Jal Vigyan Sameeksha—a publication of
High Level Technical Committee on Hydrology
Vol. II No. 2, December 1987

Network for Ground Water Monitoring

By

B. H. Briz Kishore
Professor of Water Resources
Jawaharlal Nehru Technological University
Mahaveermarg, Hyderabad - 500 028

Abstract : *Ground Water monitoring is a complex phenomenon involving several factors which vary with space and time. The utility of data networks to codify such a complex situation is analysed with the idea of its integration with computer network for effective monitoring. An algorithm is developed for such a network design for assesseing the ground water balance by adopting two different approaches. The interrelationships among the parametes and the logical flows of the algorithm are presented through a block diagram for reflecting an integrated view of the entire system. The advantages and limitations born out of the study are listed.*

1. Introduction

Precise monitoring of any ground water system involves accurate estimation of water balance (Briz-Kishore, 1983, 1984) which in turn requires systematic data collection. The process of data collection. involves identification of values for various parameters of the Hydro-geological and Meteorological phenomena through the methods of observation, measurement and computation. Values of parameters like catchment size, structure do not vary with time. But values of certain parameters do change with time and hence are to be measured directly or by direct consequence of the occurrence. Hence, maintenance of historical data on these parameters is essential in evaluating their behaviour for different applications in the management of water systems. Conventionally, this data is stored in physical files and used whenever required for any application. Thus the data is retrieved several times for different applications and, therefore, there is every possibility of redundant storage of the same data under the same processing environment (Briz - Kishore, 1986). Hence, conventional practice of storing the data in physical files is steadily replaced by computerised information systems. (Briz-Kishore, 1983 b, c, 1987, 1988).

2. Computer Networks and Data Net Works

2.1 Computer network :

Earlier those few ground water organisations which resorted to computerised systems used large computers for storage and retrieval of the data. In these cases data is collected manually at different branches of an organisation and is physically transported to a central location where the large computer system is installed, for its storage, retrieval and processing. But with the advent of microtechnology, the single large computer system serving the needs of an organisation is replaced by a set of large number of stand alone but inter-connected micro computers. This kind of inter - connected autonomous computers capable of exchanging information between themselves constitute a computer network. The stand alone micro computers in a computer network are termed as work stations and these are located at different branches/user locations of an organisation.

The computer network unlike the conventional computerised systems facilitates collection of ground water data and its storage at the respective branch level itself. The work stations located at the branches enable creation of computer file from the data collected at the respective branches. The data thus entered in the data file is validated by means of various checks and filters so that the accuracy and reliability of the data is maintained fairly high. The data is also periodically updated so that the information generated reflects the latest situation. The data file created at the branch level is processed by users at the respective branches and is also simultaneously made accessible to all other users even at other branches wherever work stations are located for use in their own applications. The inter-connectivity of the work stations thus enable users of different disciplines, located at different branches to process the same data for different applications invoving different procedures. This process allows a parallel time relationship between data collection and its updation and the ongoing activity, producing information quickly enough to facilitate effective decision making process based on the latest updated data.

2.2 Data networks

As capability to gather, process and distribute the data is on increase with the developments in computer systems such as networking, the demand for structuring of data through different data network models is also thrusted further on the user. It is to be noted that data networks designed for such purposes should have facilities incorporated to meet not only the needs of the present day but also the unforesecn demands of the future.

The information to be provided on any aspect of Ground Water Monitoring requires an integrated processing dealing with various parameters, the data of which is available at widely dispersed work station locations. Therefore, it requires a very close consideration, selection and processing of the data. This kind of processing generates an over view of the entire system termed as schema (Briz-Kishore, 1987). The schema comprises of several partial views of the integrated system which are known as sub - schemas. These schemas may be generated under a hierarchical or network data structure designs. The hierarchical structures are suitable in cases where the information required can be unfolded bidirectionally from the parameters, without much processing. However, this kind of data structure is not suitable for ground water monitoring since the data elements and environment in a ground water system are interconnected in multiple directions. Hence it is essential that the ground water monitoring is carried out through an integration of computer networks, which together will throw light on any and all aspects of the entire system.

3. Network Objectives

(a) To instantaneously analyse the ground water data at the point of data collection through low priced micro computers.

(b) To integrate the data collected over widely dispersed work stations and generate necessary information for centralised decision making.

(c) To unify the differently formatted data from different organisations, resulting in data integrity and powerful communication medium.

(d) To eliminate much of program complexity associated with computerised system of large computers.

(e) To protect and monitor the un-interrupted ground water data flow even in the situations of critically resulting due to break down at some of the work stations.

4. Design and Development of Ground Water Data Network

The Ground Water balance studies involve establishment of inter relationships among several input parameters like basin area, rainfall, draft etc., indicated in Table 1. It can be observed that any variation in rainfall in the region will have its bearing on the quantity of water percolating into the subsurface system, mass balance etc. Similarly the draft is dependent on proposed cropping pattern. ground water availability etc. This kind of establishing interrelationships in the present study (Fig. 1) has resulted in the identification of eleven derived parameters as presented in the same Table 1. The input parameters are identified with 'I' the resultant derived parameters are identified with 'D' as indexed in the table.

Table 1 : List of Parameters and Codes

Parameter Name	Parameter Code
Rainfall	I1
Basin Area	I2
Infiltration Factor	I3
No. of Seepage Days	I4
Wetted Area	I5
Seepage Factor	I6
Irrigated Area	I7
Water Requirement Per Unit Area	I8
Irrigation Return Coefficient	I9
Subsurface Runoff	I10
Water Levels	I11
No. of Wells	I12
Average Specific Yield	I13
Ph Value	I14
Electrical Conductivity	I15
Sodium Adsorption Ratio	I16
Residual Sodium Carbonate	I17
Recharge Due to Rainfall	D1
Recharge Due to Seepage	D2
Water Required for Irrigation	D3
Draft for Irrigation	D4
Recharge Due to Applied Irrigation	D5
Total Recharge	D6
Total Discharge	D7
Mass Balance	D8
Fluctuation	D9
Average Fluctuation	D10
Ground Water Availability	D11

While ariving at the ground water monitoring report two approaches are adopted for computing the mass balance. The first approach involves derivation of mass balance from Inflow to and draft from the system. The total inflow consists of flows across the boundaries rainfall, seepage from tanks etc. The draft from the system includes the crop requirements and boundary out flows. The mass balance value thus arrived is compared with the values obtained by adopting the second approach where the mass balance is computed taking into account the net ground water potential available through average fluctuation and specific yield, over the area of the basin. The algorithm developed governing these two procedures is presented in the flow chart (Fig. 2). It can be observed from the figure that the algorithm gets initiated by reading the data and terminated after printing the monitoring report during which process the derived variables are calculated at appropriate stages. A provision is also made in the algorithm to evaluate the chemical quality prior to generatiog the ultimate report.

The interrelationships established among the parameters as elucidated in the algorithm and flowchart are presented in the form of a a Block Diagram (Fig. 3). It can be seen from the figure that any kind of disturbance in any one of the parameters effects the entire system behaviour which gets distributed to all other patameters. It can also be seen from the diagram that several sets of similar networks can be taken up from the integrated model to different aspects of the total system.

5. Advantages and Limitations

1. The library facilities in the network system permit utilisation of the same software by several work stations.

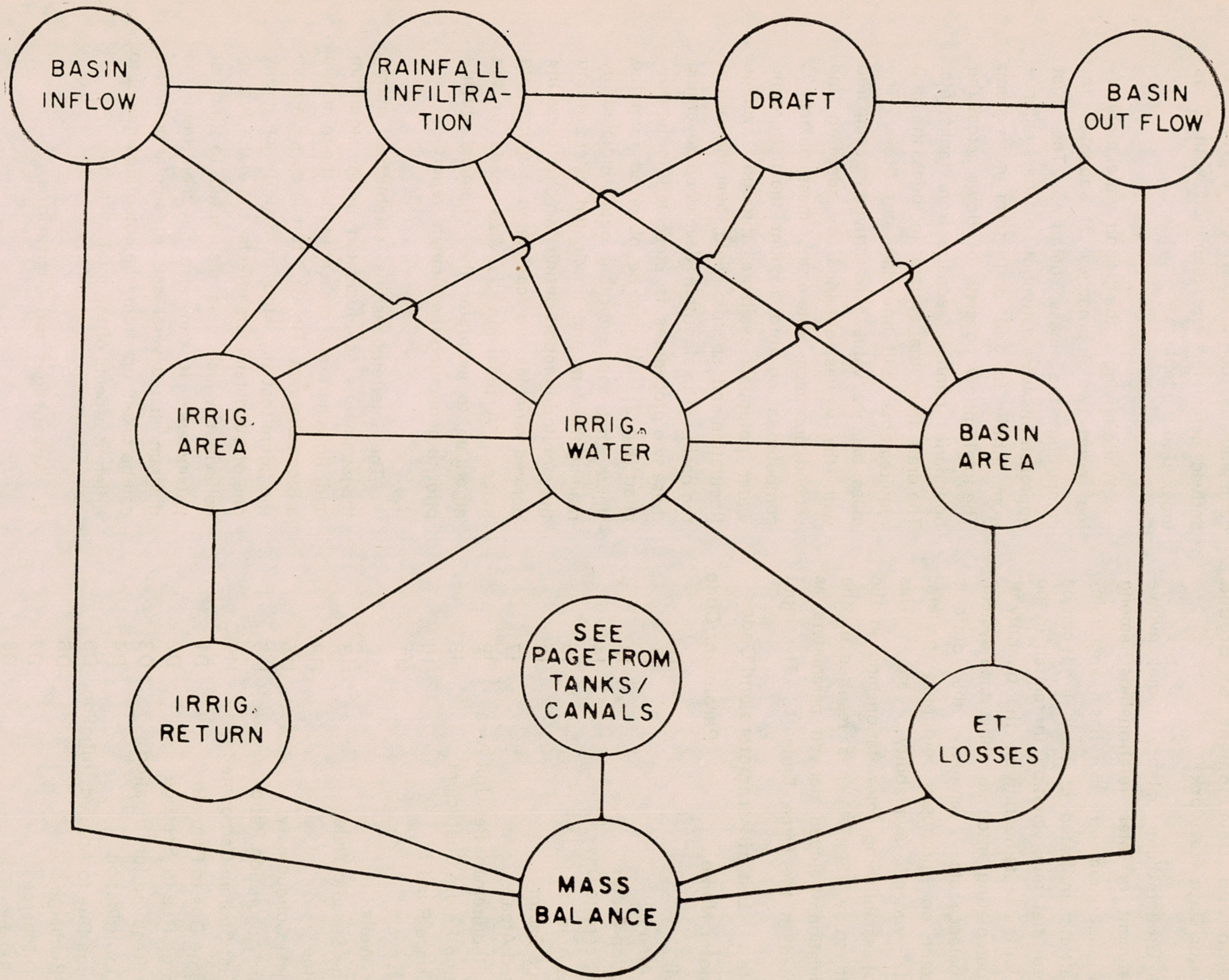


Fig. 1 : Network Interrelationships for Groundwater Monitoring

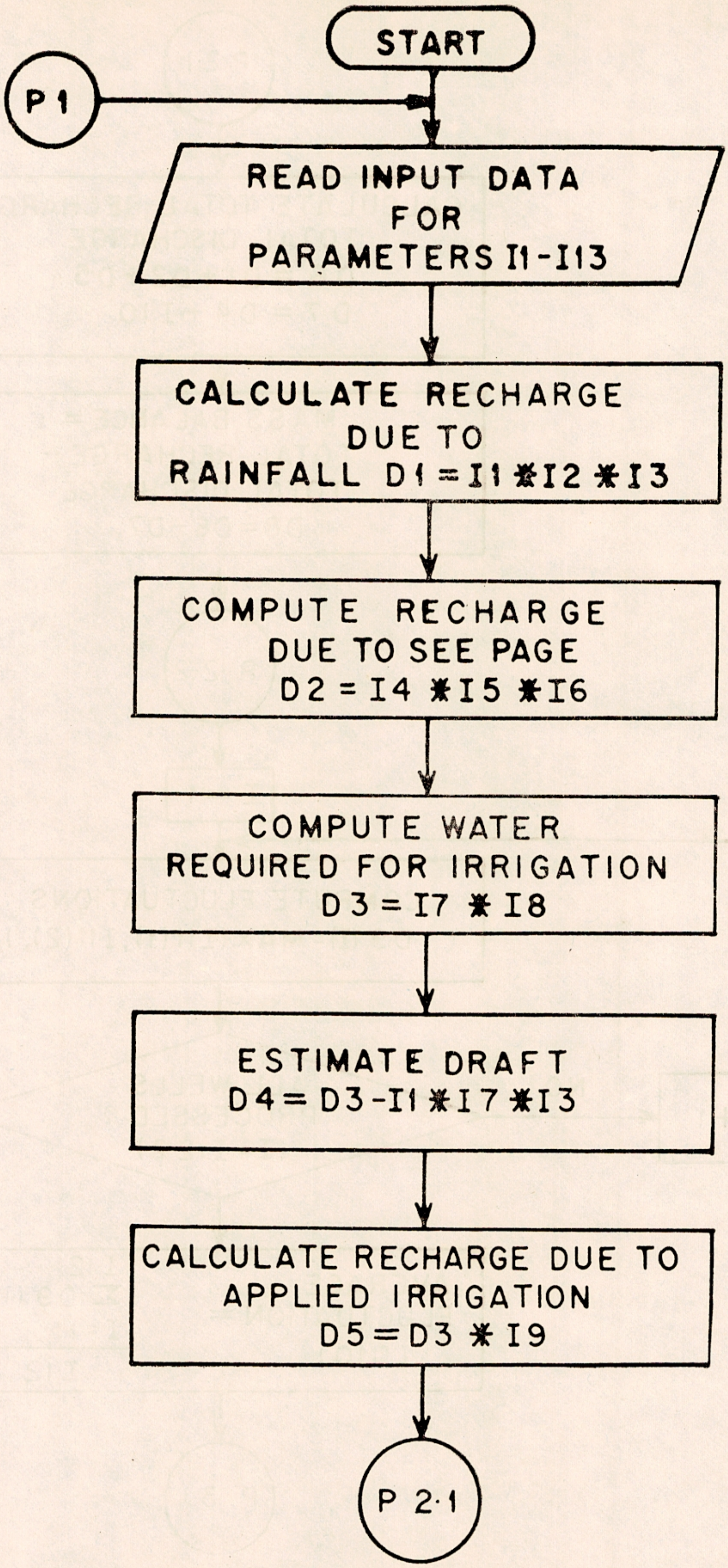
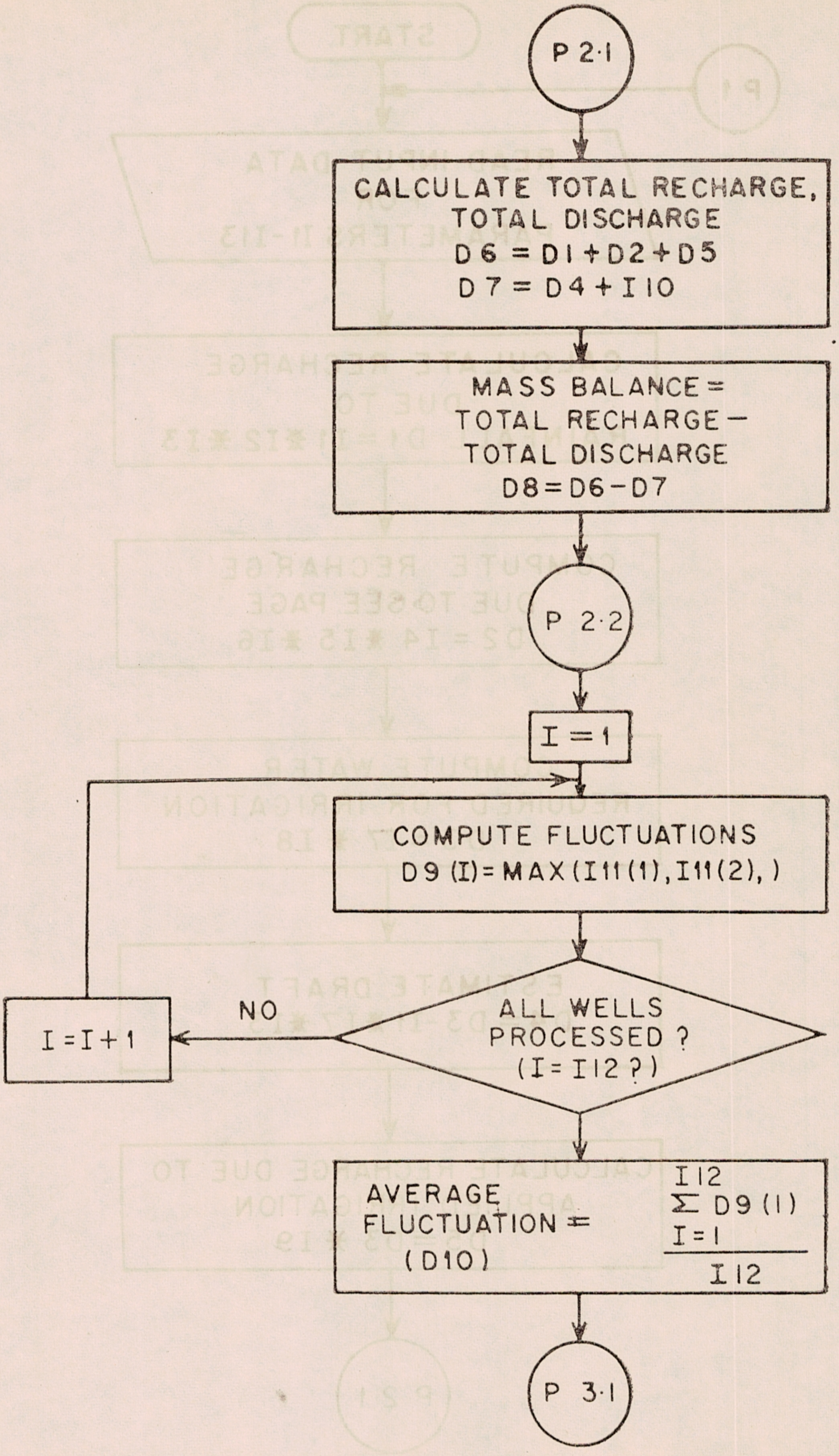
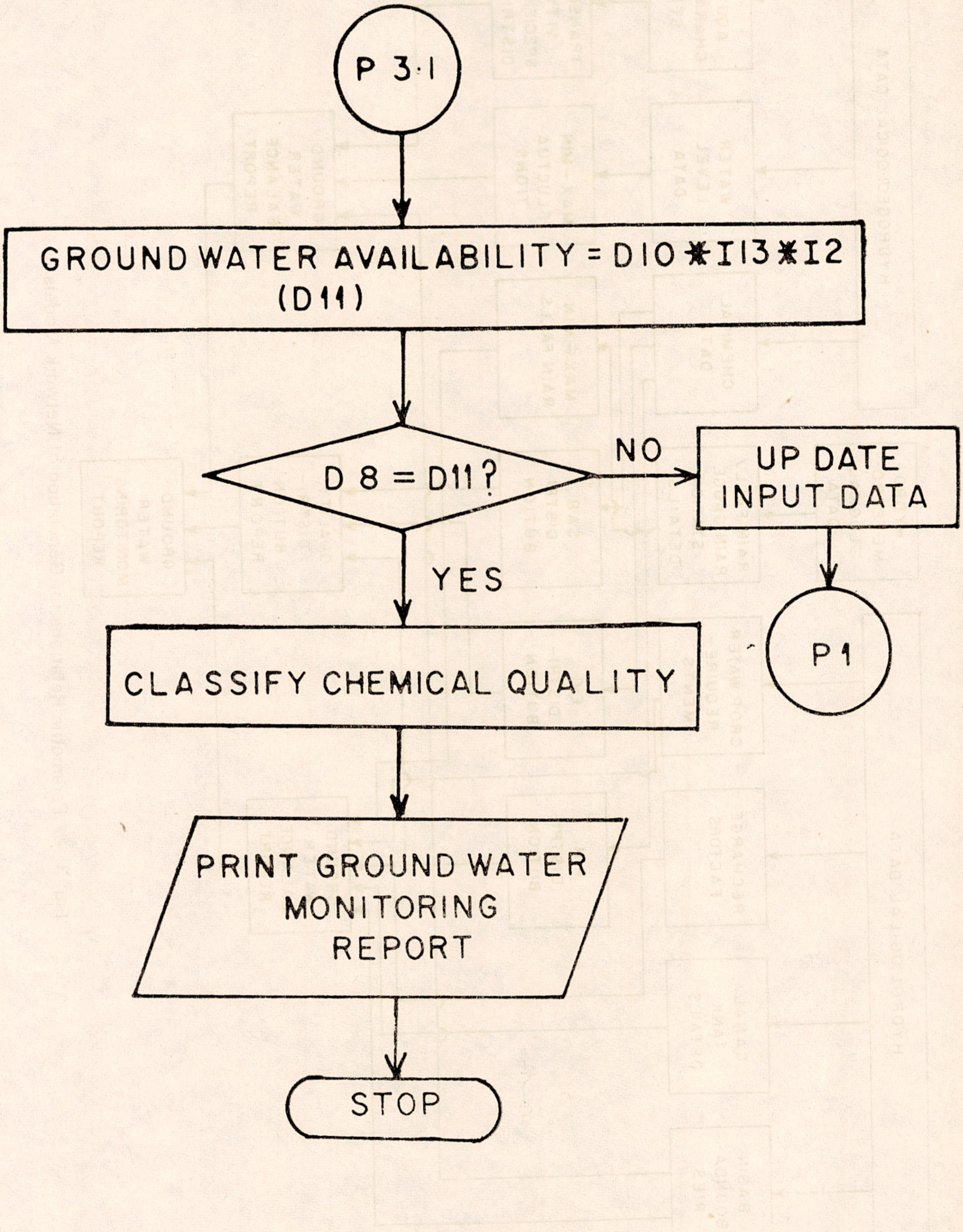


Fig. 2 : Flowchart Representing Mass Balance Algorithm



P 2·1
CALCULATE TOTAL RECHARGE,
TOTAL DISCHARGE
D6 = D1 + D2 + D5
D7 = D4 + I10
MASS BALANCE =
TOTAL RECHARGE −
TOTAL DISCHARGE
D8 = D6 − D7
P 2·2
I = 1
COMPUTE FLUCTUATIONS
D9 (I) = MAX (I11 (1), I11 (2),)
ALL WELLS
PROCESSED ?
(I = I12 ?)
NO
I = I + 1
AVERAGE
FLUCTUATION =
(D10)
I12
Σ D9 (I)
I = 1
I12
P 3·1

Fig. 2 : Contd......


P 3·1
GROUND WATER AVAILABILITY = D10 * I13 * I2
(D11)
D 8 = D11?
NO
UP DATE
INPUT DATA
P 1
YES
CLASSIFY CHEMICAL QUALITY
PRINT GROUND WATER
MONITORING
REPORT
STOP

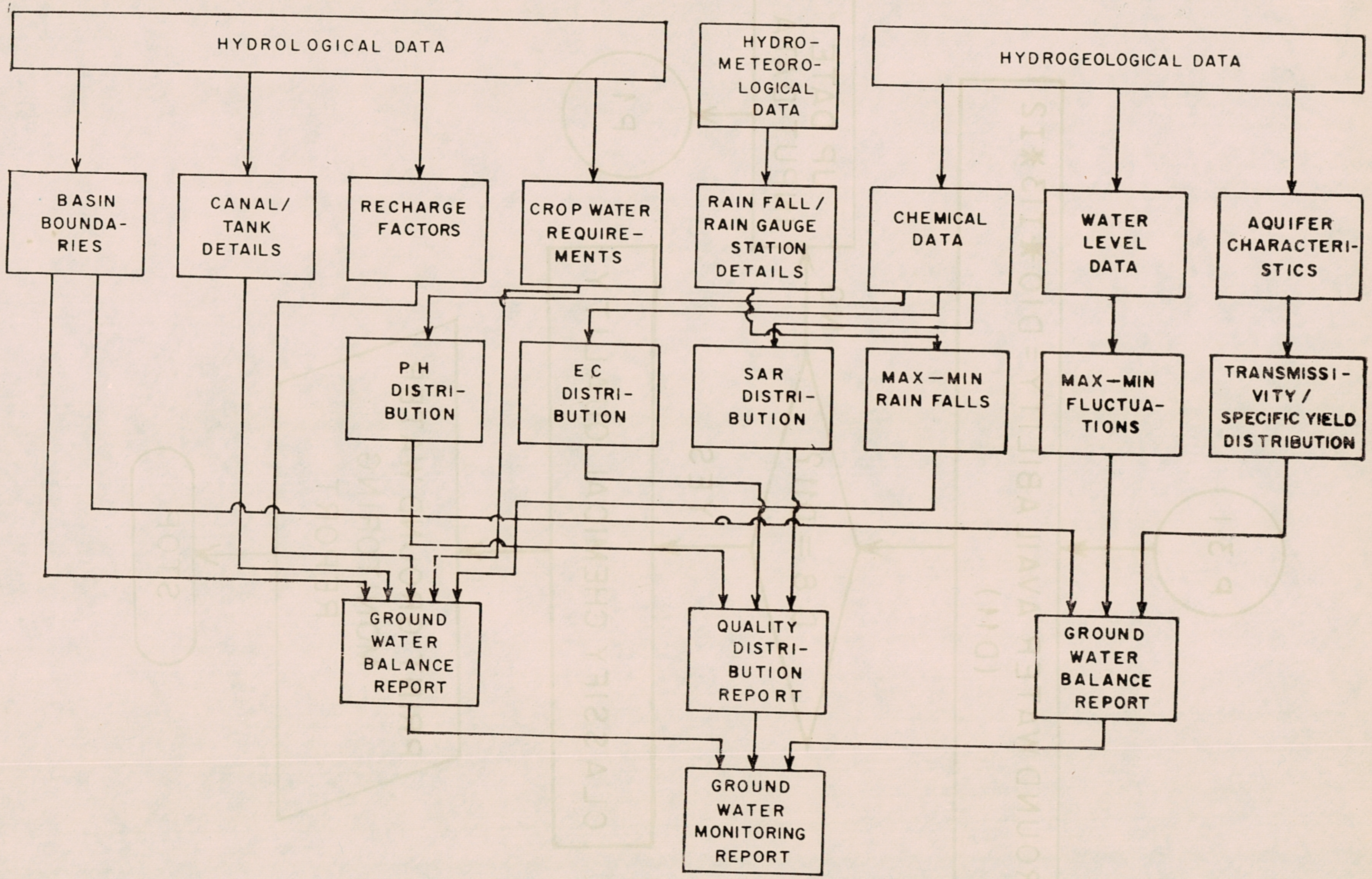


Fig. 3 : Parametric Relations for Generation of Network Models

2. Any new development or specialised application can easily be transmitted with necessary control and without loss of time.

3. Network facilitates to interact with other organisational data for fast comparative study.

4. Different precesses of data storage maintenance and monitoring can be well distributed.

5. Data communication costs are minimised due to passage of only the required data instead of the entire bulk.

6. However, the computer networks connected through a normal telecommunication channels are turbulant because of their vagaries towards natural events.

6. Conclusions

A network comprises of data network and computer network for instanatneous analysis of the data over widely dispersed groundwater organisations. Data integrity, inregration and flexibility are critical components of the data network design and the apt suitability of the same for ground water monitoring is presented. The present design is well documented with flow chart and generated block diagram for monitoring purposes which facilitates analysis of other anologous situations. The advantages justify the need for implementation of network in ground water flow monitoring.

References

1. Briz-Kishore, B.H. (1983 a), Quantitative estimation of ground-water potentiality and rainfall infiitration in a typical crystalline environment, Proc. Indian Acad. Sci. (Earth & Planet Sci.) Vol. 92, No. 1.

2. Briz - Kisore, B.H. and Avadhanulu, R.V.S.S., (1983b) An efficient computer code for monitoring hydrogeological data (Current Sciences Vol. 52 No. 6).

3. Briz-Kishore, B.H. (1983c), A simple method for accessing aquifer characteristrics through an interacting system, Geophysical Research Bulletin Vol. 21, No. 2.

4. Briz-Kishore, B.H. (1984), A digital model to evaluate the water balance in a typical hard rock environment, Proc. Indian Acad. Sci.) Vol. 93, No. 4.

5. Briz-Kishore, B.H. (1986), Hydrological data base-A modern tool for effective information, Journal of Institution of Engineers (India) Vol. 67, Part CI 3.

6. Briz-Kishore, B.H. (1987), A New Design on personal computer for storing and retriving hydrometerological data, Hydrology Journal of IAH, Vol. 10, No. 1.

7. Briz-Kishore, B.H. (1988), A compact Socrate program for an efficient water management information system, Journal of Institution of Engineeers (India), Vol. 68, P.P. 278-283.