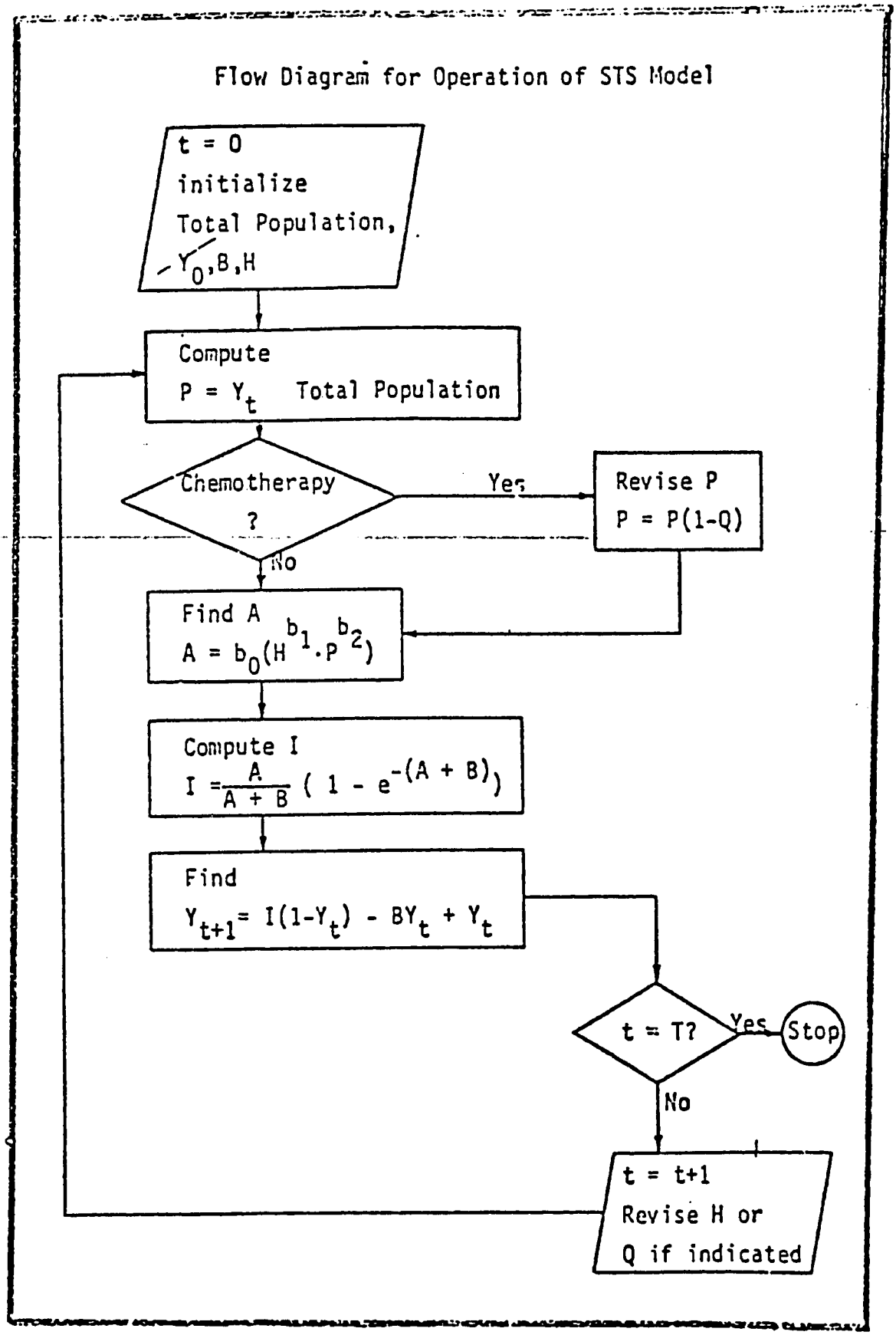
$$A = b_0 (H^{b_1} \times P^{b_2}) \qquad \text{(regression)}$$

$$I = \frac{A}{A+B} \left(1 - e^{-(A+B)} \right) \qquad \text{(transformation)}$$

$$Y_{t+1} = I (1-Y_t) - BY_t + Y_t \qquad \text{(simulation)}$$

A	=	force of infection per village.
b_0	=	intercept of line of best fit in regression equation.
H	=	accessible snail habitat (meters per village).
P	=	people infected (number per village).
b_1	=	regression computed exponent of H.
b_2	=	regression computed exponent of P.
I	=	incidence rate per village (fraction of people that becomes positive over one year).
B	=	force of de-infection per village (natural loss rate).
e	=	base of natural logarithms.
Y_t	=	fraction of population positive in year of analysis per village.
Y_{t+1}	=	fraction of population positive in following year per village.

Figure 1


Flow Diagram for Operation of STS Model
t = 0
initialize
Total Population,
Y_0,B,H
Compute
P = Y_t Total Population
Chemotherapy
?
Yes
Revise P
P = P(1-Q)
No
Find A
$A = b_0(H^{b_1} . P^{b_2})$
Compute I
$I = \frac{A}{A + B} (1 - e^{-(A + B)})$
Find
$Y_{t+1} = I(1-Y_t) - BY_t + Y_t$
t = T?
Yes
Stop
No
t = t+1
Revise H or
Q if indicated

The advantages of this methodology are that the model is based on environmentally sensitive parameters of disease transmission (i.e., meters of snail habitat) and that the data requirements are few.

In operation, prediction of the population positive with schistosomiasis is made by iterative use of equation (3). Effects of the irrigation project or changes in water contact sites may be postulated by assuming changes in the meters of snail habitats resulting from increased water availability due to the project.

The epidemiological data include information about the forces of infection and de-infection of the disease and about the prevalence of disease and extent of accessible snail habitats. Additional data that are available to the contractor from the WHO Tanzania 001 project will permit modifications of the model to increase the reliability of model predictions. These data include seven years of age-specific egg count data (a measure of the intensity of infection), observations on the duration and amount of human contact with a variety of water sites (reservoirs, canals, streams, and ponds), and seasonal variation in snail habitats and water contact activity. These observations were made prior to, during, and following use of control measures so that the data represent baseline and ex post transmission conditions.

Major efforts during this stage of the project involve refining the STS model to use egg count data and to incorporate seasonal variation and migration data in the transmission equation. In addition, the impact of the different water contact sites will be examined. Computer analyses will be made to accomplish this confirmation and consultation with the staff of the Malaria and Other Parasitic Disease Division, WHO, would be appropriate. In addition, consultations with an ecological

modeler, such as David Bradley, Director, Ross Institute of Tropical Hygiene, London School of Hygiene and Tropical Medicine, will provide useful reactions as the confirmation work continues.

This stage is estimated to require a total of 18 man-months of effort from the proposed investigator and assistant, computing time, travel to WHO, office expenses, and ecological modeling consultant - for a total cost of $48,435. A preliminary report will be submitted at the end of this stage.

b. Objective 2 - Calculation of costs and effectiveness of different combinations of control strategies to prevent or limit the spread of the disease.

Activities under this objective will lead to an estimation of the costs and effectiveness of alternative control strategies. Included in the analyses will be considerations of possible alternative combinations of control measures, such as the traditional ones of molluscicidng, chemotherapy, and engineering and also the more infrequently used controls of improved sanitation and water supplies, and health education. In addition, the design of water projects will be examined as a way of preventing the spread of schistosomiasis. The costs of different programs will be estimated. Finally, different measures of effectiveness will be studied such as reduction in the absolute level of schistosomiasis, preventing the disease from spreading, minimizing man-years sick.

The final output will present the rankings of alternative control programs based on the results of the cost-effectiveness analyses. Discussion of the different effectiveness, or environmental health goals, will take place with both health and development personnel in the field area.

It is expected that the total time required for this stage is 4 man-months which will be spent analyzing different control possibilities and estimating the costs and effectiveness of the different strategies. This stage will begin after model confirmation. This objective will require 4 man-months of effort on the part of the principal investigator and her assistant, computer time, office supplies, etc. - for a total cost of $14,516. A brief report will be submitted at the conclusion of this stage.

c. Objective 3 - Methodology for analyzing environmental health impacts of water resource projects.

The final activity for the study, based on the results of the above analyses, will be the development of a quantitative, yet practical, methodology for predicting and analyzing the economics of preventing environmental health impacts from water resources development projects.

The predictions will be made via the essential STS parameters--meters of snail habitat and number of people infected. The costs of reducing both of these terms by alternative methods will be evaluated and then compared with measures of effectiveness in disease prevention and reduction. The results are expected to be in a form compatible with development project analyses completed by AID, the World Bank, and other donor agencies. In addition, results will include the damage function for costs of controls--e.g., how much will reduction in disease reduce damages from the disease (in dollar and physical terms), and consideration of other objective functions in the context of linear programming--e.g., minimizing costs of disease and maximizing number of people healthy, etc.

It is expected that this stage will require 2 man-months for completion. At the end of the second month of the study, a final report will be submitted to AID. Inputs for this stage include time of the principal investigator and her assistant (2 man-months), a computer modeler, office supplies, computer time, etc., all valued at $12,629. The final report will be available to AID at the conclusion of this stage, at approximately 12 months after initiation.

2. Project Budget - see Attachment I.

3. Project Schedule - see Appendix I.

ATTACHMENT I

Estimated Life of Project Costs and Budget

		Man-Months	12-Month Contract Per: Estimated Cost
1.	Salaries	24	$31,060
2.	Fringe Benefits @ 20%		6,212
3.	Overhead Salaries + benefits $37,272 @ 40%		14,909
4.	Consultants	3	9,000
5.	Travel (3 RT to WHO)		2,400
6.	Allowances ($50 per diem/60 days)		3,000
7.	Other Direct Costs (none)		-
8.	Computing time (10 hours @ $500/hr.)		5,000
9.	Supplies (postage, telephone, Xerox)		1,000
10.	Report Preparation		1,000
11.	Printing and Reproducing		2,000
		2	$75,581

LIFE OF PROJECT SCHEDULE

Activity/Output	1	2	3	4	5	6	7	8	9	10	11	12
1. Objective 1. -Environmental Health Impact												
a. Epidemiological data	s								c			
b. Water contact sites data	s								c			
Prediction of environmental health changes-report									M			
2. Objective 2. -costs of Preventing Environmental Health Impacts												
a. alternative strategies analyses									s		c	
b. cost and effectiveness analyses of alternatives									s		c	
cost-Effectiveness Analyses Estimates - Report											M	
3. Objective 3. Methodology for environmental health impacts												
a. computer analyses											s	c
b. final report preparation											s	c
FINAL REPORT												FR

s - start of work
c - completion of work
M - milestone report
FR - Final Report

APPENDIX I

AID 1020-2011-731

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK

Life of Project:
From FY 1977 to FY 1977
Total U. S. Funding $75,581
Date Prepared: 9/27/76

Project Title & Number: Socio-economic Analysis of Environmental Health Problems (Short title: Water Project Effects)

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Program or Sector Goal: The broader objective to which this project contributes: Improve the quality of life of the some 700 million rural people living in areas of endemic schistosomiasis, 200 million of whom are afflicted by the disease, through more effective disease control programs.	Measures of Goal Achievement: a. Reductions in morbidity & mortality rates. b. Increased production of food and fiber. c. Improved scale of living. d. Enhanced dietary intake.	a. Official health statistics. b. FAO Production Yearbook. c. Higher average scale of living as measured by a sociological scale (e.g. Belcher). d. Growth curves of infants and children.	Assumptions for achieving goal targets: a. LDC Governments have a sincere desire to improve quality of life of their rural poor. b. LDC planners would allocate available resources in a more optimal cost-effective manner if they possessed an appropriate analytical tool. c. LDC resources, although limited, are adequate to initiate optimally planned long range programs.
Project Purpose: a. Expand previously developed STS model into methodology which will permit national planners in schisto infected countries to determine environ. health impacts of water resource development projects & choose most effective control measures. b. Provide AID a tested tool to use in preparation, for water resource projects, of environmental analyses acceptable to Council for Environmental Quality under legal requirement of Sec. 102B of National Environmental Policy Act.	Conditions that will indicate purpose has been achieved: End of project status. a. The methodology is determined to be appropriate or inappropriate for accomplishing the stated purposes. b. Methodology, if appropriate, has been published and circulated, to donor agencies and governments interested in schistosomiasis control	a. Report of application of model. b. Publication.	Assumptions for achieving purpose: a. There is a relationship between health benefits & socio-economic development projects which can be demonstrated quantitatively and qualitatively. b. Both the costs & effectiveness of each component of various mixes of preventive & curative schisto abatement control programs can be identified. c. A methodology derived from b, above, would constitute a useful planning tool.
Outputs: a. Confirmation of ability of model to predict level of schisto prevalence. b. Ability to determine cost-effectiveness of various disease control strategies. c. Methodology for predicting environmental health impacts & for analyzing cost-effectiveness of strategies to reduce adverse impacts of water resource projects.	Magnitude of Outputs: a. Report of Confirmation. 2. Milestone report ranking alternatives in terms of cost-effectiveness. c. Final report on methodology.	a. Initial Report b. Interim Report c. Final Report	Assumptions for achieving outputs: a. Data from the Tanzanian project include record of intensity of infection, costs of control measures, infection reduction, and are sufficiently comprehensive to show a cause effect relationship. b. STS Model can be modified to sequential cost-effectiveness curve. c. Established patterns of behavior can be altered if benefits of change are perceived.
Inputs: a. AID/W - Funding, monitoring, liaison with Cooperating Agency, reproduction & dissemination of final report. b. Contractor - Mathematical relationship formula, technical manpower, supervision, consultants, analysis & modeling capability, backstopping facilities. c. Cooperating Agency - Access to project data, collaboration of officials responsible for Tanzanian control program.	Implementation Target (Type and Quantity) N/A	N/A	Assumptions for providing inputs: N/A

Draft Minutes
RAC May 25, 1975

Socio-Economic Analysis of Environmental Health Problems (New) - Resources for the Future

Dr. Heady, Chairman of the Subcommittee composed of Drs. Adams, Carter and D. Peterson reviewed this project proposed for a period of 18 months with an estimated cost of $128,000. The stated purposes of the project are to 1) expand a Schistosomiasis Transmission Simulation (STS) model into a methodology which would be useful to national planners in determining socio-economic impact, in cost-benefit terms, of the presence of schistosomiasis in areas of water resource development and 2) assist AID in preparing, for each water project, environmental impact statements acceptable under the National Environmental Policy Act.

AID considers this proposal as a response to the initiative announced by the Secretary of State to the U.N. in September 1974 that the U.S. would soon propose a concerted effort to control schistosomiasis. Earlier (1972) a joint AID/WHO "Symposium on the Future of Schistosomiasis Control" recommended that economic impact studies he made of this problem.

Very little attention has been given to the adverse effects of schistosomiasis on human health, and its reflections in decreased human productivity and increased medical costs. In projects such as this, reduced productivity and increased health costs would become a part of the total project costs over time, and the cost-benefit ration would be modified accordingly. Alternatively the water system, at some cost, might be modified to prevent schistosomiasis and thereby eliminate these health and associated costs.

Basic assumptions of the model are that 1) there are relationships between health inputs and socio-economic development projects that can be related quantitatively and 2) both the costs and benefits of each component of various mixes of preventative and curative schistosomiasis abatement programs can be identified, and a cost-benefit model can be derived as a useful planning tool. Dr. Heady pointed out that although the model may be equally applicable in various countries, the equation coefficients may vary with environments with the result that the proposed Iranian application would be country specific and have little relevance elsewhere. Drs. Heady and Carter both questioned the proposed Iranian project site because the intensity of infection is light and rate of transmission is low, which essentially reduce their costs of control. The level and manner of discounting, Dr. Heady noted, is not apparent in the model. He asked if standard benefit/cost analysis procedures used by AID and the World Bank would be appropriate. The investigator may have underestimated the time required to complete the tasks and also overlooked some costs which are not implied in the analysis.

Dr. Adams commented that the project is really concerned with schistosomiasis control and focused on cost-benefits. He questioned if this task could be accomplished because of difficulties in quantifying infection levels. The proposal to do the field research serially he thought would be a more costly procedure. He accepted the concept of the study, but suggested AID staff should rework the approach and consider another contractor if necessary.

Dr. Weller also pointed out that in an area of low incidence, such as exists in the proposed study area, it is difficult to determine if

a subject is infected. He said that urine egg density, because it varies with time of day is questionable without additional information, and also raised several questions about the Iranian population sample structure. He questioned the simplicity of the model and validity of basic assumptions such as immunity.

The investigator's qualifications in the area of cost-benefit analysis is not documented, and Dr. D. Peterson expressed concern also if the task could be done. He said the project is open-ended and asked where boundaries would be drawn.

Dr. Swanson asked how such cost-benefit analysis fit into LDC decision functions.

Speaking for the project Dr. Lee Howard, TA/H, said these comments had been helpful and expressed appreciation for the committee's effort. He acknowledged that a number of things need to be done on this complex problem, and stated that the Office of Health faces this issue immediately. AID, through it's Regional Bureaus, and the World Bank are both making large loans for water projects and Health is being asked for evaluation of their benefits. He said TA/H wants to develop a framework in order to look as these problems and is pushing for an appropriate model even though the parameters may change. This study is proposed to utilize existing data which is what they would like to do operationally. Dr. Howard announced that the proposer now plans to use Ghana and Tanzania data instead of Iranian data. Although the cost-benefit phase needs to be strengthened by country, the intent is to develop a general rather than country-specific model. He agreed the proposal lacked certain fine definition and asked RAC assistance in working toward a model.

Dr. Heady said the sub-committee is sympathetic to the need for this work and noted that Dr. Howard's statements essentially propose a new project which de-emphasizes the cost-benefit aspect. Dr. Howard said the organization and data base are changed, but not the purpose or principle. Cost-benefit for individual countries is not an objective. Dr. D. Peterson noted that, in this context, the only cost is the number of persons infected and expressed favor to evaluating the first part of the model but excluding the cost-benefit phase. Dr. Howard indicated that the WHO project data for Ghana has information on land use and benefits due to the project, and said an attempt should be made to utilize it as proposed.

Dr. Adams asked if the investigator is now working on the Ghana data and if this could be funded through some media such as small research. Dr. Howard said her visit to Geneva for this purpose was a side-trip and not AID funded. Dr. Weller also asked if AID provision could be arranged for her to do this. Dr. Heady suggested AID should utilize the available data to formulate the greater problem solution. Dr. Long indicated it should be possible to fund the investigator's work in Geneva if she could go there. A formative recommendation by RAC would move such activity forward more definitely. Ms. Belcher indicated this travel and activity would have to be done through a project vehicle. Dr. Montgomery summarized the general agreement on doing the research and suggested RAC take action.

Motion: That AID (a) provide limited funds for Dr. Rosenfield to continue her schistosomiasis transmission simulation model applications to data available through WHO in Geneva, and (b) request Resources for the Future to develop a more comprehensive project proposal including complete cost-benefit analyses of schistosomiasis transmission simulation models.

Moved by Dr. Heady and seconded by Dr. D. Peterson

Vote: Unanimous approval

SOCIO-ECONOMIC ANALYSIS OF IMPACT OF WATER PROJECTS ON SCHISTOSOMIASIS

A. Significance of Problem and Rationale of Research

1. Significance of Problem

The importance of schistosomiasis as a deterrent to social and economic progress in many developing countries has been postulated for many years. While the disease has been known for centuries, calcified parasitic ova having been found in two Egyptian mummies 1250-1000 B.C. circa, it has become of increasing concern during the last two decades as water resources development projects have proliferated and spread the snail vector into new areas. Although no precise data are available, the disease undoubtedly is a costly burden contributing to inefficiency and waste in the use of natural resources, to needless consumption of food energy, and to limiting the productivity of those affected.

A quarter of a century ago an estimated 200 million persons were infected (Stoll, 1947), but as the world population doubled between 1935 and 1970, and with 50% of the population in many areas being under 15 (the age group most prone to schistosome infection), the population now infected may be in the region of 300 million. There is little sign that the number is being reduced. In fact, evidence shows that the building of dams and the irrigation schemes that follow cause an increase in prevalence and intensity of infection and spread it to previously uninfected areas. It is estimated that the disease is endemic in 70 countries or island territories which in 1972 had an estimated population of 1600 million.

AID for several years has recognized schistosomiasis as a disease of growing importance, and has noted the close association between increased transmission, development of new water projects (particularly irrigation systems

and water impoundments), low levels of sanitation, malnutrition and illiteracy. The Near East Bureau is considering the schistosomiasis risk of an irrigation scheme being planned for Morocco and is anticipating requests for assistance from Egypt and a number of other countries. The Africa Bureau has recruited technical consultants for Swaziland and is considering incorporation of plans for control in new development projects such as Volta and Senegal River Basin projects. The International Bank for Reconstruction and Development now routinely requires the incorporation of plans for schistosomiasis control in new water management schemes which it supports when they are situated in an area where schistosomiasis is a threat. The Rockefeller Foundation is supporting an extensive control project in St. Lucia, West Indies. The Edna McConnell Clark Foundation provides support for the testing of anti-schistosomal drugs. The World Health Organization is engaged in a number of abatement programs. All such programs require a heavy expenditure of funds--expenditures which might be reduced if program managers had an acceptable methodology to calculate the cost-effectiveness of each of the various experimental interventions available.

In the past, project evaluations and feasibility studies of water resource projects have concentrated on the direct economic costs and benefits of the proposed project, i.e., costs of construction and operation, plus benefits from increased employment and agricultural production. Virtually no consideration has been given to possible adverse environmental impacts occasioned by the project such as increased disease transmission which results in decreased human productivity and increased medical care costs. Examples of these studies are the guidelines for analyzing the costs and benefits of water resource development projects issued by UNIDO (1972) and Little and Mirrlees (1968). These along with more detailed works by Maass (1962) and Eckstein (1958), concentrated on the economic problems

involved: choice of appropriate discount rates, time horizons, direct and indirect monetary costs and benefits, allocation of joint costs and benefits, and other aspects of public investment criteria. Indirect costs due to adverse environmental health effects were not included nor were the benefits of preventing adverse effects through alternative project designs or protective measures.

On the other hand, the economic effects of schistosomiasis have been studied by Wright (1972), Farooq (1964), Fenwick (1972), Weisbrod (1973) and Jobin (1972), et. al. Wright and Farooq estimated costs of the disease on a natural basis, considering in each case the total costs of medical care, unemployment, and decrease in labor productivity. The others have each taken a specific project area to estimate the costs and benefits of control programs on the economic effects of the disease. Only Jobin has attempted to develop a more generalized methodology for cost-benefit analysis of control measures based on a model that simulates transmission of the disease in populations and snails. Despite these works and others concerning health resources planning and health economics there are few, if any, analyses of environmental health impacts resulting from development projects wherein the environmental health impacts have been quantitatively included in the original analysis of the project.

The increased spread of schistosomiasis is a common example of an adverse environmental impact resulting from water resource projects. Schistosomiasis is a disease intimately associated with the introduction or augmentation of water availability in places as diverse as Brazil, Tanzania, Iran, Philippines and the People's Republic of China. Numerous water resource development schemes located in endemic schistosomiasis areas have been financially assisted by AID. The disease thrives at low levels of development in the presence of inadequate domestic water supplies, inadequate waste disposal facilities, lack of formal

education, and malnutrition. The dual association of water and poverty makes schistosomiasis representative of the varied environmental health impacts from development projects.

2. Rationale of Research

To analyze the environmental health impacts of development projects and to determine the costs and effectiveness of preventing these impacts in developing countries, it is necessary to (1) predict the environmental health impact (resulting number of cases of schistosomiasis), and (2) estimate costs and effectiveness of measures which prevent the impact.

This project attempts to accomplish these tasks by using schistosomiasis as an example of an environmental health impact resulting from water resources projects. In addition to predicting prevalence changes over time as a result of the project, methods of schistosomiasis control will be considered to determine which control method or combination of controls will be most cost-effective in the given situation. The aim is a methodology regarded by AID and other donor agencies, such as the International Bank for Reconstruction and Development (IBRD), as a useful management tool for assessing the effectiveness and costs of preventing a potentially adverse environmental health impact which may result from water resource development projects.

The research proposed here is viewed as progressive development of models for management of schistosomiasis. AID supported the initial development of the model with application in an irrigated area of Iran. (Rosenfield 1975, Rosenfield, et. al., 1977). After successful verification of the methodology in that environment, it is now proposed to test the methodology in a

different situation with a different schistosome species. Over the past year, the Rockefeller Foundation has supported the principal investigator to test this in St. Lucia. This study will be completed in Spring 1977. What is proposed here is to test the methodology in yet another epidemiological situation. The aim is to have at hand eventually a series of models all related to the general form initially established but with different coefficients related to specific sites. This will enable development project planners to determine how a particular project may be evaluated and health planners to determine which combination of controls will be most cost-effective for the same particular project.

In addition, the principal investigator presented the general form of her model to the scrutiny of others interested in schistosomiasis models (mathematicians, field biologists, epidemiologists, laboratory scientists), at the Bellagio Conference on "Mathematical Models of Schistosomiasis" sponsored by the Edna McConnell Clark Foundation. The comments on the model are being taken into account in present work. As suggested re-estimation of coefficients is what is being tested. A major recommendation of the Conference was that modelers confront hard data in the field. This proposal is an attempt to accept that challenge.

B. Research Objectives and Background

1. Overall Objectives

a. To expand a previously developed schistosomiasis transmission simulation model into a methodology which will permit planners in schistosomiasis infected countries to determine the magnitude of the impact of a specific water resource development project on the spread of schistosomiasis and to choose the most cost effective combination of control measures.

b. To provide AID with a tested tool to use in the preparation of environmental analyses for water resource projects, pursuant to Agency PD 61.

Developing the methodology will involve collecting and analyzing three types of data: epidemiological (including snail habitats, frequency of human contact with snail habitats, prevalence, incidence, and intensity of infection); monetary costs (project capital costs and disease control costs); and effectiveness (man-years of infection estimated to be prevented) of the various control methods.

The study will be based on the model previously developed by the proposed investigator which predicts the level of the population infected as a function of parameters of disease transmission, e.g., human accessibility to snail habitat, extent of snail habitat, number of people infected. Through the use of this model, previously tested with data from an irrigated area in Iran, it is expected that it will be possible to demonstrate the applicability of the model to predict the impact of another water resources development project in a different geographic area on the spread of schistosomiasis. By using and expanding the cost-effectiveness analysis associated with the model, the costs and effectiveness of alternative control strategies for preventing the increased transmission of the schistosomiasis may be estimated. To a limited extent basic improvements in living conditions that will further assist in controlling the disease, e.g., improvements in domestic water supply and waste disposal, and health education programs will be considered in the economic analysis of preventing the spread of the disease. To develop the methodology, the model will be applied to data from a schistosomiasis control program in Tanzania, which are available and appropriate to study using the model.

2. Background on Model Development

Prior to conceptualization of the model it was known that the two fundamental processes of infection and de-infection of schistosomiasis may be expressed as one simple rate process by the following equation (Muench, 1959):

$$dY / dt = A(1-Y) - BY \qquad (1)$$

where Y is the fraction of the population infected with schistosomiasis, A is the force of infection, B is the force of de-infection. Equation 1 states that the rate of change in schistosomiasis prevalence is a function of the rate at which healthy people become infected and infected people lose the infection. An important assumption in the equation is that as infected individuals lose the infection, they join the pool of susceptible individuals. In contrast to previous models (Hairston, 1965), immunity to re-infection is not considered in this model. With S. haematobium infections there is reason to think that changing exposure to snail habitats (as would happen with a new water resource project) plays a more significant role than immunity in the transmission cycle (Warren, 1973).

A solution for Equation 1 for the boundary conditions Y = 0 at t = 0 has been given by Muench (1959):

$$Y = \frac{A}{A+B} \left(1-e^{-(A+B)t}\right) \qquad (2)$$

The model is based on three equations derived from the basic transmission Equations 1 and 2. These equations and their components are shown in Table 2 (page). In the transmission model, the numerical values for the infection rate A, had been determined for several villages from 1964 through 1973 from data collected by the Iranian Bilharziasis Control Project (BCP) staff

(BCP) staff through annual examination of a selected group of 0 to 10 year olds through annual examination of a selected group of 0 to 10 year olds initially diagnosed as negative on the basis of 3-day urine tests. These field values of A are directly related in the model to transmission factors of the disease, snail habitats and number of people infected, by regression analysis. After several different trial regressions, the most successful equation for estimating A was found to be the interaction of meters of accessible snail habitats (H) and number of people infected (P):

$$A = b_0 (H^{b_1} \times P^{b_2}) \qquad (3)$$

where b_0, b_1, and b_2 are determined in the regression analysis.

Meters of accessible snail habitats were chosen as an index of contact of individuals with snail-infested waters. Number of people infected were used to represent the level of miricidial contamination of the water. Each of these variables will be examined and, if so indicated, modified in the proposed study (as suggested under objective 1). It is expected that the regression-established values for the b's will vary according to site; more importantly, it is expected that the interactive form of estimating incidence will remain reliable to use. This relationship is the keystone to estimating levels of infection over time in a given population.

The force of de-infection, B, is the natural loss rate of the disease. The value used in the model was estimated from steady-state data to be 0.2, and is considered constant over all ages and years in the model. The value agrees closely with values estimated by Hairston (1965) for S. haematobium in Syria and Egypt.

Estimates of the forces of infection and de-infection are used in the simulation of changes in prevalence over time. The time unit for the model is one year because that is the unit of time the BCP used for their data collections. Simulation of prevalence is accomplished with iterative use of the following equation:

$$Y_{t+1} = I\,(1-Y_t) - BY_t + Y_t \qquad (4)$$

where Y_t is the fraction positive in the beginning of year t, B is the force of de-infection, and Y_{t+1} is the fraction positive predicted for the end of year t or beginning of year t+1. I is the fraction of uninfected people who become positive at the end of one year. I can be expressed as a function of A and B by solving Equation 2 for Y_t when t = 1:

$$I = Y_1 - Y_0 = \frac{A}{A+B}\,(1 - e^{-(A+B)}) \qquad (5)$$

The STS model simulates changes in levels of prevalence over time A flow diagram which schematically represents use of the model is given in Figure 1. With values of A, B, I, and Y_0 a model run is accomplished by solving for Y_1, Y_2, ... Y_T, where T is the number of years in the planning period, by successive application of Equation 4.

Data on prevalence (Y_0) are required for the initial year of operation. Data required for each year include meters of accessible snail habitats (H) and total population. The data used in the model are corrected to account for actual events that occurred during the year of analysis. For this reason, only meters of accessible snail habitats not molluscicided nor improved by engineering measures are included. A chemotherapy correction

factor, (Q) the fraction of total number of infected people treated over total number infected, is applied when appropriate.

Results of the twelve years of model runs for the Dez Pilot Irrigation Project, Iran from 1961-1973 are depicted in Figure 2. Prevalence predictions for the 54 villages are combined on the graph to give overall prevalence for the project area. Observed values of prevalence are based on annual field surveys in the villages. Model predictions for the area compare favorably with observed values, although it should be pointed out that predictions for certain individual villages are less accurate than the combined values plotted in Figure 2. Model predictions reproduced observed increases in prevalence in the area during expansion of the irrigation system and subsequent decreases in infection level following the initiation of control measures.

TABLE 1 - EQUATIONS AND NOTATIONS

$$A = b_0 \, (H^{b_1} \quad P^{b_2} \,) \qquad \text{(regression)}$$

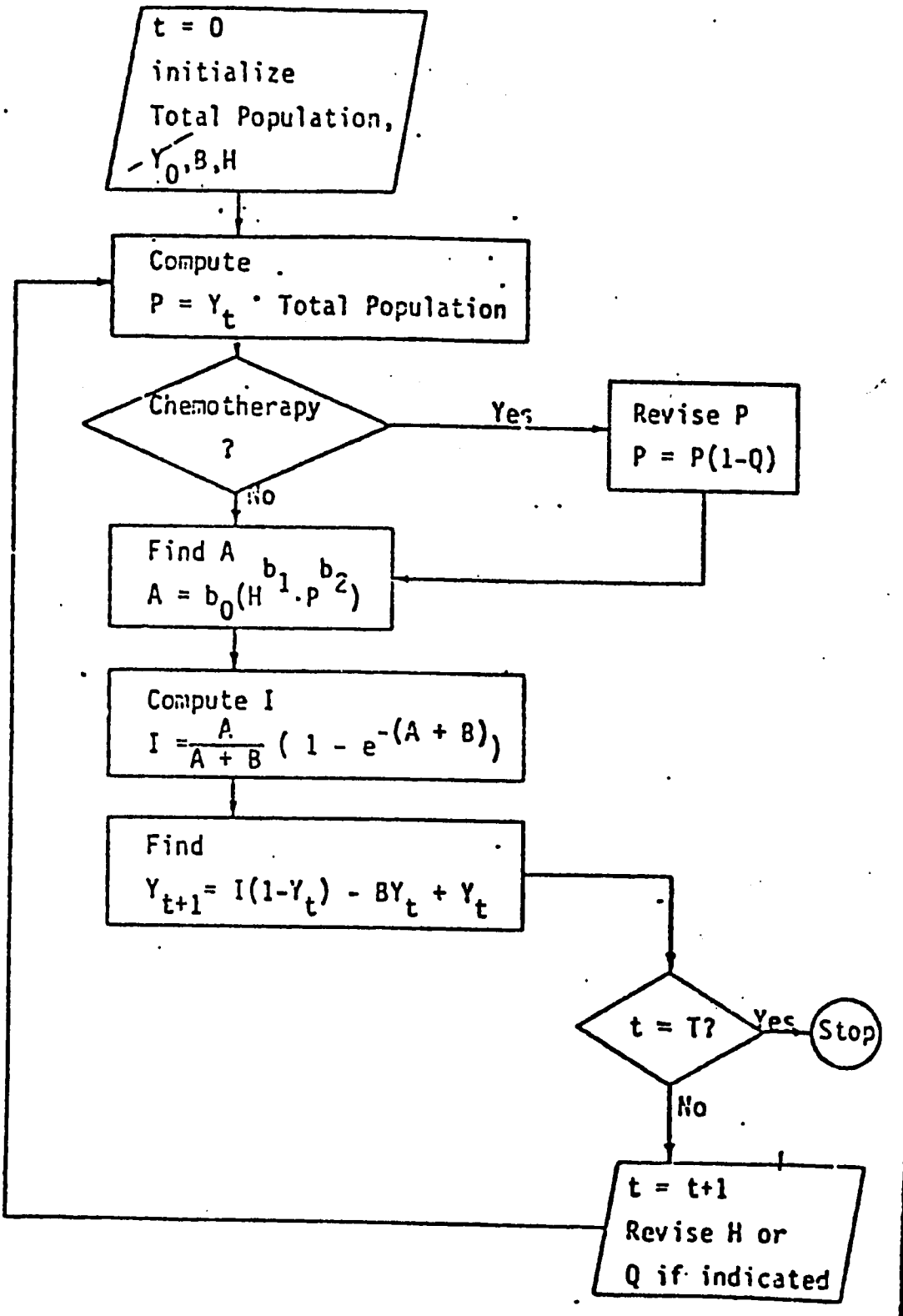
$$I = \frac{A}{A+B} \left(\quad - (A+B) \quad \right) \qquad \text{(transformation)}$$

$$Y_{t+1} = I \, (1-Y_t) - BY_t + Y_t. \qquad \text{(simulation).}$$

A	=	force of infection
b_0	=	intercept of line of best fit in regression equation.
H	=	accessible snail habitat (meters per village).
P	=	people infected (number per village).
b_1	=	regression computed exponent of H.
b_2	=	regression computed exponent of P.
I	=	incidence rate per village (fraction of people that becomes positive over one year).
B	=	force of de-infection per village (natural loss rate).
e	=	base of natural logarithms.
Y_t	=	fraction of population positive in year of analysis per village.
Y_{t+1}	=	fraction of population positive in following year per village.

Figure 1

FLOW DIAGRAM FOR OPERATION OF THE MODEL



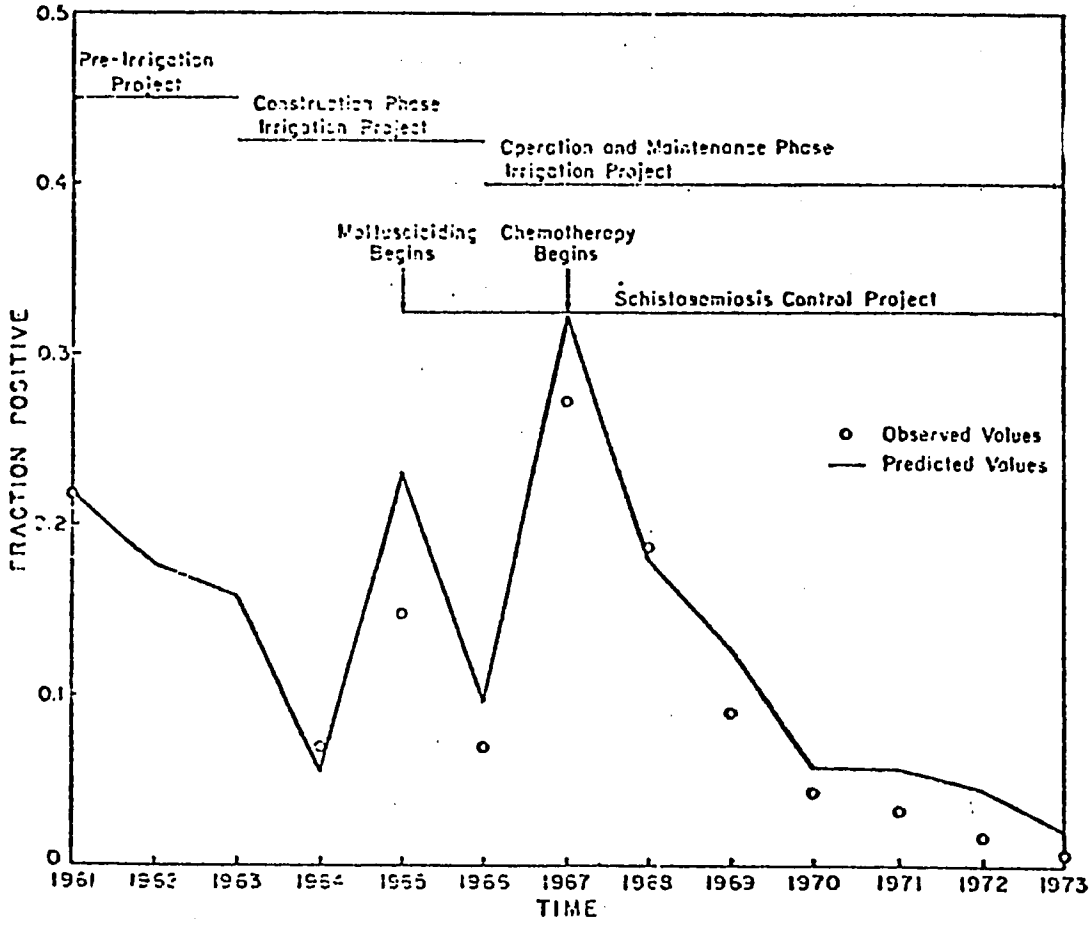


Figure 2. Verification of Model. The predicted values are compared with observed values of prevalence for years of Dez Pilot Irrigation Project construction and operation, and Bilharzia Control Project controls.

3. Proposed Modifications and Work Plan

Additional data that are available to the contractor from the WHO Tanzania 001 project will permit modifications of the model to test the reliability of model predictions. The Tanzania data are from the Misungwi Project area on the southwestern shore of Lake Victoria. The project area covers about 118 km^2 and is inhabited by more than 7000 people. Baseline data in 1967 indicated that there was 60% prevalence by *Schistosoma haematobium* and 10% prevalence of *S. mansoni*. The project ran from April 1967 to October 1975. These data include seven years of age-specific egg count data (a measure of the intensity of infection), observations on the duration and amount of human contact with a variety of water sites (reservoirs, canals, streams, and ponds), extent of snail habitat and seasonal variations in habitat and water contact. These observations were made prior to, during, and following use of control measures so that the data represent baseline and ex post transmission conditions.

One year is necessary and expected to be sufficient for completion of the project. The following factors support this conclusion. The data are now available to the principal investigator but will require considerable use of data processing techniques to put in an appropriate way for use in the modeling exercises. Consultation with other modelers and WHO staff will also be necessary in order to ensure that appropriate modifications are made to the model and transformation of the data are accurate. Past experiences of working with data collected by others have led the principal investigator to recognize the amount of time required to make sure that all uses of the data are fair to the project and accurate in the description of events.

a. Objective 1 - Testing of Schistosomiasis transmission model with data from Tanzania.

Major efforts during the first stage of the project involve refining the model to use egg count data and to incorporate seasonal variation, human water contact and migration data in the transmission equation. In addition, the impact of the different water contact sites will be examined. Computer analyses will be made to accomplish this confirmation and consultation with the staff of the Malaria and Other Parasitic Diseases Division, WHO, when appropriate. In addition, consultations with an ecological modeler, such as David Bradley, Director, Ross Institute of Tropical Hygiene, London School of Hygiene and Tropical Medicine, will provide useful reactions as the confirmation work continues.

This stage is estimated to require a total of 20 man-months of effort from the proposed investigator and assistant, computing time, travel to WHO, office expenses and ecological modeling consultant - for a total cost of $57,155. A preliminary report will be submitted at the end of this stage.

b. Objective 2 - Calculation of costs and effectiveness of different combinations of control strategies to prevent or limit the spread of the disease.

Activities under this objective will lead to an estimation of the costs and effectiveness of alternative control strategies. Included in the analyses will be consideration of possible alternative combinations of control measures, such as the traditional ones of molluscicidiing, chemotherapy, and engineering and the less often used ones of improved water supply, sanitation, and health education. The costs of different programs will be estimated. Finally, different measures of effectiveness will be

examined such as the reduction in the overall prevalence of schistosomiasis, the reduction in egg counts and the prevention of man-years of infection.

The final output will present the rankings of alternative control programs based on the results of the cost-effectiveness analyses.

It is expected that the total time required for this stage is 4 man-months which will be spent analyzing different control possibilities and estimating the costs and effectiveness of the different strategies. This stage will begin after model confirmation. This objective will require 4 man-months of effort on the part of the principal investigator and her assistant, computer time, office supplies, etc. - for a total cost of $11,431 A brief report will be submitted at the conclusion of this stage.

c. Objective 3 - Development of Integrated Methodology for Disease Control.

The third and final stage of the study is to integrate the epidemiological and economic aspects into a useable methodology. This involves using the model to predict prevalence levels in the Tanzania site and to evaluate the costs and effectiveness of controls as used in the Tanzania site in relationship to those predicted levels of prevalence. Verification of the approach will be made by comparing predicted and observed prevalence values, and estimated and actual effects of control measures. Sensitivity analyses of the results will be done by examining how changes in the parameters used to predict incidence and in the measure of effectiveness affect predictions of prevalence and control effectiveness.

The presentation of the results of testing the methodology are expected to be in a form compatible and comparable with development project analyses completed by AID, IBRD, and other donor agencies.

It is expected that this stage will require 3 man-months for completion. At the end of the second month of the study, a final report will be submitted to AID. Inputs for this stage include time of the principal investigator and her assistant (3 man-months), a computer modeler, office supplies, computer time, etc., all valued at $8,573. The final report will be available to AID at the conclusion of this stage, at approximately 12 months after initiation.

2. Project Budget - see Attachment I.

C. Technical Review

An earlier proposal to apply the model to additional data to be developed in Iran was presented in early 1976. Technical and RAC review confirmed the desirability of testing and modifying the model and developing the methodology There were, however, reservations concerning the proposal to attempt cost-benefit analysis, the use of Iranian data and the high cost of the project. The consensus was that limited funds be provided to apply the schistosomiasis transmission simulation model to data available through WHO.

In addition some questions were raised regarding specific aspects of the proposal. These questions have been taken into account in the project as presented here. It is worth noting that the goals of the project have been redefined to accomplish the specific tasks at hand - (1) the testing of the schistosomiasis transmission model under different ecological and epidemiological conditions, (2) the refinement of methods for analyzing costs and effectiveness of control measures, and (3) the presentation of the methods

in an integrated way so that the overall methodology will be usable by AID and possibly other donors. Achievement of the goals will be measured by:

1. Verification of the model with data from Tanzania.

2. Establishment of cost effectiveness rankings of control measures used in Tanzania.

3. Integration of the two parts of the project into a framework that is appropriate for use in water resources project analyses.

D. Plan to Facilitate Utilization of Research Results

As stated before, numerous organizations are concerned over the spread of schistosomiasis. The World Bank, WHO, PAHO, UNEP and others are united on the desirability of identifying effective control measures. All are eager to obtain a method of developing economically sound and environmentally sensible development strategies, and to identify those which are most cost effective.

The results of this study will be disseminated through those agencies and by the scientific and medical press. Within AID, the work should affect projects handled by TA/AGR, TA/H, TA/RD, SER/ENGR and each of the Regional Bureaus.

E. Management Considerations

1. This is expected to be a sole source procurement based upon the role of the proposed principal investigator in the development and other testing of the transmission model and her employment by Resources for the Future, Inc., (RFF).

2. The proposed contractor, Resources for the Future, Inc., is a non-profit organization partially funded by the Ford Foundation. it is capable of providing both administrative and technical supervision plus clerical, accounting, library, etc., as required.

Administrative supervision will be provided by Dr. Emery Castle, Vice-president, RFF, and by Dr. Lincoln Gordon, former Ambassador to Brazil, Assistant Secretary of State and President of Johns Hopkins University. Technical supervision will come through Dr. Clifford Russell, well known economist and environmentalist with expertise in modeling for environmental quality. Additional technical support in the various aspects of the disease and in ecologic modeling will be provided through consultation with appropriate experts. The contractor will provide office space, secretarial assistance, computer facilities and overall guidance. In addition, the Schistosomiasis Unit of WHO has offered their services as reviewers of the research at all stages.

3. The method for project evaluation will be developed jointly by the Agency's Project Manager and external expert advisors.

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ATTACHMENT I

Estimated Life of Project Costs and Budget

	Man-Months	12-Month Contract Per Estimated Cost
1. Salaries		
Principal Investigator (full-time)	12	$22,000
Research Assistant (full-time)	12	10,000
2. Fringe Benefits @ 20% of #1		6,400
3. Overhead Salaries + benefits $38,400 @ 40%		15,360
*4. Consultants	3	9,000
*5. Travel (3 RT to WHO)		2,400
*6. Allowances ($50 per diem/60 days)		3,000
7. Other Direct Costs (none)		---
8. Computing time (including programing assistance, keypuncher, storage and on-line time.)		5,000
9. Supplies (postage, telephone, xerox)		1,000
10. Report preparation		1,000
11. Printing and reproducing		2,000
TOTAL	27	$77,160

*May be negotiated

AGENCY FOR INTERNATIONAL DEVELOPMENT

PROJECT AUTHORIZATION AND REQUEST FOR ALLOTMENT OF FUNDS PART I

1. TRANSACTION CODE: A (A - ADD, C - CHANGE, D - DELETE)

PAF

2. DOCUMENT CODE: 5

3. COUNTRY/ENTITY: TA/H, RDA 13, Research

4. DOCUMENT REVISION NUMBER:

5. PROJECT NUMBER (7 digits): 931-1133

6. BUREAU/OFFICE: A. SYMBOL: TAB; B. CODE: 08

7. PROJECT TITLE (Maximum 40 characters): Water Projects Effects

8. PROJECT APPROVAL DECISION — ACTION TAKEN: A - APPROVED; D - DISAPPROVED; DE - DEAUTHORIZED

9. EST. PERIOD OF IMPLEMENTATION: YRS. 01 QTRS.

10. APPROVED BUDGET AID APPROPRIATED FUNDS ($000)

A. APPROPRIATION	B. PRIMARY PURPOSE CODE	PRIMARY TECH. CODE C. GRANT	PRIMARY TECH. CODE D. LOAN	E. 1ST FY 77 F. GRANT	E. 1ST FY 77 G. LOAN	H. 2ND FY ___ I. GRANT	H. 2ND FY ___ J. LOAN	K. 3RD FY ___ L. GRANT	K. 3RD FY ___ M. LOAN
(1) PH	511	544		77					
(2)									
(3)									
(4)									
TOTALS				77					

A. APPROPRIATION	N. 4TH FY ___ O. GRANT	N. 4TH FY ___ P. LOAN	Q. 5TH FY ___ R. GRANT	Q. 5TH FY ___ S. LOAN	LIFE OF PROJECT T. GRANT	LIFE OF PROJECT U. LOAN
(1) PH					77	
(2)						
(3)						
(4)						
TOTALS					77	

11. PROJECT FUNDING AUTHORIZED (ENTER APPROPRIATE CODE(S)) 1 = LIFE OF PROJECT; 2 = INCREMENTAL, LIFE OF PROJECT

A. GRANT	B. LOAN
1	

C. PROJECT FUNDING AUTHORIZED THRU FY 77

12. INITIAL PROJECT FUNDING ALLOTMENT REQUESTED ($000)

A. APPROPRIATION	B. ALLOTMENT REQUEST NO. ___ C. GRANT	D. LOAN
(1)		
(2)		
(3)		
(4)		
TOTALS		

13. FUNDS RESERVED FOR ALLOTMENT

TYPED NAME (Chief, SER/FM/FSD)

SIGNATURE

DATE

14. SOURCE/ORIGIN OF GOODS AND SERVICES: 000 941 LOCAL OTHER ___

15. FOR AMENDMENTS, NATURE OF CHANGE PROPOSED

FOR PPC/PIAS USE ONLY	16. AUTHORIZING OFFICE SYMBOL	17. ACTION DATE MM DD YY	18. ACTION REFERENCE (Optional)	ACTION REFERENCE DATE MM DD YY

AID 1330-8 (7-76)