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Assessment of Reservoir Routing for Kadra Dam

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ABSTRACT— Flood Routing- The procedure that determines the timing and magnitude of a flood wave at a point on a stream from the known or assumed data at one or more points on upstream side (Chow1964).
Reservoir Routing - This procedure derives the out-flow hydrograph from a reservoir from the inflow hydrograph into the reservoir with consideration of elevation, storage, and discharge characteristics of the reservoir and spillways. The conservation of mass equation is solved with the assumption that outflow discharge and volume of storage are directly relatedIntroduction

Scope of the Present Study:

Flood routing is a process used to predict the temporal and spatial variations of a flood Hydrograph as it moves through a river reach or reservoir. Flood routing is used in (i) flood forecasting, (ii) flood protection, (iii) reservoir design, and (iv) Design of spillway and outlet structures.

Traditional deterministic methods of analysis must be supplemented by methods which use the principles of probabilities. These methods enable a logical analysis of uncertainty and provide a quantitative basis for assessing overtopping of hydraulic structures; hence here an attempt is made to consider the randomness in the output parameters of flood routing for the determination of outflow hydrograph.

LITERATURE SURVEY

John D. Fenton (1992**)** has initiated that the traditional method for reservoir routing is unnecessarily complicated

The presentation incorporates the case where reservoir outflow may be varied by control of valves or spillway gates. Numerical methods for reservoir routing are examined and compared, and it is concluded that simple standard methods for solving differential equations are to be preferred to the traditional method for flood routing and should replace it

Aly. N.El-Bahrawy (1999) represented flow routing calculations for analyzing and designing water engineering systems such as reservoirs, Storm water conduits and detention ponds, spillways, pumping stations, etc. The paper introduces spreadsheets as an efficient computational tool to carry out routing calculations. After reviewing many of the flow routing procedures used by engineers and their applications for reservoir, river and catchment routing, a series of examples are worked out to illustrate the use of spreadsheets to carry out the routing calculations for the selected procedures. This emphasizes the superiority of spread sheets over other available methods as a computational tool for routing calculations. Spread sheets are both valuable for design purposes, and an excellent educational tool in the area or computational hydrology.

Study Area and Data Used
About Kadra Dam

Kadra Dam is located in the district of Uttara Kannada in the state of Karnataka in India. The dam is constructed across the River Kalinadi. The latitude and longitude of the site are $14^0 55'00''$N and $74^0 20'49''$E. The basic objective to construct this dam was to start about a hydroelectric project for the supply of water to turbines of electric power generating station. KPCL completed the project. The Kadra Dam is an integral part of the Kaiga Project that incorporates several innovative design features – common as well as site specific.

The Kadra power house has been built on the left bank of the river with an installed capacity of 150 MW. The power house integrates three 50 MW Kaplan turbines which are coupled to the generating units. The annual generation is 570 MU. The design head is 32 meters.

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The reservoir routing methods are used in the design and operation of storage facilities of dam structures. However, hydrologic variables such as inflow, elevation, storage, outflow, and time have been taken as an input data, in order to determine the inflow hydrograph, peak discharge and maximum elevation and also by which even the peak attenuation and lag time is also calculated.

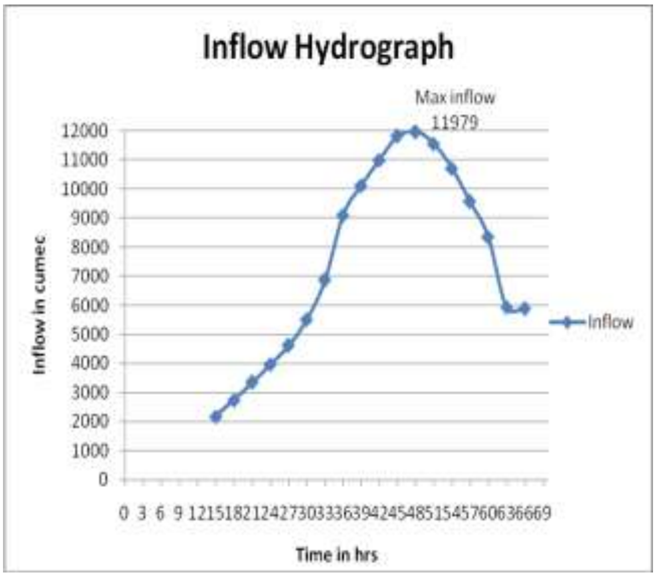
Data Used

The following data is taken for the flood routing analysis from Karnataka Power Corporation Limited (KPCL) Reservoir Operation Guidelines/Protocol for 1999 Monsoon.

a. The capacity of the reservoir is needed at different elevation, which is done by measuring the surface area of contour map with the help planimeter instrument. The graph obtained by plotting pool elevation vs. surface area & Storage is been used for the storage estimation.

b. Pool elevation vs. outflow data is used for calculation which is as shown in the graphical form below

c. The inflow flood for which routing is to be done has been taken from the source mentioned above for time period of 3 hr. Inflow data and the graph is as shown below.



Source: KHEP, KPCL, 1999

Figure 3.2 Inflow hydrograph at Kadra reservoir

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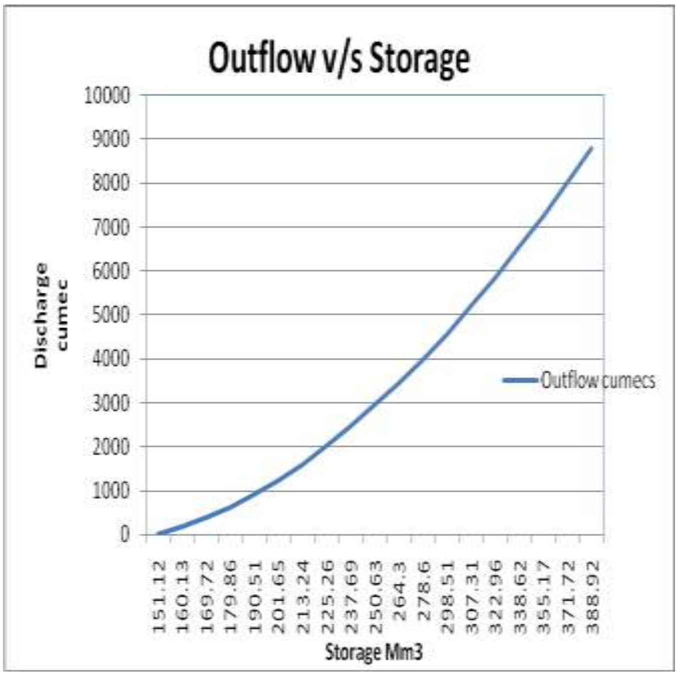
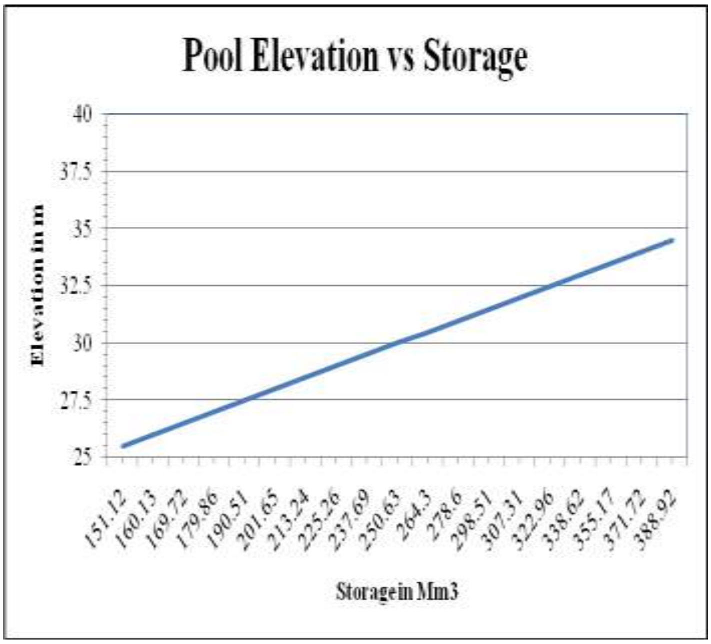


Figure Outflow v/s Storage graph at Kadra reservoir



Source: KHEP, KPCL, 1999

Figure 3.4 Pool elevation v/s Storage graph at Kadra reservoir

Methods of Reservoir Routing

Calculation for the Mass curve method of Reservoir Routing

The cumulative mass inflow for successive times are calculated, corresponding to this particular cumulative volume of inflow the amount of outflow volume is assumed and listed as assumed outflow.

If the actual volume of outflow is equal to assumed outflow volume corresponding to volume of inflow enters into reservoir during time interval, which is found from stage discharge relation available for reservoir. The trials are carried out till the accuracy and actual volume of outflow equal to assumed volume of outflow.

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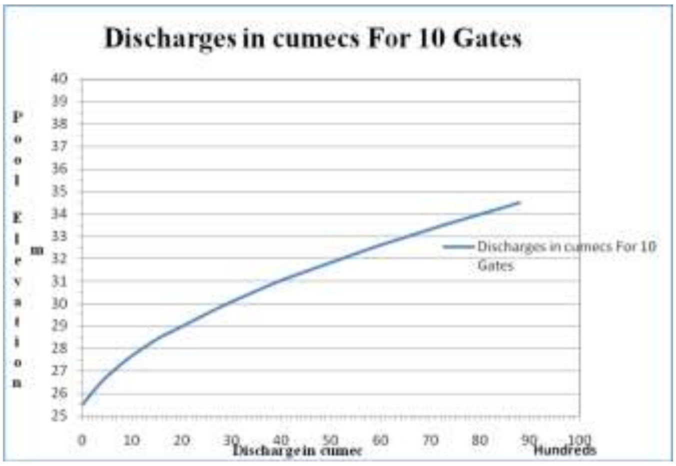
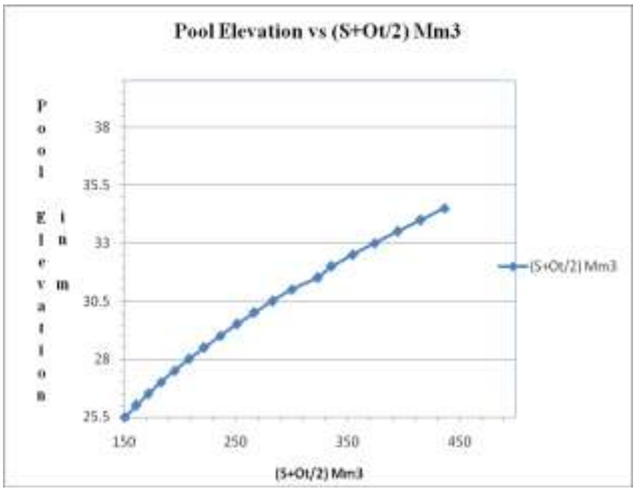
The outflow hydrograph obtained from mass curve method has Peak outflow of **11060.6 m^3/s** at **57th** hour, and the Inflow hydrograph from the data has peak of **11979 m^3/s** at **48th** hour and hence the reservoir lag and attenuation are **9h**r and **919 m^3/s** respectively.

Calculation for the Modified Pul's Method of Reservoir Routing





For Modified Pul's Method which has Peak outflow of **11074.21m^3/s** at **54th** hour, and the Inflow hydrograph from the data has peak of **11979 m^3/s** at **48th** hour and hence the reservoir lag and attenuation are **6h**r and **904.79 m^3/s** respectively

RESULTS AND CONCLUSIONS

The mass-curve method of reservoir routing is very versatile. It can be applied numerically or graphically. A mass flow curve is a plotting of accumulated volume of flow and time. At any point, that is, at any time, the slope of the mass flow curve, since it is a volume dimension divided by a time dimension, is equal to the rate of flow. The mass flow curve is the integral of the hydrograph since its ordinates measure accumulated volume at any time. The numerical routing operation is a trial and error procedure while the graphical approach is a direct solution.

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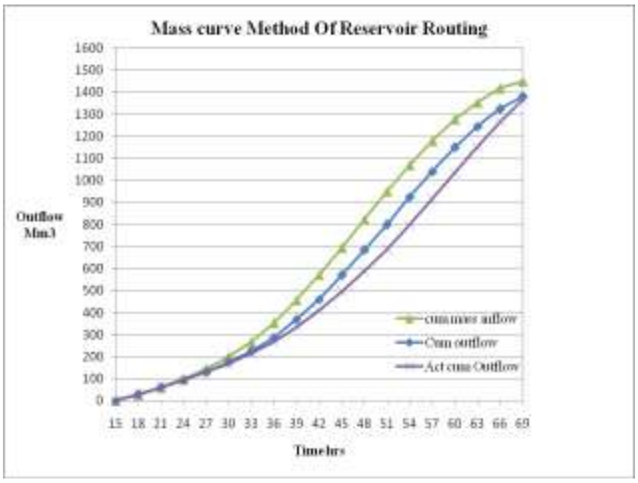
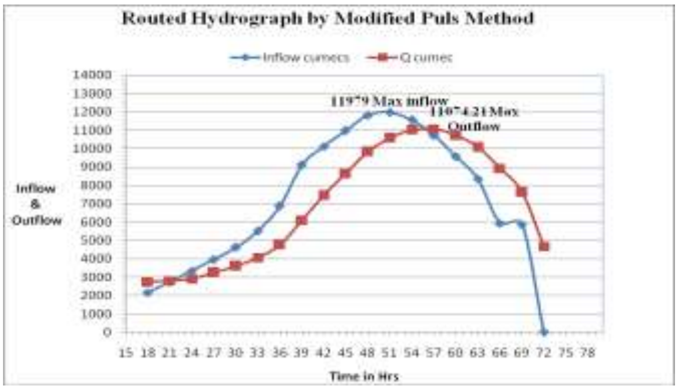


The outflow hydrograph obtained from mass curve method has Peak outflow of **11060.6 m^3/s** at **57^{th}** hour, and the Inflow hydrograph from the data has peak of **11979 m^3/s** at **48^{th}** hour and hence the reservoir lag and attenuation are **9h**r and **919 m^3/s** respectively.

The solution obtained from this method is a trial-and-error one and involves the use of elevation-discharge curves, either separately or in combination. The routing operation is simple, easily done, and efficiently adopted to complex routing problems, but the prediction of initial outflow is complicated and takes much time to arrive at solution.

Routed Hydrograph by Modified Puls Method



The outflow hydrograph obtained from Modified Pul's Method has Peak outflow of **11074.21m^3/s** at **54^{th}** hour, and the Inflow hydrograph from the data has peak of **11979 m^3/s** at **48^{th}** hour and hence the reservoir lag and attenuation are **6h**r and **904.79 m^3/s** respectively.

This method has two shortcomings. First, the assumption that the outflow begins at same time as inflow does imply that the inflow passes through the reservoir instantaneously regardless of its length. However, this weakness is not serious if the ratio of T_t/T_m is less than or equal to ½, where T_m denotes time to peak of the inflow hydrograph and T_t denotes travel time. Second one is it is difficult to choose an appropriate Δt.

CONCLUSIONS:

1. The solution obtained from Mass Curve Method is a trial-and-error one and involves the use of elevation-discharge curves, either separately or in combination, but prediction outflow is complicated and also this takes much time at desired solution.
2. The Modified Pul's method is simple, easy and can be applied to all simple and complex reservoir routing problems. As it considers the use of Elevation-Storage and elevation-Discharge curves, either separately or in combination.
3. In modified Pul's method it is difficult to choose an appropriate Δt. However, it is more convenient and realistic to use variable Δt,

keeping it small for large change in mass inflow and large for small change.

4. The outflow hydrograph obtained from Modified Pul's Method has Peak outflow of **11074.21m^3/s** at **54th** hour, and the Inflow hydrograph from the data has peak of **11979 m^3/s** at **48th** hour and hence the reservoir lag and attenuation are **6h**r and **904.79 m^3/s** respectively. These result values are compatible with actual outflow observed for the same inflow.

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