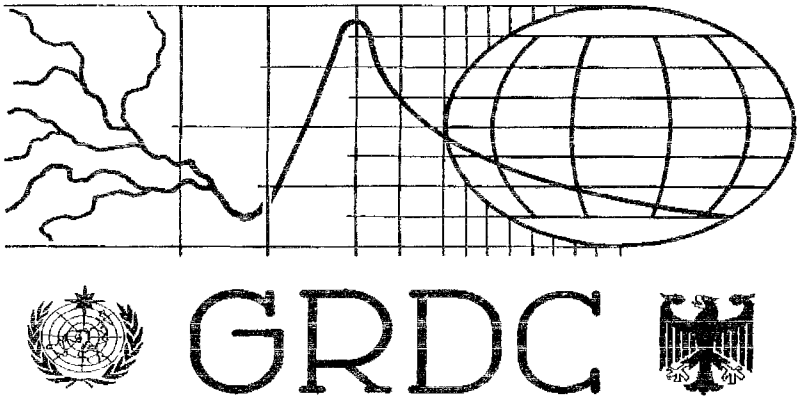
Weltdatenbank Abfluß
Bundesanstalt für Gewässerkunde
Koblenz, Deutschland

Global Runoff Data Centre
Federal Institute of Hydrology
Koblenz, Germany

Report No. 6

Report of the first meeting of the GRDC Steering Committee Koblenz, Germany, 20-21 June 1994



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CONTENTS

1. Opening of the meeting

The Steering Committee (SC) of the Global Runoff Data Centre (GRDC) convened in the Conference Room of the Federal Institute of Hydrology in Koblenz on Monday, 20 June 1994.

The President of the Federal Institute of Hydrology, Mr. Wetzel, welcomed the participants of the SC and expressed his satisfaction that the efforts of the Institute towards the development of the Global Runoff Data Centre under the auspices of the World Meteorological Organization (WMO) had come to fruition with the establishment of the Steering Committee of the GRDC. Mr. Wetzel confirmed the committment of the Federal Institute of Hydrology to support the GRDC in any way possible, even under the present difficult economic conditions.

In his reply the representative of WMO, Dr. Askew, thanked the President of the Federal Institute of Hydrology for hosting this first meeting of the SC. He noted, that the GRDC plays a vital role in the World Climate Programme of WMO and also in the Hydrology and Water Resources Programme of the Organization. He remarked that the GRDC is seen as an important tool for the hydrology and climatology communities to exchange runoff data vital for regional and global research. On behalf of WMO, Dr. Askew thanked the Federal Institute of Hydrology for its firm committment towards the development of the GRDC and expressed his pleasure at the progress made so far.

In his function as President of the Commission for Hydrology (CHy) of WMO, Prof. Hofius commented on the high priority which the CHy has given to the development of global data centres, notably the GRDC and the Global Precipitation Climatology Centre (GPCC) and the call for international support to these centres. He highlighted the close technical relationship between the Operational Hydrology Programme (OHP) of WMO and the International Hydrology Programme (IHP) of UNESCO and offered his full support in the development of the Global Runoff Data Centre.

In his opening remarks the chairman of the Steering Committee, Prof. Liebscher, referred to the history of the GRDC and the rising demand of researchers for regional and global hydrological data sets to execute hydrological and climatological studies. Since its inception in 1988, the Centre has expanded its scope of operation from a tool for climatological research to operational hydrology and the support of regional projects. Commenting on the recent progress made, Prof. Liebscher noted the growing international recognition of the GRDC due to its improved user services and the manifold linkages with programmes and projects of WMO, UNESCO, UNEP and other organizations.

The meeting was then formally opened by the chairman of the Steering Committee.

2. Organization of the work and adoption of the agenda

The meeting was attended by 12 participants representing 7 organizations. The list of participants is given in Annex 1 to this report.

During the meeting, the GRDC organized a poster exhibition of its tasks and services.

In the course of the meeting the participants had the opportunity to inspect the technical facilities of the GRDC. A guided tour was also provided to visit the city of Koblenz and parts of the Moselle valley.

The Secretary of the SC informed the participants that the representatives of UNESCO and the World Bank were unable to attend the meeting. The SC expressed the expectation that these important organizations would attend in the next meeting.

The participants agreed to a proposal of the Chairman to use a technique to visualize important remarks and recommendations by displaying cards written by the members on boards in the conference room. The meeting was held in plenum.

The agenda was then discussed and adopted by the members of the SC. It forms the table of contents of this report.

3. Review of the Terms of Reference of the GRDC and membership

The Report of the Workshop on the Global Runoff Data Set and Grid Estimation (WCRP - 22, WMO/TD - No. 302, Annex D, June 1989), had formed the organizational basis for the operation of the GRDC up until the present meeting. The SC reviewed the Terms of Reference contained in this report as Annex 2 and, after thorough discussion, decided that the GRDC should operate under the following Terms of Reference which supersede the previous Terms in the report mentioned above.

With regard to the membership of the GRDC, the SC confirmed that it is composed of representatives of international organizations and related programmes and should normally meet once a year. Observers can be invited to the SC meetings on a case by case basis. WMO undertook to write a letter to ICSU with the request that it nominate a representative to be a member of the SC.

4. Presentation of the GRDC

The Secretary of the SC, Dr. Grabs, reported on the present activities of the Centre. The briefing paper is reprinted in Annex 2. It was pointed out that the present core activities of the GRDC are:

- the improvement of the databank system including its tools for global runoff monitoring and data quality analyses
- the organization of the continuous dataflow from WMO member countries to the GRDC to ensure the continuous update of the dataholdings
- the dissemination of data in accord to the requests of data users
- the preparation of primary data products for data users

5. Review of activities

The SC noted the report and expressed its pleasure at the progress that had been made. The Federal Institute of Hydrology and through it, the Federal Republic of Germany were seen as having a real committment to the future of the Centre which was welcomed as essential for its credibility and effective operation. The full potential of the GRDC to support vital international programmes needed to be developed in the coming years. Present emphasis was to be put on consolidating the excellent achievements of the recent past, but additional staff and other resources would eventually be needed.

Dr. Askew presented a paper "The Global Runoff Data Centre (GRDC) - A look into the past, prospects for the future" (Annex 4). The paper stimulated discussion on the mid-term and future development strategy of the GRDC and guided the formulation of recommendations for the future development of the Centre.

Prof. Hofius informed the SC about relevant decisions of the Ninth Session of the CHy (January 1993) with regard to the GRDC in the WMO and UN context and explained the strategy outline of the Commission as recorded in Recommendation 2 of its Ninth Session.

6. Organizational aspects

The representative of the Japanese Ministry of Construction, Mr. Kadomatsu, suggested that the GRDC as a centre which operates under the auspices of WMO and is affiliated to the Federal Institute of Hydrology should be reflected as a seperate unit in the organization chart of the Institute. He noted that this would increase the international acceptance of the GRDC as an international entity especially in relation to the delivery of data from those countries which have conservative policies regarding the exchange of data. The SC supported this view.

In the following discussion, the SC considered what might be done to:

- improve data exchange and dissemination
- improve the awareness of the user community about the GRDC

In this regard, the members of the SC should keep the GRDC informed about relevant institutions to be contacted and meetings to be attended. The GRDC is encouraged to stimulate data exchange through attendance at regional hydrological meetings combined with selected country visits by the GRDC staff. In addition, the GRDC should actively participate in regional working groups, relevant symposia and meetings of relevant programmes. Other countries may be invited to support GRDC-related regional or national activities especially in developing countries.

In the regional context, GRDC-related workshops on specific issues could be focussed on specific geographic regions.

In order to enlarge the general knowledge of the professional community about the GRDC, a brochure and a poster for presentation at regional/national meetings should be produced, similar to the poster which was presented to the SC during the meeting. The SC thought it also useful that the GRDC prepare articles and announcements in international journals.

To facilitate the use of GRDC data under the guidance of the Centre the SC recommended that the GRDC should accept visiting scientists to work with the database on topics of mutual interest.

7. Cooperation of the GRDC in various international projects

The SC confirmed the importance of the link between the GRDC and WMO. Operating under the auspices of WMO gives the Centre an identity with regard to the UN system which is essential in establishing co-operative arrangements with UN agencies and various international programmes and in compliance with programmes of many individual countries.

The SC noted that, while the principal objective of the GRDC is to collect and disseminate hydrological data both generally and specifically to support projects within the World Climate Programme (WCP) and the World Climate Research Programme (WCRP) of WMO, it is important that the Centre be aware of the many other international and regional programmes which require and generate such data; the Centre has started to supply and collect data, as appropriate, but in all cases needs to compile the related meta-data for regional and international programmes involving hydrological data sets and store them in a global catalogue which could be used to answer queries regarding the availability of data. Eventally, the Centre might also compile meta-data on national programmes.

The WMO Rapporteur on Hydrological Data for Observing Climate and Environmental Change, Prof. Kaczmarek, emphasized the need for the GRDC to obtain more recent data to ensure the provision of data at the appropriate scale and timeliness towards international programmes such as the Global Climate Observing System (GCOS).

The SC felt that there should be a close link between the GRDC and GCOS. A direct link between the GRDC and the Global Terrestrial Observing System (GTOS) should also be explored. In this context, the SC was of the opinion that the two centres referred to earlier should be integrated into GCOS.

Mr. Rudolf of the GPCC informed the SC about the previous contacts between the GPCC and the GRDC. In particular, this cooperation is expected to bear results in the contribution of the GRDC in the WCP-Water Project B.7. Further remarks are recorded under item 9 below.

The SC felt that the GRDC and the GPCC should extend the common time series where runoff and precipitation data are available.

Representing UNEP, Ms. Skarbovic explained the strategy of the Freshwater Programme of UNEP and invited contributions of the GRDC in the implementation of regional freshwater programmes of UNEP.

The SC expressed its satisfaction that UNEP may allocate some operating funds for the GRDC dedicated mainly for country missions, data acquisition and production of primary data products. From the view of the GEMS-Water Programme, the WHO representative, Dr. Helmer, distributed a paper "Some proposals for the future development of the GRDC" which is reproduced in annex 5. The essential points of these proposals were incorporated in the recommendations of the SC.

Recognizing the close interrelationship between water quantity and quality and with a view to optimizing available resources the SC recommended that the GRDC and GEMS-Water join forces in country missions to strengthen water quantity and quality data exchange arrangements and exchange information about planned and current activities.

In view of the development of the World Hydrological and Climatology Observing System (WHYCOS), and the recent recommendations of the Working Group on Hydrology of WMO Regional Association I (Africa), the GRDC is encouraged to keep abreast of and participate actively in WHYCOS activities.

Prof. Hofius highlighted the link function of the GRDC between the International Hydrology Programme (IHP) of UNESCO and the Operational Hydrology Programme (OHP) of WMO. He pointed out the strong support which the Centre has been given in the past through the various data transfers of UNESCO and WMO to the GRDC.

The SC confirmed that the links between the GRDC and FRIEND (Flow Regimes from International Experimental and Network Data) should be continued. Selected data from FRIEND should be transferred to the GRDC and GRDC should hold the FRIEND data catalogue as meta-information. The modalities of data exchange and use and the policy for data acquisition should be worked out in more detail. Dr. Grabs reported on the first contacts in this direction with the FRIEND data base manager at the Institute of Hydrology, Wallingford.

The SC suggested that the GRDC work with other programmes to define as exactly as possible what these programmes need from the GRDC and what they will contribute to the GRDC. Speaking for GEWEX, Dr. Schaake outlined the requests of GEWEX to the GRDC and the benefits of the GRDC from a close GEWEX cooperation. The general outline of his remarks is reported in Annex 6 to this report.

The SC was of the opinion that the GRDC should seek to establish links with other programmes/agencies such as the European Environment Agency in Copenhagen.

8. Research and development

Though the GRDC at present does not undertake research on its own, the Federal Institute of Hydrology (FIH) carries out two research projects in close liaison with the GRDC. These projects are undertaken as contribution to the WCP-Water Project B.3 and B.7 as listed under item 9 below.

Two workshop papers "Transformation of measured flow data to grid points" by Dr. Lüllwitz and "Comparison study of areal mean monthly precipitation and streamflow for selected basins: The Niger river" by Mr. Winnegge, both of the FIH, were presented to the SC. The papers are reproduced in Annex 7.

The SC acknowledged the preliminary results of these projects, which are seen as valuable contributions to the WCP-Water programme and encouraged the continuation of the research undertaken with regard to gridded runoff and rainfall/runoff comparison. The SC suggested that relevant research work at the FIH should be undertaken in relation with the GRDC. Furthermore, researchers should be encouraged to use the GRDC database and the Centre should invite/accept guest-researchers to work with the GRDC database.

The GRDC was encouraged to follow current research developments and to review the results with a view to the strategic planning of GRDC activities.

9. Activities of the GRDC with regard to the World Climate Programme - Water (WCP-Water).

The SC reviewed the WCP-Water projects relevant to the GRDC and commented on issues which are important for the GRDC in the execution of these projects.

WCP-Water Project A.2 Analyzing long time series of hydrological data and indices with respect to climate variability and change.

The SC recommended that the GRDC continue to collect and make available any new data received, and any sets of results generated by the project.

WCP-Water Project A.5 Collection of global runoff data sets.

This is equivalent with the operation of the GRDC itself.

WCP-Water Project A.8 Detecting global and regional runoff trends by monitoring discharge of selected rivers.

The SC encouraged the export of vector data of river systems and watersheds through RAISON in ASCII-code. Stations should be selected and the project further developed in conjunction with GEMS-Water. The SC discussed the possibility of extending the project to include a climate component and recognized this in project B.7 (see below) in collaboration between the GRDC and the GPCC.

WCP-Water Project A.9 Monitoring changes in the characteristics of extreme hydrological events (floods and droughts).

The SC commented that the highest and lowest recorded discharges from GRDC files should be published as a contribution to this project.

WCP-Water Project B.3 Development of grid related estimates of hydrological variables.

The SC recommended that the GRDC supports this project with the supply of data and other information as available. In the medium to long term, gridded runoff data should be included as a GRDC product. See also the remarks made under item 8 above.

WCP-Water Project B.7 Comparison study of time series of areal mean monthly precipitation and streamflow of selected catchment areas.

See the relevant remarks made under item 8 above.

10. Policy matters of the GRDC

The framework within which the GRDC operates has been defined under item 3 above.

In addition to these terms of reference, the SC felt it would be useful to comment on a number of additional policy issues.

The SC considered that it would facilitate the operation of the Centre if the Federal Institute of Hydrology were to nominate a person as focal partner for the GRDC.

The GRDC should make available its catalogues of data records and gaps in the available time series of data. This has been done in the past upon request. On-line access to the data base is not foreseen at present. Where feasible, the GRDC should collect and keep meta-data on hydrology. An attempt in this direction has been the establishment of a modest library which contains inter alia hydrological yearbooks, river basin reports and relevant research papers. It is expected that this library will evolve continuously.

Though maximum use of the GRDC database is encouraged, the SC supports the present policy of the GRDC not to transfer the entire data base or large entities of it to users. The use of the data should be explained for reference purposes to inform the data suppliers about the use of their data and to review the services of the GRDC to its clients.

Information about large-scale irrigation schemes should be requested from the Secretariat of the Food and Agriculture Organization (FAO), Rome. Likewise, information about large dams and reservoirs should be requested from the International Committee on Large Dams (ICOLD). It would be decided at a later stage how this additional information could be stored in the GRDC and made available to data users.

The need for a global centre for groundwater data had been discussed at international meetings and suggestions had been made that the GRDC play a role in this regard. This was seen as a major policy issue that would need to be considered at some length and further discussed at a later date.

The SC encourages the practice of individual scientists working with the GRDC, either in Koblenz or in their home countries on studies of interest to the Centre. Results of such publications should be published under the GRDC as host institution with the collaboration of the guest institution, where appropriate.

Prof. Kaczmarek summarized the present status of discussions in WMO and other organizations about the privatization of hydrological and meteorological services and the possible implications for the GRDC.

The SC asked the GRDC to prepare a draft policy paper regarding user fees for GRDC services. A fee might be requested of all users but not necessarily required. The user fee might be charged in all cases where there is no equivalent exchange of data or other information relevant for the GRDC. Funds thus received could be used to support activities which are not covered by the contribution of the Federal Republic of Germany to the GRDC.

The GRDC will circulate the draft policy paper of user fees to members of the SC so that it might be adopted at its next meeting.

In all cases, users of GRDC data should be asked to refer in their presentations and publications to the Global Runoff Data Centre as the source of runoff data and to send results of their studies/research to the GRDC for reference.

11. Technical aspects of the GRDC

The members of the SC had the opportunity to visit the technical facilities of the GRDC. The state-of-the-art data concept was explained and the data retrieval options demonstrated. Aside from standard data products such as various tables and hydrographs, a number of user-oriented presentation graphics can be produced. The GRDC is improving this service continually on the advise and request from data users. Aside from supplying data to users, the GRDC also produces reports on the request of programmes or projects. Two present examples are reports under preparation with regard to the data base of the 20 largest rivers of the World and the compilation of a data base for rivers draining into the oceans as a response to a request from GEWEX.

A high level data product is currently being developed to monitor grid-oriented monthly runoff for continents and on a global scale. This tool enables the GRDC to supply map-based graphic displays of the continental or global runoff situation for any month and for all stations where data are available. This tool is expected to be operational by mid-1995 and will be widely published.

The control of data quality is the primary responsibility of the data suppliers. However, the GRDC is currently developing a tool for basic plausibility analysis of data which is expected to be operational in the first quarter of 1995.

The SC welcomed the progress made in the technical services of the GRDC and commented on certain aspects: It suggested that the GRDC indicate the percentage of completeness of data in a given time series and also collect station histories including rating data for selected stations for quality assurance.

Dr. Wilke, Head of Section "Water Balance Computations, Forecast Models" in the FIH reported on the logistical and manpower support of that section to the GRDC. As the GRDC is directly linked with the section he noted that it is in the interest of the section to cooperate closely and share resources where possible.

In view of the criteria for data collection, the SC suggested that the data collection criteria be re-defined under the headings: General, Project-oriented, Availability-oriented. The re-definition of such terms should be agreed upon at the next SC-meeting.

The SC re-iterated the present criteria for data collection, namely: Data should be collected for rivers with mean annual discharge greater than 100 m^3/s, from rivers with catchment areas greater than 1.000.000 km^2 and from river basins with more than 1.000.000 inhabitants.

The SC recommended that as a general policy, the aim should be to collect daily discharge data. Data suppliers should therefore be requested to supply daily data. However, the SC is aware of the fact that many data suppliers at present supply only mean monthly discharge data to the GRDC.

12. Next meeting of the Steering Committee

The SC decided that its next meeting should take place in Koblenz from **27 - 28 June 1995**.

13. Summary of results and closure of the meeting

The Secretary of the SC reviewed the work of the Steering Committee and the major conclusions and recommendations. The SC decided that the final report be made available to all members and published by the GRDC in its GRDC report series.

In the closing session, the participants thanked the President of the Federal Institute of Hydrology for its generous hospitality and genuine interest in the progress of the GRDC.

Mr. Wetzel congratulated the Steering Committee for the successful completion of its work and wished everybody a safe journey home.

In his closing remarks, Prof. Liebscher thanked the participants for the job well done under considerable time pressure.

The meeting was closed on Tuesday, 21 June 1994.

Annexes

Annex 1

Participants of the 1st GRDC-Steering Committee Meeting 20-21 June 1994 at Federal Institute of Hydrology, Coblence		
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Annex 2

GRDC

GLOBAL RUNOFF DATA CENTRE

Federal Institute of Hydrology
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PRESENT ROLE AND ACTIVITIES OF THE GRDC

- GENERAL BRIEFING -

Status: February 1994

Prepared for the 1st meeting of the
GRDC - Steering Committee
Koblenz, 20-21 June 1994

Global Runoff Data Centre (GRDC)

Koblenz, June 1994

Document for the 1st Meeting of the GRDC Steering Committee
20 - 21 June 1994

1. Scope of the document

This document informs in general terms about the activities of the Global Runoff Data Centre (GRDC).

2. Background

The knowledge of streamflow is the basic information for the assessment of water resources potential and availability. The global, regional and catchment scale long-term monitoring of runoff is therefore indispensible for water resources planning and management on all scale levels. The hydrological cycle is a sensitive indicator of climatic variability and information about the expected change of runoff is therefore required to validate output of climate change models. This includes global, regional and basin oriented water balance studies, investigation of trends in long-term hydrological time series, flux of fresh water and matter into the oceans, the coupling of runoff with water quality data and the coupling of hydrological and meteorological models.

The project A.5 of WMO under the WCP-Water Programme provides a general service for the collection, storage and dissemination of internationally available sets of hydrological data.

The GRDC was established in 1988 at the Federal Institute of Hydrology in Koblenz, Germany under the auspices of WMO. The GRDC is embedded in the Operational Hydrology Programme (OHP), WCRP and WCP-Water Programme of WMO. Close linkages exist inter alia with GEWEX, the International Hydrology Programme (IHP) of UNESCO and GEMS-Water of UNEP.

Recognizing the role of river runoff in hydrological and climatological research and especially in socio-economic activities of every society, the GRDC has been given the mandate by WMO to serve a multitude of data-users with runoff information.

The GRDC has the self-understanding as a user-oriented service center for global runoff data.

The WMO Commission for Hydrology (CHy) on its 9th session (5-15 January 1993) recommended the further support to Global Data Centres such as the GRDC and the GPCC. CHy recognized, that "These centres can only fulfil their tasks with the active cooperation of Hydrological and Meteorological Services of Members of WMO on a multilateral and bilateral basis" (CHy, 9th session, abridged Final Report).

3. Scope of Data Collection by the GRDC

Mean daily and monthly runoff data is collected on a global scale. For meteorological and climatological applications, the scope of the use of the data is primarily on the global and regional scale. For use in operational hydrology, the scope of the use of the data is mainly on the regional and basin scale.

At present, the GRDC holds global runoff data of 3.347 stations in 2.941 river basins.

Major sources of data are the WMO and UNESCO. In the further development of the GRDC, the GRDC assumes an active role in data acquisition through direct contacts to hydrological services.

4. Data acquisition of the GRDC

The capacity to update the database through direct communication with data suppliers is indispensible for the development and international acceptance of the GRDC. The institutionalized transfer of data which is established mainly by direct bilateral contacts is essential to achieve and maintain the update capacity. An intense feed back from the GRDC to data suppliers is necessary to maintain the interest of data suppliers in the GRDC. Therefore, the GRDC has offered a range of services as incentives for data suppliers.

Main problems with the global collection of runoff data can be summarized:

- Runoff data is classified in several countries
- Especially in many developing countries, the hydrological services and station network are in decline
- Political reasons prevent several countries to contribute data especially in the case of international conflicts

- There is hardly a "corporate identity" of a global hydrological community; several national hydrological services are therefore (amongst other reasons) less motivated to put additional work in the transfer of data.

- The data suppliers are responsible for the accuracy of the data. Because of insufficient ancillary information (basin parameters, gauge rating curves, river diversions and damming etc.) the GRDC finds it difficult to assess or control data quality.

5. Linkage of the GRDC with other Data Centres

The GRDC interacts with local (national) and regional data centres. To avoid an unhealthy competition of data centres, the GRDC offers assistance in the establishment of regional data centres and to establish standards to exchange data sets. However, the further development of regional centres must be closely monitored to avoid the erosion of support for global data centres. Linkages exist at present with the GEMS collaborating Centre for Surface and Ground Water Quality in Burlington, Canada and the GPCC in Offenbach. The Inter-secretariat Working Group on Information Management on its session from 30 June to 02 July 1993 stressed that emphasis should be placed on the further development of databases in the fields of:

Resource Databases	(e.g. **WMO/GRDC**, hydrometeorological data (precipitation, evapotranspiration and soil moisture inter alia))
Use and Impact Databases	(e.g. vulnerability of surface and groundwater: threats to resource degradation)
Institutional/Legal Databases	(e.g. annotated lists of UN and supporting agency water projects)

6. Current activities

At present, the GRDC is implemented under SCO-UNIX and DOS on a PC-based INFORMIX data bank system. The GRDC contains daily and monthly data for 3.347 stations in 2.941 river basins (including sub-basins).

After the organizational strengthening of the GRDC in 1993, a series of measures are under way to improve the services of GRDC for the user community:

- The first meeting of the GRDC Steering Committee in Koblenz (20-21 June, 1994) is expected to advise the GRDC in policy matters of data acquisition and dissemination, the collaboration with other water-related data centres, as well as in the definition of user-oriented data products from the GRDC data base.

- The collaboration between the GRDC and GEMS-WATER has been strengthend with regard to the regular exchange of data.

- The GEMS-WATER software package RAISON has been acquired and will be used for the generation of regional and basin information reports and graphical displays of digitized basin maps.

- The data bank is now fully relational and supports complex queries from users. The data bank facilities have been improved to simplify data retrieval and dissemination.

- A set of standard hydrological graphic displays is currently produced. This enables GRDC to serve users not only with tables but also graphic outputs of hydrological information.

- Efforts are made to update the data sets currently contained in the GRDC and to close data gaps for a number of regions. These efforts are made by incorporation of recent hydrological yearbooks which were sent to WMO by a number of countries, by direct contact to hydrological services and requests for data exchange with other national and research-oriented hydrological data banks in the world.

- The strengthening of the role of the GRDC in the Operational Hydrology Programme of WMO, the participation of the GRDC in meetings of the Regional Working Groups Hydrology and the direct links with the planned World Hydrological and Climatological Observing System (WHYCOS) underlines the efforts of the GRDC to improve links with data suppliers and users.

- With regard to quality control, the GRDC has yet to build up facilities for tests of data plausibility and homogeneity. Information about data consistency are usually not provided by data suppliers. While the principal responsibility of data quality lies with the national services supplying hydrological data to the GRDC, the practice has shown that additional quality control is necessary to advise users on possible errors or anomalies in data sets delivered to them and to give a feed back to data suppliers if errors have been detected.

- Presently, two GRDC-reports are under preparation:

  o a report on the 15 largest rivers of the world and
  o a report about runoff information from rivers draining into the oceans for the calculation of freshwater fluxes

- A computer programme is being developed to compute global mean monthly runoff in grids of 2.5° and 1.5° as monitoring "tool" for global runoff information. This tool is not comparable with the WCP-Water project B.3: Transformation of measured flow data to grid points.

- At present, requests for GRDC data are in general free of cost provided, that the user indicates in detail the purpose for which he/she requests the data. GRDC expects data users to assist in the build up of the GRDC by supplying hydrological data sets. Only sub-sets of the data bank can be ordered; requests for the contents of the total bank are not entertained.

7. Planned activities

Besides the on-going activities, the GRDC keeps abreast to improve its services. Further activities are planned to be incorporated into the routine GRDC activities:

- Improvement of data bank tools for the diplay of data bank information and the production of data products.

- Quality control and basic statistical analyses of data sets.

- Compilation of information about stations and river basin characteristics.

- Generation of a Geographical Information System (GIS).

- Mapping of long-term annual and monthly measured runoff for the documentation of the hydrological situation.

- Further cooperation with the Global Precipitation Climatology Centre (GPCC) and other relevant global data centres (e.g. UNEP-GEMS/WATER, GRID-UNEP).

8. Current and planned research at the GRDC

While the GRDC is at present not engaged in research, the GRDC collaborates actively with a number of research projects including regional and global trends in time series, calculation of water balance components in different scales, disaggregation of runoff and a nationally funded project "Transformation of measured flow data to grid points" as contribution to the WCP-Water project B.3 (see above). This project is expected to yield results which can be used for the validation of GCM's including maps of means for measured and gridded runoff.

The GRDC is involved in the WCP-Water project B.7 "Comparison study of time series of areal mean monthly precipitation and streamflow of selected catchment areas". The Niger basin has been selected for the study.

Preparations are made to participate actively in the planned ICSU/WMO ACSYS-project ("Arctic Climate System Study"). A nationally funded project "Analysis and parameterization of runoff formation on a regional and global scale" is under preparation. Rivers selected for this study are the Orinoco, the Niger and Yenissei.

Annex 3

Terms of Reference of the Global Runoff Data Centre (GRDC)

1. General

1.1 The Global Runoff Data Centre (GRDC), established at the Federal Institute of Hydrology in Koblenz, Federal Republic of Germany, operates under the auspices of the World Meteorological Organization (WMO) for the benefit of WMO member countries and the international scientific community. It provides a mechanism for the international exchange of data pertaining to river flows and surface water runoff on a continuous, long-term basis.

1.2 The Centre operates under the guidance of the Steering Committee (SC) of the GRDC which provides advice on policy matters, the functions of the GRDC, data acquisition, services and on the implementation of various tasks. It also advises on liaison with international organizations and links with international organizations and global and regional projects.

1.3 Data held by the GRDC will be made available to institutions and scientists upon request on the basis of a policy agreed by the SC.

1.4 Products produced by the GRDC will be made available to all institutions and organizations on request. This policy is intended to encourage widespread use of GRDC data. Those products may contain basic data for selected stations. These data have the status of a scientific publication and users are expected to make appropriate references to the GRDC.

1.5 Charges may be made to cover the costs of providing services to users. These charges may be waived if the individual or institution is a contributor to the GRDC.

1.6 The resources required to support the activities of the GRDC are the responsibility of the host country or institution.

1.7 The co-ordination of GRDC activities within the host country is the responsibility of the Federal Institute of Hydrology.

1.8 If for some reason, the host country is unable at some stage to continue these activities and services, it will make its holdings, records and associated computer software available to an other GRDC to be designated by WMO.

1.9 The GRDC receives data from many sources. While every attempt will be made to assure reasonable standards of data quality and related documentation, ultimate responsibility for data reliability lies with the data contributor and not with the GRDC.

1.10 The GRDC will, in general, function on the basis of principles enunciated in the "Guide to the World Data Centre System", Part 1, issued by the the International Council of Scientific Unions (ICSU).

2. Data

The GRDC will, with the assistance of WMO:

2.1 Seek and receive flow data, preferably daily data, for selected stations from national hydrological services, yearbooks, international programmes and other sources.

2.2 Establish and maintain a computerized data base and control the quality of the data by agreed-upon procedures.

2.3 Refer all queries with respect to missing or incorrect data to data suppliers.

2.4 Process and store the discharge data in a compatible form and ensure that data copies are subject to adequate standards of accuracy, clarity and durability.

2.5 Provide (i) specifications of the data retrieval service, (ii) data to users in agreed formats.

3. Other Information

The GRDC will:

3.1 Include in the database all available digitized stream and catchment boundaries and meta-data.

3.2 Prepare data products in support of international programmes.

4. Collaboration

The GRDC will:

4.1 Collaborate with WMO in the World Climate Programme - Water (WCP-Water) and with the Global Energy and Water Cycle Experiment (GEWEX).

4.2 Collaborate with the Global Precipitation Climatology Centre (GPCC), so that a co-ordinated approach can be taken, where appropriate, with respect to precipitation and runoff data.

4.3 Collaborate with the Global Freshwater Quality Monitoring Programme (GEMS-Water) of the WHO - UNEP.

4.4 Cooperate with other governmental and non-governmental international organizations such as UNESCO and ICSU.

5. Reporting

The GRDC will:

5.1 Produce yearly status reports which should include information on the following:

(i) Progress of the Centre with respect to the development of the data base and any subsequent updates/changes;

(ii) Assessment of data coverage;

(iii) Description of problems encountered with data handling (e.g. missing data);

(iv) Indication of possible discrepancies in data acquired from different sources and actions taken to resolve them;

(v) Number of requests received for data.

5.2 Circulate a draft of the yearly status report to the members of the SC and finalize the report on the basis of the comments received.

5.3 Participate in relevant workshops and studies organized by international organizations for the purpose of assessing the quality and quantity of runoff data required for various purposes and for providing information about the Centre.

6. Membership

6.1 The members of the SC are:

A. **Askew**, representative of WMO
T. **Kadomatsu**, representative of the Japanese Ministry of Construction
Z. **Kaczmarek**, WMO rapporteur on hydrological data for observing climate and environmental change
G. **Le Moigne**, representative of the World Bank
H.J. **Liebscher**, Chairman of the SC
E. **Ongley**, representative of the GEMS/WATER collaborating Centre
W. **Rast**, representative of UNEP
B. **Rudolf**, representative of GPCC
K. **Wilke**, representative of the Federal Institute of Hydrology
H. **Zebidi**, representative of UNESCO
N.N. Representative of ICSU
W. **Grabs**, Secretary and head of the GRDC

Annex 4

WORLD METEOROLOGICAL ORGANIZATION

THE GLOBAL RUNOFF DATA CENTRE (GRDC)

- A LOOK INTO THE PAST, PROSPECTS FOR THE FUTURE

A paper presented to the Steering Committee of the GRDC
at its first meeting, Koblenz, June 1994

HISTORICAL BACKGROUND

1. The idea of collecting global runoff data sets is a rather old one. Extensive analyses of river flow data sets, though mainly annual, have appeared in hydrological literature for decades. However, it was only in the late seventies that the need for such data sets was recognized as important enough to justify a truly worldwide effort. Accordingly, during the first planning meeting on the World Climate Programme - Water in 1981 a project on the collection of global runoff data series was established.

2. Within the First GARP* Global Experiment (FGGE), WMO had been entrusted to collect surface runoff (river discharge) data sets to be used as inputs to or validations of global atmospheric circulation modelling (GCM) studies carried out within FGGE. It was foreseen that such data would be necessary also for the World Climate Programme and would in general benefit the entire international meteorological and hydrological communities. The operational plan for the preparation of the surface runoff data set was considered at the seventh session of the Working Group on FGGE Data Management in December 1981 and approved by the Joint Scientific Committee of the World Climate Research Programme in March 1982.

3. In accordance with this plan WMO circulated a letter to its Member countries in August 1982 requesting data sets of daily runoff values for the time period from 1 January 1978 to 31 December 1980 for a number of selected hydrometric stations in each country. In the second circular letter to Members, dated June 1984, WMO requested maps of the catchments of the stations for which the Members had submitted data. Daily flow data for the selected stations for the years subsequent to 1980 were also solicited. In addition WMO asked Members to arrange for the supply of data for subsequent years as they became available in the National Services in charge of their collection. Altogether as many as 67 Members supplied data in response to the 1982 and 1984 circular letters of WMO.

4. The task of creating the global runoff data base was generously accepted by Professor A. Baumgartner, Lehrstuhl für Bioklimatologie und angewandte Meteorologie (Chair of Bioclimatology and Applied Meteorology), University of Munich and this work started in 1984. In May 1987, Bundesanstalt für Gewässerkunde (BfG, Federal Institute of Hydrology) in Koblenz began to take over the data sets and to process new the data for 1981-1983. In November 1988 a special unit was established in the Federal Institute of Hydrology, which became the Global Runoff Data Centre (GRDC).

5. In May 1990 a third circular letter was forwarded by WMO to Members in which the Organization informed them of the launching of the GRDC and requested further information and data. The countries were specifically requested to fill the gaps in this important global exercise, by:

- selecting a number of hydrometric stations in Member countries in accordance with criteria for inclusion in the GRDC register, if they had not already done so;

- supplying the WMO Secretariat with daily flow data for the selected stations for the period 1978 - 1988;

- supplying the WMO Secretariat with catchment maps for the selected stations.

All material received by the Secretariat in Geneva in response to these requests was transferred to Koblenz.

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* GARP = Global Atmospheric Research Programme

6. Endorsement of this endeavour to collect a global runoff data set was given by consecutive WCP-Water planning meetings (second in Paris, 1982; third in Geneva, 1985; fourth in Paris, 1988; fifth in Laxenburg, 1990; and sixth in Wallingford, 1993). A number of other WCP-Water projects were launched by these meetings, which relied on the use of the GRDC data sets.

7. In November 1988, on the occasion of the formal inauguration of the GRDC, an international workshop on "Global Runoff Data Sets and Grid Estimation" was held in Koblenz. In June 1992 a second workshop on GRDC was organized in Koblenz, which gave the overview of the first three years of the GRDC's work and formulated action plans. In late 1993 the idea of establishing a Steering Committee for GRDC came into fruition and has given gave rise to the present meeting.

STRATEGY FOR THE EXTENSION OF THE GRDC DATA BASE

8. It would be worthwhile discussing a strategy for the targeted extension of the GRDC data base. The original criteria for selection of hydrometric stations to be included in the GRDC set of data were tied specifically to the FGGE requirements.

9. The original guidelines for the selection of hydrometric stations and preparation of flow data, appended to the requests for data distributed by WMO to its Members in 1982, 1984 and 1990, included the following:

- uniform distribution consistent with network conditions, with higher density in areas of rapid variation of flow;

- coverage to the largest extent possible of each type of hydrologically homogeneous region of the country;

- availability of good quality data for the given period, originally 1978-1980 and then extended to 1978-1988.

Moreover, the following points were also to be observed:

- data should come from relatively small river basins (up to about 5,000 km^2, exceptionally up to 10,000 km^2); data from larger river basins would be used only in cases where data from small river basins could not be obtained. This criterion allowed the problem of lag time (routing) in long river reaches to be avoided.

- the flow data should represent the natural river flow, corrected for diversions, abstractions, and redistribution by storage.

10. In due course other data were included in the GRDC data base, notably those originating from:

- hydrological yearbooks, monographs and special reports, many provided by the WMO Secretariat;

- the UNESCO publication "Discharge of Selected Rivers of the World";

- a global data base compiled by Professor T. MacMahon (Australia);

- an ORSTOM data base for Niger;

- the data base gathered for the WCP-Water Project A.2 - analysis of long time series of hydrological data;

- the data base of the FREND project.

11. The above developments mean that the original set of criteria for the choice of hydrometric stations are no longer the sole basis, and perhaps not even the most important basis, for future data collection. The GRDC leaflet dated March 1993 states that it is now intended to collect daily runoff from gauging stations from larger rivers, and in particular those having:

- mean annual discharge greater than 100 m^3/s;

- river basins larger than 1,000,000 km^2;

- basins with more than 1,000,000 inhabitants.

This new statement of criteria should make the material collected by the GRDC of more interest to a wide range of applications, where an aggregated view is needed, notably by major international agencies and programmes.

12. However, the GRDC Report of the Second Workshop published in 1993 shows that there had been a drastic decrease of the amount of newer, post 1984, data available in the data base. Posing the question of future criteria for selection of the data material is therefore both timely and important. It is suggested that there is a need for a vision of a long-term strategy for targeted data collection, as opposed to just data compilation.

13. A choice of strategy could be in response to the following basic questions:

- which data sets should be up-dated?

- in what way should the data base be extended; by embracing other hydrometric stations or other types of data?

14. It is evident that many of the current gaps in the regional coverage of GRDC data arise from the unwillingness of certain countries to release water-related information, internationally and, in some cases, even nationally.

15. It will be important to fill the gaps in the regional data, the most significant gaps being in daily and monthly data from Asia. The WMO Secretariat could initiate a new request for data from WMO Member countries. However, the details of this request need to be discussed. Should it be established as a kind of "permanent request"? How often would we like the data to be forwarded by WMO Members to the GRDC - every year; every second year; and with what delay? Could we ask all countries who produce year books and other compilations of hydrological data to send a copy to the Centre, in printed form and/or on diskette or CD?

16. There should be a very close cooperation between the GRDC and the future World Hydrological Cycle Observing System (WHYCOS) and its regional manifestations. The runoff data collected in WHYCOS might be made immediately available to the GRDC.

17. The efforts to extend the GRDC data base may be made by all agencies associated with the Centre. There are several initiatives aimed at collecting national or regional data sets of river flow, which could be of interest to GRDC. For example, within the UNESCO FRIENDS project (IHP-H-5.5: Flow Regimes from International Experimental and Network Data Sets) a collection of regional data sets has been established for Europe and Africa. Further developments are foreseen in Asia and South America, and a proposition has been made for a similar project to be initiated in the Middle East. These data could be made available to GRDC.

18. Another UNESCO-IHP project, M-1-3, related to updating of IHP publications on water resources assessment will embrace the preparation of the Monograph on World Water Resources at the Beginning of the XXIth Century. The data backing the monograph could be of interest to GRDC and could be made available to the centre. The LACHYCOS initiative in South America and the UNESCO-ROSTSEA activities in South East Asia might also provide useful data. Valuable inputs can also be expected from co-operation with UNEP, in particular within GEMS-WATER.

19. Long sets of river flow data from some countries, such as the U.S.A. and Canada, are available on CDs, either free of charge or commercially. Including these data could considerably improve the GRDC statistics, both as regards the number of hydrometric stations in the data base, and the number of station/years. However, it would still not help achieve a more uniform global coverage.

MOTIVATION AND PUBLIC RELATIONS ISSUES

20. Ways of motivating individuals, institutions and countries to supply and use the GRDC data should be considered. Undoubtedly, revising the leaflet on GRDC with up-dated statistics would be of value. It may well be that increasing the degree of specification in the leaflet (or brochure) could enhance the motivation. The following also comes to mind:

- The leaflet could contain the list of data suppliers, possibly with dates of supply explicitly stated. Seeing the name of one's institution among other data suppliers, or the will to see this name on such a list could play a role in motivation.

- The leaflet (brochure) could contain selected data on requests, both in terms of statistics, and topical specification of data users and the applications. It could improve motivation to see that these data are used, in particular if they are used in a challenging research project by an institution of high repute.

However, the question of how to efficiently secure a reliable data input to GRDC on a permanent basis is still an open one.

21. Knowledge of GRDC by the scientific and operational hydrology communities is still very limited and promoting both GRDC data supply and use is necessary. It should be seen as an important permanent activity of the Centre.

22. A media information campaign in professional publications could be carried out. Information on the GRDC could be submitted for publication in major scientific journals on hydrology and water resources. The information campaign could embrace also major NGOs, particularly the International Association of Hydrological Sciences via articles in its Hydrological Sciences Journal and the IAHS Bulletin. Materials on GRDC could be also disseminated during international scientific conferences.

23. It would be very advantageous if the Centre extends further its offer beyond the raw data. It could provide the users with a range of primary data products, notably in a graphical form, consisting of results of basic statistical analyses of the regional data and of the results of search for trends in the long data series, pursuit of a greenhouse signal. Such services could be solicited by national agencies, regional bodies (e. g. the European Union), and international agencies (notably those of the UN family).

24. A catalogue of data available from the GRDC and the list of "missing data" should be prepared, regularly up-dated and broadly distributed, possibly in printed and diskette form.

COOPERATION WITH OTHER MAJOR INTERNATIONAL PROGRAMMES

25. The GRDC is already, or has the potential to be, a partner of a number of major international programmes. These include GRID, GEMS-WATER, GCOS, GTOS, GEWEX, IGBP and GOOS. The links between GRDC and these programmes can be of many kinds:

- supplying them with requested data;
- receiving data from them, which could be included in the GRDC data base;
- participation in projects where data from different centres are used in a joint endeavour.

26. There are a number of large scale initiatives where the collection of runoff data is foreseen. As examples one could mention GCIP in the drainage basin of the Mississippi, MAGS in the drainage basin of the MacKenzie, and BALTEX in the basin of the Baltic Sea. It would be highly desirable to enter the data collected in these programmes into the GRDC data base. Useful links might be established with the Arctic Climate System Study (ACSYS) of the WCRP and, as soon as it becomes operational, with the European Environment Agency.

GRDC AND THE WORLD CLIMATE PROGRAMME - WATER

27. GRDC itself is the explicit realization of one of the projects of the World Climate Programme - Water, namely Project A.5 - Collection of global runoff data sets. In addition, GRDC has been closely associated with two other on-going WCP-Water projects co-ordinated by WMO, namely: Project A.2 - Analyzing long time series of hydrological data and indices with respect to climate variability and change; and Project B.3 - Development of grid-related estimates of hydrological variables.

28. In the latter, a nationally funded research is being undertaken by the Federal Institute of Hydrology in close connection to the GRDC. It embraces gridding the runoff data for the drainage basin of the river Weser in Germany and a collaborative effort with Czech Republic for the catchment of Elbe-Labe. At the Sixth Planning Meeting on WCP-Water, GRDC presented a revised proposal for Project A.8 - Detecting global and regional runoff trends by monitoring discharges of selected rivers. Potentially, WCP-Water Project A.9 - Monitoring changes in the characteristics of extreme hydrological events (floods and droughts) could be realized in cooperation with GRDC, although the UNESCO project (IHP-H.2.3) on which this is based is currently shelved for lack of funds.

29. There is also a plan for GRDC to be involved in another WCP-Water project, namely Project B.7 - Comparison study of time series of areal mean monthly precipitation and streamflow of selected catchment areas. This project assumes the involvement of both Global Precipitation Climatology Centre (GPCC) and GRDC.

EXTERNAL SUPPORT TO THE GRDC

30. Staffing and infrastructural facilities for the GRDC are secured by the Federal Institute of Hydrology. On many occasions, the constituent bodies of WMO have expressed their gratitude to Germany for this valuable contribution to international hydrology.

31. It is understood that there are certain activities, which it would be useful for the GRDC to undertake, but which cannot currently be funded by the Institute. There is therefore, at present, a need for external financial support to the GRDC.

32. One such need is for representatives of GRDC to participate in selected international meetings, with the aim of disseminating information on the Centre, and establishing links with potential suppliers and users of data. The costs of foreign travel and attendance at such meetings cannot be covered from the GRDC regular budget.

WMO SUPPORT

33. The World Meteorological Organization, which initiated the collection of the runoff data sets and under whose auspices the Centre is functioning, expects to continue to play an important role in support of the GRDC. The Organization has statutory contacts with National Hydrological Services: the agencies which typically are responsible for collecting runoff data at the national level. Therefore it may request again, as it has done three times already, information and/or data from Member countries. Any new request from WMO would need to be more targeted than in the past and specific requests should be stated which reflect the long-term strategy of the Centre.

34. WMO's support for the GRDC has been reflected in important documents of the Organization. Attached are Recommendation 2 of the Ninth Session of the Commission for Hydrology (CHy-IX) held in January 1993 and Resolution 11 of the Forty-Fifth Session of the WMO's Executive Council (EC-XLV) held in June 1993, which articulate this support.

35. The WMO Secretariat can aid by establishing initial contacts in countries on behalf of GRDC, monitoring the possibilities for extension of the GRDC data base, and, where necessary, acting as the intermediary between the GRDC and third parties. Also the staff members of the WMO Secretariat will continue to publicize the GRDC activities (e. g. via addresses delivered to different meetings).

36. Perhaps as a first and obvious move towards a GRDC public relations campaign, a new comprehensive and fully fledged paper on GRDC activities could be printed in the WMO Bulletin and similar publications of other international organizations. Such a paper could be prepared jointly by the GRDC and the WMO Secretariat and would be translated by WMO into French, Spanish and Russian.

37. WMO also envisages providing some financial support for the participation of GRDC in a limited number of international meetings. One past example of this was the support given for Dr. W. Grabs to attend the meeting of the WMO Regional Association I (Africa) Working Group on Hydrology held in Abidjan in November 1993. Dr. Grabs took the opportunity to deliver an oral contribution to the meeting and to publicize GRDC activities. His presentation was well received and triggered promises of data from several African countries.

38. Another initiative which may lead to the extension of the GRDC data base is the proposal for the setting up of a network of operational hydrology reference basins (OHRB). This was put forward at the eleventh session of the WMO's Regional Association VI (RA VI) Europe, held in Oslo in May 1994. GRDC could benefit from the information to be collected from small hydrological basins in the eleven countries of the region which declared their willingness to participate in the network.

OTHER ISSUES

39. The collection and dissemination of data by the GRDC are not commercially based. GRDC receives data free of charge and offers them at no cost or, at most, at the marginal cost of handling (retrieval, magnetic media, postage and package).

40. The delicate issue of commercialization may yet arise, however. In a number of countries data are available nationally at cost. Sometimes this cost is quite substantial, and may even hamper the broad use of data in scientific research institutes where the latter cannot afford to pay the price required by the national service holding the data. If these data are forwarded to GRDC free of charge and are distributed by GRDC at the marginal cost of handling, magnetic media, and postage, a potential national client of the National Hydrological Service might request data free from the GRDC rather than paying for them at home.

41. Some restriction on data use might be imposed by some institutions and countries. These might require that users declare that the data will not be used commercially, that they will not be passed to a third party without the permission of GRDC, that the Centre should be informed about the scientific results based on the data provided by GRDC; or that any publication based on the data should contain a reference to GRDC.

42. In most cases the recipient would have no right to re-export data, nor to use them outside the territory of the receiving country, which is a typical practice of commercial law.

CONCLUDING REMARKS

43. The continued collection of global runoff data sets offers considerable opportunities for hydrology and related sciences. So many uses can be made of the data in so many different areas. Water resources will come under increasing stress as the future unfolds, and the value of the holdings of GRDC will constantly increase. What future unforseen needs will they also meet? Every effort must be made to ensure the future of the Centre and its contribution to resolving many of the World's problems, both in science and in socio-economic development.

ANNEX

RECOMMENDATION 2 (CHy-IX)
SUPPORT TO GLOBAL DATA CENTRES

THE COMMISSION FOR HYDROLOGY,

NOTING with appreciation the activities of the Global Runoff Data Centre (GRDC) at the Federal Institute of Hydrology in Koblenz, Germany and of the Global Precipitation Climatology Centre (GPCC) of the German Weather Service in Offenbach, Germany,

RECOGNIZING:

(1) The valuable benefits from these activities to Members of WMO, the international scientific community, and to international programmes and projects such as GCOS, GEWEX, GCIP, GEMS, WCRP and WCP-Water;

(2) That these Centres can only fulfil their tasks with the active co-operation of the Hydrological and Meteorological Services of Members of WMO on a multilateral and bilateral basis;

(3) That there is still an unequal geographic coverage of data as well as incomplete data sets in the databases of these global data centres,

RECOMMENDS:

(1) That the WMO Secretariat support the centres by continuing to establish initial contacts with new suppliers of data including relevant international or national programmes;

(2) That the global data centres establish a procedure which would ensure that data suppliers provide their data directly to GRDC and GPCC at regular intervals;

(3) That Members of WMO support the global data centres by supplying relevant data to these centres.

RESOLUTION 11 (EC-XLV)
REPORT OF THE NINTH SESSION OF THE COMMISSION FOR HYDROLOGY

THE EXECUTIVE COUNCIL,

HAVING CONSIDERED the abridged final report of the ninth session of the Commission for Hydrology,

ENDORSES the decision by the Commission to play a more active role in environment-related and inter-disciplinary matters,

NOTES the need to find ways to allow developing countries to play their full part in planning the Commission's activities,

DECIDES:

(1) To note the report;

(2) To note Resolutions 1 and 2 (CHy-IX);

(3) To embody the substance of Recommendation 4 (CHy-IX) in Resolution 21 (EC-XLV);

(4) To take action on the other recommendations as follows:

Recommendation 1 (CHy-IX) — Amendments to WMO Technical Regulations for Hydrology

(*a*) Approves the recommendation;

(*b*) Requests the Secretary-General to incorporate the amendments to the existing Technical Regulations, Volume III, Hydrology, as specified in Parts A to C of the annex to this recommendation, in his consolidated report on Technical Regulations to Twelfth Congress;

Recommendation 2 (CHy-IX) — Support to global data centres

(*a*) Approves the recommendation;

(*b*) Requests the Secretary-General to bring this recommendation to the attention of the Global Runoff Data Centre (GRDC), the Global Precipitation Climatology Centre (GPCC) and the Members of WMO.

Recommendation 3 (CHy-IX) — Funds from publication sales

(*a*) Notes the recommendation;

(*b*) Requests the Secretary-General to submit this recommendation to the twelfth session of Congress.

NOTE: This resolution replaces Resolution 12 (EC-XLI), which is no longer in force.

Annex 5

Some proposals for the future development of the GRDC

General Strategy

The BfG (Federal Institute of Hydrology) may wish to consider expansion of its GRDC through three concurrent activities:

- Expand the WCP-orientation of GRDC's data collection /management programme into global hydrological monitoring under the UNEP/WHO/WMO/UNESCO Programme GEMS-Water.

- Assume a global role in the current UNEP-Programme on Land Based Sources of Pollution (LBS) through data collection /management of river mouth stations for global river pollutant flux estimations.

- Broaden the national support basis and political mandate of GRDC through enhanced collaboration with the Ministry of Environment of Germany on international water issues of national interest.

GEMS-Water participation

Within the global freshwater monitoring programme, WHO coordinates all activities and has assigned water quality data handling to the National Water Research Institute (NWRI), Canada. Related river discharge data should be collected by GRDC under the auspices of WMO. GRDC functions therefore as the global hydrological data repository. Steps have already been taken to establish compatible data handling and exchange systems at NWRI and GRDC.

It is proposed to expand this cooperation with GRDC assuming a more pro-active role in the collection of data and establishing and maintaining operational information exchange with national and regional hydrological services. Financial support for this is foreseen in the 1994-1995 programme and budget of GEMS-Water.

Land Based Sources of Pollution

The GEMS-Water programme initiated in 1994 an activity to estimate the global flux of pollutants carried by rivers into the oceans. This will be implemented with the Land-Ocean Interface/Coastal Zone (LOICZ) working group of the International Geosphere/Biosphere Programme (IGBP), and will resume the work initiated by UNESCO's World Register of Rivers Discharging into the Oceans (WORRI). The WORRI data base is stored at the IHP/OHP Secretariat at the BfG. Data from river mouth stations will be collected for river discharges, sediment loads, water quality and sediment analyses. GRDC, together with NWRI Canada could assume an operational role in data processing for the global assessments and estimates.

The clients of this activity will not only be GEMS-Water and IGBP but also UNEP's Oceans and Coastal Areas Programme Activity Centre (OCA/PAC) which currently prepares an intergovernmental conference on Land Based Sources of Pollution in November 1995 with a preceeding Government-designated expert meeting in March 1995. The monitoring of LBS-fluxes through rivers will become a long-term requirement to validate the commitments expected from the intergovernmental meeting.

Annex 6

Outline of the cooperation between the Global Energy and Water Cycle Experiment (GEWEX) and the Global Runoff Data Centre (GRDC).

GEWEX requirements for data from the GRDC:

1. Discharge from continents to oceans and closed basins.

2. Information to verify the runoff produced by coupled models in areas of 10^3 - 10^5 km^2.

3. Runoff Information for parameter estimation of the hydrological component of atmospheric models.

4. Streamflow data to support water resources applications derived from atmospheric model information.

5. Information to support the scientifc application of data and data products from the GRDC.

GRDC requirements from GEWEX:

1. GEWEX projects keep GRDC informed and invites the GRDC to participate in the planning/implementation of regional projects.

2. GEWEX assists the GRDC to obtain data, basin boundaries and related basin information.

3. GEWEX supports GRDC activities on a case by case basis.

Annex 7

Workshop papers

Dr. Th. Lüllwitz
Transformation of measured flow data to grid points

Mr. R. Winnegge
Comparison study of areal mean monthly precipitation and streamflow for selected basins: The Niger River

Transformation of Measured Streamflow Data to Grid Points - First Results within the WCP-Water Project B.3

Dr. T. Lüllwitz, Federal Institute of Hydrology, Koblenz

I. Introduction

The presentation summarizes the method for creating gridded maps of average monthly river discharges within the WCP-Water Project B.3 "Development of Grid-related Estimates of Hydrological Variables". These calculations of runoff data can be used for validation of climate model simulations as well as for estimates of freshwater input into the oceans.The specific purpose of the project is to compute grid-based estimates of runoff using the following steps:

1. Application of discharge values only
2. Application of empirical-statistical relationships between physiographic poperties and runoff
3. Application of (2.) and hydrometeorological parameters.

Estimates of runoff will be developed on monthly basis in a 0.5° x 0.5° grid net on the period 1971-1980. First results from Phase (1) are presented whereas Phase (2) and (3) are in preparation.

II. Sources and Characteristics of Runoff Data

The hydrologic data were derived from small basins taken from archives within County Districts Databases as well within the GRDC. Another source is the European Water Archive of FRIEND (Flow Regimes from International Experimental and Network Data, Gottschalk et al., 1993). Potential problems which have to be considered when working with these data include runoff losses (transmission losses etc.), accuracy of gauging and effects on human interventions.

III. Use and Implementation of Gridded Data

These hydrological estimates are needed for various purposes such as:

1. Global and continental water balance studies.
2. Investigations on global and regional trends in hydrological time series
3. Estimations of inputs of freshwater into the oceans
4. Validation of General Circulation Models (GCM´s), Soil-Vegetation-Atmosphere Models (SVAT), Ocean Models and Hydrological Models.

GCM- as well as SVAT-models have been applied to various regions under different climatic conditions. Within these model applications seasonal river runoff data have been derived from these model simulations (Bishop et al., 1992, Kuhl et al., 1992) but without validating their results by measured, areal runoff values (Pitman et al., 1993). One of the main questions is how well do current models of SVAT-relations intercompare? Future research priorities for implementing runoff components are on investigations of the effect of topography and landcover derived by remotely sensed data.

IV. Method Used for Gridding Runoff Values

The specific purpose of the project is to compute areal weighted averages of gridded maps derived from catchment maps. The method basically involves producing a choropleth map of runoff by catchment, superimposing a regular grid by 0.5° x 0.5°, and calculating the weighted grid cell average. This approach has shown to produce reasonable estimates of gridded runoff (Arnell, 1994). The following basic procedures are performed within this method:

1. Determination of runoff for each gauged station as a depth across the catchment.
2. Plotting of a choropleth runoff map for each catchment and values are assigend to classes.
3. Superimposing a regular grid and calculation of the areal weighted average value within each grid cell.

Several practical facts have to be considered, using this method. First, most gauged catchments (Europe) are frequently nested. It is therefore necessary to substract the volume of runoff recorded at the downstream gauge, and express the difference as a depth over the incremental catchment area. Second, the method requires streamflow to be converted to a depth across the catchment. Third, to be implemented, the method requires digitized basin boundaries. A Geographical Information System (GIS) was used to organize and to develop a database and has been proven to be used as a helpful tool in this type of analysis.

V. Preliminary Results

From the digitized catchments boundaries the areas of each catchment in relation to the total grid size was calculated using a GIS. The runoff values from each gauge were transformed to areal runoff and the derived values were weighted by these factors. The results for several grids within the Weser catchment are shown in Table 1 and Figure 2. These values can be compared with the mean runoff values which are represented as well.

Grid-No.	No. of gauges	Area (km^2)	R_A (mm/a)	R_G (mm/a)
25 - 52.5°N/9.5°E, 52.0°E/10.0°E	9	1899.61	214.4	202.3
32 - 52.0°N/9.5°E, 51.5°E/10.0°E	13	1920.48	257.2	233.5
33 - 52.0°N/10.0°E, 51.5°E/10.5°E	14	1921.04	298.6	316.4

Table 1:
Serial numbers of grid cells with their location, number of stream gauges within each grid cell, area of grid cells (km^2), mean runoff R_A (mm/a, 1971-1980), and runoff from sub-catchments weighted for their area, R_G (mm/a).

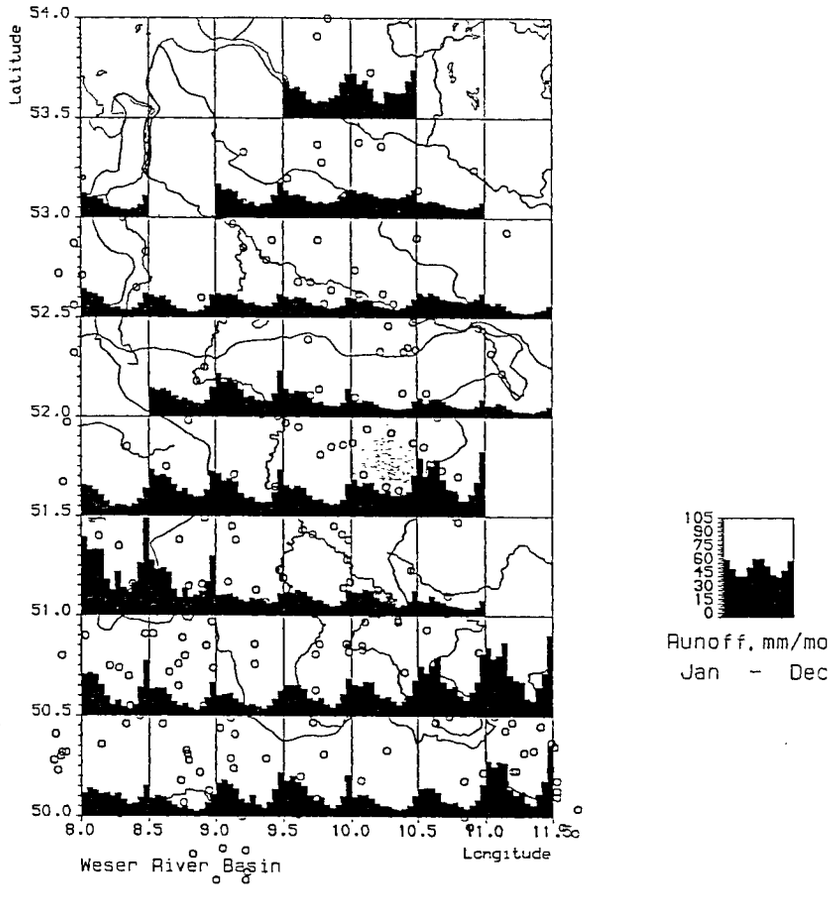

Fig. 1:
Gridnet 0.5° x 0.5° of the Weser Catchment, Germany, location of stream gauges, and histograms of mean monthly runoff within each grid cell, 1971 - 1980

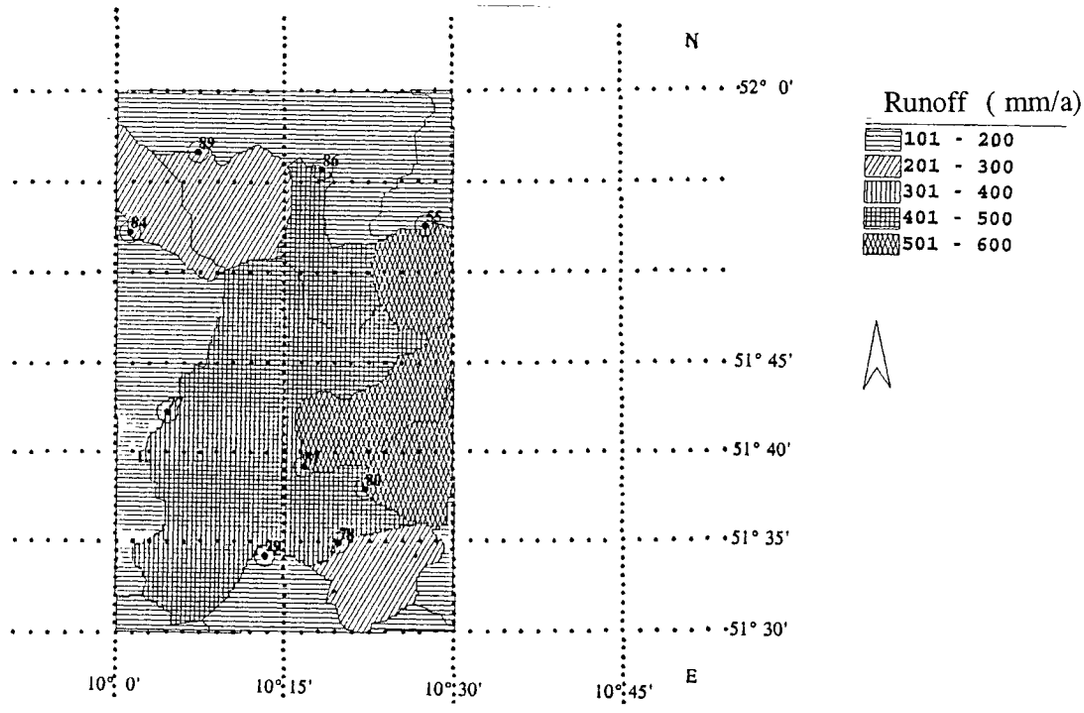

Fig. 2:
Areal weighted runoff within grid cell No. 33, 1971 - 1980, Weser Catchment, Germany

VI. References:

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WCP-Water Project B7:
Comparison study of time series of areal mean monthly precipitation and streamflow for selected basins: The River Niger

Out of the large components of the water balance rainfall and runoff can be measured most accurately. Residuals are evaporation and storage changes. Since measuring methods of both rainfall and runoff have special uncertainities, the results have to be discussed in detail. The differences of precipitation and streamflow have to be interpreted whether they represent residual components or are caused by measuring errors.
The comparison of runoff as a residual of rainfall and evaporation, done by GPCC, and runoff transferred to grid cells from measured data is the objective of this study.
Representative for the semi-arid climatic zone the catchment of the River Niger is selected.

Activities:

1. Collection and evaluation of precipitation data at the GPCC:

   The Global Precipitation Climatology Centre GPCC provides global area-mean precipitation totals on a 2,5° x 2,5° grid for the years 1987 and 1988, derived from rain-gauge measurements. **Figure 1** visualizes the results for the Niger catchment area for the year 1987.

2. Collection and evaluation of streamflow data at the GRDC:

   The Global Runoff Data Centre GRDC stores in its database about 110 gauging stations within the Niger catchment. The availability of runoff data between 1960 and 1991 is shown in **table 1**. The database will be improved in cooperation with ORSTOM, France, and with direct contact to the relevant countries.
   Figure 2 presents the station location within the catchment.

   Check and validation of runoff data:
   * The geographical position of the gauging stations has to be checked.
   * Comparison of runoff curves within a wet season along the course of the river.
   * Comparison of runoff curves of different years.

3. Digitization of catchment boundaries

   The gauging station density is highest in the upper catchment and inner delta of the River Niger, therefore the project has started in this region with digitization of catchment boundaries (**figure 3**). Up to station Tossaye/Niger 44 subcatchments are digitized. The vector data set of the river network is taken from the Digital Chart of the World (DCW), available at GRDC. Other data sets like land use, soil types, extension of flooded areas and elevation are as well stored in the DCW or in data sets of UNEP-GRID and can be integrated in this project.
   For comparison with the GPCC data set, the gauging stations with daily discharges for 1987 and their catchment boundaries are given in **figure 4**.

4. Present state

On the River Niger the occurence of seasonal flood peaks is clearly apparent. In the headwater the rainy season usually starts in June. The Upper Niger begins to rise and developes flood peaks in September. The peaks vary in their timing from year to year by 2-3 weeks. The interannual variability in the height of the peaks is great. For instance at Koulikoro/Niger the annual cumulative discharge varies from the mean of 45 km^3 by 15 km^3 in 10 years.
In 1987 the rainy season starts in May and creates a peak discharge at Banankoro/ Niger and Kirango aval/Niger in September (**figure 5**). As the flood wave passes the inner delta, the runoff curve is smoothed and a reduced peak moves to begin of November. In average (1961-1980) the annual discharge is reduced from 42 km^3 to 30 km^3 on the way through the inner delta.
It is apparent that the time lag between rainfall and runoff increases with river length. The influence of rainfall events in the headwaters is still dominant in areas downstream the inner delta.
The processes of runoff generation have to be discussed in detail. Therefore runoff will be separated into base flow and direct flow. The areal distribution of the flow components will be related to catchment characteristics like elevation and vegetation. This relation will be taken as a basis for the parametrisation of runoff generation.

5. Further steps:

* Calculation of rainfall and evaporation for a 0,5° x 0,5° grid for the upper catchment of the River Niger.
* Runoff separation, relation of flow components to catchment characteristics, parametrisation of runoff generation.
* Relate rainfall to flow components on a 0,5° x 0,5° grid.

List of figures and tables

Table 1: Niger Catchment, Availability of Runoff Data at GRDC from 1960 onwards

RIVER	GAUGING STATIO	CTR	19-60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91
Alibori	Route Kandi-B. amo	BJ	m	m	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d										pd	pd
Alibori	Route Kandi-B. aval	BJ			d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d										pd	pd
Bagoe	Guinguerini	IV	d	d	d	d	d	d	d	pd	d	pd	pd					pd	d	d	d	pd	pd											
Bagoe	Kouto amont	IV														pd			pd	pd	pd	pd											
Bagoe	Kouto aval	IV	pd	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d											
Bagoe	Pankourou	MI	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	m	m	d	
Bagoe	Papara	IV																	d	d	d	d	d		d									
Bagoe	Tombougou 1	IV	d	d	pd	d	d	d	d	pd	pd																							
Bagoe	Tombougou 2	IV				pd	d	pd	pd	pd	pd	pd	pd	pd	d	d	d	d	d	d	d													
Bani	Beneny-Kegny	MI	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d							d			d	
Bani	Douna	MI	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	m	m	m	m	m	d	m	m	d	
Bani	Mopti	MI	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	d	m			
Bani	Sofara	MI	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d						d			d	
Banifing	Kolondieba	MI												d	d	d	d	d	d	d	d	d								d			d	
Banifing	Kouoro 1	MI	d		pd	pd	pd	pd		pd			pd		pd	pd	pd	pd	pd	pd	pd	pd											
Banifing	Kouoro 2	MI																d	d	d	d	d								d			d	
Banifing	Ziemougoula	IV			pd	d	d												d	d	d	d	d											
Baoule	Bougouni	MI	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d		d						d			d	
Baoule	Dioila	MI	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	m	d	m	m	m	m	m	d	m	m	d	
Baoule	Djirila	IV			pd	m	m	d	d	d	d	d	pd	d	d	d	d	d	d	pd														
Baoule	Madina Diassa	MI												d	d	d	d	d	d	d	d	d		d						d			d	
Baoule	Samatiguila	IV			pd	d	d	pd														d	d											
Bara-Issa	Sarafere	MI	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d							d			d	
Benoue	Buffle Noir	CM		m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m													
Benoue	Garoua	CM	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	pm											
Benoue	Riao	CM	pm	pm	pm	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	pm											
Benoue	Yola	NI	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m		
Dargol	Kakassi	NR	d		d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d									
Dargol	Tera	NR		d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d												
Degou	Manankoro	IV																pd	d	d	d	d	d											
Diaka	Kara	MI	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d		d						d			d	
Diamangou	Botou	HV																					pm	m	m	pm	pm	m	pm					
Diamangou	Tamou	NR			pd	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	pd	pd											
Donga	Donga	NI																		m														
Doundian	Wahire	IV																	d	d	d	d	d											
Faga	Liptougou	HV														pm	pm		pm		pm	pm	m	pm	pm	m	m	m	m	m	pm			
Faro	Safaie	CM	m	m	pm			pm	m	m	m	m	m	pm																				
Gongola	Dadin Kowa	NI																		m														
Goroubi	Diongore amont	NR			pd	pd	d	d	d	d	d	d	d	d	d	d	d	d	d	pd	pd	pd	pd											
Gorouol	Alcongui	NR		d	d	d	d	d	d	m	d	d	d	d	d	d	d	d	d	d	d	m	m	m	m	pm	pm	m	m	m	m	pm		
Gorouol	Dolbel	NR	m	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d									
Gorouol	Korizena	HV					m					m	m	m	m		m		m	pm	pm	pm	m	m	m	pm	m	m	m	m	m	m	pm	
Goudebo	Yakouta	HV				pm	m	m	pm			pm	m	m	m	m	m	m	pm	m	d	d	d	d	d	d	m	m	pm					
Goulbi de Maradi	Guindam Roumdji	NR																	d	d	d	d												
Goulbi de Maradi	Madarounfa	NR		pm	m	m	m	m	m	m	m	m	m	m	m	m	m	m	d	d	d	d												
Goulbi de Maradi	Nielloua	NR																	d	d	d	d	d	d	d									
Irane	Koutakoukrou	BJ	d	d	d	d	d	d	d	d	d	d	d	d	d	d					pd	pd	pd											pd
Issa Ber	Akka	MI																												d			d	
Issa Ber	Dire	MI	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m			
Kabia	Gounou-Gaya	CD																			pd	d						pd	d	d	d	d	pd	
Kabia (Amont)	Pont Carol	CD																			pm	d	pd	m	d	d	d	d	d	d	d	d	pd	
Kankelaba	Debete	IV																pd	d	d	m	d	d		d									
Kori de Badeguic	Badeguicheri	NR																	d	d	d	d												
Kouroukele	Iradougou	IV			pd	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d											
Lotio	Klela	MI																	pd	pd	pd	d												
Maggia	Tsernaoua	NR																	d	d	d	d	d	d	d	d								
Mahandiabani	Wahire	IV																	d	d	d	d	d											
Mayo-Kebi	Cossi	CM	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m												
Mayo-Louti	Figuil	CM															pm	m	m	m	m	m												
Mayo-Rey	Tchollire	CM																m	m	m	m	m												
Mekrou	Barou	BJ		pd	d	pd	pd	pd	pd	d	pd	d	d	d	d	d	d	d	d	d	d	pd												
Mekrou	Kompongou	BJ	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d										pd	
Metchum	Gouri	CM					pm	m	pm	m		m	m	m	m	m	m	m	m	m	m	m	m											
Milo	Kankan	GN	d	d	d	d	d	pd	pd	d	d	d	d	d	d	d	d	d	d	d	d	d	d											
Milo	Kerouane	GN											pd	pd	d	d	pd				pd	d	d											
Milo	Konsankoro	GN	pd	pd	pd	pd		pd		m	d	pd	pd	m	d	pd	pd		pd		pd	pd	pd											
Niandan	Baro	GN	d	d	d	d	d	pd		d	d	d	d	d	d	d	pd	pd	pd		pd	d												
Niandan	Kissidougou	GN	d	d	d	d	d	pd		d	d	d	d	d	d	d	d	d	d	pd	pd													
Niangboue	Ponondougou	IV	pd	d	d	d	d	d	d	pd	pd	d	d	d	m	d	d	d	d	d	pd	m	d											
Niger	Ansongo	MI	d	d	d	d	d	d	d	d	d	d	d	m	d	d	d	d	d	d	d	m	pm	m	m	pm	m	m	m	d	m	m	d	
Niger	Banankoro	MI								d	d	d	d	d	d	d	d	d	d		pd	pd	pd	pd						d			d	
Niger	Dialakoro	GN	d	d	pd					pd	d	d	pd	pd	pd	pd	pd		pd	pd	pd	pd	pd											
Niger	Dire	MI	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	m	m	m	m	m	d	m	m	d	
Niger	Faranah	GN	d	pd	pd	pm	pd	pm	pd	pd	pd	d	pd	pd	pd	d	pd	pd	d	pd	pd	d												
Niger	Gaya	NR	m	m	m	m	m	m	m	m	m	m	m	m	pm	pm	m	m	m	m	m	pm	pm	pm			pm	pm	m	m	pm	pm	pm	
Niger	Jebba	NI																		m														
Niger	Kandadji	NR																d	d	d	d	d	d											
Niger	Ke-Macina	MI	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d						d			d	
Niger	Kirango aval	MI	d	d	d	d	d	d	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	d	m	m	d	
Niger	Koryoume	MI	pm	pm	pm	pd	pd	pd	pd	pd	pd	pd	pd	pd	pd	pd	pd	pd	pm	d	pd	pd								d			d	
Niger	Koulikoro	MI	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	m	m	d	
Niger	Kouroussa	GN	pd	d	pd	d	d	d	d	d	d	d	d	d	d	d	pd	pd	pd	pd	pd	pd												
Niger	Malanville	BJ	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d										pm	pd
Niger	Mopti	MI	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d				d	d									d	
Niger	Niamey	NR	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	m	d	d	d	d	d	d	d	d	d	d	pd
Niger	Tiguibery	GN	d	d	d	d	pd	pm		pd	d	d	d	d	d	d	d	d	d	d	d	d											d	
Niger	Tilembeya	MI	d	d	d	d	d	d	d	d																				d			d	
Niger	Tossaye	MI	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d							d			d	
Niger (Issa Ber)	Tonka	MI							pm	pm	pm	pm	d	pd	pd	pd	pd	pd	pd	d	pd	pd	pd	d									d	
Ouassoulou	Yanfolila	MI												pd	m	pd	pd	pd	pd		pd	d												
Sankarani	Gouala	MI	d	pd	pd	pd	d	d	d	d	pd	pd	pd	pd	pd	pd	pd	pd	pd	pd	pd	pd	pm	d	pm	pm	pm	m	m	d	m	m	d	
Sankarani	Guelelinkoro	MI												pd	d	d	d	d	d	d	d	d												
Sankarani	Mandiana	GN	d	d	pd	d	m	pm	m	m	d	d	d	d	d	d	pd	d	pd	pd	d													
Sankarani	Selingue	MI					pd	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	m	m	m	m	m	m	d	m	m	d	
Sirba	Bilanga	HV															m	pm	m	pm	m	pm	pm			pm	pm	pm	pm					
Sirba	Garbe-Kourou	NR			d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	pd											
Sota	Couberi	BJ	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d										pm	pd
Sota	Rte Kandi-Seg. amo	BJ	d	d	d	d	d	d	d	d	d	d	pd	d	d		d	d	d															
Sota	Rte Kandi-Seg. aval	BJ														d	d	d	d		pd	d	d											
Tapoa	W	NR				pd	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	pd	pd	d										
Tassakan	Goundam	MI	pd	pd	pd	d	m	pd	pd	pd	pd	pd	pd	pd	pd	pd	pd	pd	pd	pd	pd	d		d					d			d	
Tinkisso	Dabola	GN					m	d	d	d	d	d	d	d	pd	d	pd	pd																
Tinkisso	Ouaran	GN	d	d	d	d	pd			pd	d	d	m	pd	pd	d	d	d	d	d	d													
Tinkisso	Tinkisso	GN	d	d	d	d	d	pd					pd	d	d	d	d	d	d	d	d													

d = daily m = monthly pd = partly daily pm = partly monthly

Niger Catchment, Monthly Rainfall 1987
on a 2,5° x 2,5° Grid

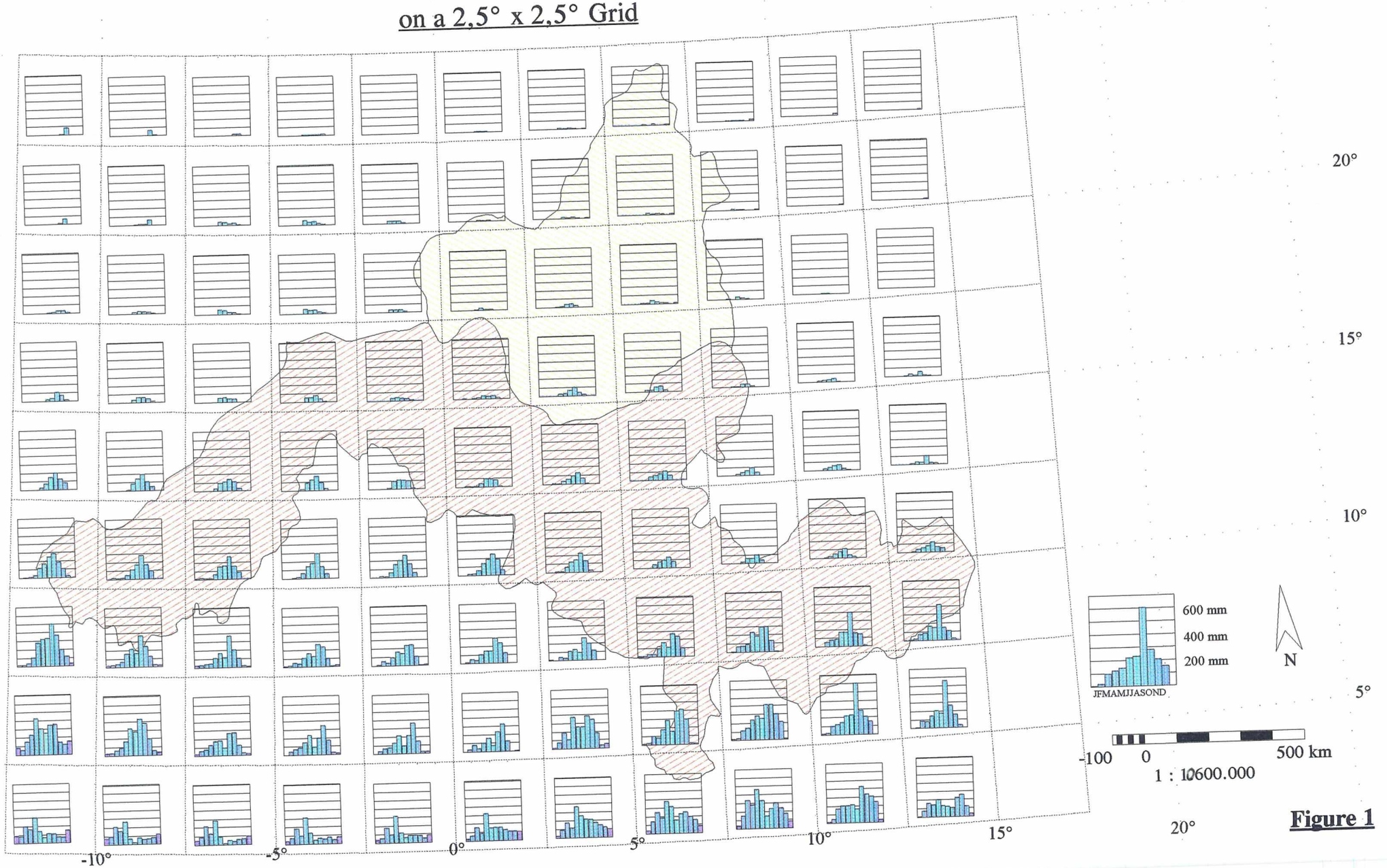

Figure 1

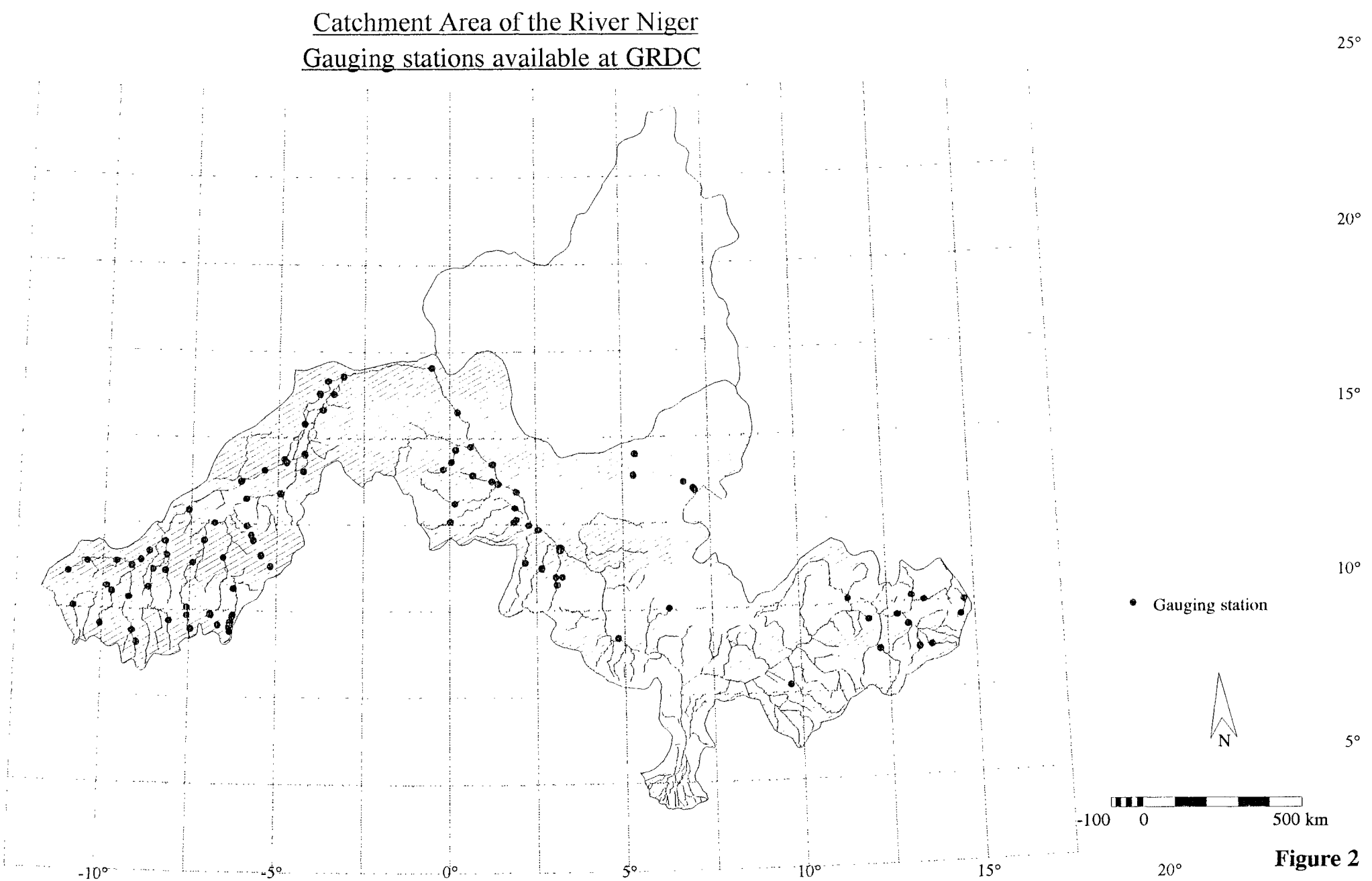
Catchment Area of the River Niger
Gauging stations available at GRDC
25°
20°
15°
10°
5°
-10°
-5°
0°
5°
10°
15°
20°
Gauging station
N
-100
0
500 km

Figure 2

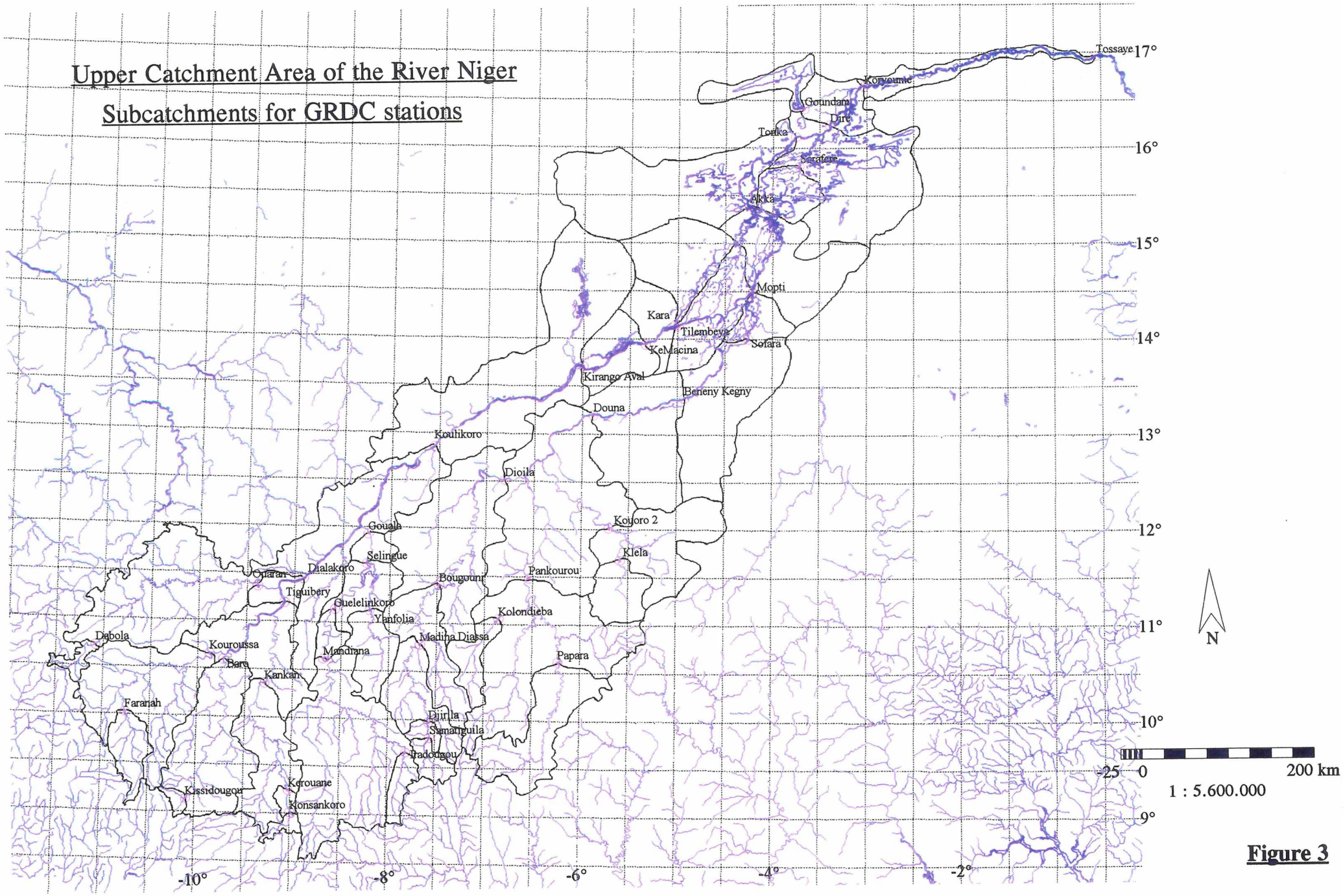
Upper Catchment Area of the River Niger
Subcatchments for GRDC stations
Tossaye
Koryoume
Goundam
Dire
Torika
Serafere
Akka
Mopti
Kara
Tilembeya
KeMacina
Sofara
Kirango Aval
Beneny Kegny
Douna
Koulikoro
Dioila
Koloro 2
Klela
Gouala
Selingue
Dialakoro
Ouaran
Tiguibery
Bougouni
Pankourou
Guelelinkoro
Yanfolia
Kolondieba
Dabola
Kouroussa
Mandiana
Madina Diassa
Papara
Bere
Kankan
Fararah
Dirila
Samanguila
Tadougou
Kissidougou
Kerouane
Konsankoro
17°
16°
15°
14°
13°
12°
11°
10°
9°
-10°
-8°
-6°
-4°
-2°
N
-25
0
200 km
1 : 5.600.000

Figure 3

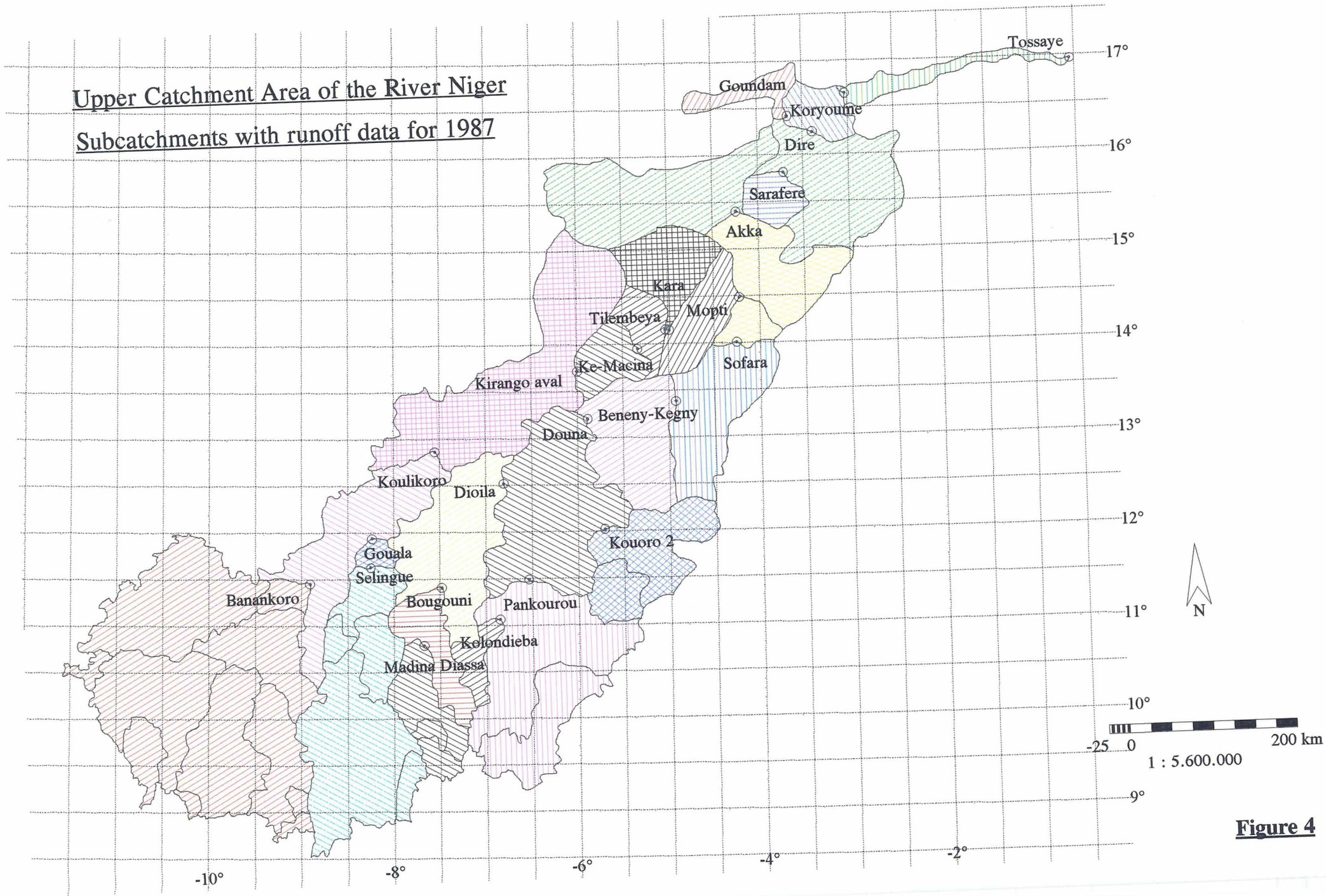
Upper Catchment Area of the River Niger
Subcatchments with runoff data for 1987
Tossaye
Goundam
Koryoume
Dire
Sarafere
Akka
Kara
Mopti
Tilembeya
Ke-Macina
Sofara
Kirango aval
Beneny-Kegny
Douna
Koulikoro
Dioila
Kouoro 2
Gouala
Selingue
Banankoro
Bougouni
Pankourou
Kolondieba
Madina Diassa
17°
16°
15°
14°
13°
12°
11°
10°
9°
-10°
-8°
-6°
-4°
-2°
N
-25 0 200 km
1 : 5.600.000

Figure 4

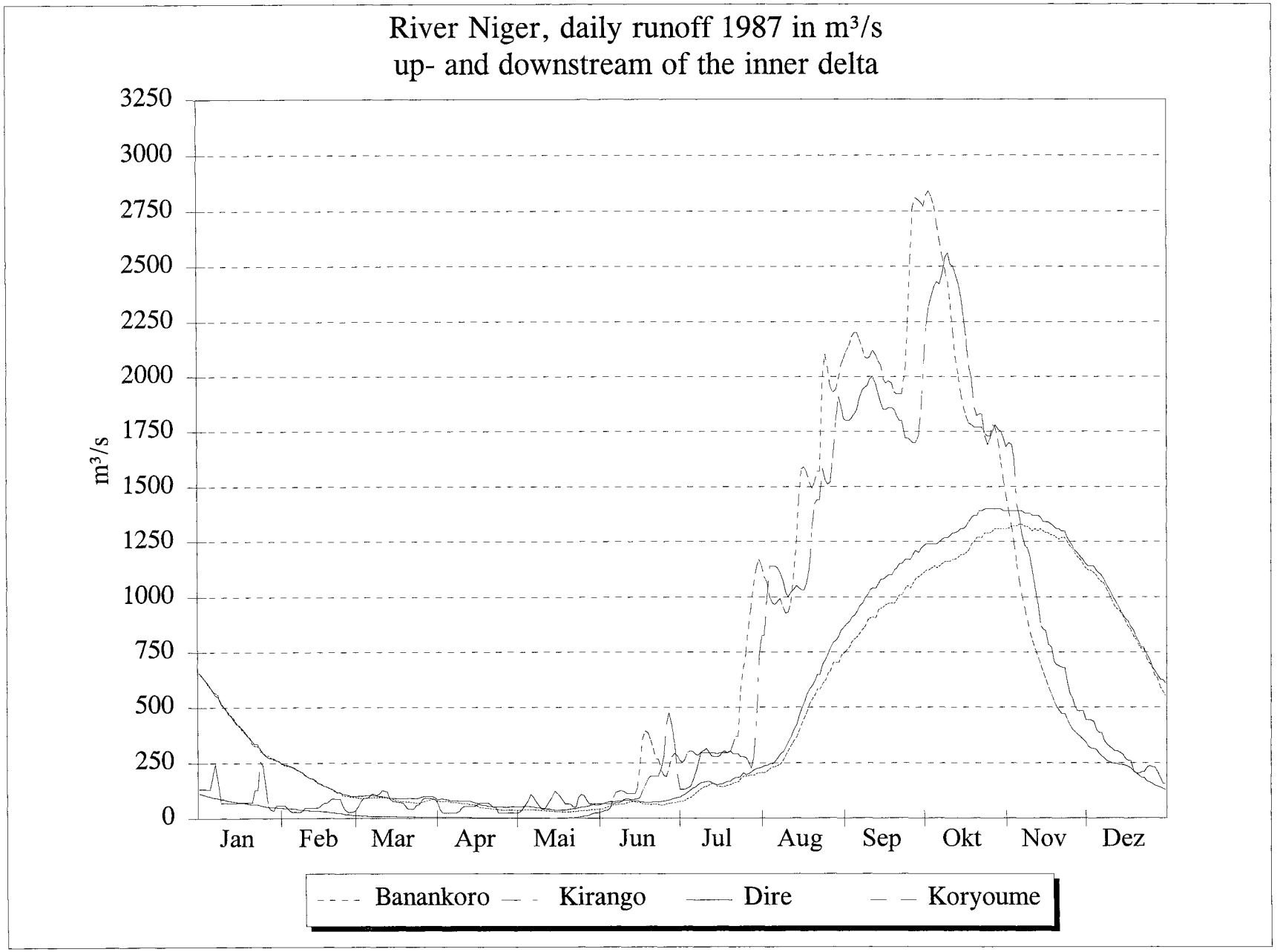
River Niger, daily runoff 1987 in m³/s
up- and downstream of the inner delta
m³/s
3250
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
Jan
Feb
Mar
Apr
Mai
Jun
Jul
Aug
Sep
Okt
Nov
Dez
Banankoro
Kirango
Dire
Koryoume

Figure 5

Reference of GRDC-Reports

Report No. 1 May 1993	Second Workshop on the Global Runoff Data Centre, Koblenz, Germany, 15 - 17 June, 1992.
Report No. 2 May 1993	Dokumentation bestehender Algorithmen zur Übertragung von Abfluß-werten auf Gitternetze. (Incl. abstract in English by GRDC: Dokumentation of existing algorithms for transformation of runoff data to grid cells). G. C. Wollenweber
Report No. 3 June 1993	GRDC - Status Report 1992.
Report No. 4 June 1994	GRDC - Status Report 1993
Report No. 5 November 1994	Hydrological Regimes of the Largest Rivers of the World - A Compilation of the GRDC Database
Report No. 6 December 1994	Report of the first meeting of the GRDC Steering Committee, Koblenz, Germany, 20 - 21 June 1994