CHAPTER 1
INTRODUCTION SCOPE AND OBJECTIVES

1.1 GENERAL

Water is the life line for the survival of all species. Early human settlements started developing around places of plentiful water supply. The ancient civilisations of Indus and Nile valleys bear testimony to this fact. Not only the general need for water, but also the necessity for its transport and exploitation were felt in early civilisations. The extensive irrigation systems in India, Egypt, Peru, and Mexico, the flood ways and deep wells of China and the underground cisterns of Alexandria are some of the best examples emphasizing the need for water and the efforts that were made to acquire it.

Water is a natural resource and, fortunately, it is a renewable one. However, the hydrological conditions of a country, such as India, may vary spatially and temporally so vastly that some parts may be repeatedly exposed to ravages of floods and cyclones while some others often suffer from aridity. Hence, a scientific study of hydrology and its application in water resources development and utilisation assume a high degree of importance.

The increase in population and the betterments in standards of living point to increased requirements of water. A satisfactory programme for water resources development and management assumes added importance, particularly in India where temporal variations in water availability is very pronounced. In such a programme steps should be taken to locate, measure, store and distribute the water accurately. The unbreakable hydrological cycle should be modified and managed so that the optimum utilisation of water is achieved.
The main source of water is precipitation; water is available to man as surface runoff or as subsurface flow. A water resource development programme has to necessarily follow the path of flow from precipitation to runoff so that the quantity of water available and its time distribution can be evaluated. In its path from the point of precipitation to the point of extraction water finds its way through streams and rivers and it is therefore necessary to route the stream and river flows.

1.2 IMPORTANCE OF FLOOD STUDIES

The runoff phase of the hydrological cycle may sometimes indicate floods. A flood is a relatively high flow which overbanks the natural channel provided for the runoff. Ordinary flows in rivers bring the much needed water to people living on their banks and in flood plain. But the extreme phenomenon of flood may be calamitous. While rivers are harbingers of fertility and prosperity, they may become disastrous to lives and economy when they carry floods. Repeated floods, which recur persistently, are a menace to the progress of industry and civilisation.

When one faces the floods, one is in direct confrontation with one of nature's extremes. It is man's endeavour to successfully control and overcome nature's extremes, with his knowledge of science and technology. It is in this context that the importance of flood studies is well understood. An in-depth study of flood enables him to predict and forecast the floods and to devise flood alleviating and flood control measures. Armed with this knowledge he could well mitigate his sufferings when he faces a flood, though he may not be able to prevent it altogether.

1.3 FLOOD ROUTING

A prerequisite for flood control and regulation procedures is the ability to follow the flood through its course. Unless the quantity
and depth of flood flow are predicted at all vulnerable points along the river reach, satisfactory flood control procedures cannot be devised. Flood routing techniques aid in tracking the flood in the channel or river reaches.

Flood flows in rivers and channels are unsteady. The mathematical treatment of unsteady flow in open channels has its origin in the two partial differential equations developed by Barree' de Saint Venant [1] [2]. These two basic equations of unsteady flow - one based on the principles of continuity and the other on conservation of momentum - are generally known as Saint-Venant equations. The solution to the equations is bound to be difficult as too many variables enter into an unsteady open channel flow problem and also because these equations cannot be integrated except under very simplified conditions.

Flood routing is a procedure by which the hydrograph at any section on a channel can be calculated from a known hydrograph at any other section, most probably from one upstream. Basically this is obtained by solving the Saint-Venant equations. During the solution some assumptions like uniform roughness, and constant bed slope are made. Otherwise the variables become too many and their inter-relationship turns complex. The method of solution would require more data to describe the channel and the wave conditions. Approximations of theoretical equations as well as of the physical description of channels are used in practice.

These techniques can be applied to study the flow of floods through channels, reservoirs and lakes. They can compute the magnitude and time of peak flood flows that occur along a river as a flood wave travels downstream. This information is a prerequisite for forecasting flood flows and for limiting the flood flows to a predetermined crest. More satisfactory flood control measures can be undertaken as some of the flood routing techniques can predict the shape of the complete wave. Flood routing can also be employed for some other problems
associated with water use. They include: (i) evaluating past floods for which records are incomplete, (ii) determining the hydrographs of channel flow from hypothetical design floods on upstream reaches of main channels and tributaries, (iii) forecasting floods along the main course of the river by use of observed or predicted hydrographs at key points in the drainage network and (iv) determining hydrographs modified by reservoir storage.

In engineering hydrology, flood routing is an important technique, necessary for the complete solution of a flood control problem and for the satisfactory operation of a flood prediction service.

1.4 FORMULATION OF FLOOD ROUTING PROBLEM

A flood routing problem can be solved either by hydrological methods or by hydraulic methods. Hydraulic methods solve both the equations of Saint-Venant while the hydrological methods confine their attention to continuity equation only. Of the hydraulic methods, the dynamic wave models obtain solutions to the complete Saint-Venant equations and the diffusion wave models ignore the acceleration terms in the momentum equation. The nonlinearity and the multiplicity of variables in the basic equation make the closed form analytical solution of these equations impossible and solutions have to be obtained adopting finite difference schemes with iterative methods of solution. In both hydrological and hydraulic methods certain factors have to be recognized before their application. For example, in hydraulic methods, the friction slope has to be properly evaluated and the section details correctly specified. Likewise, in hydrological methods the need will be felt of defining a proper storage discharge relationship.

Hydrological methods are generally simple, providing quick solutions at less computer storage and cost. Hydraulic methods, which include the dynamic effects of flood flow, are naturally complex mathematical schemes requiring large computer space, placing a premium on computational costs. However, while the latter methods can route
the floods in their entirety along the reach, the former methods solve only for the quantity of flow and mostly at specified locations. In real-time flood routing one is often faced with the problem of the choice of the method. The requirement of accuracy, the availability of relevant and dependable data and the economy of computational cost may restrict the choice of the method.

Mathematically, the hydraulic methods are expected to route the floods accurately. However, the friction factor, an essential model parameter may defy accurate estimation. Also cross-section details at close intervals may often be not available; or, if available, may not be always dependable. The inter-relationship between various factors like channel reach, channel roughness, bed slope and cross-section details may be so complex that an accurate modelling may become difficult. On the other hand, the hydrologic methods, though they ignore the dynamic effects, may solve for the quantity of flood flow sufficiently accurately if the storage-discharge relationship for the reach is fairly representative of the reach.

A detailed study of flood routing methods should include application of the methods in river routing and evaluate the performance of various methods. In natural river routing it is possible that both hydrologic and hydraulic methods produce results of similar accuracy. It is often necessary to select a particular method best suited for the problem on hand. Should the method chosen be a hydraulic method the identification of friction factor as a model parameter becomes an important criterion. The model parameter may vary for different floods and it is necessary to devise a method for identifying the same for a range of floods. The range of accuracy with which the geometric data has to be obtained should also be specified. Should the method chosen be a hydrologic method, not only a representative storage-discharge relationship be evolved but also a method of identification of the parameters of such a relationship has to be outlined.
The model parameters of neither the hydraulic nor the hydrologic methods could be developed from field data. A solution with fairly accurately assumed parameters may also show erroneous results. This is because the routing techniques solve the Saint-Venant equations expressed in some finite difference form. Any finite difference scheme will carry with it the truncation error inherent in the scheme. Such errors can be minimized by optimizing the parameters of the routing model. Application of optimization techniques may aid in identifying the routing parameters.

The importance of the study and analysis of flood routing methods cannot be overstated. Flood devastations resulting in tragedies of death and disease and heavy damage to property though not very regular are not infrequent either. Reports of such devastation pour down from some part of the world or other almost throughout the year. India witnessed an unprecedented flood situation during May-September, 1988. The north-eastern and the northern states, including Delhi, reeled under uncontrollable floods playing havoc on population and property. A preliminary assessment of flood damage had reported that a total of 139 lakh hectares of land was affected. The population hit totalled 555 lakhs and the financial loss by way of crop destruction, building collapse and damage to public utilities totalled Rs. 1,644 crores [3].

The above type of calamity only underscores the necessity for a more accurate flood prediction and more satisfactory flood management services. Flood routing is an inherent part of flood management and each should keep pace with the other, with the specific aim of mitigating the impact of floods and the reduction of human suffering.

The developments in science and technology have vastly improved flood forecasting and warning systems. Some major river basins in India are formed into a network of flood forecasting stations issuing about 5,000 forecasts every year. This network, under the control and operation of Central Water Commission, Government of India has been scoring improved forecasts of flood. Since 1980 when the forecast
success was 86.7 % (flood flow within ± 20 % cumecs), there has been a steady improvement in forecasting reaching a 95.1 % success in 1987. With better knowledge of forecasting methods and with more reliable and updated data, the accuracy of flood forecasting is bound to increase in future years. This will necessitate a corresponding increase in the accuracy of flood routing solutions. It becomes necessary to evaluate the routing models and provide methods to update the routing parameters.

Modern world has seen immense developments in remote sensing techniques. These and the advent of meteorological satellites have enabled monitoring of hydrological data at close intervals of time. It has now become possible to update the data at any time and to a fair degree of accuracy. Consequently use of such data for hydrological predictions requires sophisticated techniques which would constantly update the parameters of prediction. The problem of flood routing assumes added importance in this context in the sense that the parameters of flood routing models have to be identified more accurately.

The scope of this study is to investigate two aspects of the flood routing problem. The first aspect relates to identifying the model parameters as accurately as possible, in both hydrologic and hydraulic methods. The second aspect is one of simplifying the hydraulic routing method, without any loss of accuracy. The implicit routing technique, which is a hydraulic method, requires elaborate geometric data. The routing model possesses both geometric and hydraulic parameters which have to be individually identified. But if the routing model is formulated with conveyance as the parameter, there will result not only a relaxation in data requirement but also a saving in computer storage and computational cost.

1.5 OBJECTIVES OF THE STUDY

Based on the importance of flood studies and the scope of the flood routing problem stated in the foregoing sections, the objective
of the present study are defined as follows:

i. to apply the known methods of flood routing to selected river systems of India in order to evaluate their performance,

ii. to compare the results of such application in order to select a particular method for the river reaches studied, the selection being based on considerations of simplicity, adaptability and economy,

iii. to find an expression relating some aspect of flood to relevant routing parameters so that an easy way of identifying the parameters for a hypothetical or future flood can be devised,

iv. to quantify the importance of accuracy in geometric data and to evaluate the performance of a large space-time grid in implicit routing scheme in order that a simplification in routing models can be effected at less computer storage and lower computational costs,

v. to provide an alternative for stage-discharge relationship as a downstream boundary condition in implicit routing, and,

vi. to modify the implicit routing model such that the conveyance of the reach would be directly involved in the computations; i.e. to develop a conveyance routing model which would simplify the implicit routing model but retain its accuracy.

Two Indian rivers were chosen and their flood data were used to achieve these objectives. The rivers and reaches chosen were:
i. Narmada - Mortakka to Garudeshwar

ii. Cauvery - Kodumudi to Musiri

The Mortakka-Garudeshwar reach is 268.712 km long and the length of the Kodumudi-Musiri reach is 68.283 km. Even though this study restricts the application to two reaches, it is believed that theories and methodology presented could be easily extended to any other reach or any other river. The flood data were obtained from the Central Water Commission, Government of India. The cross-section data for the reach in Narmada were obtained from an earlier project undertaken in the Centre for Water Resources whereas such data with regard to the river Cauvery were provided by the Tamil Nadu Electricity Board.