## Flood Routing

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## Hydrologic and Hydraulic Routing

Fig. 4-1
Reservoir Concepts
(a) Reservoir Storage
(b) Inflow and outflow
(c) Storage

(b)


Example 4-1
Determine the average storage for each one-day period? What is the maximum storage?


Time distribution of Storage



## Example 4-3:

## Muskingum method

Given: Inflow, Initial outflow, K and x .

Determine: Outflow

$$
\begin{aligned}
& Q_{2}=C_{0} I_{2}+C_{1} I_{1}+C_{2} Q_{1} \\
& C_{0}=\frac{-K x+0.5 \Delta t}{D}
\end{aligned}
$$

1. Calculate $\mathrm{D}, \mathrm{C}_{0}, \mathrm{C}_{1}$ and
$\mathrm{C}_{2}$. $C_{1}=\frac{k x+0.5 \Delta t}{D}$
2. Check if $\mathrm{C}_{0}+\mathrm{C}_{1}+\mathrm{C}_{2}=1$
$C_{2}=\frac{K-K x-0.5 \Delta t}{D}$
3. Calculate all Q values one by one.
$D=K-K x+0.5 \Delta t$

| Example 4-4 | Table E4-4. |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Time (days) | Avg. Inflow (cfs) | Avg. Oufflow (cfs) | Storage (cfs-days) |
| Determination of storage coefficients | 1 | 59 | 42 | 17 |
|  | 2 | 93 | 70 | 40 |
|  | 3 | 129 | 76 | 94 |
|  | 4 | 205 | 142 | 157 |
|  | 5 | 210 | 183 | 184 |
|  | 6 | 234 | 185 | 233 |
|  | 7 | 325 | 213 | 345 |
|  | 8 | 554 | 293 | 606 |
|  | 9 | 627 | 397 | 836 |
|  | 10 | 526 | 487 | 875 |
|  | 11 | 432 | 533 | 774 |
|  | 12 | 400 | 487 | 687 |
|  | 13 | 388 | 446 | 629 |
|  | 14 | 270 | 400 | 499 |
|  | 15 | 162 | 360 | 301 |
|  | 16 | 124 | 230 | 195 |
|  | 17 | 102 | 140 | 157 |
|  | 18 | 81 | 115 | 123 |
|  | 19 | 60 | 93 | 90 |
|  | 20 | 51 | 71 | 70 |



## Tutorial:

1. Problem 4.1
2. Problem 4.2

## Storage-Indication method

The continuity equation can be written as:

$$
\frac{1}{2}\left(I_{1}+I_{2}\right)-\frac{1}{2}\left(Q_{1}+Q_{2}\right)=\frac{S_{2}-S_{1}}{\Delta t}
$$

In general form it can be re-written as:

$$
\left(I_{n}+I_{n+1}\right)+\left(\frac{2 S_{n}}{\Delta t}-Q_{n}\right)=\left(\frac{2 S_{n+1}}{\Delta t}+Q_{n+1}\right)
$$

## Storage-Indication method

$$
\left(I_{n}+I_{n+1}\right)+\left(\frac{2 S_{n}}{\Delta t}-Q_{n}\right)=\left(\frac{2 S_{n+1}}{\Delta t}+Q_{n+1}\right)
$$

Given: Inflow, Initial Outflow, Storage-Discharge relationship for reservoir

Determine: Outflow

1. Establish relationship between $Q$ and $2 S / D t+Q$ using water surface elevation in the reservoir, $h$.
2. Calculate left-hand-side for the above equation
3. Use the relationship of step 1 to determine Q at next time step
4. Repeat until you get Q for all time steps.


Example 4-5: Storage-Indication method


Example 4-5: Storage-Indication method


## Tutorial:

1. Problem 4.4
2. Problem 4.21

## Hydraulic river routing



## Continuity Equation

$$
\frac{\partial A}{\partial t}+\frac{\partial Q}{\partial x}=q
$$

Momentum Equation

$$
\begin{aligned}
& \frac{\partial v}{\partial t}+v \frac{\partial v}{x}+\frac{g}{A} \frac{\partial(\bar{y} A)}{\partial x}+\frac{v q}{A}=g\left(S_{0}-S_{f}\right) \\
& S_{f}=S_{0}-\frac{\partial y}{\partial x}-\frac{v}{g} \frac{\partial v}{\partial x}-\frac{1}{g} \frac{\partial v}{\partial t}
\end{aligned}
$$

Table 4-1. Forms of the Momentum Equation

| Type of Flow | Momentum Equation |
| :--- | :--- |
| Kinematic wave (steady uniform) | $S_{f}=S_{0}$ |
| Diffusion (noninertia) model | $S_{f}=S_{0}-\partial y / \partial x$ |
| Steady nonuniform | $S_{f}=S_{0}-\partial y / \partial x-(v / g) \partial v / \partial x$ |
| Unsteady nonuniform | $S_{f}=S_{0}-\partial y / \partial x-(v / g) \partial v / \partial x-(1 / g) \partial v / \partial t$ |

