II.4-RES-SNGL-A-POOLQ SINGLE RESERVOIR REGULATION OPERATION SCHEME
POOL ELEVATION CONTROLLED DISCHARGE

Description

Scheme POOLQ is used to simulate reservoir operations when releases are based on the elevation of the pool.

An elevation-discharge curve is used to specify the reservoir release for a given pool height. This relationship is sometimes referred to as a rulecurve though in Operation RES-SNGL a rulecurve is a relationship between pool elevation and time of the year.

An elevation determined from a rulecurve (CURVE) may be used as an elevation value in the elevation-discharge curve. When one of the elevations in the curve is specified as -999.0 it is replaced by the elevation obtained from the rulecurve before any calculations take place.

There are two different ways to determine the outflows from the elevation-discharge curve (POOLVSQ). One method is to hold outflow constant between specified pool elevations. The other method is to interpolate linearly between any specified pool elevations to determine outflow.

In either case the POOLVSQ curve, Q0 = q(H), is converted into the discharge-storage curve, Q0 = q(S) using the elevation-storage curve, H = h(V):

$$Q0 = q(H) = q(h(V)) = q(S)$$

If the observed pool elevation is available the discharge can be determined from the discharge-storage curve through interpolation:

$$QO_2 = q(V_2)$$

Otherwise the discharge can only be solved by an iterative method. The approaches used in the constant flow interpolation and the linear interpolation are different and are discussed separately.

In the constant discharge approach the pool elevation and the outflow are determined simultaneously by an iterative method. To compute the discharge for the time period the range of pool elevations containing the period starting elevation is used. The outflow specified for this range is used as a preliminary guess in the continuity equation to estimate the period ending elevation. If the calculated ending elevation falls within the same range then the estimates can be used as the values for the period i.e.:

$$QOM = QO_2 = QO_1$$

$$V_2 = V_1 + (QIM - QOM) * data\_time\_interval$$

$$H_2 = h(V_2)$$

where H is h(V) - the elevation versus storage curve for the reservoir

If the initial discharge guess causes the pool elevation to rise or fall to a different elevation range then the fraction of time and total discharge that occurs within each range is determined. The continuity equation is then solved using this estimate of total period mean discharge to compute a new value of period ending elevation. This procedure is continued until no range change occurs. The mean discharge for the period is the sum of the fractional means from all elevation ranges. The period ending instantaneous discharge is the discharge corresponding to the final elevation range. If k elevation ranges are involved the procedure used to determine the fraction (F) of time assigned to each range is summarized by the following equations. The continuity equation for time spent in each elevation range can be expressed as:

$$[(I_i + I_{i+1})/2 - O_i](F_i*\Delta t) = S_{i+1} - S_i$$

where I is the instantaneous inflow
O is the mean outflow
S is the storage
i is the subscript for each elevation range during the period

Also the inflow at the end of the elevation range can be expressed as:

$$I_{i+1} = I_i + \Delta QI*F_i*\Delta t$$

and

$$\Delta QI = (QI_2 - QI_1)/\Delta t$$

By substitution the continuity equation for the time spent in each elevation range can now be expressed as:

$$\Delta QI(F_i*\Delta t)^2 + 2(F_i*\Delta t)(I_i-O_i) - 2(S_{i+1}-S_i) = 0$$

All values except for F_i are known. F_i can be determined by using the quadratic formula to solve the continuity equation for F_1*data_time_interval:

$$F_i*\Delta t = \left(-B \pm\sqrt{B^2-4AC}\right)/2A$$

where $A = \Delta QI$,

$B = 2(I_i - O_i)$

$C = -2(S_{i+1} - S_i)$

$0 < F_i < 1.0$

After determining F_i for one range the initial inflow, I_i, for the next range can be determined from:

$$I_i = QI_1 + \Delta QI * \sum_{j=1}^{i-1} (F_j * \Delta t)$$

and the process is repeated. After determining F_i for k-1 elevation ranges the mean outflow for the time period can be determined as:

$$QOM = \sum_{i=1}^{k-1} (O_i * F_i * \Delta t) + O_k (\Delta t - \sum_{i=1}^{k-1} F_i * \Delta t)$$

V_2 and H_2 are determined as previously specified when no elevation change occurs. $Q0_2$ is determined from the discharge-storage curve, $Q0_2 = q(V_2)$.

In the linear interpolation approach, (LINEAR), the pool elevation and the instantaneous discharge are computed by solving the continuity equation and the POOLVSQ curve simultaneously.

Assume the discharge-storage curve, Q0 = q(S), consists of NSO pairs of discharge and storage. At the i th pair the discharge/storage curve can be expressed as:

$$QO_2 = QO_i + SLOPE * (V_2 - S_i)$$

where

$$SLOPE = \frac{QO_{i+1} - QO_i}{S_{i+1} - S_i}$$

The continuity equation can be written as:

$$V_2 = V_1 + (QIM - QOM) * data\_time\_interval$$

with

$$QOM = (QO_1 + QO_2)/2$$

Substitute QO_2 into the continuity equation and solve for V_2 then we have:

$$V_2 = \frac{V_1 + \left[QIM - \left(QO_1 + O_i - SLOPE * S_i\right)/2\right] * \Delta t}{1 + SLOPE * \Delta t/2}$$

Therefore for a given i th pair on the discharge-storage curve the storage at the end of the time interval can be solved explicitly.

The i th pair on the discharge-storage curve can be determined by an iterative method:

1. assume $V_2 = V_1$

2. determine an old i value so that:
   $S_i < S_2 < S_{i+1}$

3. solve for a new V_2

4. determine a new i value

5. if the old i value equals the new i value then have the correct V_2

6. otherwise increase i value by 1 if the new V_2 > the old V_2 or decrease i value by 1 if the new V_2 < the old V_2

7. repeat steps 2 thru 6

Once V_2 is determined the instantaneous and the mean discharge can be computed by the following equations:

$$QO_2 = QO_i + SLOPE * (V_2 - S_i)$$

$$QOM = 0.5 * (QO_1 + QO_2)$$

If the elevation rises above or falls below the range specified in the elevation-discharge curve then the first or last values respectively will be used in either the linear interpolation or constant discharge approach.

This process is repeated for each time period in the run.