Important Hydrologic Routing Formulas PDF

Formulas
Examples
with Units

List of 22
Important Hydrologic Routing Formulas

1) Hydrologic Channel Routing Formulas

1.1) Equation for Linear Storage or Linear Reservoir Formula

Evaluate Formula

Formula

$$S = K \cdot Q$$

Example with Units

$$100\,\mathrm{m^3} = 4 \cdot 25\,\mathrm{m^3/s}$$

1.2) Outflow given Linear Storage Formula

Evaluate Formula

Formula

$$Q = \frac{S}{K}$$

Example with Units

$$25\,\mathrm{m^3/s} = \frac{100\,\mathrm{m^3}}{4}$$

1.3) Storage during Beginning of Time Interval for Continuity Equation of Reach Formula

Evaluate Formula

Formula

$$S_1 = S_2 + \left(\frac{Q_2 + Q_1}{2}\right) \cdot \Delta t - \left(\frac{I_2 + I_1}{2}\right) \cdot \Delta t$$

Example with Units

$$15 = 35 + \left(\frac{64\,\mathrm{m^3/s} + 48\,\mathrm{m^3/s}}{2}\right) \cdot 5\,\mathrm{s} - \left(\frac{65\,\mathrm{m^3/s} + 55\,\mathrm{m^3/s}}{2}\right) \cdot 5\,\mathrm{s}$$

1.4) Storage during End of Time Interval in Continuity Equation for Reach Formula

Evaluate Formula

Formula

$$S_2 = \left(\frac{I_2 + I_1}{2}\right) \cdot \Delta t - \left(\frac{Q_2 + Q_1}{2}\right) \cdot \Delta t + S_1$$

Example with Units

$$35 = \left(\frac{65\,\mathrm{m^3/s} + 55\,\mathrm{m^3/s}}{2}\right) \cdot 5\,\mathrm{s} - \left(\frac{64\,\mathrm{m^3/s} + 48\,\mathrm{m^3/s}}{2}\right) \cdot 5\,\mathrm{s} + 15$$

1.5) Storage during end of time interval in Muskingum method of Routing Formula

Evaluate Formula

Formula

$$S_2 = K \cdot \left(x \cdot \left(I_2 - I_1 \right) + \left(1 - x \right) \cdot \left(Q_2 - Q_1 \right) \right) + S_1$$

Example with Units

$$35.8 = 4 \cdot \left(1.8 \cdot \left(65 \, \text{m}^3/\text{s} - 55 \, \text{m}^3/\text{s} \right) + \left(1 - 1.8 \right) \cdot \left(64 \, \text{m}^3/\text{s} - 48 \, \text{m}^3/\text{s} \right) \right) + 15$$

1.6) Storage in Beginning of Time Interval Formula

Evaluate Formula

Formula

$$S_1 = S_2 - \left(K \cdot \left(x \cdot \left(I_2 - I_1 \right) + \left(1 - x \right) \cdot \left(Q_2 - Q_1 \right) \right) \right)$$

Example with Units

$$14.2 = 35 - \left(4 \cdot \left(1.8 \cdot \left(65 \, \text{m}^3/\text{s} - 55 \, \text{m}^3/\text{s} \right) + \left(1 - 1.8 \right) \cdot \left(64 \, \text{m}^3/\text{s} - 48 \, \text{m}^3/\text{s} \right) \right) \right)$$

1.7) Total Wedge Storage in Channel Reach Formula

Evaluate Formula

Formula

$$S = K \cdot \left(x \cdot I^{m} + \left(1 - x \right) \cdot Q^{m} \right)$$

Example with Units

$$99.1175 \, \text{m}^3 = 4 \cdot \left(1.8 \cdot 28 \, \text{m}^3/\text{s}^{0.94} + \left(1 - 1.8 \right) \cdot 25 \, \text{m}^3/\text{s}^{0.94} \right)$$

1.8) Muskingum Equation Formulas

1.8.1) Change in Storage in Muskingum Method of Routing Formula

Evaluate Formula

Formula

$$\Delta Sv = K \cdot \left(x \cdot \left(I_2 - I_1 \right) + \left(1 - x \right) \cdot \left(Q_2 - Q_1 \right) \right)$$

Example with Units

$$20.8 = 4 \cdot \left(1.8 \cdot \left(65 \, \text{m}^3/\text{s} - 55 \, \text{m}^3/\text{s} \right) + \left(1 - 1.8 \right) \cdot \left(64 \, \text{m}^3/\text{s} - 48 \, \text{m}^3/\text{s} \right) \right)$$

1.8.2) Muskingum Equation Formula

Evaluate Formula

Formula

$$\Delta Sv = K \cdot \left(x \cdot I + \left(1 - x \right) \cdot Q \right)$$

Example with Units

$$121.6 = 4 \cdot \left(1.8 \cdot 28 \, \text{m}^3/\text{s} + \left(1 - 1.8 \right) \cdot 25 \, \text{m}^3/\text{s} \right)$$

1.8.3) Muskingum Routing Equation Formula

Evaluate Formula

Formula

$$Q_2 = C_o \cdot I_2 + C_1 \cdot I_1 + C_2 \cdot Q_1$$

Example with Units

$$51.819 \, \text{m}^3/\text{s} = 0.048 \cdot 65 \, \text{m}^3/\text{s} + 0.429 \cdot 55 \, \text{m}^3/\text{s} + 0.523 \cdot 48 \, \text{m}^3/\text{s}$$

2) Hydrologic Storage Routing Formulas

2.1) Coefficient of Discharge when Outflow is Considered Formula

Evaluate Formula

Formula

$$C_d = \left(\frac{Qh}{\left(\frac{2}{3}\right) \cdot \sqrt{2 \cdot g} \cdot L_e \cdot \left(\frac{H}{2}\right)^{3}} \right)$$

Example with Units

$$0.6596 = \left(\frac{131.4\,\mathrm{m^3/s}}{\left(\frac{2}{3}\right) \cdot \sqrt{2 \cdot 9.8\,\mathrm{m/s^2}} \cdot 5.0\,\mathrm{m} \cdot \left(\frac{3\,\mathrm{m}}{2}\right)^{3}} \right)$$

2.2) Effective Length of Spillway Crest when Outflow is Considered Formula

Evaluate Formula

Formula

$$L_e = \frac{Qh}{\left(\frac{2}{3}\right) \cdot C_d \cdot \sqrt{2 \cdot g} \cdot \frac{H}{2}^{3}}$$

Example with Units

$$4.9967\,\mathrm{m} = \frac{131.4\,\mathrm{m^3/s}}{\left(\frac{2}{3}\right) \cdot 0.66 \cdot \sqrt{2 \cdot 9.8\,\mathrm{m/s^2}} \cdot \frac{3\,\mathrm{m}}{2}^{3}}$$

2.3) Head over Spillway when Outflow is Considered Formula

Evaluate Formula

Formula

$$H = \left(\frac{Qh}{\left(\frac{2}{3}\right) \cdot C_d \cdot \sqrt{2 \cdot g} \cdot \left(\frac{L_e}{2}\right)} \right)^{\frac{1}{3}}$$

Example with Units

$$2.9993\,\mathrm{m} = \left(\frac{131.4\,\mathrm{m^3/s}}{\left(\frac{2}{3}\right) \cdot 0.66 \cdot \sqrt{2 \cdot 9.8\,\mathrm{m/s^2}} \cdot \left(\frac{5.0\,\mathrm{m}}{2}\right)} \right)^{\frac{1}{3}}$$

2.4) Outflow in Spillway Formula

Evaluate Formula

Formula

$$Qh = \left(\frac{2}{3}\right) \cdot C_d \cdot \sqrt{2 \cdot g} \cdot L_e \cdot \frac{H}{2}^{3}$$

Example with Units

$$131.4875\,\mathrm{m^3/s} = \left(\frac{2}{3}\right) \cdot 0.66 \cdot \sqrt{2 \cdot 9.8\,\mathrm{m/s^2}} \cdot 5.0\,\mathrm{m} \cdot \frac{3\,\mathrm{m}}{2}^{3}$$

2.5) Goodrich Method Formulas

2.5.1) Inflow at Beginning of Time Interval Formula

Evaluate Formula

Formula

$$I_1 = \left(\left(2 \cdot \frac{S_2}{\Delta t} \right) + Q_2 \right) - \left(\left(2 \cdot \frac{S_1}{\Delta t} \right) - Q_1 \right) - I_2$$

Example with Units

$$55\,\mathrm{m^3/s} = \left(\left(2 \cdot \frac{35}{5\,\mathrm{s}} \right) + 64\,\mathrm{m^3/s} \right) - \left(\left(2 \cdot \frac{15}{5\,\mathrm{s}} \right) - 48\,\mathrm{m^3/s} \right) - 65\,\mathrm{m^3/s}$$

2.5.2) Inflow at End of Time Interval Formula

Evaluate Formula

Formula

$$I_2 = \left(\left(2 \cdot \frac{S_2}{\Delta t} \right) + Q_2 \right) - \left(\left(2 \cdot \frac{S_1}{\Delta t} \right) - Q_1 \right) - I_1$$

Example with Units

$$65\,\mathrm{m^3/s} = \left(\left(2 \cdot \frac{35}{5\,\mathrm{s}} \right) + 64\,\mathrm{m^3/s} \right) - \left(\left(2 \cdot \frac{15}{5\,\mathrm{s}} \right) - 48\,\mathrm{m^3/s} \right) - 55\,\mathrm{m^3/s}$$

2.5.3) Outflow at Beginning of Time Interval Formula

Evaluate Formula

Formula

$$Q_1 = \left(I_1 + I_2 \right) + \left(2 \cdot \frac{S_1}{\Delta t} \right) - \left(\left(2 \cdot \frac{S_2}{\Delta t} \right) + Q_2 \right)$$

Example with Units

$$48\,\mathrm{m^3/s} = \left(55\,\mathrm{m^3/s} + 65\,\mathrm{m^3/s} \right) + \left(2 \cdot \frac{15}{5\,\mathrm{s}} \right) - \left(\left(2 \cdot \frac{35}{5\,\mathrm{s}} \right) + 64\,\mathrm{m^3/s} \right)$$

2.5.4) Outflow at End of Time Interval Formula

Evaluate Formula

Formula

$$Q_2 = \left(I_1 + I_2 \right) + \left(\left(2 \cdot \frac{S_1}{\Delta t} \right) - Q_1 \right) - \left(2 \cdot \frac{S_2}{\Delta t} \right)$$

Example with Units

$$64\,\mathrm{m^3/s} = \left(55\,\mathrm{m^3/s} + 65\,\mathrm{m^3/s} \right) + \left(\left(2 \cdot \frac{15}{5\,\mathrm{s}} \right) - 48\,\mathrm{m^3/s} \right) - \left(2 \cdot \frac{35}{5\,\mathrm{s}} \right)$$

2.6) Modified Pul's Method Formulas

2.6.1) Storage at Beginning of Time Interval in Modified Pul's Method Formula

Evaluate Formula

Formula

$$S_1 = \left(S_2 + \left(Q_2 \cdot \frac{\Delta t}{2} \right) \right) - \left(\frac{I_1 + I_2}{2} \right) \cdot \Delta t + \left(Q_1 \cdot \frac{\Delta t}{2} \right)$$

Example with Units

$$15 = \left(35 + \left(64\,\mathrm{m^3/s} \cdot \frac{5\,\mathrm{s}}{2} \right) \right) - \left(\frac{55\,\mathrm{m^3/s} + 65\,\mathrm{m^3/s}}{2} \right) \cdot 5\,\mathrm{s} + \left(48\,\mathrm{m^3/s} \cdot \frac{5\,\mathrm{s}}{2} \right)$$

2.6.2) Storage at End of Time Interval in Modified Pul's Method Formula

Evaluate Formula

Formula

$$S_2 = \left(\frac{I_1 + I_2}{2} \right) \cdot \Delta t + \left(S_1 - \left(Q_1 \cdot \frac{\Delta t}{2} \right) \right) - \left(Q_2 \cdot \frac{\Delta t}{2} \right)$$

Example with Units

$$35 = \left(\frac{55\,\mathrm{m^3/s} + 65\,\mathrm{m^3/s}}{2} \right) \cdot 5\,\mathrm{s} + \left(15 - \left(48\,\mathrm{m^3/s} \cdot \frac{5\,\mathrm{s}}{2} \right) \right) - \left(64\,\mathrm{m^3/s} \cdot \frac{5\,\mathrm{s}}{2} \right)$$

2.7) Standard Fourth-Order Range Kutta Method Formulas

2.7.1) Water Surface Elevation at i'th step in Standard Fourth-Order Runge-Kutta Method Formula

Evaluate Formula

Formula

$$H_i = H_{i+1} - \left(\left(\frac{1}{6} \right) \cdot \left(K_1 + 2 \cdot K_2 + 2 \cdot K_3 + K_4 \right) \cdot \Delta t \right)$$

Example with Units

$$10 = 18 - \left(\left(\frac{1}{6} \right) \cdot \left(1.61 + 2 \cdot 1.98 + 2 \cdot 1.28 + 1.47 \right) \cdot 5\,\mathrm{s} \right)$$

2.7.2) Water Surface Elevation in Standard Fourth-Order Runge-Kutta Method Formula

Evaluate Formula

Formula

$$H_{i+1} = H_i + \left(\frac{1}{6} \right) \cdot \left(K_1 + 2 \cdot K_2 + 2 \cdot K_3 + K_4 \right) \cdot \Delta t$$

Example with Units

$$18 = 10.0 + \left(\frac{1}{6} \right) \cdot \left(1.61 + 2 \cdot 1.98 + 2 \cdot 1.28 + 1.47 \right) \cdot 5\,\mathrm{s}$$

Variables used in list of Hydrologic Routing Formulas above

- **C_1** Coefficient C1 in Muskingum Method of Routing
- **C_2** Coefficient C2 in Muskingum Method of Routing
- **C_d** Coefficient of Discharge
- **C_o** Coefficient Co in Muskingum Method of Routing
- **g** Acceleration due to Gravity *(Meter per Square Second)*
- **H** Head over Weir *(Meter)*
- **H_i** Water Surface Elevation at i'th Step
- **H_{i+1}** Water Surface Elevation at (i+1)th Step
- **I** Inflow Rate *(Cubic Meter per Second)*
- **I_1** Inflow at the Beginning of Time Interval *(Cubic Meter per Second)*
- **I_2** Inflow at the End of Time Interval *(Cubic Meter per Second)*
- **K** Constant K
- **K_1** Coefficient K1 by Repeated Appropriate Evaluation
- **K_2** Coefficient K2 by Repeated Appropriate Evaluation
- **K_3** Coefficient K3 by Repeated Appropriate Evaluation
- **K_4** Coefficient K4 by Repeated Appropriate Evaluation
- **L_e** Effective Length of the Spillway Crest *(Meter)*
- **m** A Constant Exponent
- **Q** Outflow Rate *(Cubic Meter per Second)*
- **Q_1** Outflow at the Beginning of Time Interval *(Cubic Meter per Second)*
- **Q_2** Outflow at the End of Time Interval *(Cubic Meter per Second)*
- **Qh** Reservoir Discharge *(Cubic Meter per Second)*
- **S** Total Storage in Channel Reach *(Cubic Meter)*

Constants, Functions, Measurements used in list of Hydrologic Routing Formulas above

- Functions: **sqrt**, sqrt(Number)
  A square root function is a function that takes a non-negative number as an input and returns the square root of the given input number.
- Measurement: **Length** in Meter (m)
  Length Unit Conversion
- Measurement: **Time** in Second (s)
  Time Unit Conversion
- Measurement: **Volume** in Cubic Meter (m^3)
  Volume Unit Conversion
- Measurement: **Acceleration** in Meter per Square Second (m/s^2)
  Acceleration Unit Conversion
- Measurement: **Volumetric Flow Rate** in Cubic Meter per Second (m^3/s)
  Volumetric Flow Rate Unit Conversion

- **S_1** Storage at the Beginning of Time Interval
- **S_2** Storage at the End of Time Interval
- **x** Coefficient x in the Equation
- **ΔSv** Change in Storage Volumes
- **Δt** Time Interval *(Second)*

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