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Engineering Division

NIGER RIVER BASIN PLANNING RIVER SYSTEMS ANALYSIS

AFTER ACTION REPORT

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EXECUTIVE SUMMARY

This report was prepared by the Vicksburg District, U.S. Army Corps of Engineers (COE) at the request of the United States Agency for International Development (USAID). It reflects the COE's response to the Participating Agency Service Agreement (PASA) executed by the COE and USAID in connection with the Niger River Planning Project initially undertaken in 1982. Report preparation was necessitated by the project termination action taken by USAID, and acceptance of this document completes the COE's responsibilities in connection with the aforementioned PASA.

The report summarizes the COE's experience in West Africa, addresses current and future uses of the Niger River, and provides the principles for continuation of water resources planning in the Niger River Basin. Information presented is limited to that which was readily available to the COE. Conclusions/recommendations reflect the COE's general experience in planning, development, and management of water resources tailored to the unique problems encountered in the Niger River Basin. The planning principles and guidelines presented herein may be applied by anyone wishing to pursue comprehensive water resource planning in the Niger River Basin. They would be most effective if employed by a regional organization such as the Niger Basin Authority (NBA) assisted by substantial and firmly committed international donor support.

This report was solely prepared by the Vicksburg District COE. Its applicability to the situation in the Niger River Basin

is strengthened by our experiences in West Africa and the COE's professional qualifications to address water resources development issues.

Planning for the development of the Niger River Basin is challenging, and the Niger Basin member countries should be encouraged to continue to make every effort to build a successful Executive Secretariat to meet the needs and demands of the countries. Given experience elsewhere in the world, it is not difficult to envision a Niger River System which provides the population within its basin boundaries, within the next 50 years, such benefits as:

- hydroelectric power dams providing inexpensive electricity for industry and various human energy needs;
- irrigation; food self sufficiency through irrigated agriculture production even in drought years;
- navigation; barges of various sizes transporting merchandise, agricultural products, equipment, etc. from the Gulf of Guinea through the Inland Delta in Mali into Guinea providing outlets to the sea for inland countries;
- water supply; for the populations engaged in productive enterprise along the river;
- recreation; for the population of the basin as well as increased fisheries production.

A. PHASE II PROJECT SUMMARY

1. Project Design

The United States Agency for International Development (USAID) Phase II Project 625-0944, Niger River Basin Planning Project, was designed in support of the Niger Basin Authority (NBA) as a continuation of the work performed under Phase I USAID Project 625-0915. The stated objectives of the Niger River Basin Planning Project were to formulate an Integrated Niger Basin Development Plan and during this process to develop the capability within the NBA to perform river basin planning.

To achieve these objectives the project contained three major components.

* A River Systems Analysis was to be performed by the Corps of Engineers (COE) working under a Participating Agency Service Agreement (PASA) with USAID.
* A socio-economic survey was to be performed. This effort was to be accomplished under contract through USAID.
* An environmental survey was the third component of the project. This work was tentatively scheduled to be accomplished under the responsibility of the Corps of Engineers.

The River Systems Analysis was a continuation of the COE work begun under project 625-0915. Two components of this work were directed toward the further development of the data base required in the engineering analysis of development alternatives. A hydrographic survey contract was planned to further define the geometry of the river. Additionally, a sediment data collection program was scheduled

over a two year period to establish the baseline sediment characteristics of the river system. A water sediment routing model was to be developed in conjunction with these study activities. This model was to be capable of using the Data Storage and Retrieval System (DSRS), developed under Phase I, in mathematically modeling the Niger River and its major tributaries. The model would have been capable of projecting long term effects on the river system which resulted from proposed interventions. The COE PASA called for the analysis of six development scenarios using this model.

The project was scheduled to be implemented in two phases. The first, a study phase, would produce the baseline data references and the mathematical model. The second, a planning phase, would utilize the products of the first phase with the end result being an Integrated Niger Development Plan (INDP). Incorporated into both phases was extensive counterpart training programs oriented toward developing the planning capability of the NBA. Two primary outputs were anticipated from this project. A functional NBA Planning Unit was foreseen as emerging as a result of the active planning proecss and the extensive training program. Also, an Integrated Niger Development Plan would result. The responsibility for formulation of this plan was to be under the scope of work of the socio-economic contractor.

The socio-economic and environmental studies would have provided references of basline data to be used in the basin planning process. As a result of the project revision in September 1985, both studies were limited to collecting data from existing sources and presenting the data in a form which could be efficiently utilized by basin resource planners.

2. Evolution of Project

The following is a summary of the major events/milestones reached during the implementation of the Phase II project.

August 1982

Phase II Project Agreement signed between USAID and the NBA.

September 1984

Phase II PASA signed between USAID and COE. Selection procedures initiated by Vicksburg COE for Hydrographic Survey and Modelling contracts.

November 1984

Evaluation of Phase II performed in conjunction with Phase I Evaluation. An evaluation report was published summarizing the findings of the evaluation team and providing recommendations for changes in the implementation of the Phase II Project.

December 1984

The first longterm COE representative under Phase II arrives in Niamey.

January 1985

Counterpart Computer Technician hired under Phase I funding to assist in DSPS operation and maintenance. Funding for this position was eventually transferred to the Phase II project.

March 1985

The second longterm COE representative under Phase II arrives in Niamey.

April 1985

Trip conducted to member states of the NBA to coordinate implementation of the sediment data collection program. Secretary/Translator and project driver hired in support of the Phase II project.

May 1985

Sediment data collection program revised by COE and approved by the NBA and USAID.

July 1985

Sediment data collection training for six member country representatives conducted in Vicksburg, MS. The trainees returned to their respective countries after the training and began preparations for implementing the sediment data collection program.

July-September 1985

First NBA director trained in Vicksburg in project management.

August 1985

Vicksburg COE initiated purchasing of commodities and equipment for sediment data collection program and laboratory analysis. The equipment purchased supported the collection of data in Nigeria, Benin, Niger, Mali, and Guinea.

September 1985

First shipments of equipment sent to Niamey.

September-October 1985

Phase II project revision conducted in Niamey based

on recommendations of November 1984 evaluation team. Proposals were made to continue the River Systems Analysis as originally designed and to continue socio-economic and environmental studies with reduced scopes. An institutional analysis of the NBA was conducted as a part of this revision and was published as a part of the revision report.

October 1985

PIO/T (Project Implementation Order for Technical Services) Amendment submitted to USAID Washington requesting changes to COE PASA to provide additional resources for implementing sediment data collection program.

November 1985

Office facilities rented under the Phase II project to house COE staff, socio-economic staff, environmental staff, and NBA planning unit personnel. USAID Niamey cabled USAID Washington proposing elimination of socio-economic and environmental studies from project and to continue COE River systems Analysis.

December 1985

USAID Washington cabled recommendation to terminate all project activities. Additional computer commodities received in Niamey. The NBA computer system was expanded to accommodate improvements in the DSRS and development of the water sediment routing model.

January 1986

USAID Niamey proposed to retain COE River Systems

Analysis. USAID Washington recommended "phase-out" of project activities. Counterpart Hydrologist hired under Phase II project to direct sdeiment collection program and assist in engineering analysis.

February 1986

Counterpart Water Resources Planner hired under project to assist in model development and engineering analysis. Counterpart laboratory and computer room assistant hired under project to assist in sediment sample analysis and data entry on the DSRS. Assembly of the COE in-country technical staff was completed and ready to begin the River Systems Analysis. All required technical equipment for sediment data collection program received and assembled in Niamey. All survey equipment was received and assembled in Niamey. All laboratory equipment purchased and prepared for shipment from Vicksburg.

March 1986

Decision made by USAID to cancel all components of the project. Alternatives for "phase out" of project were discussed within USAID. All subcontractor negotiations were suspended by USAID. Shipment of all additional equipment purchased by Vicksburg under the project was suspended. COE was directed to only engage in maintenance activities. A 12-16 month phase out plan was proposed by USAID Niamey subject to the "litmus test" of member country payment of dues to NBA by 30 June 1986.

April 1986

COE Vicksburg prepared a detailed phase out plan based upon USAID guidance and restrictions. The plan was oriented on transfer of commodities and essential training activities with a completion date of 31 August 1987.

June 1986

COE prepared for a rapid phase out of the project.

July 1986

COE informed by USAID Niamey to terminate all project activities not later than 31 August 1986. In-Africa project participation by COE was terminated. All COE in-country staff terminated and paid salaries through August 1987 (end of contract). Project equipment and commodities purchased under both phases of the project were transferred from USAID to the NBA.

3. Project Problems and Resolutions

Problem 1

The ability to easily communicate and coordinate on a regional scope is an indispensable prerequisite for a regional organization such as the NBA and for a regional project such as the Niger Basin Planning Project. This prerequisite was not fulfilled within the NBA or the project organization. The NBA had no telex facilities due to lack of funding. Written communication proved to be extremely slow and uncertain. Personal travel was the only sure means of direct and responsibe coordination, but was difficult to coordinate, was not economically justifiable, and required excessive time.

Primarily as a response to the requirements of the sediment data collection program, the COE developed the plans and budget to establish regional offices. They were to be completely staffed and funded from the project with the objective of assisting in the implementation of the sediment collection program. It was foreseen that these offices would be of immense value to the COE and the NBA in other ways. They would have had the capability of coordinating with government services in their respective regions on a regular basis. They could have assisted in the regular collection and transmission of hydrologic data to update the DSRS. They could have obtained reports and publications from member countries concerning water resources development. In summary they would have had the ability to act as an extension of the NBA and COE organizations based in Niamey.

Coordination with NBA member countries would have been

greatly facilitated with the establishment of regional offices. The regional offices were planned to be located in Lokoja, Nigeria and Bamako, Mali. These locations were chosen based on the requirements of the sediment collection program. Two individuals would staff each office with one being a mid-level technician. Recruiting was to be performed through the NBA. It was anticipated that the regional manager for Nigeria would be one of the individuals trained under the Phase I project. This was another benefit of the program. All recurrent costs of the regional offices were to be paid from project funds.

Problem 2

The base document which guided the Niger Basin Planning Project was the Project Paper. This document was prepared and assembled through laborious efforts by USAID, the NBA, and the COE. It outlined administrative and technical guidelines for project implementation in support of the mission of the Niger Basin Authority. The Project Agreement between USAID and the NBA signified formal acceptance of the project as described in the Project Paper. The technical components of the project were formally agreed to in this document. The project PASA was signed between USAID and the COE after lengthy negotiations. This document delineated the technical scope of work of the COE and signified acceptance by the COE for the responsibility of implementing the River Systems Analysis portion of the project. These documents outlined technical activities of the project and represented acceptance by all organizations.

After formal acceptance of the project by all parties and initiation of activities according to the signed agreements, USAID continued to question major technical aspects of the project in relation to the current condition of the NBA. This condition basically remained unchanged from the signing of the PASA to project cancellation. During Phase II, a series of discussions proceeded within USAID regarding the utility and value of proceeding on the technical work as agreed to. These discussions arose because of doubts related to the NBA's institutional ability to use the outputs of the project. The evident political and economic weakness of demonstrated member country support of the NBA cast doubt on any future utility of current or planned study effort and thus of the value of continued U.S. support.

The factors and delicate negotiations that led to the cancellation of the project are matters within the purview of USAID, the NBA, and its member countries. However, their effects on the technical objectives of the project are addressed here. Their continued occurrence created an environment which made technical progress difficult to achieve. Continuing the conditions which existed during the first year of the project into later years could conceivably have caused the technical components of the project to fail or at least to lessen their benefits to the NBA.

The effects of this process were strongly felt at the technical level. These conditions made concrete technical management and planning difficult to achieve. As a result of the final decision to terminate the Phase II project, based principally on institutional rather than technical issues, a vast

majority of the technical progress made under the project could result in being essentially lost. Projects of this nature require a much broader base of institutional support and concomitant donor commitment to be effective. Without this, valuable gains are lost.

Problem 3

The expenditure of funds retained by USAID under the PASA was a problem during the Phase II project unforeseen during project design. Subsequent to project design, financial management problems at the NBA Executive Secretariat made it impossible for USAID to certify, as required by U.S. Congress, that the NBA had an adequate accounting system to manage U.S. funds. Thus a system of managing local cost financial transactions in Niger had to be established. Initially under the project, the COE Team was required to expend funds through the USAID system of purchase orders. This system, which was used to purchase commodities, equipment, and services required to implement the project and support the NBA, was identified as being unresponsive to the needs of project implementation. The following areas would have been difficult or impossible to accomplish under this system.

* The hiring and paying of salaries and associated costs to local COE employees in support of the sediment collection program, the computer center, and model development.
* Rental of additional office space and payment of recurring costs associated with the leased building.
* Payment of staff and costs associated with the proposed

regional offices.

* Payment of non-recurring costs associated with the sediment data collection program.

Efforts were made to utilize funds transferred to the COE under the PASA to pay for these expenses. However, no workable solution could be found to disburse funds responsively from Vicksburg to the COE staff in Niamey. The COE system of financial control was not flexible enough to meet project requirements under the existing circumstances.

To remedy this problem, the COE staff developed an advance account system following USAID guidelines. This system allowed the expenditure of local currency funds by the COE Team. A complete budget, a computerized accounting system, and operating guidelines were developed by the COE Team and approved by the USAID Comptroller. Advance operating funds were requested and accounted for on a bi-monthly basis. Control of the fund was the responsibility of the COE Team. Approval by USAID for expenditures was not required prior to disbursement by the COE staff.

It was planned to incorporate components of this system into the NBA's accounting procedures. Although it was not implemented, the structure and procedures of the advance account were designed so that they could be easily transferred and implemented by the NBA. The system had the potential to assist the NBA in addressing its continuing problems with budgetary planning and financial control. It would have placed no additional recurring costs on the NBA, and all requirements for its implementation were

available within the Phase II project.

Problem 4

The sediment data collection program outlined in the project paper was exceedingly difficult to implement. The original design for the program included the collection of 10 samples from 50 sites throughout the basin over a one year period. Basic assumptions were that data collection was to be performed by existing hydrologic data collection teams supplied by the member states. The COE was to provide initial training and necessary technical equipment required for sediment sampling. In addition, they were to furnish technical advice and to monitor collection activities as they progressed. All work performed in collecting sediment samples by member country teams was to be accomplished in conjunction with their normal workload. Therefore, it was felt that this activity would not cause increased internal costs nor create the need for additional member country staff.

As a result of an initial coordination trip in April 1985 by the NBA/COE, this program was found to contain major flaws. Difficult logistic problems prohibited the collection of samples from such a wide range of sites in the basin. The member countries strongly supported the program and understood its value; however, they were unable to meet the basic assumptions in the project paper. Hydrologic data collection teams could not be transported to sites nor could they be paid per diem and other associated costs. Teams normally did not operate in the manner required for sediment data collection. The primary contribution of the member countries was providing field personnel to accomplish the data collection.

Solutions to the above problems required the NBA and COE to assume larger roles both in the program's management and its financial suport. As a result, a program revision placed more responsibility on the COE to accomplish the program and supply additional financial resources. The revised program assumed all increased internal costs for the member countries involved. The program was reduced to data collection at 12 sites over a two year period. The first year would have allowed the development of expertise in sediment data collection techniques with the second year providing the bulk of quality data. Sites were selected to ease logistics problems, satisfy projected data needs of model development and calibration, and to satisfy projected data needs of the member states. Management of the program was to be accomplished by a full-time COE employee stationed in Niamey. Two regional offices, staffed by COE employees, were to be established in Lokoja, Nigeria and Bamako, Mali to provide management and support by the COE in support of the program to include vehicles, boats, motors, trailers, and data collection equipment. Training of collection team chiefs was scheduled to occur in Vicksburg, MS. Additional training for member country data collection teams was scheduled at each data collection site prior to initiation of the program. Technical advisors from Vicksburg and the Niamey COE staff were scheduled to accompany teams to each site for their initial sampling effort. Analysis of sediment samples was to be performed in Niamey under the control of the NBA and COE. The laboratory was to be established by the COE and staffed by personnel hired under the

project.

The revised sediment collection program, if implemented, had the potential to provide many benefits. Its primary stated objective of producing basin-wide sediment data would have been accomplished. The revised plan provided sufficient equipment, personnel, and management capability to insure the collection of quality sediment data. Additional benefits would have also been realized. The program would have been a valuable training vehicle for NBA and member country technical personnel. It would have provided the opportunity to manage a technical program that was implemented basin-wide. It provided the opportunity for the NBA to interact on a technical level with the member countries over an extended period with a highly defined set of objectives. It would have established technical expertise within the NBA in a specific technical area. The program would have been of great use in promoting the institutional development of the NBA.

Problem 5

The Niger Basin Planning Project was to consist of three components; a River Systems Analysis under the responsibility of the COE, an environmental assessment tentatively to be accomplished under COE responsibility, and a socio-economic study to be performed under contract through USAID. The design of the project proposed that these three components progress independently through their respective study and planning stages. In later stages of the project the socio-economic effort would be responsible for the formulation of the Integrated Niger Development Plan. This project

design had two major flaws, the first being that overall project coordination was not explicitly stated nor planned for. Development of an integrated plan required a well-defined, integrated effort under the overall control of one individual. This integration of effort should have begun in the early stages of the study phase so that the work in any one component complemented, guided, and supported the efforts of other components. This led to the second flaw in project design. There was no provision for iteration. The final integrated development plan was to be formulated based on the results of the three studies. Each study was to be conducted as a parallel effort producing an independent result. There was no provision to formulate a plan and modify it responding to unwanted or unacceptable impacts in other areas.

The COE River Systems Analysis and probably the studies in the other components of the project could have been accomplished within this context. However, it would have been unlikely that a viable and technically supportable plan for the integrated development of the Niger River Basin could have been formulated with the study approach set forth in the project paper. The final plan would not have fully analyzed the effects resulting from proposed interventions in the three major study areas. Complete integration of work effort within an iterative process and overall control of the three components would have insured that the final plan reflected a complete technical analysis of the proposed interventions.

The same organizational concepts formulated to enhance the functional capability of the NBA Planning Unit should have been utilized to structure an integrated planning effort for an

individual project. First, explicit organizational structure must be established between the various components or study areas. Secondly, someone must be in a position to maintain overall direction and control of all components throughout their study and planning stages. This will insure that the maximum potential will be obtained from the planning effort and that the final product reflects a complete and supportable analysis of the system.

Problem 6

Problems relating to the utility and availability of the Data Storage and Retrieval System (DSRS) and the Water Sediment Routing Model were addressed during both the Phase I and II projects. These outputs from the COE River Systems Analysis represented two valuable and longlasting tools that would be of long term benefit to the NBA. Their existence, however, presented problems which were not correctly addressed in the original project paper.

Original project design called for the basing of both the data base and the model in the U.S. Availability and utility to the NBA would have been greatly lessened. Based on overhead budgeted for computer runs, the original intention was to design the systems to operate on mainframe type computers. This further lessened their value to the NBA because of the costs associated with mainframe computer time.

Coordinated efforts by USAID and the COE during Phase I of the project resulted in the establishment of the DSRS in the NBA technical annex in Niamey. Two IBM PC's with hard disks were purchased under the Phase I project. The DSRS was installed on the

micro-computers in November 1984. This action resulted in a number of benefits. The NBA had unhindered access to the database with a minimum of overhead cost. The NBA physically possessed a technical tool which had tremendous value to NBA member countries and other international organizations. Data, which was much more easily obtainable in West Africa than the U.S., could be entered on the system and provide an up to date source of information. As a result of the decision to base the system in Niamey, numerous other issues surfaced which were not recognized in project design. The NBA had no personnel to properly operate, maintain, or support the system. With the basing of the system with the NBA, the requirement to update and improve the data bank became a responsibility of the NBA in Niamey. No system to accomplish this was established in the NBA structure or the project organization when the DSRS was installed. Proper facilities to house the system were subject to the same constraints as the other technical components of the NBA. Compatability with other existing computer systems in the basin and the maintenance of the system became important concerns. These same concerns impacted the establishment of the model which was to be developed under Phase II.

Several corrective actions were taken by the NBA, USAID, and the COE to address these problems. A computer center manager was hired under the Phase II project by the COE Team to operate and maintain the NBA Computer Center. This individual was used extensively to train NBA personnel in the use of the system and to demonstrate its use to numerous member country personnel and other international organizations. Although no formal system was established to update the database, the NBA and the COE Team established this as a

priority effort. As a result, a fulltime assistant was hired to enter and verify data in the database. This effort resulted in constant updating of the system especially for critical locations in the river system. It was also planned to utilize the regional offices in obtaining and transmitting up to date hydrologic data to Niamey where it would be entered on the system. New and expanded facilities for the computer center were leased, and additional equipment and commodities were purchased in order to expand the computer system to allow the basing of the water sediment routing model in Niamey. A hydrologist and water resources planner were hired under the project and were trained in the use of the DSRS and were to take an active role in the development and use of the model under Phase II. Provisions were made for a direct linking of the NBA computer system with the planned systems at Hydroniger and Aghrymet. This would have facilitated the exchange of data and the expansion of capabilities in the NBA system.

Problem 7

The NBA technical branches were not staffed with mid-level technicians, engineers, or other staff technical specialties. This directly impacted the NBA's ability to accomplish its overall mission. At the project level there were insufficient counterparts to take an active role in project implementation. The NBA failed to meet conditions precedent in the project agreement by not hiring three project trained personnel to work in the planning unit as permanent staff. This hampered project progress by limiting the number of counterparts available in project implementation and made

the transfer of technology and technical capabilities very difficult to achieve. These individuals would have been critical to the eventual success of the project in the areas of support and management of the Data Storage and Retrieval System (DSRS), implementation and management of the sediment data collection program, development of the Water Sediment Routing Model, analysis of development alternatives, and development of the Integrated Niger Development Plan.

To assist in meeting project requirements and to assist the NBA in developing a mid-level technical staff, the COE Team hired four mid-level technicians. The planned terms of service for these individuals were until end of project. They would have been trained in critical technical areas required by the NBA and at the same time would have made positive contributions toward achieving project objectives. It was hoped that by the time the project ended, the NBA would have developed the means to permanently employ these individuals. The NBA clearly recognized the need for these individuals and was actively pursuing the means to employ them.

The four technical positions were a hydrologist, water resources planner, computer center manager, and a laboratory assistant. The first two positions were filled by individuals who had received degrees financed by Phase I of the project. These two positions were approved by the NBA Council of Ministers, but were not yet funded under the current NBA budget. The computer center manager position was not an approved position by the NBA, but this requirement was being addressed by the NBA Executive Secretary. The laboratory assistant position was created specifically to fill the

need to maintain, operate, and manage the laboratory established under the project.

Problem 8

During the Phase II project, three organizations were directly involved with the implementation process; the NBA, USAID, and the COE. The COE was primarily responsible for the technical work under the project as defined by its scope of work outlined in the Participating Agency Service Agreement (PASA). There was a tendency to limit the role of the NBA to administrative areas. It was clearly evident that the NBA could greatly benefit from an institutional point of view by taking an active role in project implementation especially concerning technical matters. There was a tendency for the NBA to migrate toward the administrative areas of project implementation due to its limitations as a technical organization.

Several methods were utilized to integrate the NBA into a more active role. The in-country COE Team adopted the perspective that its technical work under the project was not COE or USAID work, but work performed by the NBA. Any output from the project was an NBA output; and as a result, it required full coordination with and approval of the NBA. Weekly project coordination meetings were conducted. These were chaired by the NBA Deputy Executive Secretary with attendance by the technical directors, the COE staff, and the USAID project officer. Project issues and implementation requirements were fully coordinated and resolved. Meeting memorandums were prepared and distributed to record the issues discussed and to aid in preventing communication problems.

The NBA was fully integrated into all project coordination activities. All coordination trips to member countries were presented as NBA coordination trips with NBA representatives as primary spokesmen. The COE staff were introduced as technical advisors. All requests for member country support to the project were directed and staffed through the NBA structure. These requests included data required to update the DSRS and member country technical personnel necessary to support project activities.

The NBA was placed in the forefront of the project's technical activities. Institutional problems limited their capability and success in performing this role plus added to the difficulty of implementing the project. However, it was felt that the benefits, both real and potential, far outweighed the short term difficulties. It was very important that the NBA be included in all technical issues and be seen as a technical organization by the donors and especially the member countries of the NBA.

Problem 9

As the USAID 1984 project evaluation report correctly pointed out, the technical offices of the NBA Executive Secretariat were physically inadequate for current low levels of technical activity and were inadequate to support Phase II activities. The offices did not provide an atmosphere conducive to high level technical planning functions of the NBA and COE staff. Adequate office space was severely limited for current staff levels and would have been completely unsatisfactory for any staff expansion.

To address this problem, the COE staff located and rented an office building in the vicinity of the current NBA technical annex.

This building was primarily obtained to satisfy the space requirements of the Phase II project. However, additional space was also obtained to provide office space for the additional representatives from other donors being provided to the NBA Planning Unit. This new facility greatly enhanced the technical facilities available to the NBA and the COE staff.

The Phase II project paid for all costs associated with the leased structure to include rent, electricity, water, guard services, air conditioning, and general maintenance. Negotiations were underway with other donors occupying the facility to share these costs.

4. End of Project Status

The following section describes the accomplishments of the Phase I and Phase II projects at the time of project termination.

a. Phase I

Efforts under the Phase I project were directed toward laying the groundwork for activities to be conducted in Phase II of the River Systems Analysis. The two primary outputs of Phase II were the Geomorphic Report and the Data Storage and Retrieval System. The Geomorphic Report was published and distributed throughout the member countries of the Niger Basin Authority. Its development was a valuable aid to the NBA and the COE in understanding the physical complexities of the Niger River Basin. It will be a valuable tool in the study and analysis of the basin as a whole or on a regional basis. It is a basic document required in any future river basin planning effort.

The Data Storage and Retrieval System represents the first step in the process to develop the water sediment routing model of the Niger River. It was installed in Niamey in November 1984. The database contains daily hydrologic and precipitation data from hundreds of stations throughout the basin over many years of record. A set of users manuals was published for the system and is readily available to the NBA and its member countries. Besides its support to the future modeling effort, it has tremendous value as a source of vast quantities of historical data describing the entire river basin. It has the capability to analyze and plot stored data. Its existence represents a significant step forward in the technical capability of the Niger Basin Authority.

b. Phase II

At project cancellation, no activities under Phase II had been completed. All activities under the COE River Systems Analysis had been initiated and were at various stages of progress. The socio-economic and environmental components of the project had been informally terminated in November 1985 by USAID. The following is a description of the status of the activities under the River Systems Analysis at project termination in July 1986.

The Corps of Engineers' contracting procedures were nearing completion on the modeling contract under Phase II. The A-E contractor had been selected, and a proposal had been received. Negotiations were ready to proceed with the contractor. In addition to effort directly related to development of the model, the contractor planned considerable effort in data verification and system improvement of the Data Storage and Retrieval System. In preparation for the model development effort, the COE staff in Niamey had employed a water resources planner, computer technician and computer assistant to actively assist in model development. These individuals were to be trained during all phases of model development. Extensive training was scheduled in the U.S. with the contractor during model development and calibration. After installation of the model, they were to actively participate in the use of the model in the analysis phase. Considerable quantities of equipment and commodities had been purchased and delivered to Niamey to allow for the establishment of the model in the NBA technical annex.

The contracting process for the hydrographic survey effort was also nearing completion at project termination. The A-E contractor

had been selected and a proposal received. An audit of the proposal would have preceded final negotiations with the contractor. NBA counterpart training was planned in conjunction with the survey field work in Africa. Equipment comparable to that used by the contractor had been purchased for the NBA and trainees identified. The training was to be oriented on horizontal and vertical river surveying techniques. The survey equipment is currently located in the NBA technical annex in Niamey.

The sediment data collection plan had progressed to the point of initiation of sample collection at twelve locations throughout the basin. Technical advisors from the Vicksburg District scheduled to assist in implementation of the program were within two days of arriving in Niamey when the decision was made to halt project activities in March 1986. The following major activities had been accomplished prior to the termination decision.

* The program had been developed and fully coordinated with the NBA and its member countries.
* All equipment to be used in the program had been purchased and delivered to the NBA technical annex in Niamey. This included four Toyota Landcruisers, six aluminum boats with trailers, eight outboard motors, eleven sets of sediment collection equipment, flow measurement equipment, and tools and commodities.
* Six member country personnel had been trained in Vicksburg, MS during a one month period on sediment data collection, sediment sample analysis techniques, and equipment maintenance. These individuals had returned to

their respective countries and had formed their data collection teams.

* A program manager had been hired under contract by the COE Team and was stationed in Niamey.
* All laboratory equipment required for sediment sample analysis had been purchased and was prepared for shipment from Vicksburg.
* Storage and maintenance facilities had been prepared in Niamey to support the program. Laboratory facilities had been prepared to install the sediment laboratory.
* Water quality test kits had been purchased and shipped to Niamey to begin developing baseline water quality data in the basin in conjunction with sediment data collection.
* An advance account had been established and was operating to fund the program.
* Four technicians from Vicksburg were identified and prepared to arrive in Africa to assist in program initiation.
* Personnel to staff the regional offices had been identified through the NBA. Establishment of regional offices was scheduled to take place in conjunction with training activities.

The planning staff required under the River Systems Analysis was in place in Niamey at project termination. Two longterm COE representatives had been in Niamey for a year and a half prior to termination. Three counterpart trainees were hired under contract to actively take part in the engineering analysis. These

individuals were to become part of the permanent staff of the NBA Planning Unit after completion of the project.

Many of the facilities and commodities required by the NBA technical staff were being furnished through the Phase II project at the time of project termination. The building leased under the project was being used to house the NBA Deputy Executive Secretary (Chief of the Planning Unit), the three NBA technical directors, the NBA computer center, and technical representatives from the UNDP and FAO projects. This building was almost entirely furnished with office equipment using project funds. It also contained space for administrative personnel, equipment, and a large conference room. All recurring costs associated with this building (e.g., electricity, water, telephones) were being paid with project funds.

5. Recommendations to Preserve Project Objectives and Conserve Resources

The decision to terminate the project had irreversible effects on the utility of the technical resources supplied to the NBA under Phase I and II. Notification to terminate the project was received by the COE in July 1986. Corps personnel departed Niamey in mid August 1986. The sudden cancellation decision did not allow for efficient transfer of technical equipment to the NBA. This short term project closedown primarily allowed for the administrative elements of the project to be addressed such as close out of the advance account, an inventory of Phase II commodities, and termination of employee contracts. All resources of the project were transferred from USAID to NBA.

The following resulted from the decision to rapidly shut down the project.

* Contracting procedures were cancelled for the survey and modeling contracts.
* Contracts for in-country personnel hired under the project were cancelled as of 31 August 1986. These positions were the hydrologist, water resources planner, computer center manager, laboratory assistant, and three administrative positions. Obligations under these contracts were paid through 31 August 1987 for all contracts. This payment totalled 19.0 million CFA (app. $54,000).
* All leased facilities provided to the NBA under the project ended as of October 1986. Water, electricity,

and other support for this facility under the project ended in July 1986.

* The NBA computer center ceased operation in July 1986. Personnel to operate and maintain the computer center and the DSRS departed the NBA at project termination. The computer center hardware has been transferred to Hydro-Niger, is installed and available for use. Initiative to maintain the DSRS as a part of the system will be necessary.
* Survey equipment purchased under the project for use by NBA personnel working with the survey contractor has been turned over to the NBA. It is of limited use in its present condition because no NBA personnel have been trained in its use and there is no ongoing or current survey work which requires its use.
* All equipment purchased in conjunction with the sediment collection program has been transferred by USAID to the NBA. The NBA staff is not trained in its use or even familiar enough with the equipment to identify the various components. Member country personnel trained in usage of this equipment do not presently have access to it. Anticipated beneficial returns from these resources are minimal due to the technical nature of the equipment, overhead associated with its use, and the absence of need

for the data it can provide due to the cancellation of the modeling effort.

* All laboratory equipment purchased under the project is presently in storage in Vicksburg awaiting disposition instructions from USAID in Niamey. Without the laboratory equipment, any sediment samples taken cannot be analyzed which further negates the utility of the sediment collection equipment.
* Water quality analysis equipment purchased under the project has been transferred to the NBA. Anticipated benefits from this equipment are minimal.

From a technical point of view, the primary output surviving project cancellation is the Geomorphic Report published under Phase I. Its utility is long term, and it stands alone. The DSRS and computer center have been transferred to Hydro-Niger and are available for use. Benefits from other technical equipment purchased under the project will not be realized unless resources are provided for the training and use of the equipment. Also resources must be provided to fund the overhead associated with its use.

The major, irretrievable loss associated with the cancellation of the project is the in-country personnel who were trained during the project. These mid-level technicians were a valuable resource critically needed by the NBA. The skills which they possessed as a result of their training and experience were vital to the future of the NBA. No benefits will be derived by the NBA from these individuals unless the means are found to employ them in the future.

The following recommendations are made to preserve project resources and to derive the maximum amount of benefit possible from the resources committed under the project to the NBA. These recommendations are made assuming that the NBA will be the institution to utilize these resources in the future. Transfer of these resources to other institutions or organizations is not considered as a possible alternative.

* The NBA must either internally or through donor support fund the personnel and facilities required to operate and maintain the computer system and DSRS. After funding is found, personnel hired, and facilities established, training support should be requested through USAID to again establish a functional system.
* The NBA must either internally or through donor support employ the technicians trained under the project. Without these technicians there will be no personnel available to the NBA to use or manage the use of the technical equipment purchased under the project.
* Technical equipment purchased under the project and under the control of the NBA should be consolidated and maintained in Niamey by the NBA. Distribution of this equipment without associated training in its use and maintenance and funding of overhead associated with its use will not result in benefits from the equipment. Until a project exists that can effectively manage and fund the use of this equipment, the equipment should remain consolidated in the NBA technical annex in Niamey. Degradation of components of the equipment will occur,

but the majority of the equipment will remain operational over an extended period of time with little or no maintenance, if properly stored.

B. Water Resources Planning Strategy

Based on experience gained in completing Phase I and initiating the implementation of Phase II, the balance of this report will provide commentary and recommendations to the NBA on continuing its planning efforts in the future once its institutional support issues are resolved.

1. Goals

a. Short Term Goals

The NBA Executive Secretariat should immediately direct its efforts toward technical institutional development utilizing existing staff, and, in this endeavor, strive to enhance its role as technical advisor to member countries. Immediate actions from a technical point of view which should be taken (using available data) include developing a water balance within the basin. Specific tasks required are:

(1) Division of basin into hydrologic units. The initial effort should concentrate on the main stem of the Niger River and the alluvial area adjacent to the river.

(2) Computation of runoff. Elements include:

* Rainfall
* Evapotranspiration
* Groundwater recharge
* Stream flow

(3) Computation of demand. Elements include:

* Irrigation
* Navigation
* Municipal and industrial
* Power Production

* Other

(4) Computation of consumption (losses). Elements include:

* Irrigation

* Municipal

(5) Computation of return flow.

(6) Computation of stream flow to next hydrologic unit.

b. Intermediate Goals

Efforts should be directed toward establishing a system for allocating the existing resource (stream flow) to each member country. The water balance will serve as the basis for initiating resource allocation, but results can vary widely depending on approach selected. Suggested considerations include contributing drainage area, average rainfall, total drainage area, quantification of needs, population, potential for development, and prior use. After establishing a system, the next step is developing a strategy which could be pursued by the NBA member countries, the NBA, and interested donors. Major steps include:

* Division of basin (hydrologically and politically).

* Development of a water balance.

* Allocation of resource.

* Identification of existing and future needs.

* Computing shortfalls/surpluses

* Developing strategies/plans for meeting needs.

2. Establishing Planning Objectives

In the broadest sense, the NBA should have as a long term objective the development and management of existing water resources

of the Niger River. More specific objectives could be postulated, but until basin water resources development needs are better defined, it would possibly be misleading and non-productive during initial study stages. Specific objectives can be formulated later in the planning process as basin needs and their relationships are more clearly defined. It is important to note that the NBA mission (to be discussed later) must be considered when formulating objectives. Short and intermediate term objectives should address planning needs with long term objectives addressing the more general water resource development needs.

3. NBA/Donor/Member Country Roles

Simply stated, the NBA serves as a technical advisor to donors and member countries and is responsible for the comprehensive planning and evaluation of improvements being considered for the Niger River Basin. Donors serve as partners with member countries providing financial and technical assistance. Member countries are the focal point for initiating specific actions and work directly with donors when implementing projects. Improvements undertaken within this context can be accomplished in a bilateral fashion, provided a comprehensive impartial evaluation has been completed and findings/recommendations have been incorporated. Preceding discussions are based on the continued existence of the NBA. Should other regional organizations exist, their role would remain essentially the same as the NBA. The most important consideration is the continued existence and participation of an entity having technical expertise serving as an impartial advisor to donors and member countries on matters relating to multi-lateral or international water resources development.

4. The Role of Modeling

Comprehensive basin planning requires an intuitive understanding of many physical characteristics of a very complex system. Baseline information is required and the planning process must integrate analysis of the river system, environment, and socio-economic factors in order to develop the available resources.

Mathematical modeling techniques currently available can serve as a valuable tool in this integrated approach. Models, such as the Corps of Engineers water sediment routing model, can predict the effects of considered projects/interventions. This predictive capability is central to the integration of environmental and socio-economic concerns in the planning process. The impacts associated with a single intervention or a comprehensive development plan can be superimposed on baseline environmental or socio-economic data and then analyzed. Depending on their acceptability and desirability, the intervention can then be modified to achieve the desired result. Using a mathematical model, the planner can accomplish several iterations of this process, maximizing/minimizing economic returns and/or impacts in an economical and efficient manner. Many different types of models are currently available with a wide variety of applications. A forecasting model, such as the one prepared for use by HYDRONIGER, allows the prediction of downstream flows based on upstream conditions. The basic concept predicting extreme flows has great short term planning potential for navigation, irrigation, and water supply.

Another model currently under development is the SOGREAH model. It can be used to analyze short term future flows and water levels

from upstream rainfall or flow data. It has the capability to analyze performance of specific interventions. The proposed Corps of Engineers water and sediment routing model will provide the capability of developing basin wide strategies in the areas of agriculture, hydropower, navigation, irrigation, water supply, and flow regulation. In addition to water routing, changes in sediment transport characteristics can be analyzed. Its intended use is in the optimization of water use within the basin.

5. Plan of Study

The plan of study presented in this section is a series of steps directed toward formulation of alternative plans. Each plan would address water and related land resource problems identified within the designated study area. Following evaluation of these alternative plans, it would be possible to select a recommended plan which addresses, in the best possible manner, the concerns of those involved. The process provides an orderly approach so that those interested or affected can consider the factors included in plan formulation and evaluation. Application of this procedure will be accomplished in three stages. The first stage will be an inventory during which water resource related problems will be identified, resource capacity will be determined, and base conditions established. Stage two consists of plan formulation, evaluation, and selection. The third stage involves acceptance of a development plan by those concerned and the actual implementation/construction of individual projects or interventions. Each stage as it relates to the NBA and the Niger River Basin is defined in more detail.

a. Stage I

The physical area to be studied is defined and water resource related problems within the selected areas are identified. This effort should require about one year to accomplish after the planning organization is fully functional. Initially, the geographic scope should be limited to the main stem of the Niger River and the adjacent alluvial area. Known major water resource related problems/needs which exist in this area include irrigation, navigation, municipal water supply, vector control, and hydropower production. Initially, member countries within which portions of the study area exist, will be consulted and the problems/needs to be addressed will be selected and quantified. They must then be analyzed to determine if any can be achieved by water and related land resource management. When a tentative list of needs to be addressed has been generated, it should be refined and clarified through analysis and interaction with the countries affected. Current needs would then be projected into the future taking into consideration growth factors such as population, agricultural development, income, life expectancy, and other factors which would impact water use or demand. Completion of these activities would establish base conditions, both existing and future. The next step would be to quantify the capacity of the resource to meet the needs (existing and future) previously identified. Resource capacity is then compared to needs to determine if water availability is sufficient to meet demand and, if not, to what extent do existing supplies need augmentation. It should be noted that this type analysis is undertaken on the smallest feasible separable hydrological unit, and it is likely that regional supplies/needs

would be quantified by combining the hydrological untis found in the region being analyzed. As this step nears completion, specific planning objectives may be established. Some specific examples for purposes of illustration are:

* Provide sufficient water storage at Niamey to meet municipal water supply needs during one month of "zero" flow on the Niger River. (The need has already been identified.)
* Increase power production in Mali sufficiently enough to allow exportation within 20 years. (This need has not been established.)
* Improve the channel between Bamako and Mopti to provide for a minimum of 1 meter depth 11 months out of the year. (This need has not been established.)
* Provide sufficient low flow augmentation at Gourma-Rharous to increase withdrawals for the purpose of irrigation of 5000 hectares of rice to be put in production, 500 hectares each year over a period of 10 years. The first year of production is scheduled to be 2010. (This need has not been established.)
* Provide and maintain sufficient channel markers to permit the movement of vessels between the Gulf of Guinea and Kainji Dam on the Niger River. (This need has not been established.)

These examples only demonstrate the form and content of possible planning objectives and are not necessarily valid. None of these should be adopted without substantiating that a need exists.

It should also be noted that objectives presented at this point reflect needs or desires only and should not imply feasibility. As the planning process continues through successive stages, various plans of improvement addressing study objectives will be formulated and evaluated to determine degrees of engineering and economic feasibility.

b. Stage II

The first step in Stage II is to develop a full range of alternative plans which address the planning objectives identified in the previous stage. The Stage II effort can be accomplished in 3-4 years after completion of Stage I. It is important to limit the plans to a manageable number, but sufficiently diverse enough to give the decision maker a full range of alternatives from which to choose. During this study stage the water resources planner begins to consider multiple use interventions. This point can be clearly illustrated by considering some of the objectives previously discussed. For example, increased power production in Mali, irrigation water for Ghourma-Rharous, and improved water supply at Niamey, could possibly be achieved by constructing a dam near Tossaye. Another possible effect of a dam at that location would be the inundation of the farm land which was to be placed into rice production resulting in conflicting rather than complimentary resource development. It must be understood that this example is hypothetical, but it does illustrate real life choices which the planner/decision maker must face when considering water resources development. An unbiased interdisciplinary approach during this step will result in detailed consideration of only those alternatives addressing the critical issues and needs. The second

step in this stage involves the identification, description, and measurement of likely economic, social, and environmental impacts expected to result from implementing the alternative plans. This analysis determines the expected changes that would occur when measured against the "without project conditions" which is the detailed specification of conditions which would most likely prevail over the planning period in the absence of a water resource management or development plan. The impacts are the differences in each parameter considered.

The following list represents some of the parameters that would be analyzed in the Niger River Basin.

* Villages/people displaced
* Cultivated area
* Electricity generated
* River commerce
* Fishery production
* Evaporation losses
* Low flow augmentation
* Sediment production/transport
* Wild life habitat
* Desertification
* Livestock production
* Mining
* Manufacturing
* Imports/exports

The next step in the plan formulation stage is plan comparison, and the principal evaluation criteria are:

* Acceptability by affected countries/people
* Certainty or the likelihood that planning objectives can be met.
* Completeness of available investments and action to insure plan realization.
* Effectiveness
* Costs
* Feasibility
* Equity to those affected
* Environmental impacts
* Stability/maintenance requirements
* Reversibility
* Monetary returns

The last step in plan formulation is plan selection/recommendation. The alternative considered to respond best to the planning objectives is usually designated as the recommended plan. It must be noted that the recommended or selected plan at this stage of the planning process reflects decisions which are primarily technical in nature and are appropriate in terms of what the NBA's mission should be.

The third and final stage of the planning process initiates and integrates the political and non-technical concerns. This stage can to some extent overlap Stage II but must not preclude technical work in Stage II.

c. Stage III

Stage III is directed towards plan realization. The first step is seeking plan acceptance by those concerned. During this stage, it is critical for the NBA Executive Secretariat (or any other regional organization) to remain politically neutral. Political factors must be considered, and plan revisions reflecting political concerns can be accommodated. The NBA Executive Secretariat role should remain as technical advisors. It would be its responsibility to quantify in technical terms the impacts of politically motivated revisions, but the final decision must remain with political interests. Once a politically acceptable plan is established, the NBA Executive Secretariat would assist in its implementation, but only in an advisory capacity.

Implementation of the overall plan could be accomplished in a bilateral fashion provided the individual components being considered fit within the context of the master plan for the basin wide development. The NBA Secretariat must remain politically neutral and limit its role to technical concerns. NBA Secretariat credibility in this regard is absolutely mandatory.

d. Water Apportionment

A component of water resources planning strategy is the apportionment of water among competing needs. This is best accomplished by assigning priorities to the various need categories. The first category in terms of priority includes water set aside for human consumption and food production. The second category includes navigation, hydropower, and manufacturing/industrial uses. The final category includes environmental and recreational uses. Any

apportionment must consider both the real and perceived needs of both upstream and downstream users as well as financial commitments already made for water resource use even if of lower priority for use.

(1) Category 1

Water needs in this category are municipal water supplies, irrigation, fisheries, and livestock water. Associated needs are addressed first and the resource (water) is allocated to this category and, assuming sufficient supplies remain, needs in the next highest category are considered.

(2) Category 2

These uses are not critical to sustaining life, but many times are critical to the economic development of the country involved. It may be desirable to further prioritize within this category depending upon the needs and conditions encountered. It is also important to note that uses in this category are not necessarily exclusive. Hydropower and navigation are almost always complimentary, and manufacturing/industrial water uses are many times non-consumptive.

(3) Category 3

Environmental/recreational uses are the lowest priority, primarily because they are not critical to sustaining life or essential to economic development. One cannot conclude that environmental/recreational needs are not important, but at this time in the development of

the Niger River Basin, Category I and II needs are more important.

e. Fiscal Allocation

Fiscal allocations should be directed toward the use of donor or member state resources in an efficient manner resulting in an effective, respected Executive Secretariat in the context of development of mid and long term plans for use of the Niger Basin water resources. The initiatives in this regard should be directed toward NBA Secretariat institution building. One effective way to begin this effort is to create a donor financial activity paralleling the actions previously discussed in connection with short and intermediate term goals. Longer term donor involvement could be undertaken in the context of a comprehensive planning effort outlined in the Plan of Study section of this report. However, it would be necessary to address more definitively the NBA institutions requiring substantial investments of funds, manpower, and time. The institutional efforts to be undertaken are addressed in the following section.

C. NBA INSTITUTION BUILDING

1. Definition of the Mission of the NBA

Historically the mission of the Niger Basin Authority (and the Niger River Commission) has been defined so that the institution was responsible for a wide range of basin development activities. These activities included both planning and implementation processes. The mission extended in many ways, well beyond the boundaries of water resources development. This broad mission reflected the multitude of development needs within the basin encompassing development activities ranging from land use management to infrastructure planning. The importance of the NBA in basin activities was a result of this mission. The expectations of the member states were based on the wide range of responsibilities assigned to the NBA.

The mission assigned to the NBA covers the development needs within the basin both now and in the future. It is a collection of activities and makes no attempt to prioritize immediate needs that must be addressed before other activities can be successfully addressed. As a result, the NBA has attempted to address the entire scope of its mission without a priority of tasks.

The mission of the NBA must be limited to current needs within the basin as a whole and needs which must be met within the immediate future. First the mission should focus on the collection, analysis, and distribution of data and information required in the basin. The types of data should be limited by needs defined in the water resources planning process. Second, the NBA must develop the capability to administer effort for or perform water resources planning and analysis throughout the basin. This involves the ability to analyze interventions in order to clarify and quantify

their impacts, both positive and negative, on the river system. This definition of the NBA mission is the first step in establishing the structure and the resources required to accomplish its mission.

Limiting the role of the NBA in this manner may appear to be reducing the importance of the NBA in basin activities. The NBA could continue to possess a much wider role in the basin as represented by the current mandate assigned to it. The role defined here is considered as the starting point at which resources can realistically be obtained to support the anticipated level of activities. This reduced role also requires an institutional structure which is much more simple to define than that required by the present mission of the NBA. The establishment of a simple, functioning NBA capable of performing its defined mission will satisfy the expectations of the member states. This is essential in developing firm future support for the institution.

2. Organization to Accomplish Technical Actions

a. General Discussion

The structure of the NBA is defined by the objectives of the organization and the process it must follow in reaching these objectives. Since the NBA is a regional organization with regional responsibilities, the structure must also reflect these demands. Clear lines of communication and the ability to actively coordinate between the NBA Secretariat in Niamey and the member countries is absolutely required. The NBA must also be capable of satisfying specialized water resource needs within the basin. These needs are more efficiently and economically addressed basin wide rather than by regions, sub-regions, or by individual member countries.

The NBA should provide the following types of services to the member countries.

(1) The NBA should be a source of baseline data for the entire basin addressing the entire spectrum of specialized fields of water resources development. The baseline data should be available in a format which can be easily reproduced and readily accessible. The data should be general in nature without attempting to produce site specific studies for all potential interventions. The baseline data is to be used for planning, not design.

(2) The NBA must be capable of analyzing the data in all areas or regions within the basin. It should develop and answer technical questions concerning the state of the basin in each field. The ability to identify existing data gaps and to take corrective action is critical.

(3) The NBA must generate and analyze basin wide and regional development scenarios/interventions. Proposed interventions must be studied from all aspects and the analysis presented in a quantified form with technical recommendations. This is directly related to the planning process discussed at length earlier in the report. The technical analysis must reflect political concerns, but only after optimal technical solutions are developed. Effects resulting from political concerns can in this manner be clearly identified and quantified.

(4) They should be capable of providing specialized technical support to member countries and other regional organizations with emphasis on data generation and collection. This includes, but is not limited to, sediment data collection and analysis, cartographic support, hydrologic data collection and evaluation, and hydrographic surveying. This capability should be primarily related to general studies, but can be site specific where the need is critical.

(5) The NBA must be capable of training member country personnel in all areas of its expertise. This training should be oriented on improving member country staffs which directly support the NBA such as in the collection and processing of hydrologic data.

The basic structure of the NBA discussed in this report is the minimum required in order to begin basin water resources planning and other technical support activities. This structure reflects the reduced mission of the NBA. In the future, as the NBA mission changes, so will its structure. The initial structure is critical because the NBA must be initially successful if it is to grow and strengthen itself in the future. The NBA must be able to specialize and develop its expertise in a limited role related to the basin as a whole. Future broadening of the mission and roles the NBA can play in basin development can utilize the credibility gained as a result of the expertise developed in this more limited role.

Some key elements of the proposed structure of the NBA are:

(1) A clear division of responsibility between the technical and administrative areas.

(2) Coordination and control in the technical elements of the organization. At the upper level there is a planning cell which guides overall technical activities and institutional development. At the lower level, there is direct control over short range activities and day to day activities.

(3) Clear, distinct lines of communication both internally and with member countries organizations.

(4) Complete integration of NBA staff with expatriate staff. Expatriate staff responds to directives and

guidance established by the planning cell under the Deputy Executive Secretary (DES). A strong counterpart program is built into the structure to aid in institution building.

(5) The donor structure mirrors the NBA structure. The donors and the NBA work within overlapping organizations with common direction. The goals of each are the same.

Internally the proposed structure has the capability to fully utilize all the planning and technical tools available to it. The presence of mid-level technical personnel is the most critical element within the structure. These positions should be filled by quality individuals, trained in their respective areas. They must deal exclusively with technical issues and not be used to perform administrative work. Also, the organization has the capability to analyze technical and administrative needs and to coordinate and plan for solutions to remedy these needs. The structure offers the opportunity for open, constructive discussion of technical issues and problems with input from all technical areas and a base of readily available information to input into these discussions. The organization is capable of assimilating national views and goals into the discussions through regional offices and the Executive Secretary.

b. Member Country Role in the Technical Structure

The NBA must have technical roots in the member countries of the NBA. It should receive data of all types from the member countries through an established system on a regular basis. Some of this data is listed below:

* Daily discharge and stage data for active stations on the mainstem river and major tributaries
* Daily precipitation data at existing rainfall stations
* Updated rating curves
* Updated cross sectional data
* Operating rules for dams and other applicable control structures

The member countries support and help coordinate this process of providing technical data. The NBA needs to be provided with national studies in the various areas of concern in the water resources planning process. These studies must be made available to assist in establishing and updating the baseline data used by the NBA. Current national development policies, goals, and objectives need to be made available to the NBA Secretariat. Member countries should provide qualified personnel to staff the NBA Secretariat. Finally, member countries should assist the NBA in coordinating in-country technical activities to include administrative support.

The structure to accomplish these activities should be formalized under the control and direction of NBA. Member country NBA offices would serve this purpose. They would be staffed permanently by qualified member country personnel whose salaries would be paid by the NBA. The personnel would work fulltime under

NBA control. The offices must be specifically established in the countries of Nigeria, Benin, Niger, Mali, and Guinea.

The regional offices would provide the means to communicate effectively between the NBA and the member countries. Standard points of contact would be established within each member state for matters relating to the NBA. Coordination could be conducted and issues addressed with the regional personnel acting under the general guidance of the Executive Secretary. Crucial issues would still be addressed directly between the Executive Secretary and the governments of the member states, but many other issues could be handled on a routine basis under this system.

c. Donors Role in the Technical Structure

Based on the current support provided by the member countries and the likelihood that it will not change in the foreseeable future, the donors will have to assume a much larger financial and technical role in the NBA. The limited support provided by the member countries does not allow the NBA to perform its functions. Complete payment of dues and arrears by member country governments will only ease the situation. The current budget does not permit the NBA to provide the facilities, equipment, nor staff required for them to function at an acceptable technical level.

The solutions to this problem are to increase the budget, authorize additional positions, and seek additional member country financial support. If member countries are unable to provide the required support an alternative is to accept a larger role by donors. From a technical viewpoint, if a basin planning

organization is truly needed and that need is accepted by the member countries and the donors, then perhaps the most plausible means of financially supporting it lies with the donors.

The donors must be willing to commit themselves to long term support of the NBA. This alternative is not a short term effort which will produce concrete immediate results. The evolution process should be directed toward turning over control of the NBA to the member countries gradually as their means develop. If the need for the organization is clear and accepted, then this process should be adopted. If not, the possibility for the NBA achieving any goals, or even continuing its existence, is very remote.

If the donors are going to play a larger role in the NBA's operation, their efforts must be coordinated not only among themselves, but as a technical group within the NBA. The donor group must be organized more along technical lines than in the past and reflect the structure of the NBA. These donor groups must be capable of supporting the NBA until it is able to operate independently. Institutional development of the NBA Secretariat can only take place within the framework of a well-structured, organized program of meaningful activity oriented toward establishing the NBA in fulfilling its role in basin development. Simply stated, the donors must be a part of the NBA, not outside agencies working with separate and different agendas.

d. Coordination of Activities

The focal point of the NBA's activities is the Executive Secretary. The Executive Secretary has many roles he must fulfill to promote the NBA's capabilities. He is the essential link that ties the NBA's activities to the expectations of member countries. The importance of the position cannot be minimized during the selection process. During this process, every attempt should be made to select an individual who possesses the organizational, management, and communication skills required of the job. Political factors should not be the determining factors in selection of the Executive Secretary.

The Executive Secretary must:

(1) Provide the interface or buffer between the political and technical aspects of water resources planning. He must insure that politics do not enter into technical planning. He must insure that technical planning remains competent and the results high quality. He should be able to understand the technical issues involved in the planning process and be able to clearly communicate these to the member states. He must assure that political factors which can affect technical results are considered separately and are clearly identified.

(2) Respond to the technical demands of the Committee of Experts and the Council of Ministers. He must be able to integrate these demands into the activities of the NBA in an appropriate and productive manner.

(3) Actively seek support from donors. He must identify and communicate the financial and technical needs of the NBA to donors. Programs or projects to address these needs must be formulated and integrated into the future activities of the NBA.

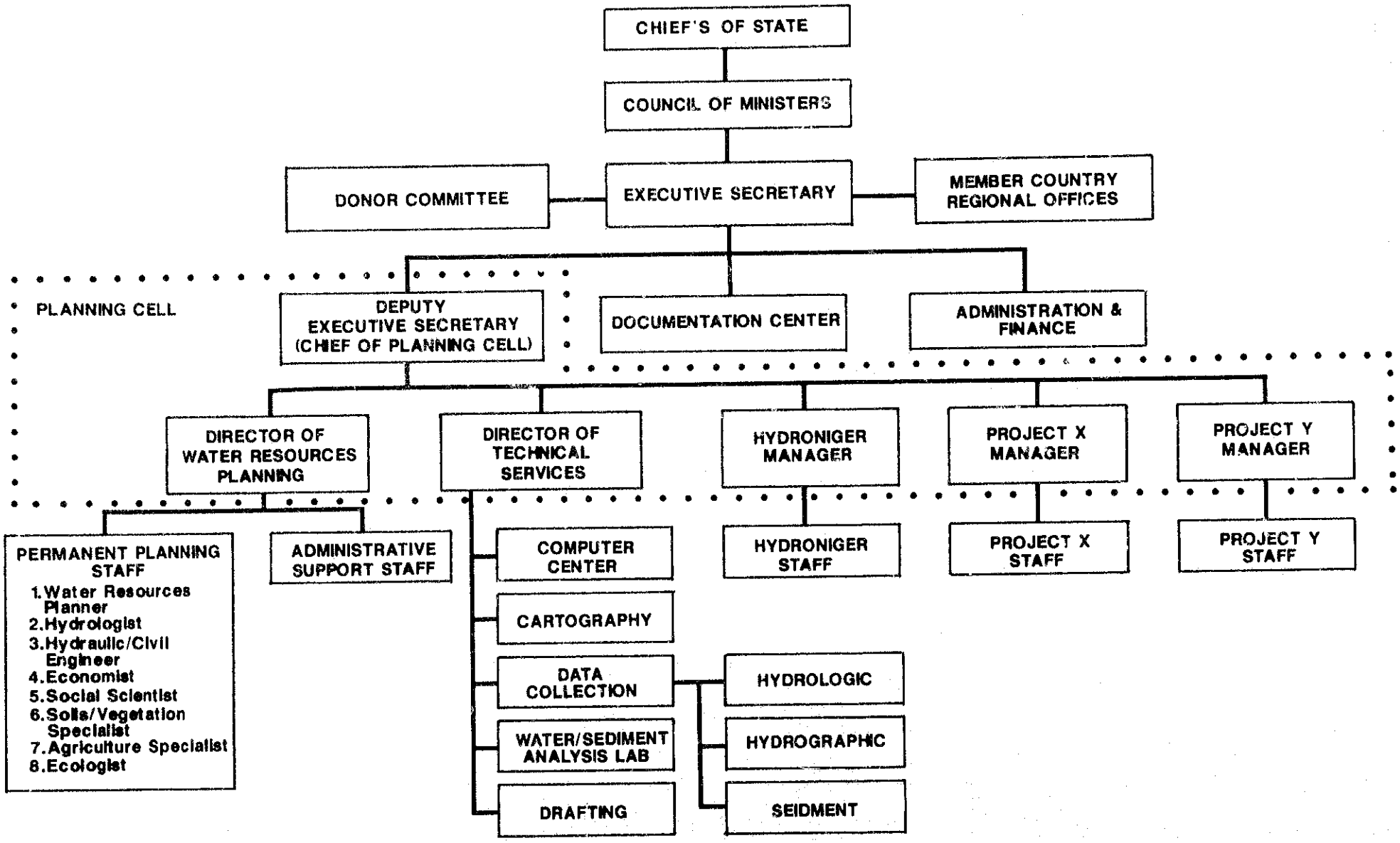
(4) Actively promote the concept of the NBA vis a vis the member states and other international organizations. The NBA must demonstrate its value in basin development activities. The Executive Secretary must clearly define the capabilities of the NBA and publicize its accomplishments. Supporters of the organization must see the technical returns from their support.

(5) Balance the technical role and influence of the donors. The Executive Secretary must insure that donor support is integrated into NBA activities in an appropriate manner. This integration must reflect general agreements reached between donors and the NBA.

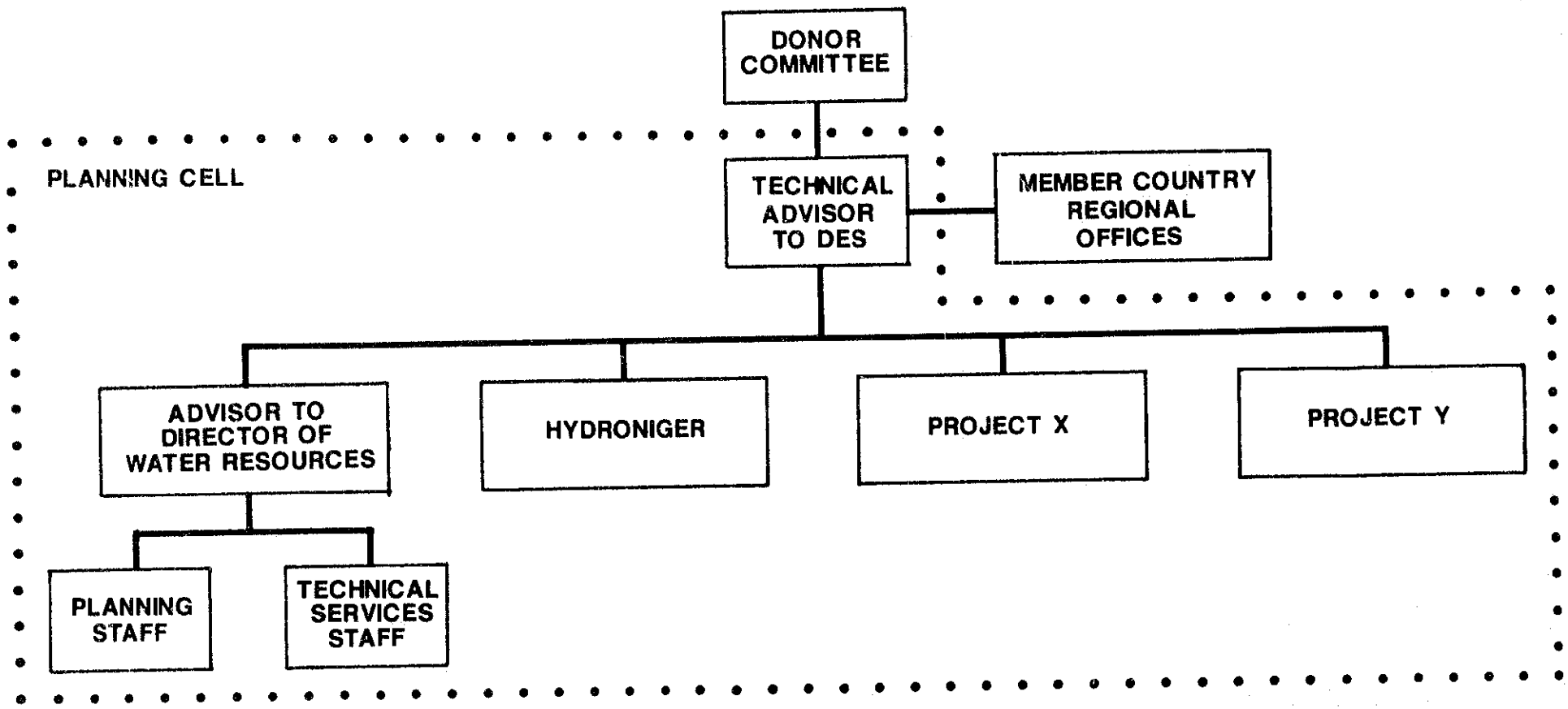
(6) Coordinate inputs into the NBA from donors, member states, and other international organizations. He must actively seek support based on the mission and structure of the NBA.

(7) Be the spokesman for the NBA in all technical matters; clearly presenting the issues, steps taken during analysis, and the position recommended by the NBA.

PROPOSED NBA INSTITUTIONAL STRUCTURE



PROPOSED DONOR STRUCTURE



e. Proposed Structure to Perform Work

The proposed structure of the NBA is presented on the preceding pages. This structure allows the NBA to address its proposed objectives and at the same time to expand in the future as its mission does. The critical component is the mid-level technical staff required to accomplish the NBA's mission. Although important, the various control and organizational relationships depicted on the charts are substantially less important than the establishment of the permanent technical staff. Additionally, the organizational charts illustrate a complete integration of donor support into the structure of the NBA. This integration is necessary to avoid parallel, non-complementary efforts by donors. The entire structure of the NBA, including donors and member country regional offices, must be fully integrated.

The following are the organizational responsibilities for each major technical position.

(1) EXECUTIVE SECRETARY

* Acts as the point of separation between technical and administrative/political areas.
* Has overall responsibility for the NBA with assistance from the Deputy Executive Secretary in technical areas.
* Is the focal point of all activities involving the NBA.
* Directs and coordinates the work of NBA member country regional offices.
* Responsible for the flow of all information external to the NBA.

(2) DEPUTY EXECUTIVE SECRETARY

* Responsible for all technical areas within the NBA.
* Acts as the Chief of the Planning Cell.
* Is focal point of all projects performed under the auspices of the NBA. Responsible for their coordination and implementation.
* Directs and coordinates activities of all technical departments. Integrates technical work being performed under active projects into the current NBA structure.
* Sets future activities for the NBA relating to Donor support and Planning/Analysis.
* Identifies NBA technical needs to Executive Secretary for donor and member country coordination.
* Establishes and enforces planning unit policy.

(3) DIRECTOR OF WATER RESOURCES

* Coordinates and directs daily planning activities for the NBA. Coordinates work between various study areas.
* Coordinates support for planning activities.
* Advises DES concerning direction and progress of planning activities. Coordinates planning strategy between elements of planning staff.
* Responsible for monitoring and coordinating training for planning staff.

(4) DIRECTOR OF TECHNICAL SERVICES

* Provides support/technical services to the NBA member countries and other international organizations as directed.
* Coordinates technical support for planning activities.
* Advises DES concerning direction, future needs, and capabilities of the technical services direction.
* Identifies donor support required in his area to the DES.
* Directs day to day operations of technical support staff.
* Responsible for the flow of information within the NBA.

(5) GENERAL DESCRIPTION OF ACTIVITIES/RESPONSIBILITIES

The DES, as chief of the planning cell, is the overall technical coordinator for the NBA. He is responsible for overall planning strategy and data acquisition, analysis, and dissemination. These are functions which are directly related to successful accomplishment of the NBA's mission. Future technical directions for the NBA are also within his realm of responsibility.

The Water Resources Planning Unit is the planning entity of the NBA. It has the responsibility for performing all water resources planning and analysis. The technical services unit acts as the support unit of the NBA. It has the capability of acquiring, storing, and presenting data. It also has the

capability to provide services to member states. These services, such as sediment data collection and analysis and hydrographic surveying, are specialized in nature. The technical services unit also has the capability to continuously update critical baseline items. This can be accomplished through coordination with member country regional offices or directly acquired if member country governmental services are not capable of providing the information. Also, the technical services unit can assist in data acquisition to support member country needs.

The basic assumption made here is the NBA cannot perform its technical responsibilities by itself under current conditions. To accomplish this, the donors will need to finance studies, assist in the planning process, and provide the technical and administrative support necessary to the NBA's growth. It is imperative the NBA possess the minimum means necessary to begin meeting its responsibilities.

Donor support to the NBA must fit the structure of the NBA. Within this framework there are three primary functions that the donors must perform. First, the donors must finance and train the technical staffs of both the NBA planning group and member country regional offices. These intermediate levels must exist before planning can begin. Initially, individuals will be hired under ongoing donor projects. Counterpart training will be accomplished under these projects and will continue during basin water resources planning. The establishment of regional offices is critical to the long term success of the NBA.

Second, the donors will be responsible for producing the baseline data required to begin the planning process. This will be done through active projects under the direction and management of project program managers. These program managers will initially be active participants in the NBA Planning Cell. Their input will be utilized in current planning activities and identifying future strategies and requirements for the NBA.

Third, the donors, together with the NBA, must cooperate in establishing the framework and overall direction the planning process will take. Throughout its existence, the NBA has failed to accomplish this. It has lacked staff, resources, but most importantly, direction. The donors must agree on the roles each will assume during the planning process. For example, one donor must accept responsibility for planning strategy and providing a technical advisor to the DES. Another must accept responsibility for direct plan formulation and providing a technical advisor to the Director of Water Resources. Other donors must accept roles directly involved with active planning and assume responsibility in various areas of data needs. Parallel efforts oriented on independent donor goals outside the context of the NBA institution cannot be seen as supporting that institution. Without agreement by donors concerning the planning process, no real forward success will take place. The NBA will once again be left with many tools, equipment, and supplies to perform their mission; but with very little real capability to actually perform their responsibilities. For NBA institutional development to take

place, the donors must be fully involved and actively participating.

This role by the donors cannot and should not be expected to last forever. However, to expect it to last for less than 10-15 years is not realistic. The member countries must assume more responsibility, especially financial support. In the short term they must supply qualified personnel to take part in the activities of the NBA. They must wholeheartedly endorse the need which the institution of the NBA represents. They must improve their management and coordination of NBA activities. They must provide cooperation and support to NBA regional offices, active studies concerning baseline data, and identification of national needs concerning the development of water resources planning.

3. ACCOMMODATIONS REQUIRED TO PERFORM TECHNICAL TASKS

a. Personnel

(1) NBA/Member States

* Executive Secretary
* Deputy Executive Secretary
* Director of Water Resources
* Director of Technical Services
* Director of Hydroniger
* Counterpart trainees for positions on the planning staff
* Counterpart trainees for positions on the technical services staff
* Counterpart trainees for positions on the regional office staffs
* Administration and support staffs at all levels
* Documentation Center Staff

(2) Donor

* Technical advisor to the Deputy Executive Secretary
* Technical advisor to the Director of Water Resources
* Project staffs

b. Physical Facilities and Equipment

The following facilities are required to perform technical activities:

* Office space to house all the technical components of the NBA
* Adequate facilities for the Documentation Center

* Office space for the Executive Secretary and the administrative elements of the NBA
* Office facilities for the member country regional offices

The following guidelines should be followed in establishing the physical facilities for the NBA.

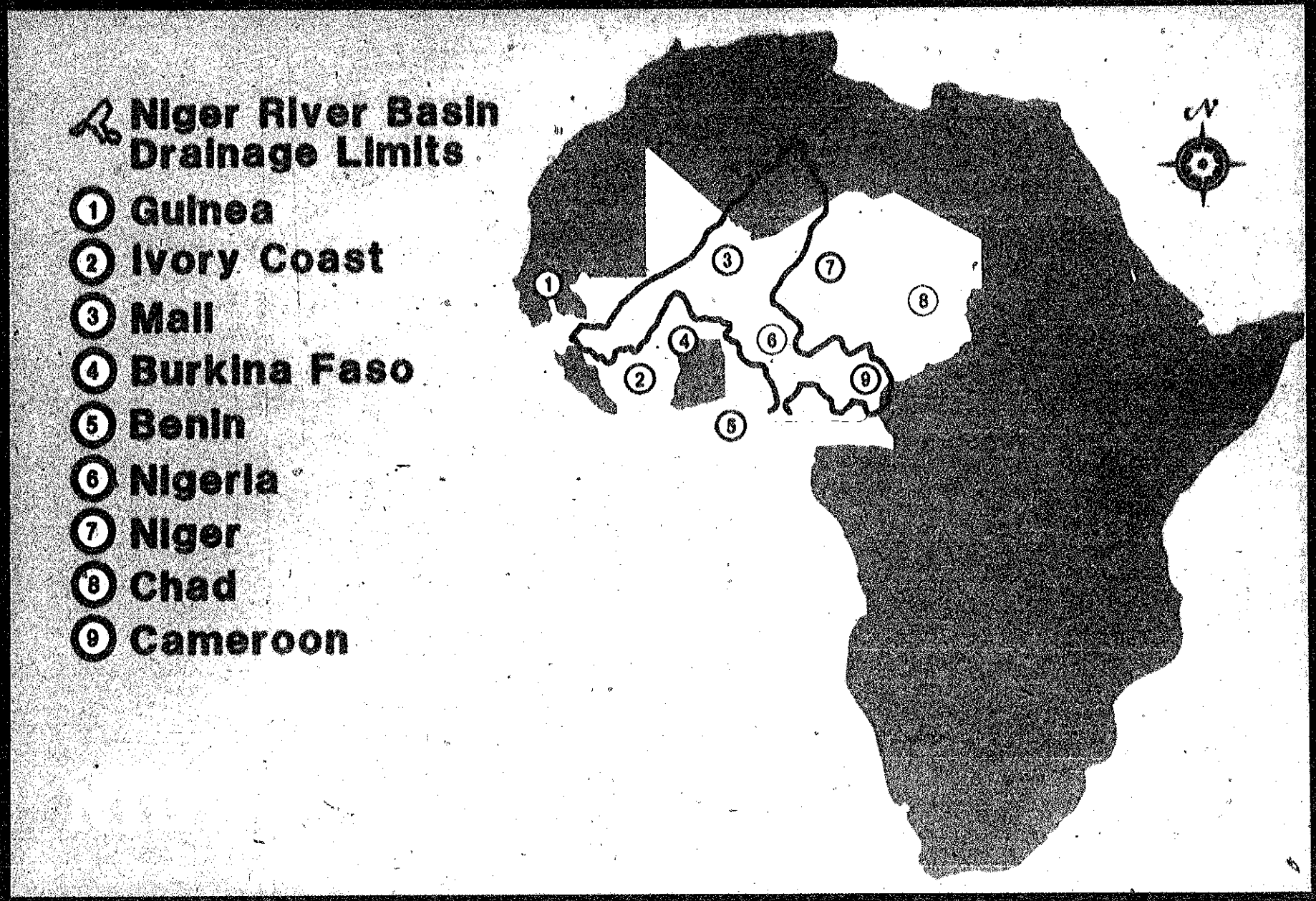
* The existing structure used for the Secretariat should continue to be used. It should be completely supported through member country contributions.
* Current facilities for technical work in the NBA are totally inadequate. Office space for all technical components should be co-located. In addition, the documentation center should be located with the technical branches of the NBA. The long range goal of constructing adequate technical facilities should be adopted by both donors and NBA member countries.
* Member country regional offices should be rented by donors or provided by member country governments.

Currently the NBA has far more office equipment than it requires. In the future, this equipment should be used by donors and NBA technical personnel. Technical equipment or equipment to be utilized in support of technical activities should be identified and purchased under future project needs. A portion of future project expenditures should be allocated directly toward the maintenance of technical equipment currently owned by the NBA.

D. Current Use of Niger River Basin Resources

1. Summary of Current and Planned Projects

a. Plate 1 shows the drainage limits of the Niger Basin and the member states of the Niger Basin Authority. The existing and planned water resources development works of the basin are described by country in the following paragraphs.


Niger River Basin
Drainage Limits
1 Guinea
2 Ivory Coast
3 Mali
4 Burkina Faso
5 Benin
6 Nigeria
7 Niger
8 Chad
9 Cameroon
N

b. GUINEA. The locations of the projects are shown on Plate 2.

(1) The Dabola Hydropower Plant, a major existing dam, is used for hydropower and flood control. A concrete sill submerges an intake to a 1.4 meter diameter penstock which feeds three Francis turbines 58 meters below the Tinkisso Falls on the Tinkisso River near Dabola. The total installed capacity is 1.5 MW providing an average annual guaranteed power of 6 Gwh. Service began in 1974, but one turbine has been out of service since 1980. The dam has flood control as a dual purpose and the reservoir volume is a modest 350,000 cubic meters.

(2) The Foungonia Banko Dam, a proposed feature, is located on the Tinkisso. The dam's purpose will be hydropower. The proposed installed power will be 5 MW, proposed head is 30 meters, and the estimated reservoir volume is 500,000,000 cubic meters.

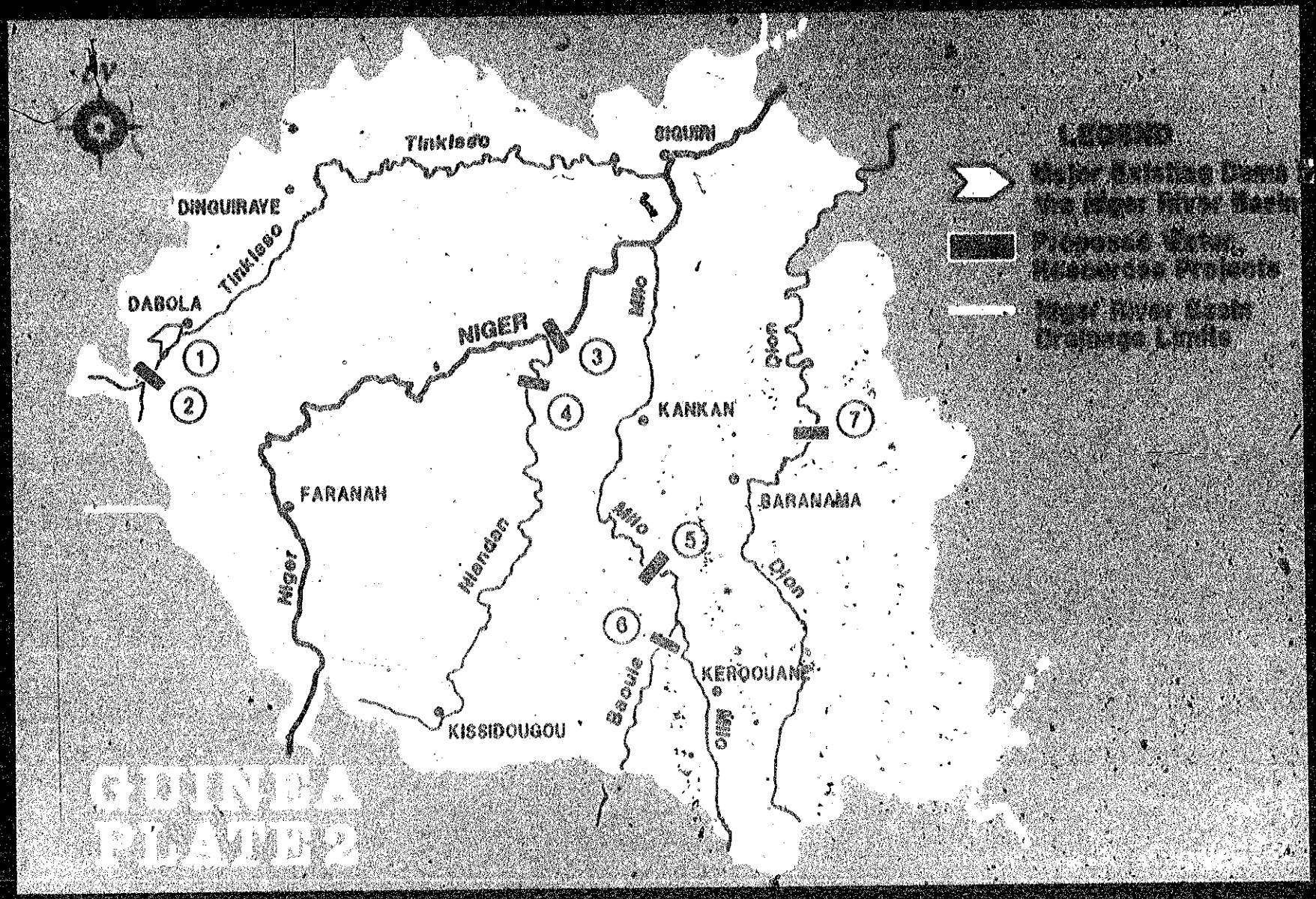
(3) The Diarouguela Dam, a proposed hydropower plant located on the Niger River, is to have an installed power of 56 MW. The proposed head is 25 meters and the estimated reservoir volume is 6,200,000,000 cubic meters.

(4) The Fomi Dam, a proposed site on the Niandan River, is to be used for navigation, irrigation, flood control, and hydropower. The dam has an estimated reservoir volume of 5,300,000,000 cubic meters. The proposed installed power is 85 MW.

(5) The Farankonedou Dam, a proposed hydropower plant located on the Milo River, has a proposed head of 15 meters and estimated reservoir volume of 1,500,000,000 cubic meters. The anticipated installed power is 21 MW.

(6) The Kamarato Dam at a site on the Baoule River is to be a hydropower plant with a proposed installed power of 17 MW.

(7) The Morisanako Dam, a proposed hydropower plant on the Sankarani River, has a head of 25 meters, an estimated reservoir volume of 6,500,000,000 cubic meters, and a proposed installed power of 70 MW.


LEGEND
Major Existing Dams in the Niger River Basin
Proposed Dams, Hydropower Projects
Niger River Basin Drainage Limits
DINGUIRAYE
DABOLA
Tinkisso
Tinkisso
SIGUIRI
NIGER
Milo
Niger
Niger
Niandan
Milo
Sankarani
Milo
Dion
Dion
FARANAH
KANKAN
BARANAMA
KEROUANE
KISSIDOUGOU
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7
GUINEA
PLATE 2

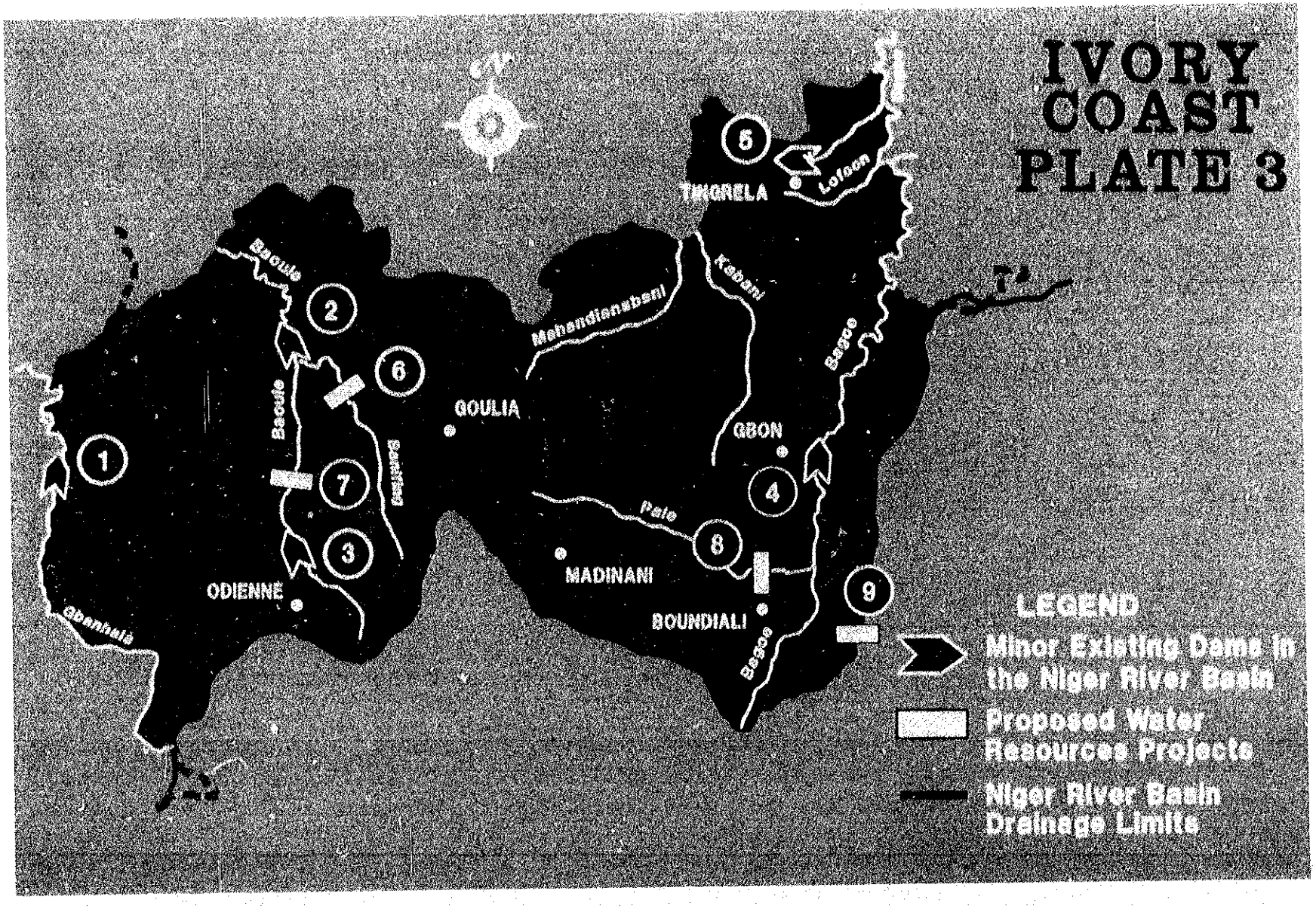
c. IVORY COAST. The locations of the projects are shown on Plate 3. Numbers 1, 2, 3, 4, and 5 are minor existing dams.

(6) Damsite #6 north of Odienne on the Baoule has been preliminarily identified for the purpose of regulating the Baoule for irrigation. Estimates of reservoir capacity are between 100 million and 500 million cubic meters.

(7) Damsite #7 north of Odienne on the Banifing Tributary of the Baoule has been preliminarily identified to provide for the regulation of the Baoule River for irrigation. Estimates of reservoir capacity are between 100 million and 500 million cubic meters.

(8) A damsite northwest of Boundiali on the Pale River has been identified. Its main purpose would be for the regulation of the Bagoe River for irrigation and the possible generation of hydroelectric power. Estimates of reservoir capacity are between 100 million and 500 million cubic meters.

(9) A damsite west of Boundiali on the Bagoe River has been identified for the purpose of regulating the Bagoe River for irrigation. Estimates of reservoir capacity are between 100 million and 500 million cubic meters.


IVORY COAST PLATE 3
N
TINGRELA
Lofoon
Kabani
Bagoe
Mehandianebani
GOULIA
Bacule
Bacule
Bagoe
GBON
Pale
MADINANI
BOUNDIALI
Bagoe
ODIENNE
Gbanhala
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LEGEND
Minor Existing Dams in the Niger River Basin
Proposed Water Resources Projects
Niger River Basin Drainage Limits

d. MALI. The locations of the projects are shown on Plate 4.

(1) The Selingue, a major dam, is used for hydropower, irrigation, navigation, and fishing. The dam was recently constructed on the Sankarani River 60 km above the confluence with the Niger and 140 km above Bamako. The reservoir volume is 2.25 billion cubic meters. The project consists of a 16 meter high earthen dam including a concrete spillway and a hydroplant. Four Kaplan turbines with an installed capacity of 45.6 MW provide a guaranteed power of 25 MW for 213 GWh per year. An irrigation intake on the right bank will eventually irrigate as much as 60,000 hectares of arable land. A fish passage is incorporated into the left bank. The storage capacity of the project is expected to sufficiently augment low flows permitting year round navigation by vessels with 50 cm draft from Koulikoro to Markala on the Niger River.

(2) The Sotuba Hydropower project is used for hydropower and irrigation. The Aigrettes Dam traverses part of the Niger River raising the water level to feed the 2.9 km Baguineda Canal. The canal delivers water to the Sotuba Hydropower Project constructed in 1966 on the right bank of the Niger, 7 km downstream of Bamako. The Baguineda Canal continues past the plant to provide irrigation for 3,000 hectares. Total head varies between 3 and 7 meters. The hydroplant has two Kaplan turbines with an installed capacity of 5.2 MW providing an average guaranteed power of 32.7 GWh.

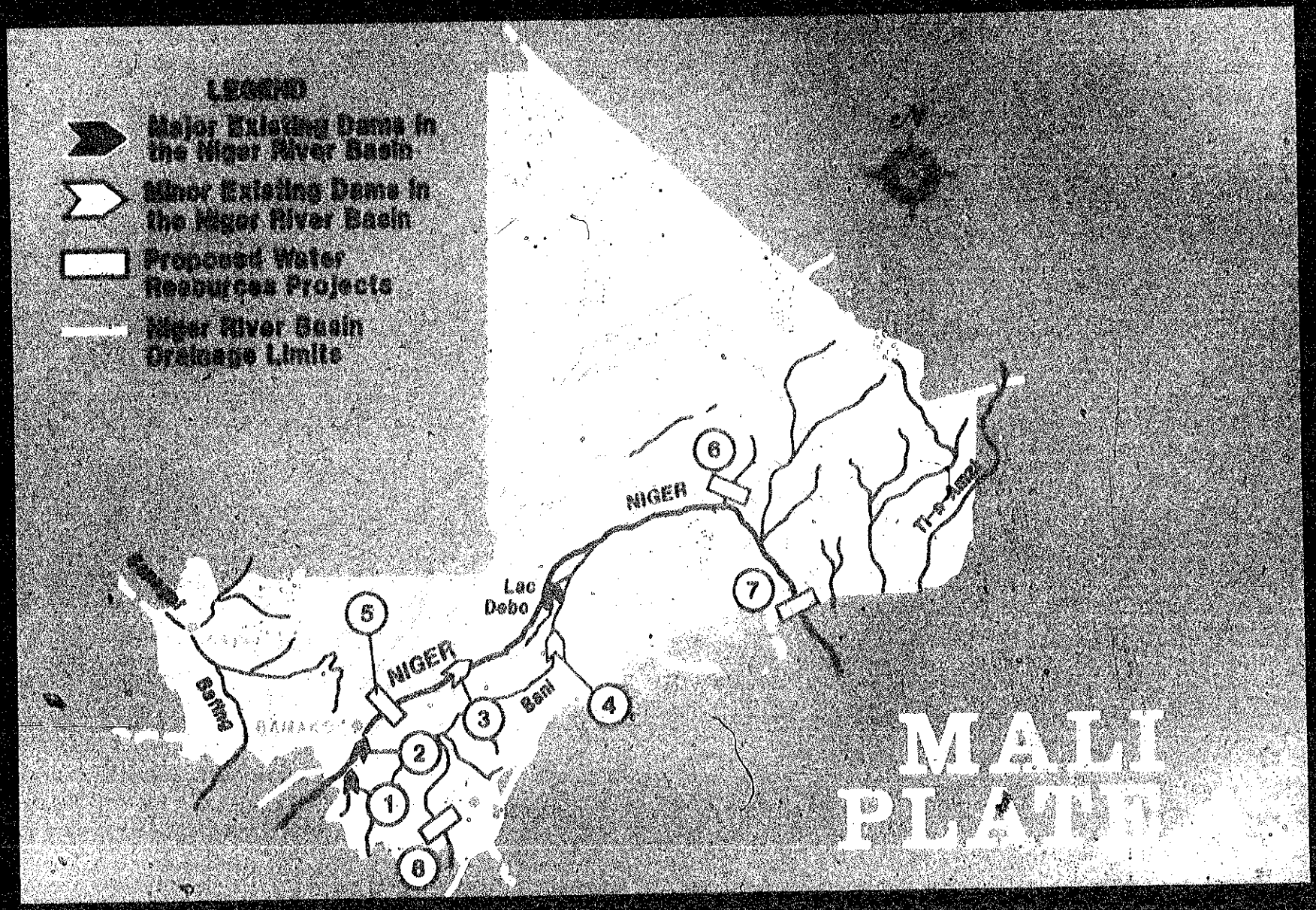
(3-4) Three and four are minor existing dams.

(5) A feasibility study for a dam or dams at Kenie located between Bamako and Koulikoro on the Niger River is under consideration. The construction of Selingue Dam and consequently the partial regulation of the Niger River has made the construction of dams upstream and downstream of Kenie a more attractive proposition.

(6) A damsite at Katioroniba will be investigated to irrigate the proposed 3,000 hectare perimeter of Katioroniba for the cultivation of sugar cane. Reservoir capacity has been estimated at approximately 60 million cubic meters.

(7) The feasibility study of a dam at Tossaye for single or multiple purposes (irrigation, power, navigation, etc.) is presently underway. A site on the Niger River is under investigation.

(8) A damsite exists on the Niger River at Labezenga. A study of this site is not known to have been conducted.


LEGEND
Major Existing Dams in the Niger River Basin
Minor Existing Dams in the Niger River Basin
Proposed Water Resources Projects
Niger River Basin Drainage Limits
NIGER
Lac Debo
NIGER
Bani
Bani
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MALI
PLATE

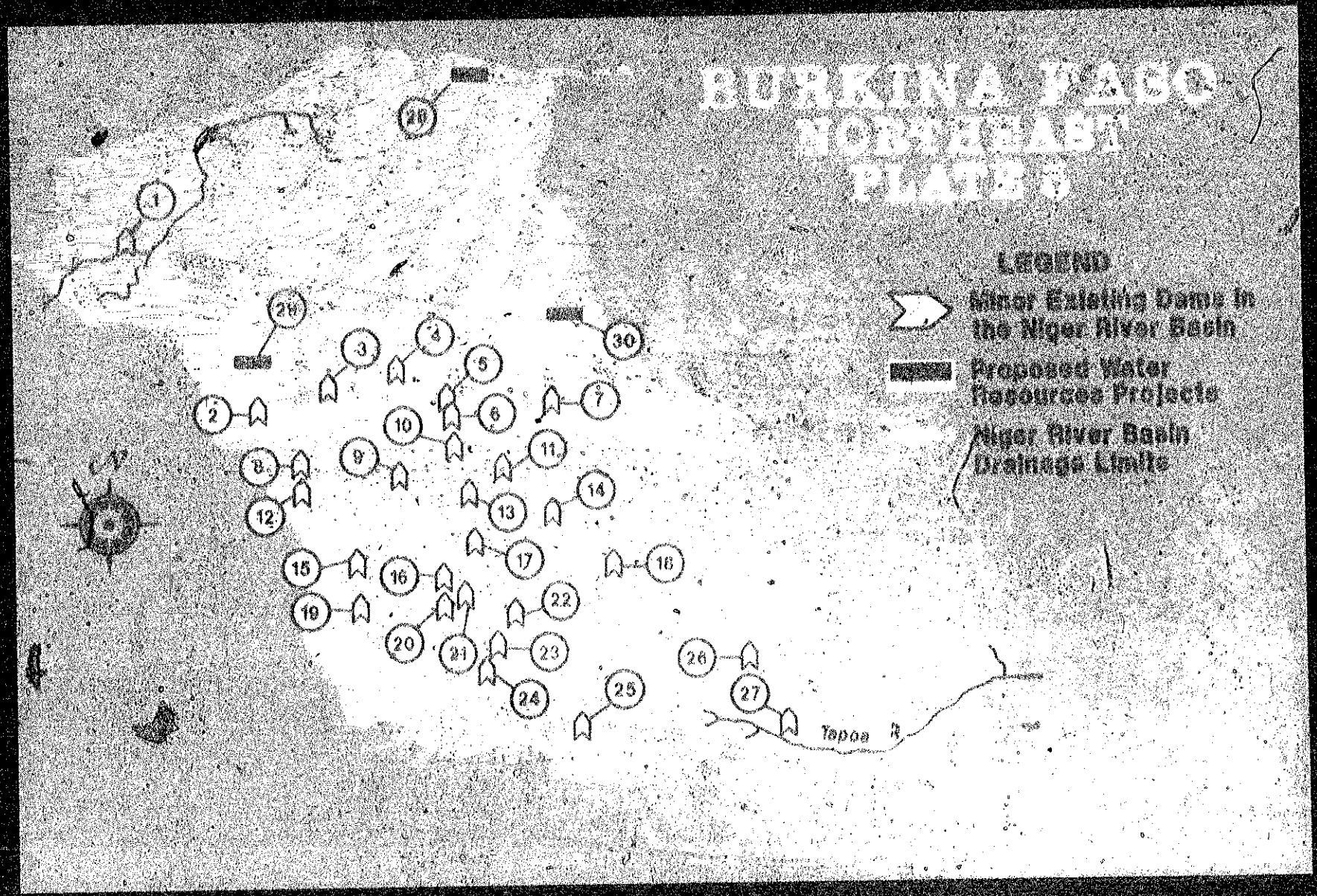
e. BURKINA FASO, NORTHEAST. The locations of the projects are shown on Plate 5.

(1-27) Numbers 1 through 27 are minor existing dams.

(28) Tin-Akof Dam, a proposed dam at Bambakari on the Beli River, would be a reservoir with a capacity of 10,135,000 cubic meters. A canal 2.5 meters in depth and 31.4 km long would supply water to the proposed mining operation at Tambao and Tin Hrassan.

(29) Dablo Dam, a proposed earthen structure, will have a maximum height of 6 meters, a capacity of 9.7 million cubic meters, and an embankment 1,255 meters long. The reservoir will supply water for domestic, pastoral, and agricultural uses.

(30) The proposed Sitenga Dam is expected to have a capacity of 9 million cubic meters. The dam will be earthen construction, 5.4 meters in height and includes a dike of 530 meters. Its purposes would be for domestic and pastoral water supply.


BURKINA FASO
NORTHEAST
RIVERS
LEGEND
Minor Existing Dams in the Niger River Basin
Proposed Water Resources Projects
Niger River Basin Drainage Limits
Tapoa R.

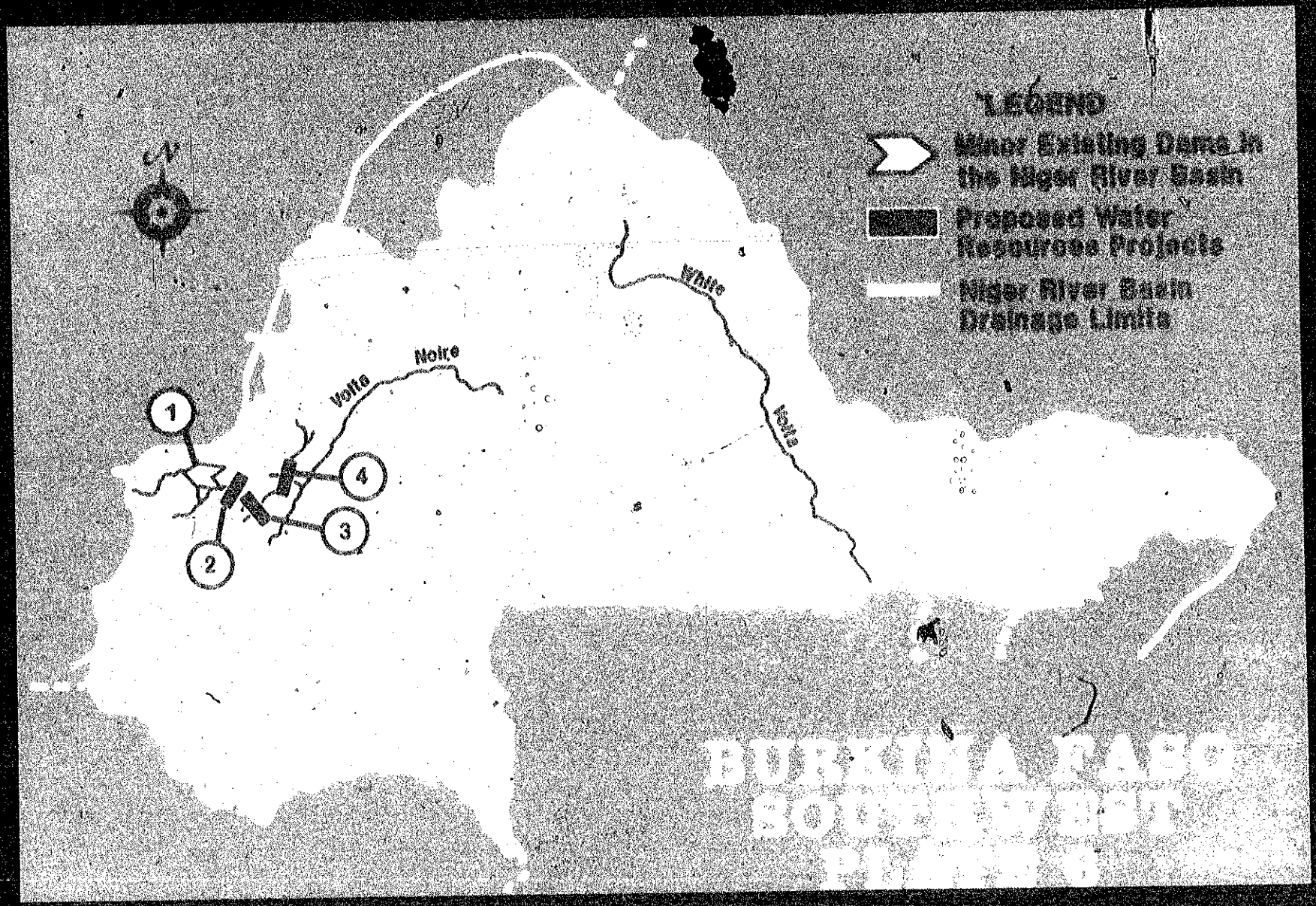
f. BURKINA FASO, SOUTHWEST. The locations of the projects are shown on Plate 6.

(1) Site #1 is a minor existing dam.

(2) Dingasso Dam is a proposed 11.34 million cubic meter reservoir with a dam 1,733 meters X 7.5 meters located on the Donga.

(3) The Kuo Dam consists of a proposed 12.9 million cubic meter reservoir with a dam 1,720 meters X 6.5 meters located on the Kuo.

(4) Kouerendeni Dam consists of a proposed 5.7 million cubic meter reservoir with a dam 850 meters long and 6 meters high located on the Ouzou.


LEGEND
Minor Existing Dams in the Niger River Basin
Proposed Water Resources Projects
Niger River Basin Drainage Limits
Volta
Noire
White
Volta
1
2
3
4

g. BENIN. The locations of the projects are shown on Plate 7.

(1) In March 1975, the Government of Niger received a preliminary draft for determining a suitable hydroelectric dam site on one of the left bank tributaries of the Niger River. A site at Dyodyonga on the Mekrou was selected from among three possible sites and a preliminary evaluation of the site conducted. This site is on a common border between Niger and Benin. The principal characteristics of the Proposed concrete arch structure are the following:

Total Storage	1.04 billion cubic meters
Total Usable Storage	0.84 billion cubic meters
Head	26 to 43 meters
Power at Turbines	26 MW

(2) The Gaya-Malanville Bridge has been constructed over a portion of the Niger River which forms a common border between Niger and Benin. The bridge is now the object of studies being undertaken by the Republic of Niger with a view toward raising it and thus facilitating transportation on the Niger River.

(3) Site #3 is the Kandi-Segbana Dam. The Government of Benin has identified a possible damsite in the Niger Basin. The information received from the Direction de l'Hydraulique et de l'Energie indicates that the site is on the Sota River located on the Kandi-Segbana Road. The purposes of the dam would be hydroelectric power generation and irrigation.

Benue
Niger
Kaduna
Sokoto
Ouémé
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2
3
LEGEND
Proposed Water Resources Projects
Niger River Basin Drainage Limits

h. NIGERIA. The locations of the projects are shown on Plate 8.

(1) The Kainji Dam on the Niger River is used for hydropower, navigation, irrigation, recreation, and fishing. The dam was completed in 1968 and is the largest in the Niger River Basin. The dam has a 550 meter long concrete center section with a rockfill dam on either side. The maximum dam height is 65.5 meters. Eight 8.55 meter diameter penstocks feed four 80 MW Kaplan turbines, two 100 MW Kaplan turbines, and two 120 MW fixed blade propeller turbines, providing 2,225 GWh of firm energy. Four additional penstocks are available for further expansion. The maximum head is 42.2 meters and the average head is 35 meters. The reservoir has a total storage of 15 billion cubic meters of which 11.5 billion are usable. Two locks measuring 12 X 195 meters on a 2,400 meter canal are provided for navigation. Awuru Lock, located downstream of Kainji Dam, has a lift of 7.7 meters and measures 12 X 112 meters. Irrigation schemes have only recently been incorporated into the project.

(2) The Jebba Dam will be used for hydropower, navigation, and other purposes. It is expected to provide 500 MW of capacity and 1,865 GWh of firm energy. The project has a total live storage of 1.1 billion cubic meters and a 29 meter average head.

(3) The Goronyo Dam will be used for irrigation on the Rima River. This project is under construction and will have a storage capacity of 946 million cubic meters and irrigate 32,000 hectares.

(4) The Bakolori Dam will be used for hydropower and irrigation. This multipurpose project is under construction on the upper Sokoto River and will have a storage capacity of 450 million cubic meters, 3 MW of installed hydropower generating capacity, and irrigate 23,000 hectares.

(5) The Dadin-Kowa Dam is a multipurpose project to be used for hydropower, irrigation, water supply, and recreation. Located on the Gongola River, the dam was estimated to be 80 percent complete at the end of 1983. It will have an installed capacity of 34 MW, provide irrigation to 44,000 hectares, and supply water to the town of Gombe.

(6) The Kiri Dam is used for irrigation and other purposes. Limited information about this project suggests that the project was completed in 1983 on the Gongola River near Kiri, impounds 290 million cubic meters, and provides irrigation for 12,000 hectares.

(7-9) Sites 7, 8, and 9 are minor existing dams.

(10) Zungeru Dam will be located on the Kaduna River below the proposed Shiroro Dam.

(11) The Shiroro Hydro Station project has the following characteristics. It has a reservoir area of 282 square kilometers, a total storage of 5.3 billion cubic meters, an average head of 105 meters, a firm energy of 2,360 GWh, and an installed power of 600 MW.

(12) The proposed Metchum Dam would be located at Atoufi on the Metchum River. The Metchum is a tributary of the Katsina Ala River, which traverses Nigeria and joins the Benue River upstream of Makurdi. The dam would be constructed solely for hydroelectric power production.

(13) The characteristics of the Lakoja Hydro Station Project are a reservoir area of 6,760 square kilometers, a live storage of 51 billion cubic meters, an average head of 32 meters, and a firm energy of 8,400 GWh.

(14) The Makurdi Hydro Station has a proposed reservoir area of 3,200 square kilometers. It will have a live storage of 27 billion cubic meters, an average head of 31 meters, and a firm energy of 4,750 GWh.

(15) Garin Dali Dam would be located on the Taraba River.

(16) Monya Dam would be located on the Donga River.

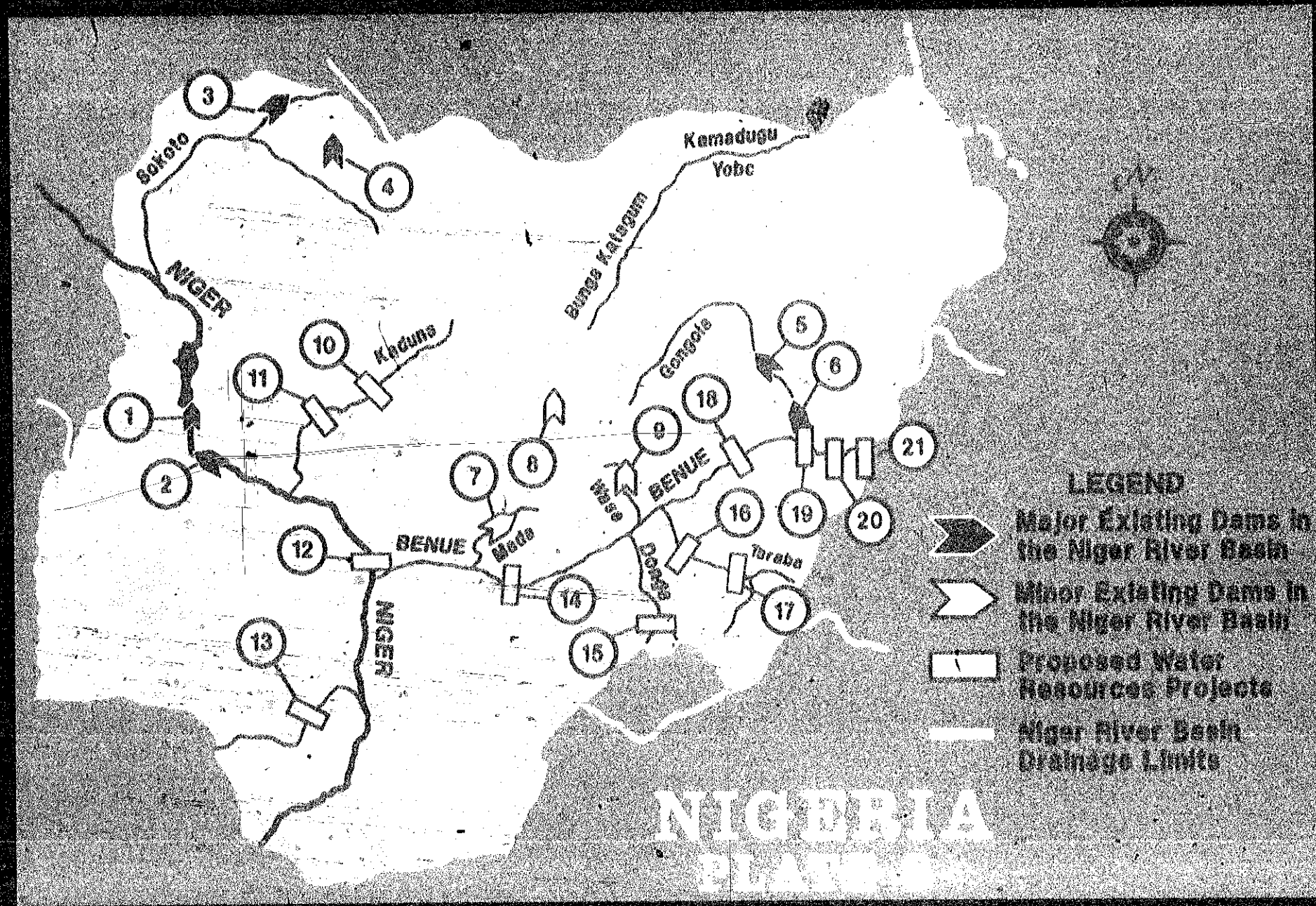
(17) Jamtari Dam would be located on the Taraba River.

(18) The bridge at Lau consists of the construction of a four lane structure with pedestrian walkways at Lau on the Benue River.

(19) The Numan Bridge consists of construction of a new four lane bridge over the Benue River near Numan.

(20) The Jimeta Bridge consists of construction of a four lane bridge at Jimeta near Yola on the Benue River.

(21) The Dasin Housa Dam would be located on the Benue River above Yola.


Sokoto
NIGER
Kaduna
Kamadugu
Yobe
Bunga Katagum
Gongola
BENUE
Mada
Benue
Taraba
Taraba
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LEGEND
Major Existing Dams in the Niger River Basin
Minor Existing Dams in the Niger River Basin
Proposed Water Resources Projects
Niger River Basin Drainage Limits
NIGERIA

i. NIGER. The project locations are shown on Plate 9.

(1-9) Site numbers 1 through 9 are minor existing dams.

(10) Kandadji Dam is the object of studies by the Government of Niger for development of a dam on the Niger River north of Niamey. The site at Kandadji has been chosen as suitable for more intensive investigations. The dam would be a multi-purpose earth structure, 12 kilometers in length and 30 meters high and would have a reservoir capacity between 13 and 15 billion cubic meters. The installed hydroelectric capacity is estimated to be about 200 MW. More investigation and study is required to determine the technical and economic feasibility of the project.

(11) The proposed Wintirga Dam is located on a left bank tributary of the Goroubi River. The dam would have an estimated volume of 5.2 million cubic meters. Detailed studies have not been accomplished. The dam would be constructed within the context of the development of the City of Say.

(12) The proposed Diapengo Dam, located on a right bank tributary of the Gouroubi, would be established to augment the development of the City of Say. It is estimated that its volume would be 15 million cubic meters with a dam height of 7.5 meters. The dam would permit irrigation of 230 hectares.

(13) Park "W" Dam on the Niger River south of Niamey has been under consideration by the Government of Niger for many years. The most recent study is a preliminary draft of the project produced in October 1969. The proposed dam would be a run of the river, multi-purpose structure. Recommendations include a dam with mobile sluices, a head between 7.4 and 12.7 meters, and an installed power capacity between 84 and 120 MW.

(14) The construction of a port on the left bank of the Niger River at Gaya is now under consideration by the Government of Niger. Feasibility studies are underway.

(15) The proposed Zango Dam would have an estimated storage capacity of 10 million cubic meters and together with the Mozague Dam would be a part of the Konni Project. A feasibility study has not been prepared.

(16) The proposed Mozague Dam would have a reservoir capacity of approximately 30 million cubic meters. This dam would be a part of the Konni Project.

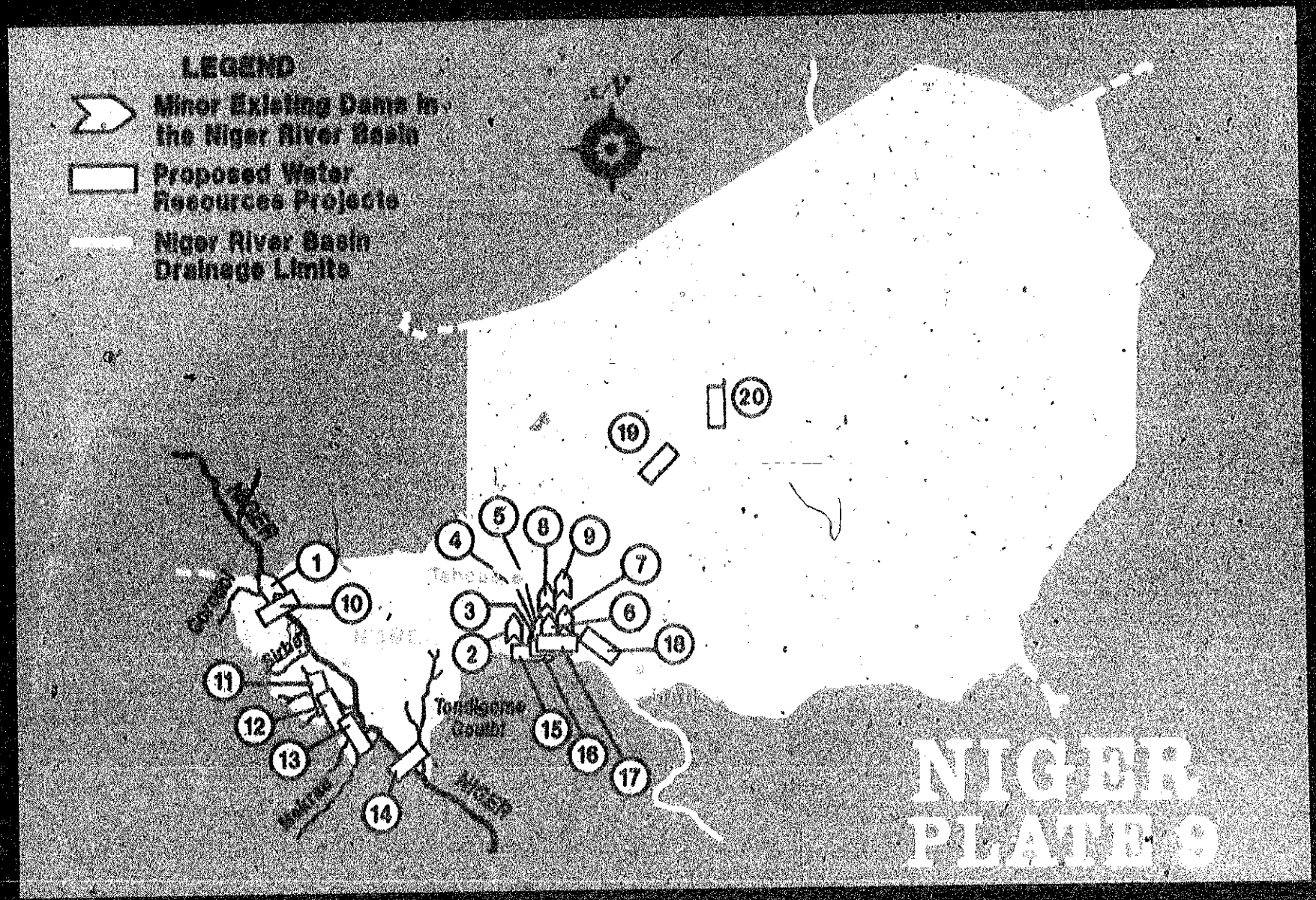
(17) Together with the proposed Guidan Kodini Dam in the Galmi Project, this project would make possible the irrigation of 480 hectares of land. The proposed Guidan

Kodini Dam would have an estimated reservoir capacity of 7 million cubic meters.

(18) The proposed Takorka Dam would impound Tapkim Baba Lake. The reservoir capacity would be 11 million cubic meters to be used for irrigating 400 hectares of land.

(19) The Irhazer II Dam has a reservoir volume of 11 million cubic meters.

(20) The proposed El Meki Dam would have an estimated reservoir storage capacity of 11 million cubic meters to be used for irrigating 400 hectares. Studies were performed in 1972.


LEGEND
Minor Existing Dams in the Niger River Basin
Proposed Water Resources Projects
Niger River Basin Drainage Limits
N
Tondigame Gouldi
Sirba
Gorouol
Dargol
Mekrou
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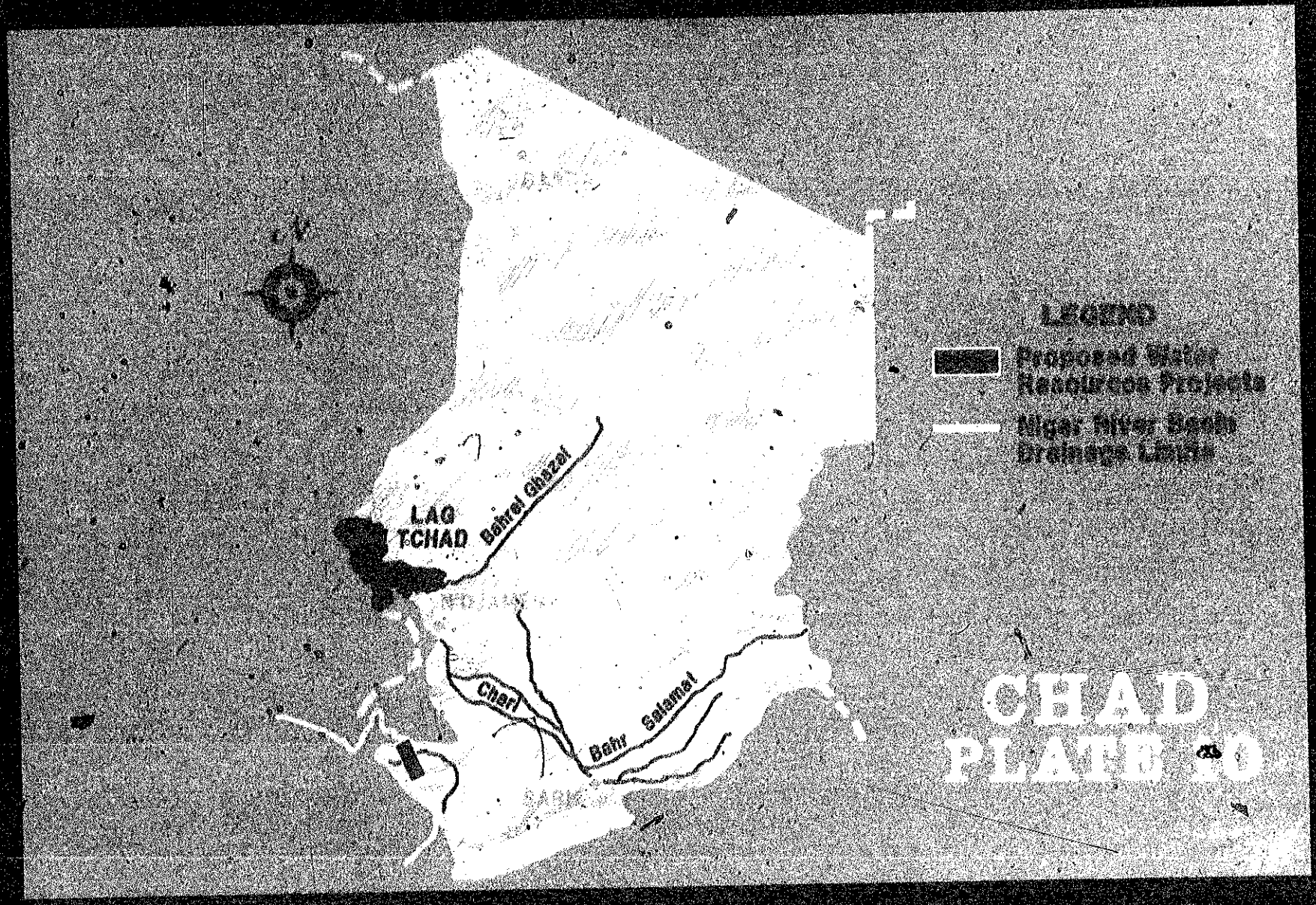
NIGER PLATEAU

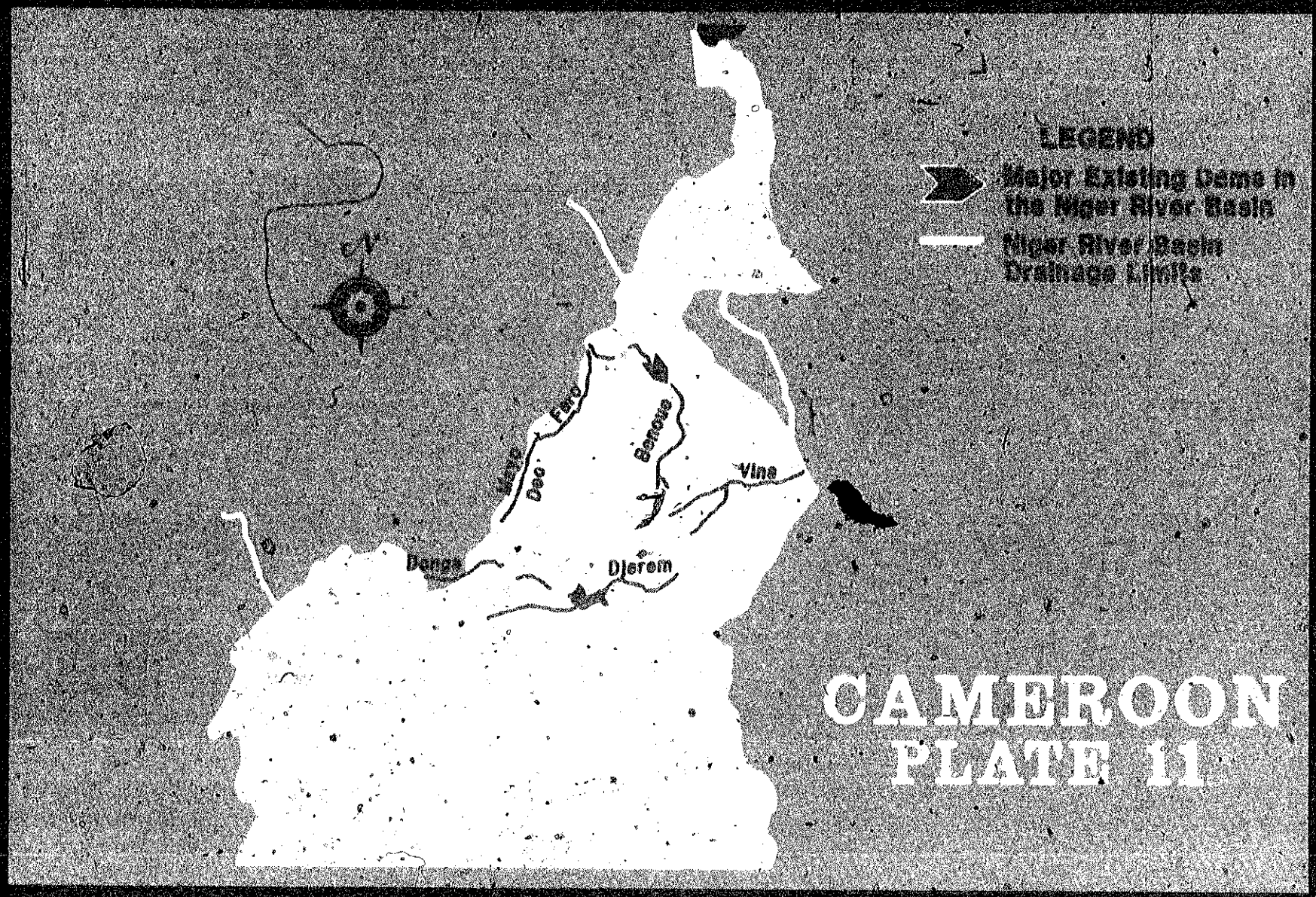
j. CHAD. The project locations are shown on Plate 10.

(1) Preliminary studies have investigated the feasibility of an upstream regulating dam at Dao-Koumi, 8.5 kilometers upstream from the falls. The dam would have a height of 13 meters. A second dam just upstream from the falls would have a head of 42 meters. The installed power capacity would be about 10.2 MW.


LEGEND
Proposed Water Resources Projects
Niger River Basin Drainage Limits
LAC TCHAD
Bahr el Ghazel
Chari
Bahr Salamat
CHAD PLAIN

k. CAMEROON. The project locations are shown on Plate 11.

(1) The Lagdo Dam is used for hydropower, irrigation, fishing, navigation and recreation. This multi-purpose dam was completed in the early 1980's on the Benue River. The original design was for a 4 billion cubic meter reservoir with an installed power capacity of 72 MW.



CAMEROON
PLATE 11

1. Efficiency of Current Water Use

Water resources development currently in existence encompasses many recognized needs of West African nations. The potential issue of efficiency of water use has been and continues to be of little concern in considering or constructing interventions. This situation primarily exists because interventions to date have not resulted in major conflicts in water use or allocation. The potential of future conflicts are great because water availability has a finite limit in this region and water demand will continue to rise.

From what is known of existing water uses, it can be concluded that there are no grossly inefficient uses of water taking place. It can be also concluded that water related needs are extensive in the Niger Basin and additional water resources development can address many of these needs. Therefore, in this sense, water resources are not being efficiently utilized. Additional water resource development will undoubtedly take place. Unless this development is undertaken within the context of an integrated development plan, major inefficiencies will likely occur.

2. Land Management Practices

The problems concerning land management practices are similar in all the countries in the Sahel region. Natural vegetation is being decimated as a result of more intensive demand for agricultural and forest products. This decimation is being accelerated by recent drought and historically poor land management practices. Present trends can be reversed with implementation of a concerted and coordinated effort directed toward reforestation, the protection and conservation of natural vegetation, improved management and production from existing agricultural practices, and closer control and regulation of land uses. Large scale reforestation projects which are undertaken in order to supply the demand for wood products generated by large urban centers are often economically unsound. There has been and continues to be research into silviculture combining features of irrigation (ditches, levees, perimeter borders, etc.) with production of forest products. These methods are particularly effective in zones with an average annual rainfall of less than 800 mm. Rainfed reforestation is generally limited to those regions receiving 800 mm or more of average annual rainfall.

It is feasible to undertake smaller scale reforestation programs within the context of meeting needs of villages, families, or individuals. It is important that full technical support be provided to insure successful implementation and operation of programs of this nature.

Rural development projects in the Sahelian zone should address problems associated with forest products and integrate improvement efforts in this regard. Reforestation projects of the types already discussed must be tailored to the specific needs and situations encountered.

The protection and conservation of natural vegetation is an important element in land management practices and the following measures are considered appropriate. Forests should be classified and their use prioritized in order to exploit the resource. Considerations in this regard include the recognition of tree stands being threatened, current role of forests such as for dune stabilization and soil stabilization in areas subject to erosion along rivers or extreme slopes.

Brush fires are a major contributing factor to the degradation of natural vegetation and control is largely a function of the attitudes of local citizens. Education is the key to control and may be undertaken with the mass media, local political organizations, schools, and citizens groups.

Improvement of existing management practices will increase production and provide measurable regeneration of forests, native vegetation, soil capacities, and urbanized green space. To pursue this, it is necessary to undertake studies, inventories, problem identification, and literature searches all directed toward the formulation of specific plans for the improvement and exploitation of existing vegetative resources.

Currently there are many competitive uses of available land resources. Many times agricultural and herding practices are in

direct conflict and the desire to increase production results in significant damage to available vegetative resources. To address this requires additional control and regulation in the form of land use classifications and zonings designed to permit and/or prohibit uses compatible with the resource capacity.

3. Potential Negative Impacts of not Planning

In the Niger River Basin there exist many factors which directly impede economic development and make it difficult for the countries of the basin to raise the standard of living of their people to an acceptable level. Among these factors is water. Water is available in general in the basin in limited supply. People are greatly affected by its availability and accessibility. The Niger River is one of the primary sources of water in the basin. In many places it provides the means for existence for people living along its banks. It is crucial in the areas of water supply, agricultural production, and local transportation.

As a critical limiting resource in the basin, water resources and its management demand a high degree of concern. The overriding reason for water resources planning is the importance of water in general, and the Niger River specifically in the lives of the people in the basin and in their future. Proper integrated water resources planning is an avenue available to address the present and future needs in the basin. It has the potential to directly improve the lives of the people of the basin by targeting water to satisfy the tremendous needs of the people. The structure of water resources planning offers the opportunity to integrate many limiting factors in development together to create a better understanding of the entire social, economic, environmental, and physical systems which relate to overall development in this region.

Failure to properly plan for the use of the water resources in the Niger River Basin risks the inefficient use and possibly waste of scarce capital available for development in the region.

Throughout the basin, there exist many plans for development ranging from numerous large dams intended for multi-purpose uses to small site specific projects intended for single-purpose uses such as irrigation and flow regulation for water supply. These projects are formulated based upon needs centered on the site chosen for the individual projects with the objective being to utilize the site to the maximum extent possible to satisfy needs. Alternatives are seldom addressed in depth to determine the benefits of other, less expensive courses of action to meet these needs. There is very little effort made to obtain the maximum amount of benefits from the minimum costs invested in any one proposed project.

The economic environment of the countries of the Niger River Basin demand that the funds that are expended in development of water resources achieve the greatest benefits possible. Additionally, these benefits should be directed toward needs designated as having the highest priority. By not planning or improperly planning water resources development in the basin, potential investors in the future of the basin cannot be assured that their funds are being spent in the most appropriate manner. Proper planning will help insure that the benefits are optimized from any expenditure of funds and are directed toward the highest priority development needs.

The failure to properly plan water resources development in this region also risks the misuse of water for other potential users in the system. Misuse in this case has a broader, more damaging meaning than incorrect, site specific use. It includes consumptive use and water losses which are irreversible in relation to downstream users. System water losses and other changes are a

part of the negative impacts which must be analyzed thoroughly prior to final design of any intervention. Reductions or changes in flow can have direct negative impacts on water availability, especially during low flow periods. Agricultural production systems which depend on historical flows can be greatly affected by changes in the patterns of flow. The river system itself will also adapt to changes in discharge and stage. Sediment transport capacities can be altered upstream which have a great influence on interventions downstream.

Water resources planning guidelines provide the structure to insure that negative effects within the river system are identified, analyzed, and quantified. This must be done over the long term as well as for the present and near term. Planning methods which do not take an integrated approach to the system will risk overlooking the negative impacts of system intervention. The situation can very easily develop where the long term negative impacts of an intervention can far outweigh the near term benefits. Proper water resources planning will lessen this risk.

Development of a comprehensive integrated basin development plan requires several working tools in the planning process such as baseline studies, models, data collection capabilities, and functional, professional technical staffs. Once developed through the preparation of an initial basin development plan these products will preclude the complete re-analysis of every proposed intervention. Without an overall plan for the development of water resources each intervention would likely be studied in a site specific mode more or less independent of other interventions. This approach results in excessive duplication of effort, requires

excessive amounts or time and money, and produces final site specific studies which are not broad enough in technical scope to advance to actual project implementation--for example, detailed studies of an upstream reservoir for hydropower or other purposes which did not consider the full potential of the site or which did not consider the potential of low flow disruption downstream.

An integrated planning approach provides the means to break the cycle of study activities in order to progress to actual project implementation. The technical structure of the planning approach provides the necessary depth of technical analysis to demonstrate feasibility and desirability of a proposed intervention. It provides the means to incrementally develop the water resources available in the basin at a rate corresponding to the projected needs of the basin in areas such as in hydropower production, food production, transportation, and water supply. The structure of the water resources planning process provides the ability to link water resources with other development needs. It creates an interactive structure where impacts of water resources development can be integrated into other development areas such as improvement of transportation infrastructure, goals of rain-fed agricultural production, and national economic policies.

A fully developed technical plan will not avoid the necessity of addressing political issues in water resources development such as potential disagreements regarding upstream instead of downstream use of water. However, it will provide better technical information to assist in political decisions.

In summary, there are several negative impacts of not planning in an integrated manner the use of the water resources of the Niger River Basin. A full understanding of the limiting factors and their interrelationships regarding development in this region will not be attained without engaging in a planning process. Inefficient use of scarce capital of the basin countries and involved donors will result from a haphazard approach to development planning. The most critical needs may not be addressed and benefits from implemented projects may not exceed long term negative impacts in the system. Misuse of water resources can result in unforeseen, irreversible negative changes to the river system. Expensive, time-consuming, site-specific studies will continue without actually leading to much needed implementation of development projects.

4. Data Gaps and Data Collection Activities

a. General

In order to address this subject, one must first clearly define the planning objectives to be pursued. The primary planning objective is the development of a framework plan that would guide the consideration and selection of specific interventions which should be pursued within the context of an Integrated Niger Basin Development Plan. It is important to note the difference between the framework planning concept presented herein and the development of an integrated plan that would ultimately guide the selection and implementation of specific interventions. Framework planning focuses on resource allocation and needs identification while development planning focuses on site specific interventions. Accomplishing framework planning will result in identifying possible intervention scenarios or an array of alternatives that would likely be feasible while an integrated development plan would consist of a specific set of interventions recommended for implementation. In the Niger River Basin, framework planning as proposed herein will accomplish the following goals.

* Available resources will be identified and quantified.
* Needs which can be addressed with water resources development will be initiated.
* Alternative d velopment scenarios will be formulated taking into consideration needs, available resources, and likelihood of feasibility.

Development of an Integrated Basin Development Plan would logically follow completion of framework planning and would build on information already acquired with data expansion to include site

specific information necessary for developing individual future costs and benefits.

The discussion of data needs will be limited to a level required for framework planning. Framework planning will eventually lead to a further and more concise delineation of data requirements in the basin planning process. As development scenarios are analyzed and probable development interventions are determined, more in depth knowledge will be required to begin the design of site specific interventions.

This section addresses data needs in two parts. First, the hydrologic and meteorologic data needs will be discussed. Secondly, the Natural Resources/SocioEconomic data needs will be addressed. This format is used for a number of reasons. Activities performed under Phase I of the USAID Niger River Development Project successfully began to address many of the hydrologic and meteorologic data needs required in framework planning. The data has been consolidated and entered on the NBA's Data Storage and Retrieval System in Niamey. It is easily accessible in this format and can be used in the planning process as it now exists. However, shortcomings in this data do exist and will be addressed in the following sections. Additionally, many of the parameters discussed under hydrologic/meteorologic data needs summarize the physical river system involved in the planning process. They represent the water resources available to be used in terms of quantity and time and the characteristics of the river system which is closely linked to discharges.

On the other hand, data needs in the areas of natural resources and socio-economics have not been addressed to the point where they are available in sufficient detail and form to begin the framework planning process. It is obvious from the Corps of Engineers' experience in West Africa that a wealth of data currently exists in these areas. However, to collect this data and to produce it in a usable format which covers the entire basin will require a substantial investment in both time and money. Basin wide coverage is critical in these areas. Many of the topics have been studied, often in limited form, due to political and economic considerations. The data base and other materials used in the planning process must contain data from the entire basin.

While covering the basin as a whole, the socio-economic and natural resources data should be limited to geographic areas that can be or are logically expected to be affected by water resources development. The focal point of water resources development is use of water to improve the human standard of living. The ways in which water can be used to this end have a direct relationship to many economic, social, and environmental factors. However, there is a general limit to the effects of water resources development and this limit must be used to establish boundaries in the scope of data needed in the socio-economic and natural resources area.

A suggested limit would be the immediate areas adjacent to the Niger River as defined by the alluvial areas of the Niger River and its major tributaries. The vast majority of needs satisfied by water resources development and impacts resulting from their implementation will be seen in these areas. Concentrating on these limited areas will reduce the funds and time required to develop the

initial baseline studies, yet will satisfy the data requirements of initial framework planning. As with any defined limit, there are always exceptions, and these exist in the development of data for basin planning. Hydropower production, for example, impacts areas far removed from the river itself. In the preparation of any effort to assemble data for use in water resources development planning, care must be taken to insure that those areas affected by water resources development are included. Data outside these limits is not immediately necessary in the water resources development planning process.

Natural resources and socio-economic data are critical in the planning process. In the manner that the hydrologic and meteorologic data describe the water resources available to aid in basin development, the natural resources/socio-economic data describe the needs, costs, and impacts of this development. It must be determined how and where water can be most effectively and efficiently used to promote regional development.

b. Hydrologic and Meteorologic Data Needs

(1) River Stage/Discharge

Existing station records are available for 173 hydrologic gaging stations within the Niger River Basin, but data is incomplete at many locations. Missing data has been identified and should be determined in order to transform the information into a more complete data base. Some are inactive and should be reactivated and all stations require "one time" measurements as follows.

* Bench marks should be established and current cross-sectional profiles at each station determined.
* Physical conditions of gages should be determined. They should be repaired or replaced as necessary and elevations re-established.
* Cross sections for gages located at bridges or similar structures should be supplemented with cross sectional data taken at an adjacent location so that effects of scour will be negated.
* Bed material samples should be obtained and analyzed for gradation at each cross section.

(2) River Stage/Discharge-Supplemental Stations

Based on the length and discharge of the various tributaries and the type of projects being considered within the river system, an additional thirty new gaging station locations are recommended at various locations in the upper and lower basin. Specific information in this regard can be found in the documents prepared and published in connection with the development of the Automated Data Storage and Retrieval System.

(3) Sediment Transport Gaging Stations

There are no existing sediment transport measurement stations within the system and establishment of a minimum

program is required if comprehensive water resources planning is to be pursued. A specific plan in this regard was proposed in connection with the Corps of Engineer River System Analysis, but implementation was not possible because of project termination. Details can be obtained from the draft PASA amendment developed in connection with the project.

(4) Reservoir Surveys

Generally, information available in this regard is inadequate for planning purposes. Minimum information consisting of the following is required.

* Location and physical characteristics of structures including spillways.
* Pool characteristics including areas, capacities, elevations, fluctuations, etc.
* Operational strategy and rules to include daily inflows/discharges.

(5) Channel Cross Sections and Profiles

It is known that a significant amount of data exists in this regard, but to date the only attempt to centralize has been the development of the Automated Data Storage and Retrieval System which was a part of the Niger Basin Planning Project. Substantial data resides in this system and substantially more is in existence. Details of the DSRS are available upon request through USAID. It is important to note that the data in this system can be easily accessed. Acquisition of additional survey data is possible either from existing sources or execution of a survey program as proposed in the Niger Basin Planning Project. Data development from new surveys would require substantial expenditures, but acquisition from existing sources would be less costly and should be

evaluated to determine if they can meet planning requirements. After complete compilation of existing data, the necessity of acquiring additional data through a survey program can be more thoroughly analyzed.

(6) Meteorological Data

The DSRS contains meteorological data from almost 600 stations and represents a vast amount of information which addresses to varying levels of completeness rainfall, temperature, evaporation, humidity, vapor pressure, barometric pressure, wind speed and direction, solar and back radiation, and cloud cover throughout the basin. A review of stations within the basin has revealed significant data gaps in terms of geographic coverage and measurements being taken. This subject is more comprehensively addressed in the documents prepared in connection with development of the DSRS.

(7) Water Quality

Data in this area is almost non-existent. An extremely limited program was proposed in connection with the sediment data collection program, but termination of the project halted activities in this regard. The subject of water quality monitoring is comprehensively addressed in the supporting documentation prepared for the DSRS.

c. Natural Resources/Socio-Economic Data Needs

(1) Agriculture

Extensive quantities of agriculture related data exists covering all regions of the basin. The Carlo-Lotti Report is an excellent first step in consolidating this type of data to be used in the planning process. However, the data must be expanded to include Nigeria. Additional topics that need to be addressed in data collection acvities are:

* present and projected food and agro-products demand
* identification of regional agricultural problems and recommended solutions
* irrigation demand by region and river reach
* fertilizer demand
* existing and projected agro-processing requirements
* existing and projected storage facility requirements
* existing and projected transportation related requirements
* existing and projected unit production costs

(2) Energy
* current production by type and location
* projected demand
* projected production capacity by type and location
* production costs
* current and projected interconnection plans and associated costs

(3) Environment
* inventory of basin archeological, historical, and paleontological resources and features
* description of the botanical, aquatic, and zoological resources and features
* physiographic inventory and description

(4) Fisheries
* existing and projected consumption of fish
* fish potential as a food source and for other uses
* aquaculture potential
* fishery development potential
* fish processing requirements
* fish inventory

(5) Forestry
* timber demand existing and projected
* timber availability existing and projected
* potential areas for forestry development
* production costs of forestry related products
* energy and transportation requirements related to forestry production

(6) Industry
* inventory of existing industries by type, size, and location
* projected national and regional industrial development
* industrial potential and resulting requirements in energy, transportation, and infrastructure

(7) Livestock
* livestock population by type and quantity
* livestock potential
* pasture demand
* food demand other than pasture
* processing facilities existing and projected
* historic patterns of raising livestock as a function of vegetation, weather, cyclic river changes, etc.
* livestock comsumption existing and projected
* other potential benefits of livestock production
* cost of production

(8) Mining
* inventory of existing mines and current production levels
* projected production levels
* inventory of mineral reserves
* current and future unit production costs
* processing requirements

(9) Socio-Economic
* population
* projected population growth
* distribution of population
* age structure
* education level
* current occupations and projected work force availability
* ethnic structure
* identification of constraints to development

(10) Transport
* inventory and description of existing air, ground, and water transport facilities, and infrastructure
* existing and projected air, ground, and water transportation needs

* potential development of air, ground, and water transportation infrastructure
* current and projected unit transportation costs by air, ground, and water

(11) Other Physical Elements Related to Water Resources

* inventory of groundwater
* groundwater usage feasibility
* municipal and industrial water demand existing and projected
* water purification requirements
* waste water treatment requirements
* analysis of water related diseases within the basin and their relationship to development

5. Training Needs of the NBA in Water Resources

a. General

Training requirements for NBA personnel are mission related. Each individual should be capable of accomplishing the objectives required by that mission. Currently, technical training and experience is required at all three levels in the NBA. Any future expansion of the NBA technical staff must be accompanied by a well structured training program. The basic objective of a training program should be to develop personnel of all levels so that they may perform their technical roles competently. Additionally, the training must be oriented on developing a functional team of technical personnel. Water resources planning is an interactive process that involves a diverse range of technical specialties. Unless the personnel are capable of functioning together as a team, individual expertise is meaningless.

In this section, training will be broken into three different levels each one required by the structure of the NBA. The three levels consist of the professionals, the technicians, and the technical support personnel.

Training required at the first level falls into two categories. First is the need for academic training in the various disciplines required in water resources planning. Second and equally important is the practical use of the academic training. This should be conducted with other professionals who have both academic training and on-the-job experience. This supplement to academic training should be related to a well defined project possessing concrete technical objectives. On-the-job experience is critical in the development of a professional staff. It should provide a technical

familiarization with physical characteristics of the entire basin and an appreciation of the role each discipline plans in the water resources planning process. As well as providing competent professionals, a well structured training program should develop a team of professionals. They should be capable of positively interacting with others to produce well conceived studies and well supported analysis.

Training at the second level requires less academic time and an absolute requirement for on-the-job training. Lengthy field or laboratory training can replace most of the classroom training. In order to be effective, training of technicians must be done in conjunction with specific projects whose outputs can be visualized as integral parts of a total project effort.

Training at the third level primarily is conducted on site by other technicians. Realistic training of this type personnel cannot take place until qualified technicians are available. A frequent failure in training systems design is a lack of recognition that technical support personnel require structured training programs. Training at this level is more readily accomplished when done within the context of a project of sufficient duration for repetitive work efforts to be required.

b. Professional Training

Personnel with the requisite academic credentials for most of the technical areas required for water resource planning are available in the member states. Some of these personnel have completed academic training at advanced degree levels but have not been able to work with an experienced professional assigned to a

specific water resource planning project. The primary training need for training of professionals in the member states is not additional academic training, but work to reinforce academic learning with practical experience in specific areas of water resources planning and analysis. Such counterpart training with experienced professionals on a project carried to conclusion would result in a much more qualified water resource personnel or technical expert than non-reinforced academic training. Training groups of professionals in counterpart roles within a project environment benefits the cohesive qualities of the group. The varying technical specialties can be blended into a common effort by demonstrating the interrelationships required in water resources management and planning. During any project some short term training would be required in order for professionals to remain abreast of new advances in their field. This could also be used to overcome educational deficiencies in specific technical areas. Access to a professional library would also be necessary to assist in continued professional development.

c. Technician Training

Necessary training for technicians to support professionals in water resource planning is also related directly to the need for counterpart training on a specific project. A part of technician counterpart training is the need for the necessary equipment utilization over a period of time. Comprehensive water resources planning provides training for laboratory technicians, computer technicians, survey and data collection personnel, draftsmen, cartographers, and many other technical specialties. Personnel with less than advanced degree academic training are available in the

member states to receive requisite counterpart training needed as part of long term projects.

d. Technical Support Personnel Training

The basic training requirement for technical support personnel is to work with qualified technicians and professionals on a project of sufficient scope and duration. Minimum academic training is required for technical support personnel, provided a project is available for work. Long duration projects provide an additional avenue for technical support personnel. They have the opportunity of moving into a technician's position should one exist.

e. Conclusion

As stated above, the primary training requirement of NBA member states personnel is not academic training. In general, sufficient personnel with these credentials already are available in the member countries of the NBA. The type training necessary is reinforced academic and counterpart training with experienced professionals during the implementation of active, technically oriented projects.

6. Level of Effort Needed to Attain Specific Products

a. General

This section addresses the level of effort needed to attain several specific products related to water resources development in the Niger River Basin. Several of these products were identified as requirements in the basin planning process under the Niger River Development Project. Other products are addressed as legitimate development topics related to the use of water resources within the basin. The products are:

* A programmer's reference manual for the DSRS,
* A water and sediment routing model of the Niger River,
* An assessment of realistic hydroelectric power capacity and feasibility of electricity for irrigation pumping,
* Analysis of water demand in low flow to estimate shortage effects and mitigating measures,
* An analysis of effect on agricultural productivity of river system water control and regulation in the Mali Inland Delta.

These products were identified by USAID at project termination to be addressed in this report. They are considered appropriate because of their association with the water resources planning strategy in the Niger River Basin. The programmer's reference manual for the DSRS is an improvement to an existing system in the NBA. The water and sediment routing model, required to properly conduct water resources planning, is an extension in the technical capability of the NBA. It is one of the technical tools required by the NBA. The remaining three study topics represent various stages in the planning strategy addressed earlier in this report. The analysis of water demand at low flow represents a small component of need identification within the basin. The hydroelectric power capacity assessment represents the process of capacity identification to satisfy present and future needs within the basin.

The hydroelectric power capacity assessment represents the process of capacity identification to satisfy present and future needs within the basin. Finally the analysis of effects on agricultural production in the Mali Inland Delta due to water regulation represents a portion of effects analysis resulting from proposed development plans. These effects would be derived from plans formulated to address basin needs. These products represent small components of the entire water resources planning strategy outlined earlier in this report. The efforts required to attain these products must reflect the system or strategy which is followed. They must also reflect the institution which uses and produces these products. The system proposed to begin the water resources planning process is extremely complex. The effort required in the attainment of these products will be described and quantified in relation to the proposed planning strategy and the proposed institution of the NBA.

Failure to implement planning or analysis activities within a comprehensive planning strategy greatly increases the possibility of plan formulation and decision making which is not technically sound enough to withstand questioning by various special interests. To consider the analysis of water resources related topics as individual studies would be simplifying the complexity of the problem to a level where the results of the studies have no real value in development. Independent studies of, for example, the three topics identified in this section would not contribute directly to water resources development in the basin. Independent studies would result in reports which would not reflect the complex nature of the Niger River Basin. They would provide results lacking

in scope and unsupportable in promoting future water resources development projects.

As an example, the analysis of effects on agricultural productivity of river system water control and regulation in the Mali Inland Delta will be used. Independent study of this topic could be addressed with currently available information. The results could be both quantitative and descriptive. Even without a modeling component, effects could be analyzed based on various assumed duration and stage changes in relation to the present "without project" condition of the river. These changes could be derived from assumed interventions upstream of the inland delta. This type of exercise could cover almost any conceivable set of changes to the current condition.

What this type of approach lacks is a relationship to other factors which in the end will lead to actual development. Some associated questions to this topic are: What are the needs upstream of the Mali Inland Delta which can be addressed by water resources? What plans can be formulated to address these needs? Which is the most feasible? What are the benefits of this plan both upstream and downstream to include in the Inland Delta? What are the negative impacts in areas such as disruption of navigation, water losses, health problems, social problems? In other words, not just agricultural productivity in the Mali Inland Delta. An integrated approach will lead to technically supportable development projects. Independent study of water resource related topics will not. Consequently, the following discussions address the specific tasks required to accomplish the various components of a comprehensive planning effort.

b. Programmer's Reference Manual for the Data Storage and Retrieval System

Development of a programmer's reference manual for the already developed Data Storage and Retrieval System should include more than merely writing a manual. The basic components of this task should be those items needed to provide the most functional Data Storage and Retrieval System possible. The estimated tasks necessary to accomplish this are:

* Software revision and modification of the DSRS aimed at improving the utility of the system.
* Loading of the DSRS with any new information. This task is an ongoing one which should be performed in a continuous manner to maintain the most useful system. Data on the system should be evaluated and improved.
* Preparation of the reference manual.

Development of any of these tasks will require substantial effort for the review of the DSRS software and development of an in-depth knowledge of the functions and usage of the system. The time required for this would be somewhat less for personnel who had previous knowledge or had previously used the system but would still be required for a person with some knowledge of the system. Other cost factors must also be considered. Travel costs for review of the system in Niamey and its final installation in Niamey must be included. Computer costs are also included. The organization assigned to accomplish this task could use the system in Niamey if it is functional at the time of task assignment or provide a system identical to the system in Niamey. Use of the Niamey system would greatly increase travel and related costs and would be less efficient than using a system at a location where all required personnel are available. Finally, management cost for the contracting agency for this work must be included. This effort is

estimated to be about three person months of effort which would include the effort required to award the necessary contractual type effort, manage and supervise the contractor, and accept and distribute the final document. The estimated time duration to accomplish this task based on current conditions is one year, not including any review time.

c. Water and Sediment Routing Model

The development of a Water and Sediment Routing Model is a principal task necessary to provide the essential information required for the analysis of water resources in the Niger River Basin. The model would use the data included in the Data Storage and Retrieval System and would be required to completely interface with this system. The most efficient means of preparing the Programmer's Reference Manual would be as a part of model development. The reference manual cost was estimated as a separate task because it can be developed independent of other activities.

Three principal tasks required to develop and use the water and sediment routing model will be, to some extent, interactive and can be most effectively accomplished under an overall management unit. The tasks are:

* Task 1 - Acquisition of sediment data to include data collection and laboratory analysis of the data. Costs and efforts associated with this effort are based on complete contractual effort. Integration of this work with the NBA and member country activities would reduce costs associated with the performance of this work and would be institutionally beneficial to the NBA.

* Task 2 - Additional cross sections and profiles of the Niger River will be necessary to fill data gaps. The surveys must have both vertical and horizontal control to be utilized with available survey data.

* Task 3 - Development of the water and sediment routing model which can interface with the DSRS. This model must be able to simulate the effects of various water uses on the water balance of the Niger River and to determine the physical changes in river morphology over time as water uses vary. A model with these capabilities will provide the basic fundamental tool for short and long range engineering analysis of water use interventions on the Niger River.

The level of effort required for each of these tasks is summarized below.

Task 1--Sediment Data Collection

* Establishment of three sediment data collection teams in the basin; one each in Nigeria, Niger, and Mali.
* Establishment of a laboratory to analyze the data collected. This laboratory should be centrally located.
* Collection for at least a two year period of monthly samples at 10-20 locations on the main stem of the Niger River.
* Monthly samples would include suspended sediment samples at each cross section and bed load samples.
* Sufficient horizontal control would be required to assure repetition of sample locations.
* Due to the necessity of sampling teams being at a location to acquire sediment samples, water quality samples should be taken at the same time since this can be accomplished at minimal additional cost. This would provide preliminary baseline data within the basin in an area in which little data currently exists.
* The total duration of this effort would be about three years. Two years of actual field work, six months of mobilization, and six months of final data analysis would be required to complete the program.

Equipment requirements and costs for this effort are summarized in Table 2. This equipment requirement is approximately the same as that purchased or planned for purchase by the recently cancelled Niger River Basin Development Project. Use of equipment currently owned by the NBA would reduce these estimated costs. In-country labor requirements do not include necessary back-up and specialized labor.

Task 2--Hydrographic Surveys

* Hydrographic surveys will be necessary to fill data gaps and provide comparisons to previous surveys. The minimum necessary surveys necessary are at 400 river cross sections with a continuous longitudinal profile.
* Completion of these surveys would be necessary by about the midpoint of model development. The estimated duration of the survey effort is 18 months of field work after the mobilization period.
* Detailed estimates of personnel and equipment required for the survey effort are included in Table 3. Cost estimates are based on performance of this work using the maximum amount possible of local labor.

Task 3--Model Development

* The water and sediment routing model specific to the Niger River must interface with the DSRS. It should be based on physical processes route sediment by size in order to properly evaluate general aggradation and degradation. It must be able to simulate the effects of changes in land use and other interventions related to navigation, irrigation, hydropower, and flow regulation. It should be developed using existing computer programs adapted with modifications.
* The model should start at Onitsha, Nigeria and extend to Kouroussa, Guinea. The model should allow qualitative and semi-quantitative analysis of the impact of various alternatives on the Niger River.

The estimated duration of this work is three years after initial mobilization. The most effective means of accomplishment would be by contract to a firm with experience in similar modeling. For the model effort to be accomplished on schedule the tasks of surveying and sediment data collection must be performed on schedule to provide input into the modeling effort.

The major tasks necessary for model development have substantial differences in the type of engineering experience required to result in a quality product. A substantial overall management/coordination effort will be required to accomplish these widely varying tasks. This overall management effort can be most effectively performed as an umbrella over all the model related tasks with both in-Africa and overseas components. The in-country requirements will be necessary for the total duration of work. Substantial back-up effort will be required for the sediment data collection and survey effort. The estimated management/coordination effort will require at least one in-country individual for the duration of the work effort. These estimates are included in Table 4. Failure to accomplish these tasks in a coordinated effort will result in a piecemeal approach which will leave gaps in the work at

a higher cost. The estimates included in this section assume that the data necessary for model development is available when required.

It should be noted that the preceding activities consisting of the programmer's reference manual, sediment data collection, hydrographic surveys, and water sediment routing model encompass the activities that were to be accomplished by the COE under the authority of the original USAID/COE PASA. Costs are summarized on the following pages. The assumption is made that equipment currently with the NBA will not be available necessitating the purchase of new computer systems and other project support equipment.

TABLE 1

COST ESTIMATE FOR PROGRAMMER'S REFERENCE MANUAL

FOR THE DSRS

Assumption: The manual would be prepared under contract.

Note: p.m. = person-months

ITEM	UNIT	COST/UNIT ($)	TOTAL COST ($)
I. CONTRACT COST			
Personnel			
Senior Civil/Hydraulic Engr	6 p.m.	4,500	27,000
Jr. Civil/Hydraulic Engr	3 p.m.	4,000	12,000
Translator	2 p.m.	3,500	7,000
Clerical	3 p.m.	2,000	6,000
Subtotal			52,000
Overhead (Including computer Cost)	@ 110%		57,200
Travel			
r/t to Niamey	1 trip	2,500	2,500
r/t out of Africa	1 trip	1,000	1,000
Per Diem			
Africa	20 days	100	2,000
out of Africa	10 days	75	750
Printing and Distribution			
200 copies of report (English)	200 pages	@ .10	4,000
300 copies of report (French)	200 pages	@ .10	6,000
Total Contract			125,450
		Use	125,000
II. CONTRACT MANAGEMENT			
Sr. Engineer	3 p.m.	4,000	12,000
Hydraulic Engineer	1 p.m.	3,000	3,000
Subtotal			15,000
Overhead @ 100% (Includes all Fringes)			15,000
Total			30,000
Total for all effort			$ 155,000

TABLE 2

COST ESTIMATE FOR SEDIMENT DATA COLLECTION

Assumptions: 1) Major component of labor will be local hire by contractor
2) Data Collection will be for a 24 month period

Note: p.m. = person-months

ITEM	UNIT	COST/UNIT ($)	TOTAL COST ($)
Labor cost - Non local			
Program Manager/Engineer	30 p.m.	4,500	135,000
Laboratory Chief	24 p.m.	4,000	96,000
Mechanic	24 p.m.	3,500	84,000
Party Chiefs	72 p.m.	3,500	252,000
Engineer Technician	18 p.m.	3,000	54,000
Subtotal			621,000
Overhead and Benefits @ 100%			621,000
Labor-Local			
Laboratory Assistant	30 p.m.	500,000	15,000,000
Party Assistants	90 p.m.	500,000	45,000,000
Drivers	120 p.m.	100,000	12,000,000
Labor	144 p.m.	100,000	14,400,000
Boat Operators	72 p.m.	200,000	14,400,000
Guardian	30 p.m.	50,000	1,500,000
Secretary	30 p.m.	125,000	3,750,000
Translator	15 p.m.	50,000	750,000
			106,800,000 CFA
	CFA @ 300/$ U.S.		356,000
Overhead @ 50%			178,000
Office and Residences			
Office and laboratory rent	30 mo.	300,000	9,000,000
Electricity	30 mo.	200,000	6,000,000
Telephone	30 mo.	100,000	3,000,000
Misc office expense	30 mo.	200,000	6,000,000
Residences	120 mo.	300,000	36,000,000
Residence support	120 mo.	300,000	36,000,000
Subtotal			96,000,000 CFA
	CFA @ 300/$ U.S.		320,000

Travel		
r/t U.S. to Africa	20 trips @ 2500	50,000
r/t U.S. to Africa (family)	40 trips @ 2500	100,000
r/t in Africa		
Manager 6 trips/year X 2 years = 12 X 700		8,400
Mechanic 6 trips/year X 2 years = 12 X 700		8,400
Party Chiefs 3 chiefs X 2 trips X 2 years =12 X 700		8,400
Per Diem		
Manager 100 days/yr @ 100 X 2 years		20,000
Mechanic 100 days/yr @ 100 X 2 years		20,000
Party Chiefs 40 days/yr @ 100 X 2 years X 3 chiefs		24,000
150 days/yr @ 20 X 2 years X 3 chiefs		18,000
Engr Technician 200 days @ 100		20,000
Party Assistants 150 days @ 20 X 2 years X 3 persons		18,000
Labor 150 days @ 10 X 2 years X 6 persons		18,000
Drivers 150 days @ 10 X 2 years X 4 persons		12,000
Boat Operators 150 days @ 10 X 2 years X 3 persons		9,000
Subtotal		334,200
Equipment - Field		
4 wheel drive vehicles	4 @ 15,000	60,000
Trucks	3 @ 30,000	90,000
Boats	5 @ 5,000	25,000
Trailers	5 @ 2,000	10,000
Motors	8 @ 2,500	20,000
Bottom Samplers	8 @ 1,000	8,000
Suspended Samplers	8 @ 1,000	8,000
Reels	4 @ 1,500	6,000
Cable for Reels	8 @ $500	4,000
Bridge Reel/sampler	1 @ 3,000	3,000
Tool Kits	5 @ 1,000	5,000
Tents	4 @ 250	1,000
Sleeping Bags	20 @ 100	2,000
Hach Kits	4 @ 2,000	8,000
Generators	8 @ 1,000	8,000
Miscellaneous Tools & Equipment		20,000
Subtotal		278,000
Equipment - Laboratory		
Estimated cost of initial laboratory equipment		50,000
Replacement cost/yr 10,000 X 2		20,000
Subtotal		70,000

Fuel	
4 four wheel drive vehicles 2 years 300 days use/year 25 liters of fuel/day 250 CFA/liter 300 CFA/$	50,000
3 trucks 2 years 300 days use/year 30 liters of fuel/day 250 CFA/liter 300 CFA/$	45,000
3 boats 2 years 200 days use/year 10 liters of fuel/day 250 CFA/liter 300 CFA/$	10,000
Miscellaneous Supplies	20,000
Communications $100/month/office = 100 X 24 months X 3 offices	7,200
Shipping Costs Boats, Motors, Trailers, Misc Equipment	50,000
Total Cost	$2,960,000

TABLE 3
COST ESTIMATE - HYDROGRAPHICS SURVEYS

Assumptions: 1) Surveys will be accomplished by contractor.
2) Major labor component will be local hire.
3) Three survey parties required.
4) Total time for surveys is 2 years (18 months in field).

Note: p.m. = person-months

Labor Cost-Non local			
Program Manager	30 p.m.	5,000	150,000
Senior Engineer	30 p.m.	4,500	135,000
Engineer Technician (Survey)	18 p.m.	3,500	63,000
Civil Engineer	24 p.m.	4,000	96,000
Mechanic	18 p.m.	3,000	54,000
Engineer Technician	12 p.m.	2,500	30,000
Subtotal			$ 528,000
Overhead and Benefits @ 100%			$ 528,000
Profit @ 15% of Labor and Overhead			$ 158,000
Labor Costs-Local			
Program Manager	24 p.m.	@ 500,000	12,000,000
Assistant Party Chiefs	72 p.m.	@ 500,000	36,000,000
Surveyors	72 p.m.	@ 300,000	21,600,000
Labor 4 persons/party X 18 mo.	216 p.m.	@ 100,000	21,600,000
Drivers 7 drivers X 18 mo.	126 p.m.	@ 100,000	12,600,000
Guardian	24 p.m.	@ 50,000	1,200,000
Secretary	24 p.m.	@ 150,000	3,600,000
Subtotal (CFA)			108,600,000 CFA
	at 300 CFA/$		$ 362,000
Overhead and benefits @ 50%			$ 181,000
Office and Residences			
Office Rent	24 mo.	@ 300,000	7,200,000
Residence Rent	48 mo.	@ 300,000	14,400,000
Telephone	24 mo.	@ 100,000	2,400,000
Office Support	24 mo.	@ 300,000	7,200,000
Residence Support	48 mo.	@ 300,000	14,400,000
Misc. Office Expense	24 mo.	@ 100,000	2,400,000
Subtotal			48,000,000 CFA
	at 300 CFA/$		$ 160,000
Travel			
r/t U.S. to Africa	24 trips	@ 2,500	60,000
r/t in Africa			
Manager 6 trips/year X 2 years X 700			8,400
Senior Engr 6 trips/year X 2 years X 700			8,400
Mechanic 6 trips/year X 2 years X 700			8,400
Subtotal			$ 85,200

Per Diem		
Manager	200 days @ 100	20,000
Sr. Engineer	200 days @ 100	20,000
	100 days @ 20	2,000
Party Chiefs	100 days @ 100	10,000
	360 days @ 20	7,200
Mechanics	50 days @ 100	5,000
	100 days @ 20	2,000
Asst. Party Chiefs	60 days @ 100	6,000
	1080 days @ 20	21,600
Surveyors	1080 days @ 20	21,600
Labor	5760 days @ 10	57,600
Drivers	2580 days @ 10	25,800
Subtotal		$198,800
Equipment		
4 wheel drive vehicles	5 @ 15,000	75,000
Trucks	3 @ 30,000	90,000
Boats	3 @ 5,000	15,000
Motors	3 @ 5,000	15,000
Trailers	3 @ 2,000	6,000
Survey Equipment	4 sets @ 10,000	40,000
Fathometers	3 @ 5,000	15,000
Misc. Tools and Equipment		10,000
Personal Computers	4 @ 5,000	20,000
Parts & Maintenance @ 5% of Original Cost/Year		25,000
Subtotal		$311,000
Shipment Cost		
Boats, Motors, Trailers, etc.		30,000
Shipment of parts/year X 2		20,000
Subtotal		$ 50,000
Fuel		
5 four wheel drive vehicles 2 years 300 days of use/year 50 liters/day 250 CFA/liter 300 CFA/$		125,000
3 trucks 1 1/2 years 240 days of use/year 75 liters/day 250 CFA/liter 300 CFA/$		67,500

3 boats 1 1/2 years 240 days of use/year 10 liters/day 250 CFA/liter 300 CFA/$		9,000
Communications Costs		
Radios 5 sets @ 2,000		10,000
Telephone 500/month X 24 months		12,000
Aircraft Rental (Review Survey Routes)		
100 hours @ $500/hour		50,000
Miscellaneous purchase and supplies		20,000
Program Total		$2,855,500
	USE	$2,856,000

TABLE 4
COST ESTIMATE FOR DEVELOPMENT OF THE
WATER AND SEDIMENT ROUTING MODEL

Assumption: 1) Data Storage and Retrieval System is available.
2) Survey and Sediment Data is available.

Note: p.m. = person-months

Labor			
Project Manager	6 p.m.	5,000	30,000
Senior Hydraulics Engr.	36 p.m.	4,500	162,000
Junior Hydraulics Engr.	42 p.m.	3,500	147,000
Senior Computer Technician	28 p.m.	3,000	84,000
Junior Computer Technician	20 p.m.	2,500	50,000
Draftsman	6 p.m.	2,500	15,000
Clerk	6 p.m.	2,000	12,000
Translator	6 p.m.	3,500	21,000
Subtotal			521,000
Overhead @ 100%			521,000
Travel and Per Diem			
r/t to Africa	2 @ 2,500		5,000
r/t in U.S.	10 @ 700		7,000
Per Diem in Africa	40 @ 100		4,000
Per Diem in U.S.	50 @ 75		6,000
Subtotal			22,000
Computer Costs			
Internal computer charges in excess of overhead			50,000
Computer System			150,000
Subtotal			200,000
Profit or fee @ 10% of labor and overhead			104,000
Total Development Cost			$1,368,000

TABLE 5
COST SUMMARY
ENGINEERING ANALYSIS

PROGRAMMER'S REFERENCE MANUAL	155,000
SEDIMENT DATA COLLECTION	2,960,000
HYDROGRAPHIC SURVEYS	2,856,000
WATER SEDIMENT ROUTING MODEL	1,368,000
TOTAL	$7,339,000

The preceding discussion and cost estimates provide a reference point from which the true costs of NBA/USAID project termination can be viewed. The following discussion focuses on those remaining activities required if comprehensive water resources planning is to be pursued. It is also important to note that the specific products needed to address anticipated short term issues can be developed only in the context of comprehensive water resources planning. Consequently, the activity descriptions and cost estimates presented are associated with a comprehensive effort, not with the singular approach suggested by the request for specific products. Three components, in addition to the four already presented, are considered essential to undertaking comprehensive water resources planning at the minimum level of detail required to produce a framework plan which could be pursued in developing the water resources of the Niger River Basin. Each of the three are discussed in detail in the following sections.

d. Natural Resources/Socio-Economic Study

A natural resources socio-economic baseline would be required to provide a baseline against which effective assessment of those parameters could be made. Such a baseline would be a reconnaissance level effort utilizing all previous work to the maximum extent possible. It consists of a natural, social and economic atlas of the Niger River Basin, an atlas descriptive text, and a volume describing specific data needs. Since this baseline information is required for realistic water resource evaluation or effects assessment, the estimate of the cost for development of such baseline data is included in Table 6.

The Niger River Basin Project Revised Implementation Plan provides an excellent starting point for the scope of work required in these baseline studies. Additional effort would be required for specific types of analysis and/or effects assessment once the baseline information was available. Such analysis should be generic in nature for any water resources development. The effort required for a generic assessment of the three topics listed above is included in the cost estimates presented in Table 7. These topics would be addressed in conjunction with the development of an integrated Niger Basin development plan which at the same time would address many other topics. These assessments would require an overall water resource planner as the principal coordinator for development analysis. The individual would be supported by various specialists in the social, economic and natural resource fields to assure realistic assessment of a generic water resource plan. Specific detailed analysis of water resource interventions would be

required on a case by case basis once generic assessment has provided the most readily effective direction to proceed in development of water resources in the Niger Basin.

The natural resource/socio-economic baseline should as a minimum include:

* Social and demographic factors
* Soils and vegetation
* Irrigated agriculture
* Aquatic ecology and fisheries
* Terrestrial ecology
* Geohydrology
* Public health
* Cultural resources

These items should principally be acquired from secondary sources and presented as an atlas using satellite imagery and appropriate map scales.

A descriptive text of the atlas should be prepared to show and describe in detail the various factors shown on the map atlas. The factors which should be described in detail follow:

* soils
* vegetation
* groundwater resources
* surface water resources
* mineral and geological deposits
* prime farm and pasture land
* irrigation potential
* fisheries resource
* agricultural systems
* other economic systems
* administrative boundaries
* ethnic groups
* demography
* parks, refuges, etc.
* cultural resources

In addition to the two products described above, a data needs estimate should be prepared. It would describe the data shortages in each basic area of consideration. The data shortages should reflect the areas where additional data is required to perform

various levels of water resources planning. Secondary sources would be adequate for this level of generic water resources planning. Additional data would be required for mid-level planning and substantial site specific data would be required for future specific project analysis and design.

Effects assessment of the various types of water resource inventories for economic development is also necessary for total integrated basin development planning. The baseline tools described herein, however, are adequate to perform first level effects assessment of any potential water resource plan. The Natural Resources/Socio-economic baseline studies are a necessary part of the Stage I activities in water resources planning. Their preparation is a prerequisite to any water resources analysis which is conducted in later stages of the planning strategy.

TABLE 6

COST ESTIMATE FOR THE

NATURAL RESOURCES/SOCIO-ECONOMIC BASELINE STUDIES

Assumptions:
1) Basic work effort is to be performed under contract.
2) Necessary time for this type of contract is three years.
3) Two individuals will be full time in Africa.
4) Counterpart training is provided as part of this work.

Note: p.m. - person-months

	UNIT	UNIT COST ($)	TOTAL COST ($)
Labor - Non local			
Project Manager (U.S.)	15 p.m.	5,000	75,000
Project Manager (Africa)	39 p.m.	5,000	195,000
Senior Water Resource Planner	39 p.m.	4,500	175,000
Natural Resources Specialist	17 p.m.	4,000	68,000
Social Scientist	17 p.m.	4,000	68,000
Agricultural Scientist	17 p.m.	4,000	68,000
Ecologist	17 p.m.	4,000	68,000
Senior Cartographer	8 p.m.	3,500	28,000
Photo Interpreter	6 p.m.	4,000	24,000
Junior Cartographer	6 p.m.	3,000	18,000
Draftsman	22 p.m.	2,000	44,000
Clerk (U.S.)	21 p.m.	1,800	37,800
Translator	14 p.m.	4,000	56,000
Clerk (Africa)	36 p.m.	1,000	36,000
Guardian (Africa)	36 p.m.	200	7,200
Driver (Africa)	72 p.m.	200	7,200
Subtotal			$975,200
Overhead @ 110%			$1,073,000
Consultants (various disciplines) 300 person days @ 450			135,000
Labor - Local (Counterparts)			
Project Manager-Water Resources	36 p.m.	2,000	72,000
Water Resources Planner	36 p.m.	2,000	72,000
Natural Resources Specialist	24 p.m.	2,000	48,000
Social Scientist	24 p.m.	2,000	48,000
Agricultural Scientist	24 p.m.	2,000	48,000
Ecologist	24 p.m.	2,000	48,000
Subtotal			$336,000
Overhead @ 50%			$168,000
Personnel Total			$2,687,200

Special Costs for Long Term Personnel

Moving to Africa (two families @ 40,000	80,000
Storage of Household Effects 72 mo @ 400	28,800
Schooling 2 children/family for 3 years @ 15,000/yr	90,000
Housing 72 months @ 400,000 CFA	
Utilities 72 months @ 300,000 CFA	
House Maintenance 72 months @ 150,000 CFA	
850,000 CFA/month X 72 months = 61,200,000 CFA	
at 300 CFA/$	204,000
Travel	
Family round trips 8 people X 2 trips X 2,500	40,000
Home Trips 4 people X 2 trips X 2,500	20,000
School trips 4 children X 6 trips X 1,000	24,000
Travel	
Project Manager	
2 trips to U.S./year X 3 years X 2,500	15,000
6 trips in Africa/year X 3 X 700	12,600
Senior Technical Specialist	
1 trip to U.S./year X 3 X 2,500	7,500
6 trips in Africa/year X 3 X 700	12,600
Technical Specialists	
4 people X 3 trips to Africa X 2,500	30,000
Photo Interpreter	
1 trip to Africa @ 2,500	2,500
Trips in U.S. 20 trips @ 600	12,000
Other Africa travel, Technical Specialists 4 @ 2,000	8,000
Consultant Travel 6 trips @ 2,500	15,000
Contractor Backstop travel 6 trips @ 2,500	15,000
Counterparts 6 trips/year to U.S. @ 2,500 X 2	30,000
Counterparts 24 trips in Africa @ 700	16,800
Subtotal for Travel	$ 261,000
Per Diem	
Project Manager	
30 days in U.S./year X 3 @ 80	7,200
180 days in Africa @ 100	18,000
Senior Technical Specialist	
30 days in U.S./year X 3 @ 80	7,200
300 days in Africa @ 100	39,000
Technical Specialist	
4 X 330 days X 100	132,000
Photo Interpreter	
30 days @ 100	3,000
Atlas Preparation in U.S.	
100 days @ 80	8,000
Contractor Backstop	
6 trips X 20 days X 100	12,000
Consultant	
300 days @ 100	30,000
Counterparts 180 days in U.S. @ 100	18,000
Counterparts 360 days in Africa @ 100	36,000
Subtotal	$ 310,400

Equipment and Supplies (not including special costs)

Office Rental		
Rent 36 months @ 400,000 CFA/month		
Utilities 36 months @ 300,000 CFA/month		
700,000 CFA/month X 36 months = 25,200,000 CFA		
At 300 CFA/$		84,000
Automobiles 2 @ 18,000		36,000
Gasoline and Maintenance 2 cars X 3 years X 5,000		30,000
Copiers 5 @ 3,000		15,000
Paper & maintenance 5 copiers X 2 years X 2,000		20,000
Aerial Survey		50,000
Computer Equipment		50,000
Office Supplies		
200,000 CFA/month X 36 months @ 300 CFA/$		24,000
Map & Cartography supplies		30,000
Atlas Production Costs		50,000
Communication Cost @ 10,000/year		30,000
Shipping costs @ 10,000/year		30,000
Miscellaneous Costs		10,000
Subtotal		$ 474,000
Fee @ 15% of labor and overhead		$ 403,100
Total cost for baseline studies		$ 4,538,500
	USE	$ 4,538,000

e. Alternative Assessment

The costs which follow reflect the effort required to establish the planning structure necessary to conduct water resources planning. The goal is a framework plan for basin development and results of the described approach could be used to address development options in the basin. The assessment effort will provide a single point where trade-offs can be evaluated while balancing the conflicting desires of various specialties. Development of water resources in this manner will usually result in improved decision-making when considering the allocation of scarce commodities such as water in the Sahel Region of West Africa. It is anticipated that assessment activities could begin just prior to completion of the preceding work items and extend a minimum of two years.

TABLE 7
COST ESTIMATE FOR PLAN FORMULATION
INCLUDING ANALYSIS OF THREE SPECIFIC TOPICS

Assumptions:
1) Assessments will be performed for hydropower capacity and feasibility of electricity for irrigation, water demand in low flow and effect on agricultural productivity of river system water control and regulation in the Mali Inland Delta as a part of the development of an integrated basin development plan.
2) Basic working tools will be available for assessment analysis.
3) Basic analysis and assessment will be accomplished by a team in Africa with necessary back-up in U.S.

ITEM	UNITS	UNIT COST ($)	TOTAL COST ($)
Labor			
Program Manager (U.S.)	12 p.m.	4,500	54,000
Project Manager (Africa)	30 p.m.	4,500	135,000
Hydraulics/computer Engr (Africa)	30 p.m.	4,000	120,000
Hydraulics Engr	12 p.m.	4,000	48,000
Electrical Engineer	4 p.m.	4,500	18,000
Agricultural Engineer	6 p.m.	4,000	24,000
Agronomist	4 p.m.	4,000	16,000
Soil Scientist	4 p.m.	4,000	16,000
Civil Engineer	6 p.m.	4,000	24,000
Ecologist	6 p.m.	4,000	24,000
Economist	6 p.m.	4,000	24,000
Social Scientist	6 p.m.	4,000	24,000
Computer Technician (Africa)	30 p.m.	1,500	45,000
Water Resources Planner (Africa)	30 p.m.	2,000	60,000
Clerk (U.S.)	12 p.m.	1,500	18,000
Clerk (Africa)	30 p.m.	500	15,000
Guardian (Africa)	30 p.m.	200	6,000
Driver (Africa)	30 p.m.	200	6,000
	Subtotal		$ 677,000
Overhead and fee on labor @ 110%			$ 745,000
Travel			
Round Trip to Africa			
Project Manager	6@		
Family	6@		
Hydraulic Engineer	4@		
Family	6@		
Program Manager	2@		
Technical Specialists	10@		
	34@	2,500	85,000
Trips in Africa			
Project Manager	10@		
Hydraulic Engineer	5@		
Technical Specialists	20@		
	35@	700	24,500

Round Trip to Europe			
Project Manager	2@		
School Trips	8@		
	10@	1,000	10,000
		Subtotal	119,500
Per Diem			
Project Manager	100 days @ 100		10,000
Hydraulic Engineer	50 days @ 100		5,000
Program Manager	30 days @ 100		3,000
Technical Specialists	900 days @ 100		90,000
		Subtotal	108,000
Office and residences			
Office 30 months @ 300,000 CFA/month =		9,000,000	
Electricity 30 mo. @ 200,000 CFA/mo. =		6,000,000	
Residences 60 mo. @ 300,000 CFA/mo. =		18,000,000	
Residence support 60 mo. @ 400,000/mo. =		24,000,000	
57,000,000 CFA at 300 CFA/$			190,000
Equipment			
Two 4 wheel drive vehicles @ 18,000			36,000
5 years vehicle support @ 4,000/year			20,000
Office furniture			10,000
Office personal computer with software			10,000
Office supplies @ 5,000/year			12,500
Vehicle rental for technical specialists 60 months @ 1,500 month			90,000
Communications 30 months @ 300/month			9,000
		Subtotal	187,500
Shipping Costs			
Family transfer @ 40,000 X 2			80,000
Miscellaneous shipping			10,000
Miscellaneous postage, etc.			5,000
		Subtotal	95,000
Profit or Fees @ 15% of labor and overhead			213,000
Total for Planning Effort			$ 2,335,000

f. Scheduling of Water Resources Planning Effort

The tasks described for attainment of specific products of water resources planning effort, when scheduled efficiently and managed as an integrated effort, will provide the basic components of an integrated basin development plan. The data produced from each of the tasks have some degree of sensitivity to changes in the physical and environmental parameters of the river basin and for this reason, piecemeal development of the tasks must be avoided. A schedule for activities leading to a realistic and useful basin water resources planning effort is summarized below.

TASK	DURATION	ES	LS	EF	LF
WATER SEDIMENT MODEL	36 MO	1-1	1-1	4-1	4-1
SURVEYS	24 MO	1-3	1-6	3-3	3-6
SEDIMENT DATA COLLECTION	30 MO	1-1	1-6	3-6	3-6
PROGRAM REFERENCE MANUAL	6 MO	1-1	1-1	1-6	1-6
NATURAL RESOURCE/SOCIO-ECONOMIC BASELINE STUDIES	36 MO	1-1	1-3	4-1	4-3
ALTERNATIVE ASSESSMENT	30 MO	3-6	3-9	6-1	6-1

The numbers shown (1-1) are the year and month from initiation of activities.

ES = Early Start
LS = Late Start
EF = Early Finish
LF = Late Finish

g. Management Requirements

The tasks required for development of an integrated basin plan for water resources as previously described are complex and in most instances interactive. The requirement for completing tasks before or at critical points of other tasks makes the overall management of river basin planning effort critical for efficient use of planning resources. In order to provide effective overall management, a single point of contact for donor financial matters should be established. This point of contact must possess functional capability in the areas of project administration and general technical expertise.

To provide this management effort in a multi-contractor mode, one qualified individual should be the project manager for the duration of the work effort. This individual should be assigned to the donor sponsoring the work effort in Niamey. He should function as an active participant in the NBA Planning Cell. Such a management assignment will allow administrative integration of tasks on a day-to-day basis and help insure complete integration of the technical work.

Should a decision be made to contract the total effort to one source with sub-contracting effort to other organizations, the principal contractor should be required to provide management personnel assigned to Niamey for the duration of the work. This will allow reduction in the administration requirements for the technical work force and more efficient utilization of their talents and expertise.

The overall management effort of the river basin planning effort described above would last about six years. Management

personnel would be required on site about six months before contract effort is initiated. They should remain on site until final contract completion. The estimated cost of this management effort is summarized below.

TABLE 8
COST ESTIMATE FOR
OVERALL MANAGEMENT

Note: p.m. = person-months

	UNITS	UNIT COST	TOTAL COST
Personnel			
Water Resource Planner	72 p.m.	5,000	360,000
Overhead @ 110% of direct salary			396,000
Subtotal			$ 693,000
Travel			
Planner 2 R/T U.S. to Africa/year X 6 @ 2,500			30,000
Family 3 individuals 1 RT/year X 6 @ 2,500			45,000
Planner 6 trips in Africa/year X 6 years @ 700			29,400
Family (School) 2 children X 6 years X 2 @ 1,000			24,000
Subtotal			$ 128,400
Per Diem			
Planner 450 days total @ 100			45,000
Miscellaneous Per Diem			10,000
Subtotal			$ 55,000
Other Expenses			
Vehicle 2 during period @ 15,000			30,000
Vehicle Maintenance Cost @ 4,000/year X 6			24,000
Housing Cost 72 months @ 1,000			72,000
Housing Maintenance & Utilities 72 months @ 1,000			72,000
Schooling cost 8 child years @ 15,000			120,000
Subtotal			$ 318,000
Profit or Fee @ 15% of labor and overhead			$ 113,000
Total			$ 1,370,400
		USE	$ 1,370,000

h. Cost Summary

A total cost summary of the effort described is provided in Table 9. This cost estimate is based on September 1986 prices and an exchange rate of 300 CFA per dollar U.S. No contingencies or inflation allowances are included in the cost estimate. For an effort of this magnitude, a contingency of 15% is realistic.

TABLE 9
COST SUMMARY

TASK	COST ESTIMATE
PROGRAM REFERENCE MANUAL	155,000
SEDIMENT DATA COLLECTION	2,960,000
SURVEYS	2,856,000
WATER SEDIMENT ROUTING MODEL	1,368,000
NATURAL RESOURCE/SOCIO-ECONOMIC STUDY	4,538,000
ALTERNATIVE ASSESSMENT	2,335,000
OVERALL MANAGEMENT	1,370,000
TOTAL	15,582,000

E. POTENTIAL FUTURE USE OF NIGER RIVER BASIN RESOURCES

1. Agriculture

a. General Discussion

Farm activity and products play an important role for people living in the Niger River Basin. The potential level of agricultural production is limited by numerous factors. The following represent the more important:

* Availability of land with soils suitable for farming.
* Availability of water for rain-fed or irrigated agriculture.
* The existence of irrigation infrastructure, which may consist of pumped systems requiring energy for pumping, gravity fed systems or combinations of the two.
* Farm prices conducive to production in excess of the needs of the individual farmer.
* The necessary human resources for farm management and farm labor. Development of this resource requires broad-based agricultural education.
* The availability of farm equipment, seed, fertilizer, and agricultural chemicals.
* The existence of a dependable low cost transportation system for shipment of agricultural commodities.

There is no attempt in this report to segregate the numerous factors nor trace the importance of each in production. The potential role of water resources development in improving agricultural production is addressed in a very general sense. Water resources development can affect only two or three of the above factors. It must be recognized that this type development undertaken independently of consideration of the other limiting factors cannot provide dramatic improvement in productivity.

b. Sahelian Region

The availability of water in the form of rainfall or irrigation is certainly a limiting factor in agricultural production within this region. However, sufficient water is available to allow significant production increases provided that irrigation infrastructure is developed and adequate management is introduced. Implementation of projects involving increased irrigated area or providing for dual cropping on existing irrigated lands has great potential. However, the returns from such projects would not likely be substantial without complementary actions addressing other production factors. A vast array of alternatives can be developed for irrigation infrastructure. These include ground and surface water pumping systems, flow regulation providing for gravity-fed distribution canals, pumped irrigation during the low water season and/or regulation in the interest of recessional agriculture. It can be concluded that food production deserves the highest priority when considering resource allocation. However, it must be realized that irrigation is a highly consumptive water use with evapotranspiration, evaporation, and infiltration from reservoirs, canals, and irrigated lands potentially resulting in a considerable net water loss from the system. This result could adversely affect or even preclude other water uses. Development of the Niger River as a primary transportation artery or improvement of its present use as a local and regional artery in conjunction with road or rail transport should also receive careful consideration as an adjunct to agricultural development. Identification of the "best plan" for future development of irrigation and other water uses requires a

comprehensive analysis considering all of the above factors and effects.

c. Sub-sahelian Region

The availability of water in this region is generally not the limiting factor in agricultural production. Water resource related improvements addressing navigation could possibly play a role in farm production by reducing transportation costs. Transportation costs are a primary component of the market costs of agricultural products. There is certainly an enormous potential for improved navigation on the lower reaches of the Niger River and more efficient and reliable transportation of products ranging from chemicals to farm produce could be realized. Other factors more directly related to the supply of and demand for farm products in this region must also be addressed. As with other water uses, comprehensive planning is necessary to assure that the positive aspects of navigation development are not offset by adverse impacts on other water needs.

2. Hydropower

a. General

The evaluation of the potential hydropower development requires an understanding of future electric power needs and of the positive and negative effects of facilities constructed for hydropower generation. As with waterborne transportation, hydropower should be compared with alternate methods such as fossil fueled generating systems. Some considerations for use in assessing the feasibility of hydropower generating facilities in the Niger Basin are provided in this section.

b. Current Hydropower Facilities

The principal existing hydropower facilities in the Niger Basin are shown in Table 10.

c. Electric Power Needs

The present and future electric power needs in the Niger Basin may be categorized as municipal, industrial, rural domestic,and agricultural. Each of these involves a somewhat different power demand. Municipal and rural domestic uses result in demand which varies markedly during each day, but changes only moderately season to season. The primary agricultural need is for operating irrigation pumps. With careful power management, this use does not produce a daily variation in demand. However, the seasonal variations may be dramatic. Industrial power demand may vary daily, seasonly, or both depending on the nature of the industries involved.

d. Types of Hydropower Facilities

Hydropower facilities can be classed as follows.

(1) Flow Regulating

Facilities of this type involve construction of a dam which creates an impoundment sufficient to provide for storage of excess water during high flow periods. The stored water is released during the low water season. A carefully designed facility can provide for reliable generation year round. The dam also produces a difference in potential energy from upstream to downstream (head). The power generated at any point in time is a direct function of the head and the discharge through the turbines. Previously proposed sites for this type facility are shown in Table 11.

(2) Non-flow Regulating

This type facility may involve constructing a comparably low dam or the addition of hydropower appurtenances to an existing low dam constructed for another purpose such as navigation. Non-regulating facilities may also be constructed in a channel bypassing a naturally steep river reach. Reaches sufficiently steep in gradient typically occur only at geologic controls and are characterized by the presence of waterfalls or rapids. Non-regulating facilities, sometimes called run-of-the-river systems, depend on the natural flow of the stream. Since the head is generally small, a high flow is required for significant power production to be realized. In developed nations, facilities of this type are used to supplement existing power grids. Since the power produced varies greatly from month to month, generation is not sufficiently reliable

enough to serve as the primary electric energy source for municipal, industrial, or rural domestic use. Sites suitable for this type of facility are limited primarily to the middle Niger.

e. Evaluation of Hydropower Potential

An evaluation of the potential for hydropower generation at a particular site is reasonably straight forward provided that sufficient hydrologic information exists. However, determining the economic feasibility together with the environmental and social desirability of a facility or group of facilities involves consideration of a number of complex, interrelated factors. These are discussed below along with some specific Niger Basin considerations.

(1) Regulating Facilities

(a) Potential uses of generated power

Flow regulating hydropower facilities provide a dependable and easily variable source of generated power. Within the limits of the plant's operating capacity, the generation rate may be varied daily or seasonally to meet peak demand.

(b) Costs

First costs are usually high when compared with fossil fueled generating systems. Operation and maintenance costs, however, are very low by comparison. This first cos. relationship should hold true throughout the basin. However, due to the difference in price and availability of fossil fuels, operating costs for fossil fueled plants

would be considerably less in Nigeria than in, for example, Niger or Mali.

(c) Other Water Uses

The regulating effect should generally result in an improvement in the availability of water for municipal and industrial uses. However, the water available for use in recessional agriculture downstream could be greatly reduced. In addition, the creation of large impoundments in the arid Sahel region would result in significant losses of water to evaporation and infiltration.

(d) Resettlement

There are few activities more disruptive to the existing population than the construction of dams creating large impoundments. Since the population tends to be centered along the river, resettlement of significant numbers of people would be anticipated as a direct result of dam construction along the Niger or any of its major tributaries. In addition, the impact of changes in the availability of lands and water for agriculture must be carefully considered.

(e) Environmental

The effects of flow regulation on water and water related habitats can be profound. The spawning and feeding habitats of most aquatic and many land species are dependent on the natural flooding cycle. Flow regulation can increase or reduce habitat depending on the requirements of the specific species. Creation or destruction of habitat has important implications for the

human inhabitants of the basin in at least two respects: habitat of fish species which are important food sources and habitat of vectors for parasitic waterborne disease.

(2) Non-regulating Facilities

(a) Potential Uses of Generated Power

As noted above, non-regulating or low-head facilities provide neither a dependable nor easily variable source of generated power and are generally unsuitable except as a lower cost supplementary power source. In the middle Niger, however, low-head facilities may prove reasible for generating power for irrigation use. Power generation would occur during the high-water season when irrigation water is available for the traditional growing season.

(b) Costs

First costs are usually very high when compared with other generating systems. Operation and maintenance costs, however, are comparatively lower than fossil-fueled systems. Substantial savings in first cost can be realized when a low-head hydropower plant is combined with a low-head dam constructed for navigation purposes.

(c) Other Water Uses

Low-head facilities do not generally result in either a significant positive or negative impact on other water uses except in the immediate area of the project.

(d) Environmental

The effects of low-head facilities on water related habitat are generally limited to the immediate area. The

primary exception is the disruption of fish migration, an adverse impact which can be addressed in some cases by constructing fish ladders.

f. Conclusions

The potential for hydropower production in the Niger Basin is sufficiently large enough to warrant considering it as a primary planning objective. The adverse environmental and socio-economic impacts of high-head hydropower facilities, especially facilities constructed on the main stem, can be very great and should be carefully evaluated. Low-head facilities constructed at suitable sites along the middle Niger may prove to be a feasible means of providing power for irrigation.

TABLE 10
NIGER BASIN
EXISTING HYDROPOWER FACILITIES

NAME	RIVER	COUNTRY	TYPE	CAPACITY MW
DABOLA	TINKISSO	GUINEA	HIGH-HEAD	1.5
SOTUBA	NIGER	MALI	LOW-HEAD	5.2
SELINGUE	SANKARANI	MALI	HIGH-HEAD	45.6
KAINJI	NIGER	NIGERIA	HIGH-HEAD	760.0
JEBBA	NIGER	NIGERIA	HIGH-HEAD	500.0
DADIN-KOWA	GONGOLA	NIGERIA	HIGH-HEAD	34.0
BOKOLOR 1	SOKOTA	NIGERIA	HIGH-HEAD	3.0

TABLE 11
NIGER BASIN
CURRENTLY PROPOSED HYDROPOWER FACILITIES

COUNTRY	NAME	RIVER
BENIN	DYODYONGA	MEKROU
	KANDI-SEGBANA	SOTA
CAMEROUN	METCHUM	METCHUM
CHAD	DAO-KOUMI	
GUINEA	FOMI	NIANDAN
	KOMARATO	BAOULE
	FARANKONEDON	MILO
	FOUNGONIA BANKO	TINKISSO
	MORISSANKO	SANKARANI
	DIAREQUELA	NIGER
IVORY COAST	NORTHWEST OF BOUNDIALI	PALE
MALI	TOSSAYE	NIGER
NIGER	KANDADJI	NIGER
	PARK "W"	NIGER
NIGERIA	SHIRORO	GURARA
	MAKURDI	BENUE
	LOKOJA	NIGER
	ZUNGERU	KADUNA
	TAMTARI	TARABA
	GARIN DALI	TARABA
	MONYA	DONGA
	DASIN HOUSA	BENUE

3. Water Supply

a. General

A dependable source of clean water for municipal, industrial and rural domestic use is a necessity of economic growth. The potential for improving the surface water supply in the Niger Basin is discussed in this section along with some planning considerations.

b. Present Surface Water Supply

Table 3 presents the dependable water yield at various stations along the main stem of the Niger. Dependable yield is determined by a statistical analysis of the flow records at each station. The values in Table 12 represent the seven day average flow with a probability of occurrence of 10 percent in any year. On average, the mean flow for any seven day period would be less than the value shown once in every ten years. Due to inaccuracies in the low flow data for these stations the validity of these data is questionable. However, the trend shown and the approximate magnitude of each value is adequate to illustrate the location of present and future surface water deficiencies. The dependable yield of the Niger from the mouth upstream to Kainji Dam appears more than adequate to provide for any future demand. Throughout the Sahel Region, however, the present surface water yield during low flow periods is barely adequate to meet present needs.

c. Future Surface Water Needs

Since domestic and industrial water use tends to increase with economic development, the future water needs in the Sahel are difficult to predict. Even without significant economic growth, the general increase in population and the migration from rural areas to

cities along the river can be expected to result in serious water shortages unless steps are taken to improve the availability of surface water during the low water periods. The minimum per capita domestic water use in developed nations is about 80 liters per day (LPCD). The maximum is about 360 LPCD. The average for domestic, public, and commercial water use in the United States is almost 500 LPCD, with industrial use accounting for an additional 160 LPCD. At the minimum domestic use rate for a developed area the present dependable surface water supply in the eastern Sahel would support a population of less than half a million people, even if no water were used for industry, commerce, or livestock watering.

d. Potential for Improvements

Table 12 also presents the average annual discharge at each station and the ratio of dependable yield to average discharge. The average annual discharge represents the maximum dependable yield which could theoretically be achieved by flow regulation. In practice, it is seldom possible to achieve fully regulated flows. However, the ratio of dependable yield to average flow indicates that even a small degree of flow regulation could greatly increase the availability of surface water for municipal, industrial, and rural domestic use along the Niger River. This could be accomplished by construction of storage reservoirs on the main stem of the middle Niger or by smaller reservoirs constructed in the headwater tributaries in Guinea. The proposed Kandadji Dam for example could increase dependable yield at Niamey to about 100 cubic meters per second if only ten percent of the proposed storage were used for this purpose.

e. Relationship to Other Water Uses

(1) Irrigation

Under present conditions, irrigation water use generally does not conflict with municipal, industrial, and rural domestic use. The traditional growing season coincides with the period of high water availability for recessional farming. More modern irrigation methods, however, make withdrawals during the low water period possible and if not properly managed, could produce disastrous reductions in surface water availability. Irrigation use does compete with other water supply needs for allocation of water stored in reservoirs and the careful apportionment of reservoir storage is an important planning consideration.

(2) Livestock Watering

Since livestock require a year round water supply, this use is in direct conflict with municipal, industrial, and rural domestic water use. The large domestic livestock population in the Sahel amplifies the need for improving the dependability of the surface water supply.

(3) Hydropower

High-head hydropower facilities used for constant (base-load) generation enhance the availability of surface water for non-seasonal needs. Hydropower facilities used primarily for peaking power generation can also enhance surface water availability downstream provided that provisions are made and storage is allocated for releases during non-generating periods.

f. Adverse Effects of Surface Water Storage

The adverse socio-economic and environmental effects associated with water supply reservoirs are essentially the same as those involved with high-head hydropower facilities. They are a reduction in water availability for recessional agriculture, relocation of the population from the reservoir area, and the loss of productive farm land in this area. The potential destruction of fish and wildlife habitats must also be considered.

g. Water Quality

No discussion of surface water supply in the Niger Basin would be complete without some consideration of water quality. Throughout its length the Niger is used for drinking water, washing, and waste disposal contributing to a high degree of biological contamination. The poor water quality, especially during low flow periods and in slack water areas near villages is a primary contributor to the high incidence of waterborne disease. An increase in flow during the low water period should result in an overall improvement of surface water quality. However, this problem will only be moderated by improvement of sanitation and water and wastewater treatment.

h. Conclusions

Improved availability of water for domestic, commercial, public, and industrial use is an immediate need in the Sahelian area of the Niger Basin. A reliable surface water supply in this area is an absolute necessity for economic growth. Flow regulation of water supply should be a primary water resources planning objective for the Niger Basin.

TABLE 12

NIGER RIVER

DEPENDABLE SURFACE WATER YIELD AT VARIOUS STATIONS

STATION	COUNTRY	RIVER KM	(1) DEPENDABLE YIELD (CMS)	(2) AVERAGE ANNUAL DISCHARGE (CMS)	PERCENT (1) OF (2)
ONITSHA	NIGERIA	407	780	6057	12.88
LOKOJA	NIGERIA	615	610	5822	10.48
BARO	NIGERIA	646	420	2115	19.86
MALANVILLE	BENIN	1351	18	1181	1.52
NIAMEY	NIGER	1646	4	996	.40
ANSONGO	MALI	2000	3	1190	.25
TOSSAYE	MALI	2210	4	1208	.33
KOULIKORO	MALI	3376	23	1510	1.52
TIGUIBERY	GUINEA	3650	19	1166	1.63

NOTE: (1) VALUES REPRESENT 7-DAY, 10 YEAR LOW FLOWS AND ARE COMPUTED FROM LONGEST PERIOD OF HOMOGENOUS RECORD AT EACH STATION.

4. Transportation

The Niger River currently has significant movement of commodities along several reaches when and where streamflow and channel conditions permit. Navigation in general may be characterized as being mostly undeveloped and unreliable. Improved navigation certainly has great potential for assisting economic and agricultural development by providing a more efficient mode of transportation. Other water resource uses, such as hydropower, can enhance multi-use potential. However, navigation should be viewed within the context of the total transportation network since waterway traffic is only one component of a system used to efficiently transport goods. Navigation needs cannot be accurately identified without considering other modes of transportation which serve in conjunction with movement of waterborn commerce. An analysis of total transportation needs and segregation of the waterway component is required before specific large scale improvement can be recommended. Other factors important in developing recommendations are the quantification and evaluation of trade-offs associated with consumptive uses such as irrigation and municipal and industrial water supply. Based on known conditions, it is possible to conclude that certain navigable reaches could be improved with relatively minor changes such as placement of buoys marking the channel, removal of obstructions, or localized channel excavation and training. Member countries or donors could pursue a plan of action in this regard and significant returns are possible without substantial expenditures. Pilot projects/actions of this

nature would provide an opportunity to observe changes in levels of use and possibly identify levels of demand.

Larger scale expansion of navigation would be possible through storage of water at upstream locations with controlled releases during periods of low flows downstream. Other improvement schemes such as series of locks and dams could provide reliable navigation depths, but costs would be substantial. Developments of this nature require a comprehensive approach addressing the full range of other conflicting/complementary water use. Supporting infrastructure needs to be addressed and resource allocation accomplished taking into consideration the level of navigation required to support basin wide goals and objectives. It is essential that improvements in navigation be considered only as one element in a comprehensive effort addressing all water resource related needs.

5. Fisheries

The Niger River is used for fisheries production by those people living adjacent to it. Fishing is accomplished as it has been done historically with little or no development of the fisheries resource. Fishing is a supplemental income source and protein source of the fishers.

Future use of the river for fisheries will be closely tied to other uses of the water resource. Any storage development, such as for hydropower, will make available larger water areas for fisheries in a local area. Such fisheries can be developed for larger fisheries production than currently exists in that location, but will require the different technology for lake ishing as opposed to river fishing.

Additionally, higher fisheries production in a localized area will require development of the necessary markets for sale of the product in order for fisheries development to occur.

Modified river flows by any infrastructure development in the Inland Delta area of Mali, which would reduce the area flooded naturally, could have an adverse effect on the stream fishing habitat due to modification of the breeding and spawning habitat in the shallow water area during floods.

Future fisheries utilization is likely to remain as a complementary use of the water resource to other uses for any developed fishing.

6. Complementary/Conflicting Uses

Considerations in this regard should be contemplated from more than a single vantage point. At a given location, the available resource (water) must be allocated to identified needs at that point. A single country must view water needs from a broader perspective. This could be done by allocating flow at various locations and regulating withdrawals. Allocation of water from the basin wide point of view becomes a difficult problem because conflicts are likely to be multinational. It is from this broad perspective that the following discussion is presented.

Initial efforts should be directed toward identifying the total amount of water available for allocation. The next step is identifying existing uses, adjusting water availability accordingly, and then quantifying net amounts available for allocation. This should be accomplished for the nine countries which contribute to the flow of the Niger River. The next step involves the actual allocation of water and would be extremely sensitive. For this reason it is important that allocation procedures be technically well based. Political negotiations could then take place with technicians serving as advisors assessing effects of the various politically motivated schemes proposed. It is at this point that complementary/conflicting uses must be addressed. One of the principal tasks in establishing resource allocation is identification of needs. Other obvious factors are contributing drainage area, rainfall, prior use, and geographic location. Whatever basis is selected, it must be supported by the countries involved and in addition the five riparian countries must have the dominant role in managing the Niger River resources.

Existing uses of water may be segregated into consumptive and non-consumptive and it may be further stated that consumptive uses are generally conflicting. An example in this regard is irrigation and water supply. Both are consumptive and water allocated to one use is not available for the other. Non-consumptive uses may be complementary in some instances but not in all. An example would be navigation uses involving construction of locks and dams and upstream storage reservoirs to augment low flows. A system of this nature would allow hydropower and navigation to be generally complementary, but withdrawals for irrigation would be conflicting. In addition, it may be concluded that during low flow conditions operation of hydropower facilities constructed in conjunction with locks of dams could be curtailed because of navigation needs. Consequently under these conditions, navigation and hydropower would be conflicting. In addition, the international viewpoint must be accommodated. Water used in or released from upstream countries could serve to the advantage/disadvantage of countries downstream. Consequently it must be concluded that well founded, technical tools are essential to any effort where international and/or comprehensive water resource allocation and development is pursued.