DETERMINATION OF RULE CURVES

BY

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RULE CURVE

The rule curve specifies the ideal storage or empty space to be maintained in a reservoir during different times of the year. The implicit assumption is that a reservoir can satisfy its purposes to the maximum possible extent if the storage levels or empty space specified by the rule curve are maintained in the reservoir at different times. The rule curve, as such, does not give the amount of water to be released from the reservoir. This amount will depend upon the actual inflows to the reservoir.

The rule curves are generally derived by operation studies using historic flows or generated flows where long term historic records are not available. Many times, due to various conditions like low inflows, minimum requirements for demands etc., it is not possible to stick to the rule with respect to storage levels. It is possible to return to the rule curve in several ways. One way can be to return to the rule curve by curtailing the release beyond the minimum required if the deviation is negative or releasing an amount equal to the safe carrying capacity of the downstream channel if the deviation is positive.

DERIVATION OF RULE CURVES

A. Reservoir with seasonal storage

First of all, a simple case of a reservoir with seasonal storage serving for conservation needs will be considered. The seasonal storage requires carryover of water from wet to dry season and a reservoir with seasonal storage does not remain full at all times of the year. Further if the reservoir is able to meet the demands during the critical year, it will be able to serve its purpose for all other years.

In Fig. 1(a), the streamflow of a river and the water requirements have been plotted. Let us assume that at time A, the reservoir is full. From A to B, the demands exceed the natural inflow and hence the contents of the reservoir will be depleting. The mass curve of inflow and demands have been plotted in Fig. 2(b).

From time at A onwards, the inflow and demand curves diverge and the difference is maximum at B. Now, in Fig, 1(b) at point C, the reservoir is empty. From this point, the demand curve is plotted backwards in time and curve CB is obtained which is curve AB lowered and extended to the left. The vertical ordinates between the inflow mass curve EAC and demand mass curve EC represent the volume of water which is in storage at different times of the year. These vertical ordinates have been plotted against time in fig 1(c) and the resulting curve is the rule curve. This rule curve shows the storage requirement at any time of the year. Since it has been assumed earlier that this analysis is being done for the driest year on record and reservoir is of adequate capacity, it can be concluded that whenever there is more water in the reservoir than specified by rule curve, there is no danger of subsequent failure of the reservoir.

In case of multipurpose reservoir with seasonal storage, serving for more than one purpose, a common combination of purposes is conservation uses and flood control. The reservoir space at the top of conservation pool is allocated for flood control and the space below it is meant for serving conservation uses of water. The river basins in India typically experience major floods during monsoon months of July, August, Sept. and October. During other months of years, the probability of a major flood hitting the reservoir is very small or sometimes insignificant. Hence towards the end of monsoon months the empty space above conservation pool is utilized to store water which could be used for meeting conservation demands later on.

In Fig. 2 annual plans of operation of a multipurpose reservoir where flood control is one of the purpose is shown. It gives the rule curve for reservation for flood control storage during monsoons and non-monsoon period and normal operation for conservation purposes for later part of the year.

(B) RESERVOIR WITH MULTI ANNUAL STORAGE

Streamflows of a river for the most critical period of record have been plotted in Fig. 3(a) along with the hydropower and other conservation use requirements. It is seen from the figure that a carry-over storage is required as the water is carried over from one year to another. The reservoir will be full at time A and thereafter, passing through various stages will become empty at B. The mass curve of streamflows and the hydroelectric energy and other demands are plotted in fig (3b). The ordinate AC represents the required reservoir storage. The ordinate between the mass curve of streamflows and the mass curve of demand represents the amount of water available in the reservoir at that particular time. These ordinates are plotted on a horizontal base in fig. (3c). This exercise is repeated for other critical flow periods to obtain similar type of curves from A to B. Now these curves are screened month by month and the highest deficiency points are chosen. An envelope curve can be drawn using these points which is the required rule curve. At the time of actual operation if the reservoir is above the rule curve elevation on any date then all the water which could be used to generate useful energy is released from the reservoir. If the reservoir contents fall below the rule curve elevation, the releases are made to supply the minimum hydro-energy and other requirements and an attempt is made to return to the rule curve as quickly as possible.

FLEXIBLE OPERATION OF RESERVOIR

A reservoir operation schedule for reservoirs with adequate forecasting system for streamflows and precipitation is termed as flexible schedule. The reservoir operation decisions are based on analysis of the reservoir system, except in case of probable maximum flood where rigid operation schedule become operative. This flexible operation requires use of better models and careful planning and use of computers. However, the significant amount of larger benefits which can be derived by the flexible schedule makes it imperative to flow them for major reservoirs particularly when the resource availability is limited and allocation has to be done among a number of competing users.

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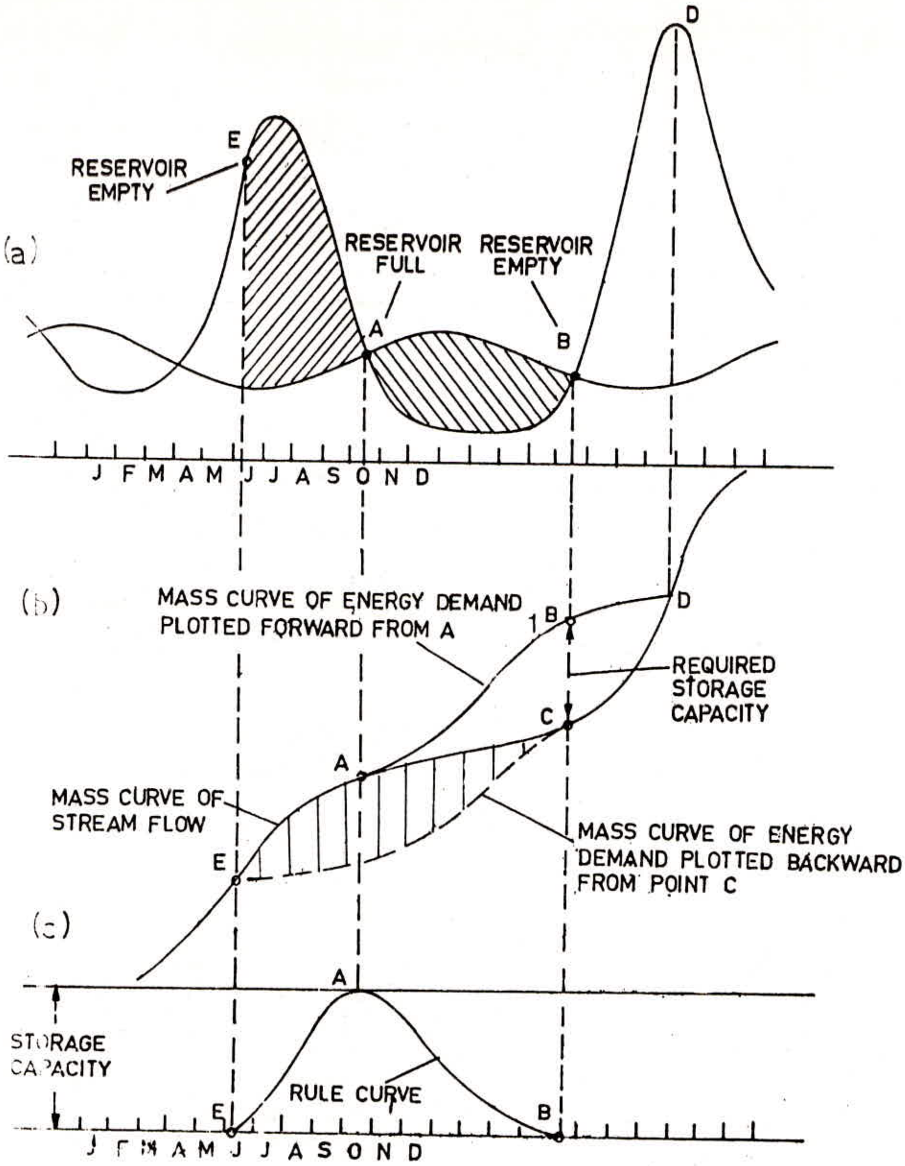

Fig. 1 Development of Rule Curves for Conservation Purpose

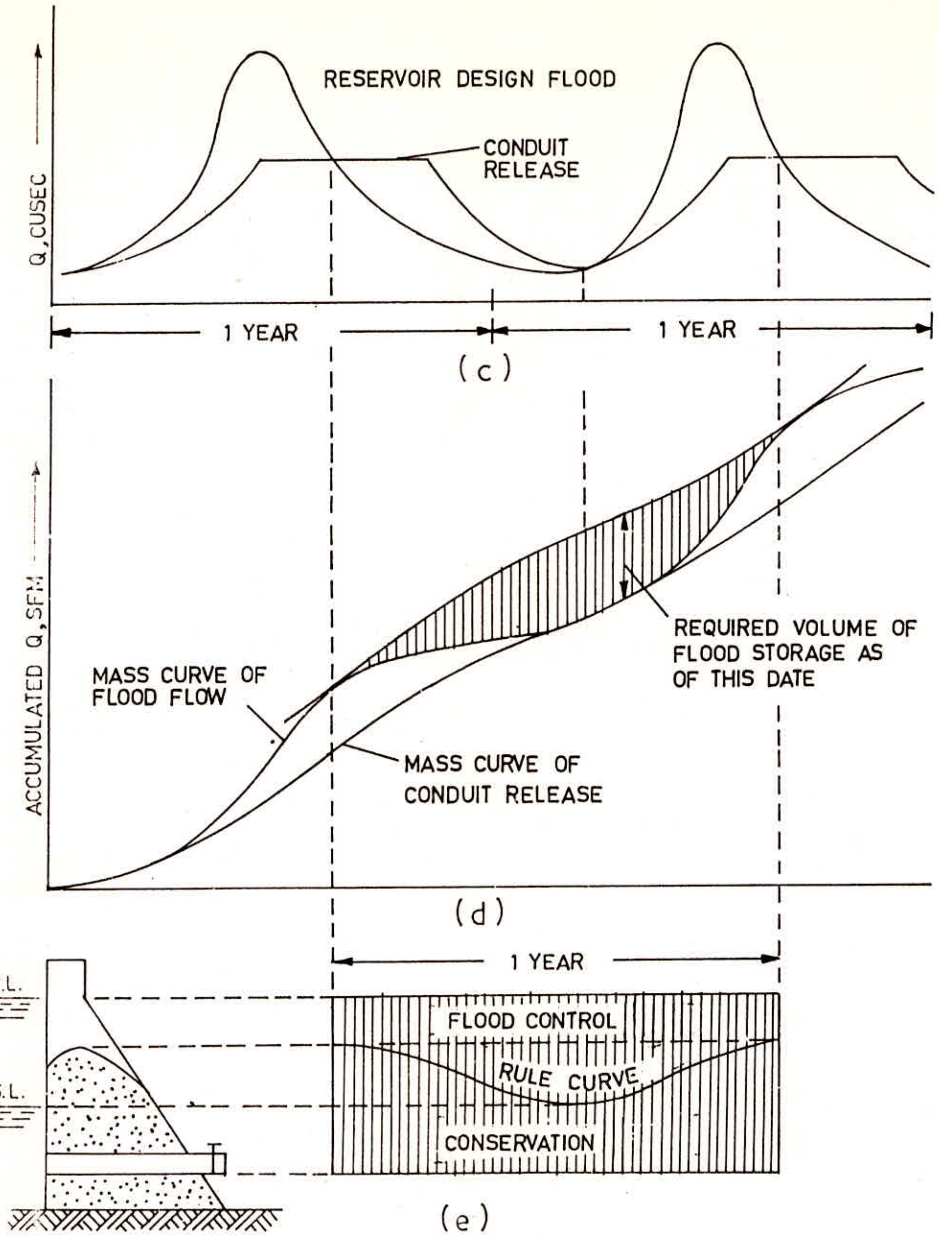

Fig. 2 Development of Rule Curves for Flood Control Operation

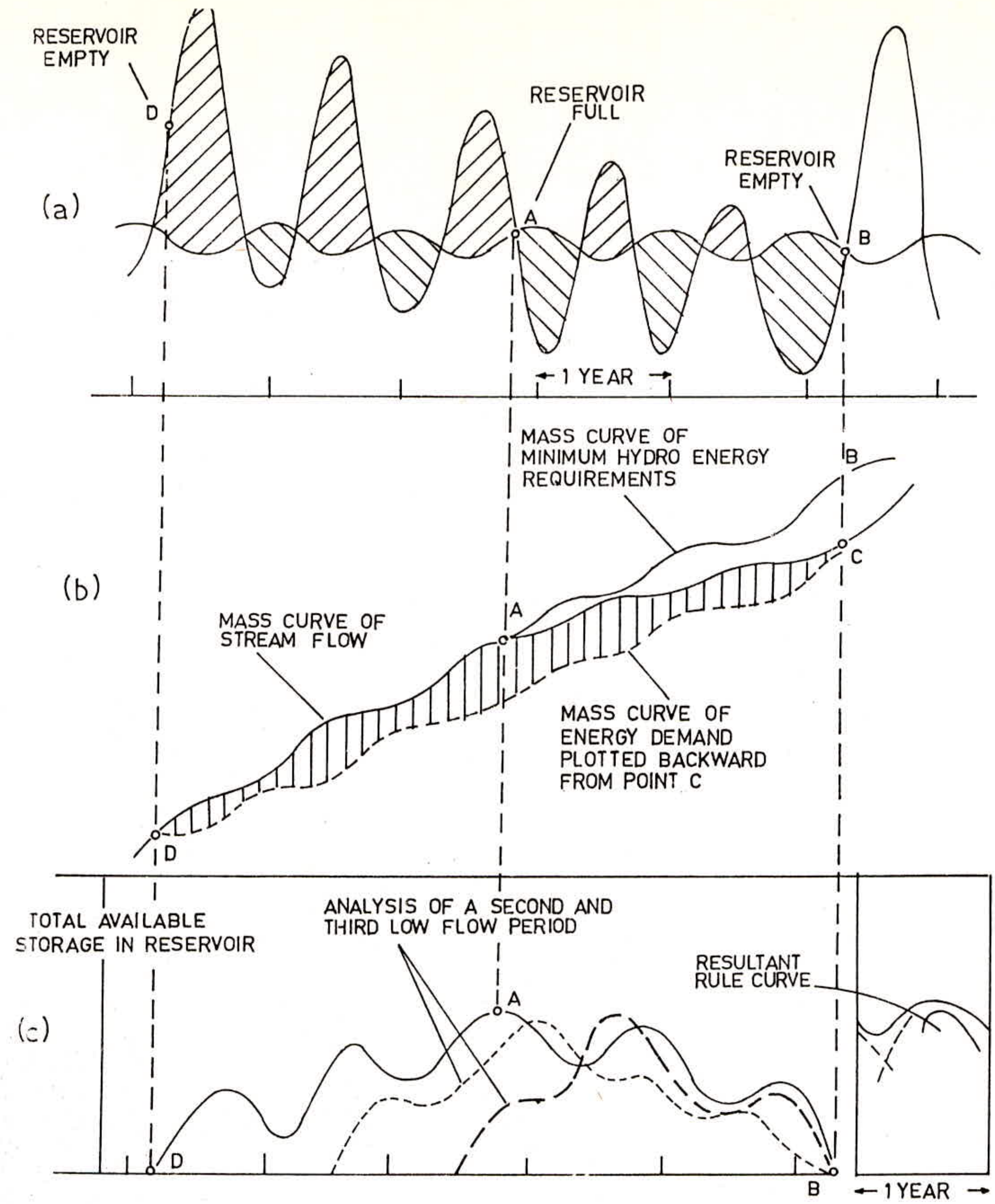

Fig. 3 Development of Rule Curves for a Reservoir with Multi-annual Storage