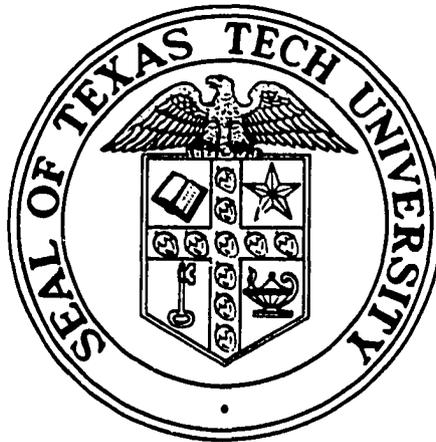


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FINAL REPORT TO:
U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT
AMMAN, JORDAN

REVIEW OF:

"Monitoring of Surface and Groundwater in Jordan
- Request for Financial Aid" Submitted by the Uni-
versity of Jordan and the Royal Scientific Society
through the National Planning Council - April 1981



PREPARED BY:

G. Fred Lee and R. Anne Jones

Department of Civil Engineering
Texas Tech University
Lubbock, Texas 79409

Contract Numbers: NEB-0224-S-00-2060-00

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PREFACE

Many individuals aided in the completion of this assignment, one of the most notable of whom is James Cassanos, an engineer with the US AID in Amman. Boulos Kefaya of the Jordanian National Planning Council (NPC) was helpful during the early phases of the visit in explaining the purpose of the assignment and setting the stage for meetings with various governmental agencies and the university representatives. Dr. Fuad Hashwa, one of the principal investigators of the proposed project, provided assistance especially in reviewing with us current water quality of the surface water resources in the Amman region, including the King Talal Reservoir. Dr. Hani Shakaa of the Royal Scientific Society (another of the principal investigators for the proposed project) spent many hours with us arranging for meetings with various governmental agencies and either personally chauffeuring us or providing us transportation to these meetings. His role in the completion of this assignment deserves special recognition.

During the latter portion of the visit, Dr. Isa Khubeis of the NPC provided assistance in securing meetings with representatives of the Natural Resources Authority. Without these arrangements, this assignment could not have been fulfilled. We also greatly appreciate the time that he took to act on behalf of the president of the NPC to assist us in fulfilling the terms of our contract by meeting with us at the termination of our visit to review our findings and conclusions.

We also wish to thank all of the representatives of the Jordanian governmental agencies and the University of Jordan who took time to meet with us to discuss Jordan's current water quality monitoring programs, the need for additional efforts in this area, and how the proposed project could fill this need. The names and affiliations of these individuals are provided in the text and Appendix A of this report.

We are especially thankful to the Jordanians who provided us with an opportunity to meet with them and their families socially and allowed us to thereby gain some insight into Jordanian culture and social systems. A special thank you is also extended to F. Montanari of the US Aid-Washington, DC for providing us this opportunity, and to his associates, especially S. Freundlich, for working out the contractual arrangements of this assignment.

In addition to the support for this project provided by the US AID, various Jordanian governmental agencies, and the University of Jordan, support was provided by the Department of Civil Engineering and the Water Resources Center at Texas Tech University, Lubbock, Texas USA.

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EXECUTIVE SUMMARY

In response to a US AID request stimulated by a request from the Jordanian National Planning Council (NPC), the reviewers were contracted by the US AID-Jordan to review a proposal for establishing a water quality monitoring program for Jordan submitted by the Royal Scientific Society (RSS) and the University of Jordan. In accord with the provisions of the contract, meetings were held with the agencies involved in water quality management in Jordan, as well as many others concerned with this topic area. Discussions were held with approximately 50 professionals over a 10-day period. Also, over 1000 pages of professional reports, papers and other material pertinent to water quality management in Jordan were reviewed. Further, two, half-day seminars were presented at the University of Jordan in which water quality management approaches being developed and used in the US were discussed by the reviewers. Approximately 50 scientists and engineers attended each seminar; representatives from each of the agencies visited attended.

NEED FOR THE PROJECT

The future economic development of Jordan will be closely linked with the quality of the country's water resources and how they are managed. A key component of water resources development will be a properly designed and implemented water quality monitoring program. There is a definite need for a water quality monitoring program. Some of the activities proposed in the proposed project would overlap with those of ongoing programs. Each of the ongoing programs, however, has deficiencies which could be eliminated by the University of Jordan/RSS proposed project.

In addition to monitoring the waters of the country, there is a need to develop and implement an approach for controlling chemical contaminants in Jordan's water. Upon

review of the "202" regulations recently promulgated in Jordan, it was found that in large part, these values are unnecessarily strict when used as effluent standards. The implementations of certain of these standards will result in expenditures for contaminant control with no concomitant improvements in beneficial uses of the water. There is a need to develop water quality criteria and standards in Jordan for chemicals of potential concern that will protect those beneficial uses of Jordanian waters of significance to Jordanian society. The water quality monitoring program carried out in Jordan must include an assessment of how the concentrations of contaminants in the country's water compare with the criteria - concentrations known to impact beneficial uses.

CAPABILITY OF THE PROPOSED PROJECT STAFF

The principal investigator for the University of Jordan portion of the proposed study is highly talented and is current with the US literature on analytical methods. It was found that he runs a high-quality laboratory and understands analytical procedure and quality control.

The RSS professional staff associated with the proposed project have the potential of becoming proficient in the water quality analysis area. However, at this time, the RSS water laboratory staff is using some analytical methods which are generally known in the US to be unreliable.

Based on a tour of the laboratory facilities of the Natural Resources Authority (NRA) and discussions with the laboratory's director, it is believed that the data being generated by the NRA should be of high quality.

COOPERATION/COORDINATION AMONG WATER QUALITY-RELATED AGENCIES

There is generally poor cooperation, coordination, and communication among agencies currently involved in water quality monitoring and assessment in Jordan. There has been some lack of communication and coordination between the University of Jordan and RSS on "cooperative" work. Measures should be

taken to ensure that these and other similar problems are resolved or will not interfere with the execution of the proposed study.

The funding of this project should include support for the active involvement of professionals outside of Jordan who are thoroughly familiar with the development and implementation of reliable water quality monitoring programs. The primary role of these professionals would be to ensure that the kinds of problems that currently exist in conducting water quality monitoring programs in Jordan will not significantly affect the cost-effectiveness and reliability of the proposed study.

ADEQUACY OF PROPOSED SAMPLING PROGRAM

There are several significant deficiencies with the proposed sampling program, the most important of which is that it is not well developed at this time. It is also clear that the RSS staff has a limited understanding of the approaches that should be used for assessing groundwater quality; significant problems exist with proposed frequency of sampling groundwater.

EQUIPMENT NEEDS

Much of the equipment listed in the budget is needed for the project. There is, however, some duplication of equipment that needs to be eliminated from the budget.

EDUCATIONAL NEEDS IN WATER QUALITY MONITORING

There is need to significantly expand the environmental engineering educational opportunities in Jordan and to include more environmental engineering in the design and implementation of the national water quality monitoring program.

RECOMMENDATIONS

This project should not be funded unless the participants develop a demonstrated, coordinated effort among themselves and with the governmental agencies responsible for water quality

monitoring in Jordan.

It is recommended that a water quality coordinating committee be established with participants representing the RSS, the university, and governmental agencies and industry concerned with water quality monitoring and management in Jordan. This committee would have the responsibility of conducting a review of current water quality monitoring programs in Jordan, recommending the program that the University of Jordan and the RSS should follow as part of this project and ensuring that the project is carried out in accord with an agreed-to program defined by the committee.

SECTION I

INTRODUCTION

In the summer of 1981, the reviewers were contacted by Mr. F. Montanari, a US AID-Washington, DC representative, about their interest in reviewing a proposal developed by the University of Jordan and the Jordanian Royal Scientific Society (RSS) to conduct a water quality monitoring program for Jordan's surface and groundwaters. The reviewers indicated interest and capability in providing technical assistance of this type. In the summer of 1982, they were asked to visit Jordan and provide a critical evaluation of that proposal.

During their approximately two-week visit to Amman, September 3-15, the reviewers met with about 50 individuals representing Jordanian governmental agencies, the University of Jordan, the Royal Scientific Society, as well as the US AID in Amman, Jordan. The purpose of these meetings and the visit as a whole was to:

- (a) determine the need for the University of Jordan/RSS proposed project,
- (b) assess the adequacy of the proposed project to meet the water quality monitoring needs of the country that were not being met by ongoing programs, and
- (c) recommend approaches that would eliminate deficiencies in integrating proposed University of Jordan/RSS with existing water quality monitoring programs.

In addition to meeting with agency and university representatives in Jordan, the reviewers had the opportunity to present two seminars at the University of Jordan. One of these was devoted to the use of the hazard assessment approach for development of water quality management programs in developing countries. The other was devoted to the application of the US OECD eutrophication modeling approach to the management of water quality in reservoirs, with particular emphasis on the King Talal Reservoir. These discussions, which were attended by approximately 50 scientists and engineers,

provided an opportunity to acquaint many of the Jordanians with recently-developed, yet-unpublished, water quality management approaches being developed and used in other countries. The group discussion as well as individual discussions following these presentations provided the reviewers with additional insight into water quality management approaches and problems in Jordan.

The other primary sources of information for making assessments of the proposed project need and appropriateness of approaches were several thousand pages of reports, publications and preprints of publications regarding Jordan's past and current surface and groundwater quality and studies done on their quality. These materials provided an indication of the state of the science and engineering in water quality evaluation in Jordan as well as providing certain background information. These materials are listed in Appendix B.

SECTION II

SYNOPSIS OF MEETINGS WITH AGENCIES AND OTHERS CONCERNED WITH WATER QUALITY MONITORING AND MANAGEMENT IN JORDAN

This section of the report presents a synopsis of the various meetings that the reviewers had with representatives of Jordanian governmental agencies and the University of Jordan concerned with various aspects of water quality monitoring and management in Jordan. Some of the discussions were very general in nature, providing the reviewers with overall impressions of various situations in Jordan rather than specific detail. Some meetings also yielded minimal new information but reinforced information or impressions formed through discussions with others. For the most part the discussion in this section does not provide a repeat of similar information provided by more than one group or individual, nor does it provide detailed review of general discussions. It is designed to present the key information and sources of impressions which served as the basis for the conclusions and recommendations made.

NATIONAL PLANNING COUNCIL

Several meetings were held with members of the National Planning Council (NPC). At the outset of the visit to Jordan, a meeting was held with Mr. Boulos Kefaya and Ms. Janet Abboud of the National Planning Council to obtain an overview of Jordan's current water quality-related activities and agencies, and desired goals for the proposed project. Mr. James Cassanos of US AID and Dr. Fuad Hashwa of the University of Jordan were also in attendance. Mr. Kefaya pointed out that the overall objective of the proposed project was to monitor all water resources (springs, wells, and surface waters) and determine the current quality of each. He also indicated, as others did, that the development of a mechanism by which the monitoring would continue beyond the project period was desired. He identified the

primary Jordanian agencies and briefly discussed their roles in water quality monitoring and management.

Early in the second week of the visit to Jordan, meetings were arranged with another group within the NPC. Dr. Isa Khubeis, Director of the Department of Science and Technology at the NPC, Yousef Batshon, Director of the Infrastructure Department, and Mr. Hussein Shafa'amri, a chemical engineer working with Dr. Khubeis were met. The prevailing feeling given to the reviewers by the Jordanian participants at the meeting was that the study program should first be linked with the NRA and the help of the other agencies elicited as needed. At the end of the reviewers' visit to Jordan, another meeting was held with Dr. Khubeis to discuss general conclusions drawn from the meetings with the various agencies in Jordan and to provide an overall summary of conclusion to him. He was serving as the official representative of the president of the NPC.

During the discussion with Dr. Khubeis, it became clear that he was not familiar with the "Statement of Duties" as called for in the contract covering the reviewers services (See Table I). Dr. Khubeis indicated when he was informed that the proposal as written by the University of Jordan and RSS, was very general in nature and did not provide the information that would enable the reviewers to conduct a detailed review of all components of the proposed monitoring program, that he would like to have the reviewers rewrite the proposal to eliminate these deficiencies. Dr. Khubeis was informed by the reviewers at the time that he first suggested this approach and then again at the final briefing, that such an approach was beyond the scope of duties called for in the contract and more importantly was inappropriate from a technical point of view. The reviewers have had considerable experience in working with groups both in the US and overseas in developing water quality monitoring programs. They have found that developing a program for a group-country in which the program is given to the group rather than generated within the country

TABLE I

ARTICLE I - STATEMENT OF DUTIES

Purpose: To review and evaluate a proposal which was submitted to the National Planning Council of Jordan by the University of Jordan/Royal Scientific Society to monitor surface and groundwater in Jordan and to investigate the implementation of the proposal in terms of coordinating it with a variety of other ongoing and planned water-related activities in Jordan. Finally to provide the National Planning Council with recommendations concerning the implementation and cost of the subject proposal.

Description: The Contractor, as a member of a two-person team, will make a trip to Amman, Jordan and during a period of approximately 25 person days will:

- (A) Review the objectives and methodologies of the UOJ/RSS Proposal and recommend changes (if appropriate).
- (B) Make detailed review of the Proposal's implementation plan and network design, with special emphasis on:
 - 1. Water quality variables to be tested;
 - 2. Procedures for selection and establishment of sampling stations and sampling frequency;
 - 3. Sampling techniques;
 - 4. Analytical procedures;
 - 5. Adequacy of available analytical equipment and need for additional equipment.
 - 6. Adequacy and competence of proposed staff.
- (C) On basis of review of implementation plan, suggest ways of reducing costs, while achieving objectives
- (D) Comment on proposed uses of information from water quality monitoring and improvement program (Phase III).
- (E) Determine if there are adequate provisions for coordination among institutions performing similar studies (such as the Natural Resources Authority's AID financed Groundwater Investigations Project).
- (F) Possibly provide concerned G.O.J. officials with brief (one day) symposium on various aspects of the alternative approaches that could be utilized to conduct a study of the type described in the Proposal.

or group almost certainly results in a significant waste of time and effort. There is no way that a reviewer-consultant who spends a few days reviewing the situation in a particular location, especially in a foreign country, can fully appreciate all of the specific difficulties of trying to carry out a water quality monitoring program. Reviewers-consultants can comment on deficiencies of proposed programs and suggest approaches to eliminate these deficiencies once the investigators of proposed programs make clear the difficulties that they have in carrying out a particular approach within the social, political, economic, and technical constraints that they work. As discussed in other sections of this report, there are many more problems in trying to carry out water quality monitoring programs in Jordan than in the US. Only the Jordanians who have experience in trying to conduct programs on a day-to-day basis are in a position to fully appreciate these difficulties.

It was also pointed out by the reviewers to Dr. Khubeis that there was little point in trying to develop a detailed water quality monitoring program until such time as the various Jordanian groups concerned with water quality monitoring could develop a cooperative working relationship and the details of approach and results of their ongoing programs are shared with each other. The reviewers indicated to Dr. Khubeis in the final briefing that they were going to recommend that the project not be funded unless the various Jordanian agencies and the university develop a cooperative working relationship which would ensure that the funds devoted to the project would be used in a cost-effective, technically valid manner and in the best interest of developing a strong, appropriate water quality monitoring program for Jordan. Such a program would have to include the elimination of the proposed duplication between the proposed project and ongoing programs within the NRA. This point is discussed further in subsequent sections of this report.

UNIVERSITY OF JORDAN

Dr. Fuad Hashwa of the Department of Biology at the University of Jordan has been working with the biologists,

chemists, and hydrogeologists at the University of Jordan over the past three to four years investigating water in the King Talal Reservoir and the Zarqa River system. He has investigated biological aspects of Zarqa River water and sediments, and has also conducted studies on the nutrient and algal characteristics of the reservoir water in conjunction with, as well as independent of, the recently completed RSS study. The characteristics of the reservoir water were therefore discussed with him.

Several other University of Jordan faculty who would be involved in the proposed project were also met: Dr. Elias Salameh, a hydrogeologist at the university; Dr. Leila Hanaineh-Abdelnour, an organic chemist; and Dr. Hani Khoury, a geologist. Discussions were held with the University of Jordan staff on the analytical methods currently in use in their water quality studies. These discussions included consideration of the areas of interest of each faculty member and his/her proposed activities in the project.

An informal discussion was held with Dr. Marwan Kamal, Dean of the Faculty of Agriculture at the University of Jordan. This discussion included the use of fertilizer and pesticides in the development of the Jordan Valley. He also emphasized the significance of the salt buildup problems resulting from drip irrigation on future development of agriculture and water resources of the Jordan Valley. Dr. S. Khader, a soils expert at the university, also discussed some of the industrial wastewater problems and their implications for agriculture of Jordan. He indicated that their problems with salt were not only in the Jordan Valley, but also in the King Talal Reservoir water as well as in the Zarqa and Asraq areas.

A meeting was held with Dr. Subhi Qasem, Dean of Science at the University of Jordan. He stressed the crucial nature of the water resource of Jordan and indicated some of the general areas of activity of the university in water management related areas. He mentioned that the university is

forming a center for water research with the objective to do studies on the quality of water. This service center would continue the current work and expand to find more sources of water. The formation of the center has been approved through the Board of Trustees of the university and will now go to the king for a royal decree. Dr. Qasem called attention to the fact that the initiation of the proposed study between the University of Jordan and RSS will strengthen the relationship between the two groups. This cooperation will then determine how well the project will proceed.

At the time of the visit to Jordan, a geological conference was being held at the University of Jordan. The program on one afternoon appeared to have a number of speakers who would be presenting papers which would be pertinent to the review being made of the overall water quality situation in Jordan. One of the speakers spoke of the mutagenicity of the Zarqa River system water. This individual presented a distorted view of potential mutagenicity problems associated with the use of King Talal Reservoir as a drinking water source. He reported that Ames mutagenicity tests were positive for waters of the Zarqa River which empty into the King Talal Reservoir, citing heavy metals and metabolites as potential culprits. What he did not discuss was how his results compare with results of similar tests on the actual raw water (i.e., King Talal Reservoir water) or on raw drinking water sources common in the developed world. He also did not make an evaluation of the change in mutagenicity of the water after conventional domestic water treatment. Further, the data presented were for samples collected between October 1981 and April 1982, apparently before treatment implementation was begun at the various industries along the Zarqa River; what is currently being discharged by these industries may be substantially different from that discharged during the study period. The situation with this paper is not atypical of what was frequently encountered by the reviewers while in Jordan. Some

Jordanian national water quality policy has been based on a limited understanding not only of water and wastewater treatment processes, but also of proper evaluation of the hazard that contaminants in water represent to man and the environment.

VISIT TO ZARQA RIVER AND KING TALAL RESERVOIR

A visit to the Zarqa River basin and to the King Talal Dam was made with Dr. Hashwa and Dr. Gerd Föerch, a German engineer who was Visiting Professor of Environmental Engineering at the University of Jordan. Dr. Föerch provided information on the Ain Ghazal wastewater treatment plant serving Amman. According to him, it was designed more than 15 years ago by a Swedish firm, for a population of 250,000 using a European water usage of 200 liter per day per person. The current water usage in Jordan is approximately 60 liters per day per person which makes the treatment plant underloaded in terms of water, but highly overloaded in terms of biochemical oxygen demand (BOD). The plant was designed to treat wastewaters of about 250 mg/l BOD, whereas the wastewaters it is receiving have about 1000 mg/l BOD.

This situation further points out the lack of native environmental engineering within Jordan. In the opinion of the reviewers, far too much emphasis has been placed on foreign environmental engineers who do cursory studies and then recommend a course of action for the country to follow. While developing countries like Jordan must rely heavily on foreign engineering talent in the development of their water supply and pollution control facilities and programs, they must also have sufficient Jordanian talent to ensure the proper incorporation of Jordanian social, cultural and economic factors into the design of the management program or facilities.

One of the greatest overall environmental needs of Jordan in the water quality monitoring and management field, is in the environmental engineering area. There is a significant deficiency in Jordan today in the use of the well-established

principles and practice of water and wastewater treatment. Major governmental decisions have been made in Jordan, such as not to use the King Talal Reservoir waters for domestic water supply purposes, without a review of the commonly followed water treatment practices of Western Europe and North America. It is also readily apparent upon review of the recently adopted "202" regulations that those who formulated these regulations have limited understanding of normal environmental engineering practices in assessing the significance of contaminants in impairing beneficial uses of water and in determining the degree of treatment necessary to protect beneficial uses. Water quality monitoring programs must be developed for the purpose of providing a technical base of information on which water quality management programs can be formulated. The development of monitoring programs without a good understanding of management principles and practices normally results in inadequately defined current or projected water quality. This is the situation that will likely occur in Jordan unless there is a much greater input of environmental engineering principles and practices into the water quality monitoring programs. It is essential that a high priority be given to the development of environmental engineering education in Jordan to eliminate the current deficiencies of talent in this area.

Dr. Föerch and Dr. Hashwa indicated that the first heavy rain each year which usually occurs in October, washes approximately six months of contaminant accumulation from the Zarqa basin and surrounding areas into the Zarqa River and King Talal Reservoir. This situation is of particular importance in establishing a water quality monitoring program for the Zarqa River and King Talal Reservoir since during that time approximately one-half of the annual load of some contaminants enters the reservoir. As far as the reviewers have been able to ascertain, the previous and ongoing monitoring programs of the river and reservoir have not given adequate attention to this situation.

The water in the Zarqa River downstream of the Ain Ghazal

treatment plant can no longer be used for irrigation according to governmental policy. This policy appears to the reviewers to be an over-reaction to the cholera scares of the past several years. While the waters in this area should not be used for irrigation of vegetables which come in contact with it, these waters could readily be used for irrigation of a wide variety of other crops. This situation also demonstrates a lack of understanding within Jordan today of normal public health and environmental engineering principles and common practices in other parts of the world.

During the visit to the Zarqa River at the Jerash Bridge, just upstream of the reservoir, it was observed that the water was highly turbid and that there were small fish in the water. Dr. Hashwa indicated that these fish were some type of "trout." The presence of these fish indicates that the chemical characteristics of the water at this location did not preclude the existence of fish there. This situation points to an important aspect that must be considered in the development of a water quality monitoring program for Jordan. While not verified by the reviewers, it was reported by several individuals that there are substantial discharges of heavy metals and other potentially toxic contaminants from municipalities and industries upstream of the Jerash Bridge. If this is the case, it appears that the contaminants from these sources are, at this point, unavailable or have considerably less availability to affect aquatic life than expected based on the total concentrations of contaminants present. This decreased availability would be due to the suspended solids - particulate matter in the river. Normally under conditions of high turbidity, the commonly measured "total" contaminant concentration provides a poor estimate of the potential impact of the contaminant on aquatic life or other beneficial uses of the water. It is important that any water quality monitoring program for Jordan include use of bioassays to assess the availability of contaminants. The proposal as submitted is significantly deficient in considering the availability of contaminants. This must be remedied if Jordan is to

avoid many of the errors made in the US and elsewhere in the development and utilization of water quality monitoring programs.

Two of the engineers responsible for King Talal Dam operations, Mr. Naim Dabbur the site engineer, and Mr. Rajeh Masser, were met during the visit to the dam. They reported that the dam is to be raised about 15 m beginning in February 1983.

The reviewers obtained conflicting information on the depth of the water at the dam. This discrepancy is being pointed out in this report since it has apparently affected the water quality monitoring program currently underway by the RSS with the assistance of the University of Jordan. An incorrect estimate of the depth caused an error to be made in locating the deepest waters for sampling. Hence the water at the deepest, and one of the most important parts of the reservoir, near the dam, was not sampled in that study.

In reviewing the studies on King Talal Reservoir, it was learned that at times there were significant problems in obtaining the samples from the reservoir. These problems have been caused by such events as a boat operator's going on vacation without having the JVA's designating another operator. During the reviewers' visit to the reservoir, Dr. Hashwa had intended to take the reviewers on the reservoir and to collect water samples at the same time. Upon arrival at the dam, Dr. Hashwa learned that the boat operator had gone on vacation and that no one was available who was authorized to operate the boat; Dr. Hashwa indicated that he has encountered similar problems in obtaining university drivers to transport sampling crews to the reservoir or river. These types of problems are symbolic of overall problems that exist in Jordan with respect to the importance given to achieving the objectives of a particular sampling program. It appears to the reviewers that the primary limitations on sample collection are often beyond the control of the investigators, namely availability of transportation. This could readily result in the failure to collect some of the most crucial data of a monitoring program. At this point, the reviewers are uncertain as to the cause of these logistics

problems. The principal investigators must give supporting groups sufficient notice to allow them to arrange suitable transportation; the supporting agencies must be sufficiently committed to the project to provide substitute drivers/operators, or to allow the principal investigators to operate the necessary vehicles. Failure to achieve this kind of logistics support would, in the opinion of the reviewers, raise serious question about whether this project should be supported. It should be noted that to the knowledge of the reviewers, the type of sample collection logistics problems encountered by Dr. Hashwa is essentially unheard of in the US.

US AID

A meeting was held with Mr. Thomas Pearson, Mr. Larry Brown, and Mr. James Cassanos to discuss the involvement of the reviewers in this project. Mr. Pearson indicated that one of the primary concerns for the proposed project was whether the proposed measurements and sampling periods would be satisfactory to meet the objectives of the study. He also expressed a concern about the adequacy of the proposed study program for assessing the current water quality of the Jordanian groundwaters.

Mr. Cassanos, in response to questions about the breadth and depth of the review of the proposal, indicated that US AID wanted something fairly definitive on the appropriateness of the proposed study, and recommendations on the organization and the scientific aspects of the project including equipment needs compared with equipment requested. He felt that the NPC would be interested in discussing any methods to guarantee that the program would be continued beyond the initial three-year study phase.

The reviewers feel that they have obtained a good overview of current Jordanian water quality monitoring programs and capabilities to conduct such programs with the key findings being discussed in this report. Considerable difficulty was encountered in evaluating many of the details of the pro-

posed project as called for in the "Statement of Duties" (Table 1). This was largely because the principal investigators of the proposed project had not yet developed many of the details of the study program. As discussed subsequently, the investigators were unable to provide the reviewers with detailed information on where and when the samples would be collected and in some instances, what would be measured. There was even disagreement among the investigators as to whether the proposed project was to sample all waters of the country or to be essentially restricted to the waters of the Amman region. As indicated in the above statements, these difficulties were discussed in detail with Mr. Cassanos on several occasions during the reviewers' visit to Jordan and with Mr. Pearson and Dr. Isa Khubeis of the NPC at the final briefings by the reviewers at the end of their visit. In the briefing document prepared by the reviewers and provided to Mr. Pearson on September 14, 1982. under Section IV, Sampling Program, (A) states, "The sampling program proposed is not fully developed." Section VIII, Recommendations, (A) states:

"Do not fund the project unless:

2. A new proposal is submitted which discusses existing water quality monitoring programs in detail. This revised proposal must also outline the details of how the proposed study will complement the existing projects, and define sampling frequency and specific locations. A clearly defined mechanism for governmental agency assumption of the expanded water quality monitoring program resulting from this project

should be delineated in the revised proposal."

As indicated in the above statements it was impossible for the reviewers to provide an assessment of the appropriateness of the details of the proposed monitoring program beyond recommending that before the project is funded, these details be clearly thought out, specified and reviewed by qualified professionals. The reviewers discussed with the RRS and the University of Jordan staff the thoughts of the proposed investigators as well as their own general recommendations for sampling frequency and locations, and parameters of importance. They also gave these staff members materials describing how surface and groundwater quality studies should be carried out. This information should be used by the project's principal investigators to develop a revised proposal in accord with the recommendations made by the reviewers.

ROYAL SCIENTIFIC SOCIETY

Dr. Hani Shakaa, Head of the Environmental Protection Section of the Royal Scientific Society (RSS) was the reviewers' primary contact at the RSS. The reviewers spent many hours with him discussing water quality monitoring and management within Jordan. Dr. Shakaa also reviewed the development of the RSS which was established in 1970 to help Jordan's industrial development. Between 1972 and 1973, it was largely a mechanical engineering group. In 1980, work on the Zarqa River system began at the RSS and in 1981 to 1983, they have been and will continue to work on assessment of the King Talal Reservoir water quality.

Dr. Said Alloush, Head of Organics and Spectroscopy at the RSS, discussed some of the work in which his group has been involved. This work has been directed toward pesticide

residues in vegetables, and other aspects of food technology.

Dr. Albert Butros, Director General of the RSS, provided a discussion of the responsibilities and involvement of the RSS. It was designed to be a national applied research institute providing high-level technical support for contract work.

A tour of the RSS laboratory facilities was made to determine the kinds of equipment present in these laboratories that could be used for this project. It was found that a Hach kit was being used for nitrate, nitrite, phosphorus, and pH measurements. It was pointed out by the reviewers that the Hach kit does not provide reliable analyses for many of these parameters in many types of water. It would not be accepted in the US as a reliable method for water quality monitoring of the type required for the proposed project.

The RSS has an atomic absorption spectrophotometer which has been sent to Germany for repairs; the lab staff does not expect it back for another six months. From the reviewers' discussions with several groups, it became apparent that equipment repair is a serious problem in Jordan. It is clear that a water quality monitoring program of the type proposed cannot be done under existing arrangements for equipment repair. Either duplicate equipment has to be provided or a more effective mechanism developed for processing of samples at some other location when equipment breakdown occurs.

It was also found that there were several other problems with the RSS water analysis procedures. These included the use of the phenol disulfonic acid method for nitrate. It has been known in the US for many years that this method is unreliable. The RSS laboratory staff was also inconsistent in its filtration of samples. Samples were only filtered when the technician felt that they were "excessively turbid." There was an apparent lack of understanding of the role of colloidal and other suspended matter in influencing water quality analytical results and hence, of the significance of the way they were handling the samples. The reviewers found

that the analytical quality control used by the RSS was inadequate for routine water analysis.

The reviewers met several times with Dr. Arafat Tamemi, Head of the Industrial Chemistry Department at the RSS. He discussed with them various aspects of RSS's involvement in water and other research in Jordan. He also provided information on the RSS's involvement in education.

The reviewers also met with Mr. Khadra Mohamed, a chemical engineer at the RSS who apparently had primary responsibility for preparing the recent RSS report on its King Talal Reservoir studies. The reviewers pointed out to him a number of problems with the report. There was confusion regarding such things as station numbers, the units of measurement used for a number of the chemicals such as phosphorus and nitrogen compounds, and the analytical methods used for these analyses.

A meeting was held with Dr. F.A. Daghestani, Technical Director of the RSS. He discussed the philosophy behind the RSS's involvement in the proposed joint project. It became apparent upon discussions with Dr. Daghestani that there was not agreement among the RSS staff and administration on the role that the RSS should play in water quality monitoring in Jordan. Dr. Daghestani indicated that he would like to see the RSS assume a major role for routine water quality monitoring in the country. The reviewers and others feel that this is an inappropriate role for the RSS. Water quality monitoring programs should ultimately be carried out by governmental agencies that have designated responsibilities for water quality management. In the opinion of the reviewers, the RSS should focus on developing programs and approaches for water quality monitoring. They should not, however, devote a substantial amount of their facilities and resources to long-term routine monitoring.

While visiting with the RSS staff, the reviewers met Dr. Musa Nazer, formerly of the Chemistry Department of the University of Jordan. He has an interest in environmental chemistry in the Chemistry Department there. He has also been involved

in the Arab Chemistry Research Project which is a regional activity of the Arab states under the overall auspices of the UNESCO science and technology group.

WATER SUPPLY CORPORATION

A meeting was held with Yasin Kaed, Director General, and Colonel Aref Baha-Eddin, Deputy Director General of the Water Supply Corporation. The Water Supply Corporation is responsible for municipal and industrial waters outside Amman and outside the Jordan Valley. Agricultural use of the water is, however, under the jurisdiction of the NRA and the Ministry of Agriculture. Industrial uses include electrical utilities. The Water Supply Corporation assumes responsibility for the water after the NRA has found water sites, drilled wells, sampled the wells, tested the samples, and provided a water quality report. The bacteriological quality of the well water is monitored by the Ministry of Health. The chemical quality, according to the Water Supply Corporation, is initially defined by the NRA. It appears that there is no systematic, subsequent sampling of the waters, however, after the initial NRA study.

In the opinion of the director general and deputy director general, there are two major water quality problems in Jordan. One is the problem of salt buildup in the water north of the Zarqa area and the second is the problem of disinfection of drinking water. According to them, there is no evidence that rural water supplies they are using have been linked to the cases of cholera; they are injecting 2.5 to 3 ppm chlorine for treatment. There are very few places having organic matter in the well water although in certain areas, there are elevated BOD and COD levels in the well water apparently due to cess-pool infiltration. They cited Amman as one area in which this occurs. The nitrate concentration in well water outside the Amman region is reportedly lower than that in well water in the Amman region.

A meeting was also held with Engineer Akram Najjar and

Engineer Omar Shadid of the Water Supply Corporation who have the responsibility for collecting information on the quality of the water for which the Water Supply Corporation is responsible. Discussions were held on the kinds of studies that are being done, frequency of sampling, and data storage and retrieval methods.

It was found that the data that have been collected previously by the agency were not in a form that could be readily reviewed by the reviewers. It was concluded by the reviewers that such a review should be made, however, in order to ensure that an adequate water quality monitoring program was being conducted by the Water Supply Corporation to meet the needs of the country and especially its urban population. While detailed information was not available to the reviewers on the nature of the ongoing program, it was their impression that there are significant deficiencies in the program that could and should be eliminated by a new water quality monitoring program such as that proposed by the University of Jordan and the RSS. It appears to the reviewers that neither the University of Jordan nor the RSS had critically reviewed the current Water Supply Corporation's current water quality monitoring program in order to integrate and coordinate their proposed program with ongoing programs by this agency. The reviewers found that there are significant deficiencies in the proposed project which should be eliminated before the project is funded with respect to monitoring urban water quality.

AMMAN WATER AND SEWERAGE AUTHORITY

Discussions were held with Mohammad Kilani, General Manager of the Amman Water Sewerage Authority (AWSA). This agency has responsibility for the water in the Amman area. Most of the approximately 30 wells in Amman are in shallow aquifers; two or three of them are essentially surface waters which are adjacent to the wells. Engineer Kilani indicated that they were of acceptable quality, but were not excellent. Most of the water for Amman is obtained from wells in the

Asraq area.

The characteristics of the AWSA wells are being monitored under the supervision of Howard Humphreys Consultants who also supervised the development of the Asraq project. The monitoring program, begun in 1982, consists of several sections: water levels are measured weekly; biological analyses are conducted periodically by the Ministry of Health; chemical analyses are done in-house. Engineer Fayez Bataineh and Dr. Saqer Salem provided information on the current chemical monitoring program for the springs and wells, as well as the sewage from Amman.

Mr. Kilani indicated that the wastewater treatment plant for Amman, the Ain Ghazal treatment plant, was currently about 70% overloaded. On the order of 50 to 60% of Amman is serviced by this plant; the remainder of the inhabitants have cesspool systems. The current peak discharge from the treatment plant is 37,000 m³/day. This is consistent with, but is about one-third higher than the discharge computed based on the 700,000-person population estimate for Amman cited by Dr. Shakaa, and the 60 l/person/day water use estimate provided by Dr. Föerch. According to Mr. Kilani, it is expected that 75% of Amman will be sewered within the next year. Within two to three years he expects more than 90% of the city to be sewered. This should result in a significant increase in the wastewater flows from Amman which should be considered as part of developing any expanded water quality monitoring program for the country. The reviewers found that the principal investigators for the proposed project had given inadequate attention to these changes that will take place in Amman's wastewater discharges in developing their proposed water quality monitoring program. Since the wastewaters from Amman represent one of the most important water resources of the country, any expanded water quality monitoring program must, if it is to meet the needs of the country, appropriately incorporate studies to determine the characteristics of Amman's domestic wastewaters and their impact on the surface and groundwater resources of the country. Inadequate attention has been given in the proposal to

this area.

There has been a variety of proposals put forward for the expansion of the Amman and vicinity sewage treatment facilities. At the time of the reviewers' visit, they were planning for a central treatment plant which would be located in the Sukhneh area, approximately 25 km downstream on the Zarqa River from the Ain Ghazal treatment plant. A sand filter was to be incorporated into the new plant for removal of coliforms and other organisms of public health concern. They would not be treating the industrial wastewaters directly at this plant. Instead, the industries will have their own package treatment plants. The plan which Mr. Kilani indicated was, in his opinion, one of the most desirable was to connect the Ain Ghazal treatment plant to the treatment plant in the Sukhneh area with a reinforced concrete pipe into which the industries would discharge their treated wastewaters. This effluent, combined with the treated effluent from the central treatment plant, would then be discharged directly into the King Talal Reservoir. He felt that this option would allow the agricultural land along the Zarqa River to be reclaimed. The reviewers found that this particular plan has numerous, obvious deficiencies in it and would likely be cost-ineffective for Jordan to implement. In discussing the proposed piping plans, Mr. Cassanos indicated that plans were underway to expand the Ain Ghazal treatment plant from 30,000 to 45,000 m³/day and to build a new facility with a capacity of 30,000 m³/day, making a total treatment capacity of 75,000 m³/day.

Subsequently, the reviewers were informed by Mr. Pearson of the US Aid that the proposed expansion of the Amman sewage treatment plant, as discussed above, had been abandoned in favor of a desert irrigation program in which the effluent from Amman and other communities of the region would be transported to an oxidation pond(s). The effluent from this pond would be used for irrigation.

MINISTRY OF HEALTH

The Ministry of Health's role in water quality evaluations

was discussed with Dr. Suleiman Subeihi. He indicated that on a once-per-week basis the Ministry of Health staff measures fecal coliforms at all water supply sources. They also periodically collect surface water samples and sewage. He emphasized that the recent cholera outbreaks were not water-borne, but rather the organisms were transmitted in food; cholera organisms have never been found in Jordan's water sources. There is apparently some problem with recontamination of water that is stored in individual homeowners' storage tanks, especially in the Zarqa area where they do not chlorinate as well as in other areas. In general, the water is heavily chlorinated because of poor distribution systems which are often not under positive pressure. This situation can readily lead to recontamination of drinking water in the distribution system because the chlorine residual is not and cannot be readily made to be sufficient to provide adequate disinfection under these conditions. This is especially noted in the Amman and Zarqa areas. There is supposed to be a free chlorine residual in the water of 0.5 mg/l, but if this level drops to 0.2 or 0.3 mg/l, this is also acceptable. The analytical method used by the Ministry of Health for chlorine is the OTA method. This method was discontinued in the US several years ago, since it was found to be unreliable, but is still apparently recommended by WHO. The Ministry of Health is also concerned about high nitrate in some Jordanian groundwaters. For example, in the Ramtha area concentrations as high as 100 ppm of NO_3^- have been found.

Mr. Pearson of the US AID pointed out to the reviewers that at least in some instances in Jordan, water supply and sewage pipes are laid in the same ditch. To the extent that this occurs, there is even a greater hazard of significant contamination of drinking waters by wastewaters than would normally occur where the water supply system is not kept under positive pressure. As discussed with Mr. Pearson, this situation necessitates a markedly different monitoring program for the water supply system than is typically used for systems kept under positive pressure. The reviewers were unable to find

any evidence that those conducting the monitoring of domestic water supplies had designed their program to consider this situation.

Dr. Subeihi indicated that the problem of hazardous waste discharges was especially pronounced in the Zarqa area where most of the light industry in the country is. The Ministry of Health has had some chemical analyses of waste discharges done although the presence of carcinogens, pesticides, etc. in the drinking water is not, at this time, a high priority for water quality monitoring by the Ministry of Health. Dr. Subeihi thought that the greatest needs for additional work in water quality monitoring management in Jordan were in two areas. First, the establishment of capable laboratories to conduct analyses, and the second was in connection with industrial chemicals. He also reported that there was no evidence of mercury or cadmium levels in fish although it was not clear who, if anyone, measured the chemical content of fish. There are problems with fluoride contamination of the water associated with the phosphorus mining in the Zarqa area. He felt there should be no problem with future development of surface water supplies in Jordan if there were no chemical pollution of the water. When asked about the overall role of the Ministry of Health in evaluating and making recommendations for guarding the quality of water, Dr. Subeihi indicated that the Ministry of Health's role was only in testing and providing advice; it has no regulatory authority.

There has been a committee developed for new industry discharge which includes the Ministry of Health; Ministry of Municipal, Rural, and Environmental Affairs; RSS; NRA; and others. If, for example, a recommendation were to be made for phosphorus control in an effluent, the Ministry of Health or the committee, of which the Ministry of Health is head, could make this recommendation. There is also a move to regulate toxic chemicals which are entering the country.

The Department of Environmental Health is part of the Ministry of Health. A tour was taken of the Department of Environmental Health laboratories, which was conducted by

Dr. L. Oran, a pathologist there. Most of their work was being done on the analysis of foods, although they apparently measure cholera organisms, salmonella, shigella, as well as E. coli and fecal streptococcus occasionally in water and wastewater. They do not attempt to measure waterborne viruses.

JORDAN VALLEY AUTHORITY

The Jordan Valley Authority (JVA) has responsibility for all of the water in the Jordan Valley. The King Talal Reservoir also is under its jurisdiction. The role of the JVA in water quality monitoring and management was discussed with Dr. Munther J. Haddadin, Acting President of the Jordan Valley Authority. He pointed out the need for continuous quality monitoring as well as quality control. While they had not tried to set up a separate laboratory to maintain quality control, the JVA staff has indicated what measures should be taken. Only when the need arises do they request specific testing. In those cases, the RSS or a contract laboratory does the analytical work.

The JVA is also concerned with the quality of groundwaters in the Jordan Valley. There is particular concern for the sanitary quality, heavy metals, and salt. There apparently is no problem with the sodium adsorption ratio (SAR) for the use of the water for irrigation. As far as the King Talal Reservoir water is concerned, since the water is not used for irrigation until approximately 40 km downstream from the discharge, the JVA feels that there is no health or trace element problem with the reservoir discharge. Severe salinity problems are expected by the JVA within the next couple of years in the Jordan Valley; it is therefore setting up a soils and water quality laboratory for the evaluation of the salinity problems in the valley. According to Dr. Haddadin, the greatest water quality problem facing the JVA is the preservation of the quality. They are expecting to reuse 50% of the water for irrigation in the Jordan Valley. There is concern with the salt buildup as groundwater areas are recharged. There is also concern about the recharge rate.

Because of the lack of drainage of the irrigation water back to the river, the salt content of the groundwaters increases. This higher salt content water is currently blended with other irrigation water for reuse. Primary crops grown in the Jordan Valley include citrus, bananas, green beans, tomatoes, eggplant, cantaloupe, watermelon, onions, and corn. The potential problem with boron in the water with the citrus crop was pointed out. The potential role of household detergents as a source (via domestic wastewaters) of boron for the King Talal Reservoir was also discussed.

In all, the Jordan Valley Authority is in charge of approximately 80% of the water resources of Jordan and is in need of technical assistance. Dr. Haddadin advocated the pipe system described by Engineer Kilani, but did not believe that the treatment plant effluents were to go directly to King Talal Reservoir. The JVA is interested in the modeling of salt buildup in its reused waters.

As with other agencies, there was little evidence that the principal investigators for the proposed project had attempted to integrate the proposed project with the proposed activities and needs of the JVA for water quality monitoring in the Jordan Valley. The reviewers feel that before the project is funded, a significant attempt should be made to integrate the proposed project with current JVA activities in the Jordan Valley to ensure that an appropriate water quality monitoring program is developed for that part of the country. Failure to do so could readily result in serious water quality problems developing in the Jordan Valley which would have significant impact on Jordan's economic development.

MINISTRY OF MUNICIPAL, RURAL, AND ENVIRONMENTAL AFFAIRS

A meeting was held with seven members of the Ministry of Municipal, Rural, and Environmental Affairs, Department of the Environment. These were: Daher Hajaj, geographer; Dr. Salih Sharu, agriculturist and chief of the Land Protection Division; Ahmais Rusan, social researcher; Gazi Odat, chemical engineer; Suleiman Hanbali, landscape planner; Dr. Khaled

Amin Sharaiha, chief of the Department of Air Pollution; and Ziyad Alawneh, a chemical researcher. Mr. Alawneh was, for the most part, the spokesperson for the group. He indicated that this was a new department created in Jordan in about 1980. Its staff is currently composed of ten people. Although the group supposedly has water quality monitoring responsibility, it is not now directly involved in water analysis. It sends such work to other agencies, such as the RSS. Eventually the department will have a laboratory. The mandate of this group does not include enforcement authority although it was established to have some legal authority. It can and does make recommendations to the government as to what should be done. For example, the "202" guidelines in Jordan came from this group.

The current activities of this group are centered on redirecting development in Jordan, that is municipalities and industries, away from groundwater recharge areas. Mr. Alawneh indicated that because cities are already located near water sources, these sources are already "polluted." They are moving several communities out of particular recharge areas and feel people are listening to them, especially in the Asraq and Baqaa areas. They are also looking at hazardous waste and air pollution problems, and are aware of pesticide problems in the Jordan Valley, but this group did not think that they had made any recommendations to the government regarding the use of pesticides there. The approach for establishing regulations or standards for pesticides would be that this ministry would make recommendations to the Ministry of Trade and Industry, which would, in turn, make a recommendation to the Prime Minister.

From the discussions with the representatives of the Ministry of Municipal, Rural, and Environmental Affairs, the reviewers concluded that many of the actions of this group, with respect to relocating people and industry, were being made without having an adequate data base to justify this relocation. This is clearly a case where there is an urgent need for a significantly expanded water quality monitoring

program which could serve as the basis for formulating population redistribution programs in order to protect and enhance the country's water resources-water quality.

This group is not now directly involved in the King Talal Reservoir situation. The RSS apparently made a recommendation to this group that all industry in the Zarqa River basin treat and obtain permits for their new discharges. The Ministry of Municipal, Rural, and Environmental Affairs approved this recommendation and sent it on to the Prime Minister. They believe that there will be a national law for pollution control within the next two years and believe that the country is heading toward establishing a national council for water, an overall group having responsibility for water, an umbrella for all the other groups. They are hoping to get bacteriological equipment within the next budget period to conduct some of their own analyses.

NATURAL RESOURCES AUTHORITY

A meeting was held with Yousef Nimry, Director General of the Natural Resources Authority (NRA). Mr. Nimry pointed out that the NRA has water laboratories which are doing chemical analytical work on water samples. They are not doing bacteriological analyses but are instead sending these samples to the Ministry of Health for analysis. The NRA has a regular sampling program with emphasis on the sources of water currently used for drinking which include springs, wells, and streams in the countryside. The NRA also does testing for commercial suppliers of water. In the Amman area there is regular sampling of wells except those for which the Amman Water and Sewerage Authority has the responsibility. Standards such as those of the WHO are used in drinking water data interpretation. They do not have a standard system to review and interpret data that they collect which is now stored in files. The computer storage of data is limited to certain of the sites that they are monitoring. The NRA produces special pamphlets every three years with hydrologic data in them. The reviewers have examined several of these

pamphlets and have found that they are largely tabulations of data with little or no interpretation. There are data currently for water quality parameters in the files. The NRA also acts as an educational institute but this aspect was not elaborated upon. Mr. Nimry indicated that the NRA will become or should become more involved in pollution problems like pesticides. The NRA is conducting hydrology studies in the Asraq area, but not for quality characteristics; they are measuring precipitation, flooding, wind, humidity, and similar parameters.

Another of the objectives of the NRA is to define the areas of water recharge. It is mostly directed toward springs and private wells, but does not give much attention to anything under control of AWSA or the Water Supply Corporation. Mr. Nimry reported that the Ministry of Health uses the NRA as an arbitrator with AWSA, and the Water Supply Corporation also asks the NRA for help. The NRA tries to coordinate with all the various agencies, according to him. The NRA, according to Mr. Nimry, is the only group that is supposed to be in charge of water resources but they find it is distributed among the JVA, AWSA, etc. Mr. Nimry also indicated that the government was wanting to develop one group to be in charge of all water in Jordan.

The NRA will be collaborating with the US Geological Survey (USGS) in a \$5 million project financed by the US AID, in the Amman and Asraq areas of Jordan. This project is providing a computer for water data storage/retrieval for water quality control purposes although they have not procured the computer yet. The USGS will provide the software. The NRA has already recruited a hydrogeologist and a computer person as advisors for this project.

The NRA has some apparently vague responsibility for water quality monitoring in the King Talal Reservoir. The reservoir belongs to the JVA and was designed mostly for irrigation water supply. It is, therefore, JVA's responsibility. However, the NRA has also been monitoring chemical characteristics of the reservoir's water. The NRA is, accord-

ing to Mr. Nimry, monitoring for "all" pollution parameters in the King Talal Reservoir. He believed that another group was responsible for sewage pollution aspects of the reservoir.

Following the meeting with Mr. Nimry, the reviewers met with Mr. Abdelhamid Khatib, the engineer in charge of the water analysis laboratories for the NRA. Mr. Khatib indicated that they are measuring all sources of water at least yearly for a variety of water quality parameters. They are also conducting short-term intensive projects in several areas including the Dhuleil area, Asraq, the Zarqa River system to the King Talal Reservoir, and the East Ghor Canal. They will have a report out next year (1983) on the results of their study of the King Talal Reservoir. The only other report on their work is a preliminary report published in 1973. Results indicated, according to Mr. Khatib, that the salinity and nitrate content in groundwaters was rising. They will investigate the causes of this as well as the best way to conserve water in these areas. He briefly discussed the USGS - US AID - NRA study on groundwaters previously described by Mr. Nimry and that a Mr. McKenzie from the USGS was an advisor for these studies.

According to Mr. Khatib, the NRA is currently measuring the following parameters in the Zarqa River on a bimonthly basis: iron, manganese, cadmium, mercury, cyanide, phosphorus, nitrate, and ammonia. Last year some weekly and some monthly samples were collected, but there were problems with the availability of the vehicle to collect the samples, which impacted the frequency of sampling. They collect surface water samples from the King Talal Reservoir as well. It should be noted, however, that such a program in which only the surface water is sampled, is of limited value in characterizing the quality of a reservoir's water. When asked about water quality data interpretation and limnological interpretation of the data, Mr. Khatib indicated that he would be the one responsible for these evaluations. The analytical procedures they are using are mostly the American Public Health Association (APHA) et al. Standard Methods of 1976. In general the laboratory appears to be fairly well-equipped and, if the analytical

procedures described were being followed properly, the laboratory should be capable of generating good data.

Mr. Khatib informed the reviewers that the Ministry of Trade and Industries (MTI) plans to expand its chemical analytical laboratory capabilities so it would be in a position to conduct analyses on industrial wastewaters for the NRA. Dr. Hani Shakaa, however, indicated that the RSS has a contract with the MTI to do all laboratory work needed on industrial wastewaters. The reviewers are not in a position to resolve this discrepancy; it is, however, another example of the communication difficulties among the agencies involved in the evaluation of water quality in Jordan which must be resolved before they could recommend the expenditure of US monies for a monitoring study.

Review of NRA Comments on University of Jordan/
RSS Proposal

A copy of the official NRA comments on the project proposal was provided to the reviewers. The reviewers have concluded, after examining these comments and after meeting with the various agencies in Jordan, that while the NRA has the authority and responsibility for investigating and monitoring the quality of Jordan's water, its past and current activities in these areas have deficiencies. Several of these have been pointed out in this report. It is apparent that the NRA is either not physically or fiscally able to conduct a water quality monitoring program sufficient to ensure that Jordan's water resources will be developed and utilized in the most technically valid, cost-effective manner. One option to eliminate these deficiencies would be to expand the current NRA staff and facilities. The reviewers do not feel that this option is in the best interest of Jordan. Instead, they believe that it is important to cooperatively draw on the talent and resources available in the other water quality-related agencies and the university to develop a comprehensive water quality monitoring program in Jordan. There are some aspects of water quality monitoring at Jordan's current state

of development which are more experimental or investigative in nature, such as assessing available forms of chemical contaminants. This type of work could best be carried out at this time by research-oriented groups such as the University of Jordan and the RSS. Once these aspects of water quality monitoring are resolved, the routine monitoring should be shifted to the NRA or other appropriate governmental agency. A study on the order of that jointly proposed by the University of Jordan and the RSS could readily do the investigative work needed as well as promote an air of cooperation among the water quality-related agencies in Jordan.

SECTION III
COMMENTS ON PROPOSAL

OVERALL PROPOSAL

The proposed project objectives as outlined in the proposal are considerably more ambitious than can be accomplished by the principal investigators. While the overall program as outlined in paragraph 1, page 1, of the proposal, is needed and should be carried out, the reviewers do not believe that the University of Jordan and the RSS can command sufficient authority to gain the attention of the Jordanian operating agencies that have the legal responsibility for water quality monitoring within the country in order to fulfill the objectives set forth in the proposal. One of the specific points of concern is the statement on page 1, "...project is proposed to monitor and control the water quality in different areas in Jordan..." Neither the University of Jordan nor the RSS have any significant technical competence in water quality control. Further, neither of these entities has any legal responsibility for such activities. This responsibility is assigned to other agencies. It was made quite clear to the reviewers that the other agencies are not about to relinquish this responsibility to the RSS and the University of Jordan.

In the middle of page 1, mention is made that the project will deal with the following areas which include the Yarmouk Area, however, as discussed elsewhere in this report, when discussing the study areas with the geology group of the University of Jordan, it was made quite clear to the reviewers that they had no interest in studying the Yarmouk River area. Further, they understood that the project was to be restricted to the Amman, Zarqa River, King Talal Dam area.

Pages 2 through 9 provide general information on Jordan's water resources. The reviewers have made no attempt to check the reliability of the numeric values presented since this discussion is largely extraneous to developing a water quality

monitoring program for Jordan.

Page 10, item 9 (1), states that one of the objectives of the project is to develop water quality standards and guidelines for Jordan. It is quite clear to the reviewers that this objective cannot be achieved by the project since the development of such standards is a function of other agencies within Jordan.

On the same page, item 2 indicates that one of the objectives of the project is to "assemble a data base pertaining to water quality..." Since the principal investigators of the proposed project have been unable to acquire the massive amount of NRA data on water quality in Jordan and there is little likelihood that they would be able to do so in the future, it appears that the data base that would be developed as part of fulfilling this objective would not contain the most important water quality data that has been and likely will be developed in Jordan, i.e., that of the NRA. As indicated elsewhere in this report, no additional water quality monitoring program should be initiated in Jordan until a suitable mechanism has been found to ensure that those programs will not be largely duplicative of existing ongoing programs.

Pages 11 through 15 present a general discussion of the methodology that will be used to achieve the objectives set forth on page 10. The reviewers are unable to provide a detailed review of this methodology since those proposing the project did not plan to develop the details of the approaches to be used until well into the project. For example, page 13, Phase II, item I, states that the project would "determine water quality variables to be monitored...". Page 14, items 2,3, and 4 indicate that the project would "prepare monitoring network design, determine sample station sites, and determine sampling frequency at each site." Page 44, section 19.1, "Site studies and sampling will be obtained after studying the areas and after determination of sample station and sampling frequency." The proposal on page 20,

second paragraph, indicates that those components of the detailed monitoring program such as sampling location and frequency, methodology, analytical methods, etc., will not be determined until Phase II of the project. It appears to the reviewers that this might be six months to a year after the project has been initiated.

It is clear from these as well as several other statements in the proposal that the proposal was a general proposal and that specific aspects of the monitoring program had not been formulated by the principal investigators. The principal investigators indicated to the reviewers that such factors as water quality variables to be tested at a specific site, sampling station location, and sampling frequency were to be determined after the project had been funded. The principal investigators were not in a position to provide this type of information to the reviewers at the time of their visit in September 1982. This situation caused the reviewers to have to restrict their review to the general aspects of the proposal rather than conducting a detailed review of specific components of the proposed monitoring program.

In an attempt to provide guidance on the overall approach that should be followed in developing a national water quality monitoring program in Jordan, the reviewers have developed a supplemental report to this report. This supplemental report to the US AID/Amman is entitled "A Water Quality Monitoring Program for Jordan." It is based on the reviewers' experience in establishing, conducting and utilization of the results of surface and groundwater quality monitoring programs in various parts of the world. It is suggested that this supplemental report be reviewed as part of formulating the details of a water quality monitoring program for Jordan. Additional information on any aspect of this proposed program is available from the reviewers upon request.

Pages 16 through 19 present the Phase I Implementation

Plan. This plan omits a very significant component of any properly developed water quality monitoring program. This component is the review of all previously collected data on the water quality characteristics of a proposed study area. This should be done before any additional survey work is undertaken. It is clear, however, in light of the principal investigators' inability to acquire the NRA data, that they have deliberately left this step out of their implementation plan. As discussed elsewhere under recommendations, the project should not be funded unless this step is an integral part of the program.

On page 23, paragraph 3, the statement is made that computer storage and processing of data will be part of the project. The reviewers learned that the NRA with the assistance of the US Geological Survey, is developing a comprehensive, computer-based water quality monitoring data storage and retrieval system. It appears that the project as proposed for work in this area will be largely duplicative of what the NRA has underway. It seems to the reviewers, inappropriate to fund two computer-based water quality monitoring data management systems in Jordan.

On page 24, line 3, it is unclear what is meant by "the reader."

Overall Comments on Phase II. From an overall point of view, Phase II is well written and except for ignoring ongoing work by the NRA, describes the general aspects of many of the items that must be considered in setting up an appropriate water quality monitoring program. The reviewers find a significant paradox between what is described in Phase II of the proposal and what was done over the last three years by the University of Jordan and the RSS in the Zarqa River-King Talal Reservoir studies. It is clear to the reviewers that the approaches described in Phase II were not used in setting up these studies. The reviewers cannot help but be concerned should the proposed project be funded, that it would follow the approaches advocated in Phase II rather than what was done in the Zarqa River-King Talal Reser-

voir studies carried out by the same groups. A mechanism to ensure that the Phase II approach with appropriate modification is followed should be built into the contractual arrangements of the proposed project.

Overall Comments on Phase III. Page 25, paragraph 6, mentioned the development of a water quality model. Since, to the knowledge of the reviewers, none of the proposed participants in the project have any expertise in water quality modeling and the proposal provides no information on the approaches that would be used in such modeling, the reviewers suggest that before the project is funded, the principal investigators from the RSS and the University of Jordan should provide a fairly detailed discussion of the proposed approach that they would follow in water quality modeling. It should be noted that the reviewers have many years of experience in work in water quality modeling and find that most work done in this area is a waste of time and money. Most modelers do not understand aquatic chemistry sufficiently well to formulate appropriate models for the relationships between concentrations of contaminants and water quality-impairment of beneficial uses to ensure that water quality is properly incorporated into such models. The reviewers have become sufficiently concerned about the problems in trying to develop so-called water quality management programs in the US and elsewhere that they authored a paper devoted to this topic that appeared in the Journal Water Pollution Control Federation in 1982. A copy of this paper is attached to this report. It provides additional details on what a project of this type should consider in water quality monitoring, modeling, and management.

On page 26, under "Project Duration," mention is made that the project would be three years in duration and that the monitoring program developed should be carried on indefinitely. In the opinion of the reviewers it is going to be very difficult, if not impossible to accomplish a significant part of the objectives set forth in the proposal in a three-year period. It is recommended that the project be extended to five

years or the objectives be significantly scaled down so that there is a reasonable chance of completing them in three years. Also, the project proposal should spell out, in detail, how the project's principal investigators propose to ensure that the monitoring program developed by the project will be carried out beyond the end of the project. It appears to the reviewers that there is a very good likelihood that the data generated by the project will simply go into a report and be largely ignored once the project is completed. This is especially likely to be true since the principal water quality monitoring investigator of the country (NRA) has indicated to the NPC, that much of what is proposed in this project is already being done by the NRA. Since the NRA is the agency that would likely carry out much of the program developed by the project, they must be an integral part of the project planning and implementation. If the integration of the NRA in the proposed project cannot be achieved, then the proposed project should not be funded.

Pages 27 through 37 discuss the RSS activities. Essentially all of this discussion is extraneous to the project except one small section on page 33 which briefly discusses water quality. In rewriting the proposal, the section on water quality should be significantly expanded, with the other sections on RSS activity mentioned only briefly, if at all. The expansion should provide details of RSS activities in the area of water quality.

Project Advisory Committee. Pages 42 and 43 list the proposed advisory committee which includes the NRA. Since the NRA is on record with the NPC as opposing the initiation of the project and, since the reviewers found that no lines of communication had been established between the principal investigators of the project and the NRA, the reviewers cannot help but question whether the NRA will be an active member of the proposed advisory committee. Because of the importance of the NRA in water quality monitoring in Jordan, the revised proposal should contain a statement from the director of the NRA as well

as from all other Jordanian agencies that will serve as members of the advisory committee, delineating the roles that the respective agencies will play in helping to implement this project. This will clearly establish from the outset how the areas will be covered, provide a written indication of cooperation and support of the project by the agencies, and formalize each agency's cooperative commitment. If an agreement cannot be reached on these statements, it will indicate that the project does not have the necessary cooperation and communication among agencies and should not be funded. Specifically, the NRA's participation is essential to the success of the project and those who are interested in seeing the project funded should be able to find a mechanism to ensure active participation in the project by the NRA.

Technical Part. On page 44, section 19. 2.1, the coliform counts should include the determination of fecal coliforms. Also, fecal streptococci should be added to the list.

Normally "cyanobacteria" are part of the algae rather than the bacteria. On page 45, section 19. 2.2, the algae information should include the determination of total counts and dominant species. The work on diversity should be deleted and an explanation should be provided of what is meant by "algae...distribution."

Section 19. 2.3 should include the determination of total chlorophyll a, corrected chlorophyll a, and pheophytin a. In section 19. 2.4, specific information on which macrofauna that will be monitored should be provided in the revised proposal.

In section 19. 2.5 what specific pesticides will be monitored?

There is disagreement between the proposal and members of the NPC on whether trihalomethanes are to be studied in the project. They are listed in this section as to be monitored yet representatives of the NPC indicated that those types of chemicals were not of interest to Jordan at this time.

What is meant by "total cations" and "total anions"?

It is believed that "sodium activity ratio" should be "sodium adsorption ratio."

The following parameters should be added to the list of

parameters to be considered for monitoring: nitrite, nickel, silver, selenium, barium, beryllium, bromide, residual chlorine, antimony, organic nitrogen, oil and grease, anionic surfactants, PCB's, as well as any of the chlorinated hydrocarbons on US EPA's toxic pollutant list for which they have developed water quality criteria as released in the US Federal Register, Volume 45, Number 231 of November 28, 1980 that are suspected to be present in Jordanian waters.

It is also suggested that some samples be analyzed for radioactive components to determine gross alpha and beta, total radium, radium-226, and uranium.

It is also suggested that selected surface water samples be tested for aquatic life toxicity using fish and daphnia or other suitable similar organisms.

Page 46, last line, indicates that other parameters would be determined "whenever it is needed." The anticipated "other" parameters should be listed and the procedure for their selection should be delineated.

No information is provided in the proposal on the analytical methods that will be used for determination of parameters listed on pages 45 and 46. As discussed elsewhere, there are significant problems in some of the analytical methods that have been used by the RSS in their ongoing water quality studies. These problems were discussed in detail with RSS staff and some members of the administration. It is not clear to the reviewers, however, that the RSS staff with whom we discussed these problems, fully understood or appreciated the significance of the problems with the analytical procedures being used. Before funding this proposal, specific commitment should be made by the participants on the detailed analytical procedures that will be used for every parameter that will be measured. This detail should include specific information for each parameter on how the samples will be collected, sample preservation techniques, data handling-storage and retrieval methods, and approaches that will be used in determining water quality significance of the data. Also, analytical quality control programs for

sampling and analyses should be delineated.

On page 47, section 19. 2.6, devoted to "geochemistry and leaching of the aquifers", needs to be significantly expanded in order to present the details of these proposed studies. The reviewers discussed these proposed studies with the University of Jordan geology group and did not obtain a very clear description of what they proposed to do in this project. This should be firmed up before any funds are made available for these studies.

RSS Budget. Discussions were held with RSS staff (Dr. A. Tamemi and Dr. H. Shakaa) to clarify some of the details of the budget (pages 48-51) for the RSS portion of the proposed study. The funds listed for the RSS project director would provide half-time support for Dr. Tamemi and half-time support for Dr. Shakaa. The yearly equipment rental rates are established as 10 to 12% of the purchase cost of the equipment. Overhead is established at 50 to 60% of the direct personnel costs. The travel to the US is for three people, for training, one time per year, for three to four weeks' duration.

The major item to be considered on the budget is laboratory equipment. The reviewers requested and received a list of specific equipment that would be purchased with project funds. In general, the reviewers have concluded that this analytical equipment is needed by the RSS in order to carry out the project. If anything, because of the difficulties in trying to maintain and repair equipment in Jordan the successful completion of the project will likely require a substantial increase in funds for equipment in order to have spare equipment available when there is equipment failure.

The proposed equipment budgets for both the RSS and the university, however, list items which, while desirable, are not necessary to properly carry out the project, such as photocopiers and vehicles. The RSS requests three four-wheel drive vehicles to be funded. The reviewers were unable to verify that three such vehicles were needed. While this

request might be justifiable, the details of the revised sampling program have not been worked out; once the sampling program is finalized, it may be found that existing vehicles within the RSS, the University of Jordan, or cooperating agencies would be sufficient. Another example of desirable but unnecessary items in the budget is that both groups are asking for substantial funding for literature. Both wish to use the project to strengthen their respective library holdings. A single, in-depth collection of the world's water quality literature should be adequate for Jordan. The participants in the proposed project should be encouraged to establish a mechanism for keeping more abreast of recent developments in the water quality monitoring field than they have in the past. This is especially true of the RSS staff.

The reviewers found that the RSS staff was not familiar with the US literature in the water quality management field. The reviewers feel that this is a particularly significant deficiency since the USA is recognized as being in the forefront of new developments in the water quality monitoring-management area. The lack of familiarity with US literature can readily be the cause for substantial difficulties that the RSS has had in conducting water quality monitoring programs in a meaningful way. The reviewers feel that one way to overcome this deficiency in background of the RSS staff is through the development of a close working relationship with US scientists-engineers who would serve as advisors to the project should it be funded. This relationship should be more than the typical passive approach that is normally followed by US scientists and engineers working in foreign countries. There should be active communication between the project participants and the US advisors in which, on at least monthly intervals, and preferably biweekly during the initiation of the project, there would be some type of communication between the parties on the details of the project. Further, the US participants should make at least two trips per year of two weeks' duration each to critically review the work underway. The reviewers

have been conducting a program of this type in Spain, with the Spanish Ministry of Public Works, devoted to monitoring about 20 of Spain's reservoirs. They have found the above mentioned approach to be highly successful in carrying out a program of this type. It is likely that the budgeted items for US professionals (3 man months) will not provide adequate funding to enable the US participants to become sufficiently involved in the details of the project to ensure that the funds are being spent in the most technically valid, cost-effective manner towards achieving the objectives of the project. It is suggested that this amount be doubled from that listed in the RSS budget.

Both the RSS and University of Jordan's budgets make no allowances for increased costs due to inflation during subsequent years of the project. This should be done in the revised proposal budget.

University of Jordan Budget. The budget for the University of Jordan portion of the project is presented on pages 52 through 55. Many of the comments made about the RSS budget apply to the University of Jordan budget as well.

The breakdown of the responsibilities for study in the University of Jordan's portion of the joint project, and details of the university's budget, were discussed with Dr. Hashwa. Pesticide, phenol, BOD, and COD measurements would be made by the chemistry department. The hydrogeologists would be investigating the leaching of contaminants in the aquifers, especially in northern Jordan. Biological investigations would be carried out by Dr. Hashwa and his co-workers. The biological work would focus on eutrophication, selected macrofauna such as snails, and parasites and amoebae. The current survey of all the surface waters for the snail situation in Jordan shows that the *Bulinus* snails, vectors for schistosomiasis, are apparently moving upstream in the Zarqa River. The studies on the algae would be focused on diversity, including total count and stained count; identification of dominant species of algae, their progression through the seasons, and species distribution; photo-

synthetic rate; and chlorophyll concentrations. Some routine bacteriological monitoring of groundwater would also be included in the project.

Personnel listed in the budget for the University of Jordan's portion of the study included: three technicians, two of which would be biologists and one a chemist, all three of whom would do field work; one full-time secretary; and six graduate students, four in the biology department and two in the chemistry department, or, alternatively, three biologists, two chemists, and one geologist. Another item in the budget was literature. This would include journals, books, etc., in topic areas of pertinence to the project. Trips to the US were also listed in the budget. These were to be one-month trips for two people, once per year, during which time the individuals selected would attend meetings and meet with groups within the US, such as US EPA laboratories, university people, and others. Funds were budgeted for training of technicians and staff to operate the instruments. There was a fairly substantial "miscellaneous" category for what were termed "unforeseen" expenses to be covered under the budget.

While as noted above, the RSS list of analytical equipment could be fairly readily defended based on the proposed project, this is not necessarily the case with respect to the University of Jordan list. The reviewers are familiar with the equipment requested by the University of Jordan and how it might be used in a water quality monitoring program. They have substantial difficulties in relating some of the requested equipment to the parameters that they propose to measure and that need to be measured, however. The equipment list looks more like a general list to equip a laboratory, rather than one that was developed to specifically fulfill the needs of the project. While the reviewers can appreciate that all of the items requested by the University of Jordan are needed in hydrobiology, water chemistry, and hydrogeology laboratories to undertake water quality-related research, the relevance of some items of equipment to this project is somewhat questionable.

Before the project is funded, the principal investigators should be required to specifically delineate the equipment actually needed for the project, including manufacturers, model numbers, costs, and most importantly, how this equipment will be used to obtain data of relevance to the project.

From an overall point of view, it is impossible for the reviewers to determine the adequacy of the proposed budget for both the RSS and the University of Jordan. It is clear that the principal investigators have not carefully evaluated the amount of funds needed to carry out the project set forth at the beginning of the proposal. It is the reviewers' opinion that the project could easily require twice the amount of funds requested. On the other hand if the project were closely integrated with ongoing NRA activities, it might be possible to significantly reduce the total funds needed. As it was suggested elsewhere in this report, many of the details of the project need yet to be defined. Once this is done, it will be possible to develop a more meaningful budget.

Project Proposal Appendices. The last third of the project proposal is devoted to appendices which include additional information on the RSS activities and curriculum vitae for the various project participants. The information on the RSS has little relevance to the project. In view of the principal participants, curriculum vitae show that none of them been or are currently active in professional societies which are actively involved in water quality monitoring and management. The reviewers found in discussing with the project's proposed participants that, except for Dr. Hashwa, they have limited understanding of current approaches being used in water quality monitoring and management. Dr. Hashwa does have a good understanding of appropriate procedures for limnological type studies. He, like the others, has no experience in water quality management. None of the project's proposed participants have any formal background, experience, or expertise in environmental engineering. The reviewers consider this a significant deficiency since it is virtually impossible to develop meaning-

ful water quality monitoring programs without considerable experience in the use of such data in carrying out management programs. This project, if conducted in an appropriate manner with active participation of scientists and engineers who are professionally trained and active in water quality monitoring and management could, in addition to achieving many of the objectives set forth in the proposal, provide valuable training for several Jordanian scientists and engineers in the water quality monitoring management field.

Proposed Project Organization. As discussed in this report in several locations, there are serious communication problems among several groups interested in or concerned with water quality monitoring in Jordan. This situation in Jordan is not atypical of what is found in any country. This situation, however, is of particular importance to this project in that no line of communication has been established between the governmental agencies responsible for establishing water quality (NRA) and the principal investigators of the proposed project. There is a lack of cooperation among these groups with respect to developing a project. This lack of cooperation will almost certainly cause this project to fail to meet its objectives in the most cost-effective, technically-valid manner. As it stands now, the reviewers recommend against funding the proposal. This recommendation is based on a number of factors, the most important of which are the lack of communication between the NRA and the proposed project's principal investigators, the duplication of the proposed project programs with ongoing NRA projects, the lack of familiarity of the project's principal participants with the current state of knowledge in the water quality monitoring and water quality management fields, and the lack of detail of the approaches that would be followed for many of the key components of the proposed project. The reviewers feel that many of these deficiencies can be overcome if an appropriate project administrative structure can be formulated. They wish to suggest that an overview committee be established for admini-

stration of this project. This committee should be composed of individuals representing all of the Jordanian agencies concerned with water quality monitoring and management. In addition representatives from the University of Jordan and from key water-oriented Jordanian industry should be members of the committee.

The first responsibility of this committee should be to review the current water quality monitoring programs of each group. Emphasis should be given to defining the details of these programs, including what is being monitored, how the samples are being collected and analyzed, the analytical quality control procedures being followed, and data storage and retrieval systems. All participants should make their data available to the other participants through this committee.

Those members who represent agencies that have a need for water quality data in formulating public policy should prepare statements describing the data they feel they need and the reliability that these data should have for public policy formulation.

Once this committee has been organized and has developed this information, then the RSS and the University of Jordan should prepare a revised proposal which would focus on providing the data that are needed to formulate water resources management policy but that are not being gathered by other governmental agencies. It would likely be that additional participants would become co-investigators in the project so that funds could be channeled to that agency to help expand water quality monitoring into areas that are not now being adequately covered. The water quality monitoring coordinating committee would play a major role in formulating the revised proposal and in execution of the project once it is funded. This role should include periodic review of the progress being made on the project. The committee should also assist the participants in the project in resolving any problems encountered in conducting the project.

It is recommended that a water quality criteria-standards

committee be developed which would have as its primary responsibility, the development of revised "202" guidelines for municipal and industrial wastewater discharges in Jordan. This committee should become thoroughly familiar with the technical basis of any water quality standard that it adopts. It should also establish a mechanism which would allow a site-specific evaluation of the significance of exceeding a particular, proposed standard in impairing the beneficial uses of the receiving waters for the wastewaters containing the apparently excessive concentration of the contaminant. This committee should define the water quality monitoring programs that are needed to ensure compliance with the standards by industry, municipalities, and others. It is likely, and in fact desirable that the member of this committee be the same as the project coordinating committee. The reviewers feel that if this kind of project administrative framework could be established, then they would reverse their recommendation with respect to funding the project.

The reviewers wish to suggest an approach to eliminate some of the other deficiencies they found in the proposed project as it relates to the project's academic and professional backgrounds in the area of water quality management.

It is recommended that a series of intensive short courses be held in Jordan in the near future devoted to current principles and practices in environmental engineering. Particular emphasis should be given to water and wastewater treatment and the management of municipal and industrial solid waste.

It is also recommended that an advisory committee be appointed to critically review the current environmental engineering educational needs and opportunities within Jordan. This committee should formulate recommendations which would be implemented into programs to eliminate the current deficiencies in this area.

SECTION IV

CONCLUSIONS

1. There is a need for an expansion of Jordan's current water quality monitoring program. The proposed project and investigation provide a potentially suitable framework through which this could be accomplished.
2. The proposed principal investigators at this time, do not have the necessary academic and professional backgrounds to properly carry out the project without significant assistance-supervision by individuals who have high degrees of expertise in the water quality monitoring and water quality management areas. A significantly greater effort will have to be made by the proposed project's principal investigators and other key members of the staff in becoming acquainted with and keeping up with the US and the world water quality literature on new developments in the water quality monitoring-management field than has been made in the past. There is a need for someone thoroughly familiar with appropriate analytical procedures for water quality parameters to work with the RSS staff in the development and use of analytical procedures that reliably measure water quality characteristics of importance in Jordan.
3. The proposal, while composed well, has insufficient detail to be properly evaluated on its own or to be readily executed.
4. Both the RSS and the University of Jordan are in need of equipment to properly carry out the proposed study. Both budgets are padded with what are traditionally "overhead" items (e.g., photocopiers, typewriters) and items which are not directly pertinent to the proposed study. There are also overlaps in requested items such as literature between the two groups' budgets.

5. A mechanism acceptable to all agencies involved in water quality monitoring in Jordan has not been developed for continuation of the monitoring program after the initial three-year study period.
6. There is need to significantly expand environmental engineering educational opportunities in Jordan and to increase the application of environmental engineering principles in water quality management. One of the aspects of environmental engineering that needs particular emphasis is environmental chemistry. There is particular need for individuals thoroughly familiar with this area, to work with the chemists at the University of Jordan to increase the chemists' knowledge of the use of environmental chemistry in formulation of public policy for water quality management.
7. There are significant problems with the "202" water quality regulations recently adopted in Jordan. The numbers adopted are basically safe and aesthetically acceptable levels of contaminants in drinking water and in general are inappropriate for use as effluent standards.

SECTION V
RECOMMENDATIONS

1. Before more money is invested in the proposed project, the proposed investigators should prepare a revised proposal for consideration which:
 - a) demonstrates the mechanism by which they will ensure cooperation among agencies involved in water quality monitoring, especially with the NRA;
 - b) provides a thorough review of all current water quality monitoring efforts being conducted in Jordan and describes how the proposed project will complement existing work;
 - c) provides for review, detailed delineation of proposed sampling frequencies and locations, and specific analytical and quality control methods to be used (This discussion should be provided based on the assumption that 100% of the requested funds are provided. Also a discussion should be provided of what would be eliminated if substantially less money was made available); provides description of mechanism to ensure the production of high-quality data when equipment fails or support personnel (e.g., drivers, trucks, boats) are not readily available when needed; and
 - d) outlines a program for continuing the monitoring beyond the initial three-year period, indicating the agency or agencies which would agree to carry out the essential parts of the program.

2. A water quality coordinating committee composed of representatives from the RSS, the university, and all governmental agencies and industry concerned with water quality monitoring and management in Jordan should be established to evaluate the existing water quality monitoring programs and to oversee the development of a

revised proposal. If such a proposal is funded, this group should oversee the execution and follow-through on this project.

3. The Jordanian water quality criteria-standards committee should revise the "202" guidelines for municipal and industrial wastewater discharges in Jordan. This committee should become thoroughly familiar with the technical basis of any water quality standard that it adopts. It should also establish a mechanism which would allow a site-specific evaluation of the significance of exceeding a particular, proposed standard in impairing the beneficial uses of the receiving waters for the wastewaters containing the apparently excessive concentration of the contaminant. This committee should define the water quality monitoring programs that are needed to ensure compliance with the standards by industry, municipalities, and others.
4. A series of intensive short courses should be held in Jordan in the near future devoted to current principles and practices in environmental engineering. Particular emphasis should be given to water and wastewater treatment and the management of municipal and industrial solid waste.
5. An advisory committee should be appointed to critically review the current environmental engineering educational needs and opportunities within Jordan. This committee should formulate recommendations which would be implemented into programs to eliminate the current deficiencies in this area.

APPENDIX A

PERSONS WITH WHOM MEETINGS WERE HELD

National Planning Council

Dr. Isa Khubeis, Director, Department of Science and
Technology
Yousef Batshon, Director, Infrastructure Department
Boulos E. Kefaya, Engineer
Hussein Shafa'amri, Chemical Engineer
Janet Abboud, Environmental Health

Natural Resources Authority

Yousef Nimry, Director General
Abdelhamid Khatib, Engineer

University of Jordan

Dr. Subhi Qasem, Dean, Faculty of Science
Dr. Marwan R. Kamal, Dean, Faculty of Agriculture
Dr. Hamid El-Hajj, Head, Department of Biological Sciences
Dr. Fuad Hashwa, Associate Professor, Department of Biology
Dr. Elias Salameh, Assistant Professor, Geology
Dr. Tawfiq Samaneh, Environmental Engineer, Faculty of
Engineering
Dr. Hani Khoury, Geologist
Dr. Leila Hanaineh-Abdelnour, Associate Professor of
Chemistry
Dr. Gerd Föerch, Visiting Professor, Environmental Engineering
S. Khader, Soils Expert
Reem Bsaiso, Formerly of University of Jordan

Royal Scientific Society

Dr. Albert Butros, Director General
Dr. Fakhruddin Daghestani, Deputy Director General
Dr. Arafat Tamemi, Head, Industrial Chemistry Department
Dr. Hani Shakaa, Head, Environmental Protection Section
Dr. Said Alloush, Head, Organic Chemistry and Spectroscopy
Mr. Khadra Mohamed, Chemical Engineer

Water Supply Corporation

Yasin Kaed, Director General
Col. Aref Baha-Eddin, Deputy Director General
Eng. Akram S. Najjar
Eng. Omar Shadid

Amman Water and Sewerage Authority

Eng. Mohammad Kilani, General Manager
Mahmoud Hiari, Technical Manager
Dr. Saqer Salem, Engineer
Fayez M. Bataineh, Engineer

Ministry of Health

Dr. Suleiman Subeihi, (M.D.) Undersecretary
Dr. L. Oran, Pathologist, Environmental Health Laboratories

Jordan Valley Authority

Dr. Munther J. Haddadin, Acting President
Rajeh Nasser, Engineer, King Talal Dam
Naim Dabbur, Site Engineer, King Talal Dam

Ministry of Municipal, Rural, and Environmental Affairs

Daher Hajaj
Dr. Salih Sharu
Ahmad Rusan
Gazi Odat
Suleiman Hanbali
Dr. Khaled Amin Sharaiha
Ziyad Alawneh

US AID

Walter Bollinger, Director
Thomas Pearson, Chief, Projects Office
Albert Karian, Chief, Engineering Office
Larry Brown, Project Development Officer
James Cassanos, Sanitary Engineering Consultant

APPENDIX B

LITERATURE REVIEWED

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