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AVAILAVLE DATA BANKS AND INFORMATION ON HYDRO-POWER

BY

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SYNOPSIS

In connection with the quantification of the available hydro-power resources of Pakistan, a considerable amount of information has been compiled, processed and synthesized.

With regard to Hydrology and Sedimentation, a comprehensive computerized data bank has been developed for the main rivers and tributaries in the north of the country (NWFP, AJK and Northern Areas) and Balochistan. The data bank, which is jointly being developed by WAPDA, SHYDO and GTZ, contains modules for processing and synthesis of the data. It comprises all the hydro-logic data recorded and published in Pakistan since the year 1960. Presently, the data bank contains information of 120 hydro-logic stations. The parameters include water levels, stream flow measurements, suspended sediment load, bed load and water quality.

Concerning topography, available GT sheets on scales 1:250,000 and 1:50,000 constitute the initial source of topographic information to carry out any investigation. However, the level of detail in these maps (contours every 20 to 40 meters) is not sufficient to evaluate the projects. Quick assessment of levels and heads can be achieved with help of high precision altimeters, although the horizontal distances must be determined using other methods. Global Positioning System (GPS) allows a very accurate determination of 3-dimensional coordinates. It has been adopted to establish base lines for conventional topographic surveys and also to develop a basic surveying network along Indus River and its main tributaries upstream of Tarbela reservoir.

With respect to seismicity, originally, telemetric data of various catalogs (American, Russian and Chinese) was obtained from NOAA (USA). The data relevant to Pakistan was selected by defining a window extending beyond the borders. Important seismic sources, such as Hindukush have been included. Nowadays, the information of the telemetric network can be obtained though the Internet, allowing to keep updated information. In order to derive the required design parameters, the data bank includes computer software to scan and process the seismic events for the areas of interest.

All the socioeconomic data collected as part of the power market studies and demand forecasting has been systematically stored on magnetic media. Some of this information, especially with regard to population, will be updated when the results of the census in 1998 are available.

With help of GPS and satellite imagery, a Geographic Information System (GIS) is presently being developed for the Indus River valley upstream of Tarbela. The aim is to have an integrated system, which will allow an objective and reliable assessment of the implications of the any project proposed on Indus River and its main tributaries.

Extensive documentation is available about the inventories of hydro-power potential carried out in the country, including low-head projects in the Indus plains as well as medium- and high-head projects at higher elevations.

Guidelines have been developed and regularly applied for works in hand. Additionally, training material has been developed in various relevant topics and used at WAPDA Engineering Academy and CEWRE/UET.

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1. INTRODUCTION

As part of the identification and quantification of the available hydro-power resources of Pakistan, a considerable amount of information has been compiled, processed and synthesized. This document briefly describes the most relevant data available.

2. HYDROLOGY AND SEDIMENTATION

A comprehensive computerized data bank has been developed for the main rivers and tributaries in the north of the country (NWFP, AJK and Northern Areas) and Balochistan. WAPDA, SHYDO and GTZ are jointly developing the data bank. It comprises all the hydro-logic data recorded and published in Pakistan since the year 1960.

Presently, the data bank contains information of 120 hydro-logic stations with different record length. The parameters include water levels, stream flow measurements, suspended sediment load, bed load and water quality. Figure 1 shows the location of the stations.

The stations with the longest records were installed for planning and operation of Warsak, Mangla and Tarbela. The majority of these stations do not have recording equipment of any kind, only staff gauges.

In connection wit the activities carried out by WAPDA, SHYDO and GTZ 36 new stations have been installed and are in operation. Presently 18 stations have automatic recording equipment combined with staff gauges. The remaining stations have only staff gauges.

The stations are regularly monitored in order to ensure the required reliability. Special attention is given to stream-flow measurements and the determination of rating curves. In this regard, the available computer software allows a speedy processing of the data, helping to identify and correct anomalies in the information within a relatively short time.

In recent years, efforts have been intensified in the field to collect and process sediment data, both suspended sediments and bed load. Intense field sampling campaigns will be undertaken in coming months, especially at sites where promising projects are located. Needless to say, the information is also very useful for existing dams (i.e. Tarbela) and power plants.

The software used for the hydro-logic data bank (DBHYDRO) contains various modules for processing and synthesis of the data. Figure 2 schematically shows the main modules of the software.

On the other hand, computer models extensively applied to estimate discharges at ungauged sites. Hydro-logic estimates (monthly flows and flow duration curves) have been obtained at for following catchments:

Name	Number of Points	Remarks
Chitral	781	Up to Chitral
Swat	759	Up to Chakdara
Gilgit and Hunza	1606	Up to Confluence with Indus
Indus, Besham Qila to Dassu	1083	
Indus, Dassu to Shatial	869	
Indus, Shatial to Karmang	1730	Includes Shyok River
Punch	452	Area in AJK
Neelum	763	Area in AJK
Jhelum, Upstream of Mangla	914	Area in AJK
Shingo	617	Area in Pakistan

This information has been used as a basis to derive hydro-logic design parameters for identified hydro-power projects and can be also used in the future for any water resources project in these areas.

3. TOPOGRAPHY

Available GT sheets on scales 1:250,000 and 1:50,000 constitute the initial source of topographic information to carry out any investigation. However, the level of detail in these maps (contours every 20 to 40 meters) is not sufficient to evaluate the projects. Besides, due to various reasons, the maps are not accurate in some areas of the country.

Quick assessment of levels and heads can be achieved with help of high precision altimeters, although the horizontal distances must be determined using other methods. The daily fluctuations of the air pressure affect the reliability of these measurements. This limitation can be partially overcome with the use of at least 3 units and long measurements at each site. In any case, these measurements are normally used only for preliminary evaluations.

Global Positioning System (GPS) allows a very accurate determination of 3-dimensional coordinates. GPS determines the coordinates in WGS 84 (World Geodetic System 84). The local coordinates are established through the determination of transformation parameters, which is achieved by carrying out measurements at Bench Marks for which the local coordinate are known. In Pakistan, the Bench Marks of Survey of Pakistan (SOP) constitute the basis for the determination of local coordinates.

The reliability of the determined local coordinates strongly depends on the reliability of the available coordinates of SOP BM, which were established using conventional

surveying methods. It should be noticed that because of the technological evolution during recent years, the accuracy of the measurements has increased considerably. Therefore, discrepancies will always exist between the coordinates determined by SOP and the ones recently obtained with GPS.
For hydropower projects, GPS has been adopted to establish base lines for conventional topographic surveys and also to develop a basic surveying network along Indus River and its main tributaries upstream of Tarbela reservoir. The present coverage of the GPS network along Indus River and its main tributaries is shown in Figure 3.

4. SEISMICITY

Originally, telemetric data of various catalogs (American, Russian and Chinese) was obtained from NOAA (USA). The data relevant to Pakistan was selected by defining a window extending beyond the borders. Important seismic sources, such as Hindukush have been included.

Nowadays, the information of the telemetric network can be obtained though the Internet, allowing to keep updated information.

In order to derive the required design parameters, the data bank includes computer software to scan and process the seismic events for the areas of interest. The computer software allows both deterministic (i.e. Maximum Credible Earthquake-MCE) and stochastic analysis (Operational Basis Earthquakes-OBE).

Figure 4 shows typical results of recorded epicenters around a site in the north of the country.

5. SOCIOECONOMIC DATA

Field surveys were carried out to compile socioeconomic data related to the power market and to establish demand foreçasts. All the socioeconomic data collected in the field has been processed and systematically stored on magnetic media.

Some of this information, especially with regard to population, will be updated when the results of the census in 1998 are available.

6. GIS

With help of GPS and satellite imagery, a Geographic Information System (GIS) is presently being developed for the Indus River valley upstream of Tarbela. The aim is to have an integrated system, which will allow an objective and reliable assessment of the implications of the any project proposed on Indus River and its main tributaries.

Figure 5 shows a typical digital elevation model of a reach along Indus River obtained on basis of a 1-km grid.

Figure 6 shows a sample of LANDSAT TM image for North-Pakistan.

7. INVENTORIES OF IDENTIFIED HYDRO-POWER POTENTIAL

Extensive documentation is available about the inventories carried out in the country, including low-head projects in the Indus plains as well as medium- and high-head projects at higher elevations.

7.1 LOW HEAD

The inventory of potential sites was carried out for barrages and canal falls. A total of 586 falls at canals and 12 barrages have been included. The report was published in June 1991.

Keeping in view the large number of sites, the information for canal falls does not include time series of heads and discharges. The potential has been determined on basis of design data.

The potential at barrages was determined on basis of 10-daily flows and water levels.

7.2 HIGH-HEAD

The following table contains a list of the regions studied up to now and for which reports have been published.

NWFP **Region Name**	**Date of Publication of Report**
1. Upper Chitral	March-1989
2. Lower Chitral	February-1991
3. Swat Valley	October-1990
4. Indus / Kohistan	January-1991
5. Indus /Swat / Mansehra West	August -1991
6. Dir-Kohistan	March-1992
7. Kaghan Valley	December-1991
Ajad Kashmir **Region Name**	**Date of Publication of Report**
1. Punch River Catchment-Small Projects	June-1992
2. Punch River Catchment -Medium size Projects	January-1992
3. Jhelum River Catchment -Small Projects	January-1992
4. Jhelum River Catchment -Medium Projects	December-1994
5. Neelum River Catchment (Partially Covered)	November-1992
Northern Areas **Region name**	**Date of Publication of Report**

Chilas Astor Gilgilt Hunza Ishkuman Yasin Skardu Shyok Rondu/Haramosh Kharmang Khunjerab Ghizar Gultari / Minimarg	

8. GUIDELINES

Guidelines have been prepared for different stages of development of the projects.

The DIPEO (**D**efinition, **I**dentification, **P**lanning, **E**xecution and **O**peration) guidelines provide comprehensive information for the different stages of development of small hydro-power projects. Following modules are available:

Definition (D)
D1/1 Introduction to System DIPEO
Identification (I)
I1/1 Identification of Optimum Size to start Regional Power Development from proximity Hydro-power in Remote Areas
I1/2 Coordination of Identification Activities
I2/1 Manual for Study of General Socioeconomic and Power Market
I2/2 Manual for Energy and Power Demand Analysis and Forecast in Rural Areas under
Consideration of isolated Power Supply.
I2/3 Manual on Economic Comparison of Alternative Power Supply Opportunities for Rural Areas
I2/4 Selection of Priority Development by means of Alternative Regional Power Development Models for Isolated Systems.
I2/5 Inter-relationship of Peripheral Planning Regions to large Grid Systems
I3/1 Site Identification of Hydro-power Potential
I3/2 Guide for Preliminary Hydrological Assessments
I3/3 Selection and Layout of Structures for Small Hydro-power Plants
I3/4 Cost Estimate for Rural Isolated Small Hydro-power Plants.
I4/1 Cost Estimate of Electro-mechanical Equipment for Small Hydro-power Plants
Planning (P)
P1/2 Coordination of Planning Activities
P3/1 Topographic Survey
P3/2 Hydrometry of Water Streams
P3/3 Geo-technics
P34 Planning of Project Elements

P3/5 Hydraulic Computation
P3/6 Measurement of Sediments
P3/8 Static (Structural) Computations
P3/9 Unit Rates of Civil Works in the Planning Stage
P4/1 Selection of the Electro-mechanical Equipment
P4/2 Design of Steel Penstocks
P4/3 Planning of Gates and Racks
Execution (E)
E1/2 Coordination of Execution Activities
Operation (O)
O1/2 Coordination of Operation and Maintenance Activities
O4/1 Operation and Maintenance of Small Hydro-power Plants
O4/2 Analysis of Weak Points of the Electro-mechanical Equipment
O4/3 Corrective Measures to the Electro-mechanical Equipment

Besides, guidelines applicable to low- and high-head projects are available on following topics:
Hydro-logic data bank
Seismic risk analysis
Stability analysis of retaining walls
Stability analysis of slopes
Stability analysis of weirs
Selection of water turbines (low- and high head)
Selection of electrical equipment for hydro-power projects (low- and high head)
Dimensioning and costing of hydro-power plants (medium size high-head)
Capacity expansion planning of interconnected systems

9. TRAINING MATERIAL

Training material has been developed in various relevant topics and used at WAPDA Engineering Academy and CEWRE/UET.

Up to now, following relevant training material is available:
Design of Open Channels
Basics
Basics of Hydraulic Engineering
Sediment Transport
Design of Open Channels
Design of Channel Structures
Sediment Transport – Suspended Load
Basics
Calculations
Sediment Load Management
Sediment Transport – Bed Load
Basics
Calculations

Sediment Load Management
Hydro-power Development
Hydro-power in general
Low-Head
Components
Data collection and processing
Layout and sizing
Engineering design
Economic and financial analysis
Project implementation
High-Head
Components
Data collection and processing
Layout and sizing
Engineering design
Economic and financial analysis
Project implementation