Important Indirect Methods of Streamflow Measurement Formulas PDF

Formulas
Examples
with Units

List of 33
Important Indirect Methods of Streamflow Measurement Formulas

1) Flow Measuring Structures Formulas

1.1) Discharge at Structure Formula

Evaluate Formula

Formula

$$Q_f = k \cdot \left(H^{n_{system}} \right)$$

Example with Units

$$35.9632\,\text{m}^3/\text{s} = 2 \cdot \left(3\,\text{m}^{2.63} \right)$$

1.2) Free Flow Discharge under Head using Submerged Flow over Weir Formula

Evaluate Formula

Formula

$$Q_1 = \frac{Q_s}{\left(1 - \left(\frac{H_2}{H_1} \right)^{n_{head}} \right)^{0.385}}$$

Example with Units

$$20.0067\,\text{m}^3/\text{s} = \frac{19\,\text{m}^3/\text{s}}{\left(1 - \left(\frac{5\,\text{m}}{10.01\,\text{m}} \right)^{2.99\,\text{m}} \right)^{0.385}}$$

1.3) Head over Weir given Discharge Formula

Evaluate Formula

Formula

$$H = \left(\frac{Q_f}{k} \right)^{\frac{1}{n_{system}}}$$

Example with Units

$$2.8002\,\text{m} = \left(\frac{30.0\,\text{m}^3/\text{s}}{2} \right)^{\frac{1}{2.63}}$$

1.4) Submerged Flow over Weir using Villemonte Formula Formula

Evaluate Formula

Formula

$$Q_s = Q_1 \cdot \left(1 - \left(\frac{H_2}{H_1} \right)^{n_{head}} \right)^{0.385}$$

Example with Units

$$18.9937\,\text{m}^3/\text{s} = 20\,\text{m}^3/\text{s} \cdot \left(1 - \left(\frac{5\,\text{m}}{10.01\,\text{m}} \right)^{2.99\,\text{m}} \right)^{0.385}$$

2) Slope Area Method Formulas

2.1) Eddy Loss Formula

Evaluate Formula

Formula

$$h_e = \left(h_1 - h_2 \right) + \left(\frac{V_1^2}{2 \cdot g} - \frac{V_2^2}{2 \cdot g} \right) - h_f$$

Example with Units

$$15.9694 = \left(50\,\text{m} - 20\,\text{m} \right) + \left(\frac{10\,\text{m/s}^2}{2 \cdot 9.8\,\text{m/s}^2} - \frac{9\,\text{m/s}^2}{2 \cdot 9.8\,\text{m/s}^2} \right) - 15$$

2.2) Frictional Loss Formula

Evaluate Formula

Formula

$$h_f = \left(h_1 - h_2 \right) + \left(\frac{V_1^2}{2 \cdot g} - \frac{V_2^2}{2 \cdot g} \right) - h_e$$

Example with Units

$$30.4334 = \left(50\,\text{m} - 20\,\text{m} \right) + \left(\frac{10\,\text{m/s}^2}{2 \cdot 9.8\,\text{m/s}^2} - \frac{9\,\text{m/s}^2}{2 \cdot 9.8\,\text{m/s}^2} \right) - 0.536$$

2.3) Head loss in Reach Formula

Evaluate Formula

Formula

$$h_l = Z_1 + y_1 + \left(\frac{V_1^2}{2 \cdot g} \right) - Z_2 - y_2 - \frac{V_2^2}{2 \cdot g}$$

Example with Units

$$2.4694\,\text{m} = 11.5\,\text{m} + 14\,\text{m} + \left(\frac{10\,\text{m/s}^2}{2 \cdot 9.8\,\text{m/s}^2} \right) - 11\,\text{m} - 13\,\text{m} - \frac{9\,\text{m/s}^2}{2 \cdot 9.8\,\text{m/s}^2}$$

2.4) Non Uniform Flow Formulas

2.4.1) Area of Channel with known Conveyance of Channel at Section 1 Formula

Evaluate Formula

Formula

$$A_1 = \frac{K_1 \cdot n}{R_1^{\frac{2}{3}}}$$

Example with Units

$$494.221\,\text{m}^2 = \frac{1824 \cdot 0.412}{1.875\,\text{m}^{\frac{2}{3}}}$$

2.4.2) Area of Channel with known Conveyance of Channel at Section 2 Formula

Evaluate Formula

Formula

$$A_2 = \frac{K_2 \cdot n}{R_2^{\frac{2}{3}}}$$

Example with Units

$$477.7378\,\text{m}^2 = \frac{1738 \cdot 0.412}{1.835\,\text{m}^{\frac{2}{3}}}$$

2.4.3) Average Conveyance of Channel for Non-Uniform Flow Formula

Evaluate Formula

Formula

$$K_{avg} = \sqrt{K_1 \cdot K_2}$$

Example

$$1780.4808 = \sqrt{1824 \cdot 1738}$$

2.4.4) Average Energy Slope given Average Conveyance for Non-Uniform Flow Formula

Evaluate Formula

Formula

$$S_{favg} = \frac{Q^2}{K^2}$$

Example with Units

$$0.1406 = \frac{3.0\,\text{m}^3/\text{s}^2}{8^2}$$

2.4.5) Average Energy Slope given Frictional Loss Formula

Evaluate Formula

Formula

$$S_{favg} = \frac{h_f}{L}$$

Example with Units

$$0.15 = \frac{15}{100\,\text{m}}$$

2.4.6) Conveyance of Channel at End Sections at 1 Formula

Evaluate Formula

Formula

$$K_1 = \left(\frac{1}{n}\right) \cdot A_1 \cdot R_1^{\frac{2}{3}}$$

Example with Units

$$1823.1843 = \left(\frac{1}{0.412}\right) \cdot 494\,\text{m}^2 \cdot 1.875\,\text{m}^{\frac{2}{3}}$$

2.4.7) Conveyance of Channel at End Sections at 2 Formula

Evaluate Formula

Formula

$$K_2 = \left(\frac{1}{n}\right) \cdot A_2 \cdot R_2^{\frac{2}{3}}$$

Example with Units

$$1738.9539 = \left(\frac{1}{0.412}\right) \cdot 478\,\text{m}^2 \cdot 1.835\,\text{m}^{\frac{2}{3}}$$

2.4.8) Conveyance of Channel for Non-Uniform Flow for End Section Formula

Evaluate Formula

Formula

$$K_2 = \frac{K_{avg}^2}{K_1}$$

Example

$$1737.0614 = \frac{1780^2}{1824}$$

2.4.9) Conveyance of Channel for Non-Uniform Flow for End Sections Formula

Evaluate Formula

Formula

$$K_1 = \frac{K_{avg}^2}{K_2}$$

Example

$$1823.015 = \frac{1780^2}{1738}$$

2.4.10) Conveyance of Channel given Discharge in Non-Uniform Flow Formula

Evaluate Formula

Formula

$$K = \frac{Q}{\sqrt{S_{favg}}}$$

Example with Units

$$2.4495 = \frac{3.0\,\text{m}^3/\text{s}}{\sqrt{1.5}}$$

2.4.11) Discharge in Non-Uniform Flow by Conveyance Method Formula

Evaluate Formula

Formula

$$Q = K \cdot \sqrt{S_{favg}}$$

Example with Units

$$9.798\,\text{m}^3/\text{s} = 8 \cdot \sqrt{1.5}$$

2.4.12) Frictional Loss given Average Energy Slope Formula

Evaluate Formula

Formula

$$h_f = S_{favg} \cdot L$$

Example with Units

$$150 = 1.5 \cdot 100\,\text{m}$$

2.4.13) Length of Reach given Average Energy Slope for Non-Uniform Flow Formula

Evaluate Formula

Formula

$$L = \frac{h_f}{S_{favg}}$$

Example with Units

$$10\,\text{m} = \frac{15}{1.5}$$

2.4.14) Eddy Loss Formulas

2.4.14.1) Eddy Loss for Abrupt Contraction Channel Transition Formula

Evaluate Formula

Formula

$$h_e = 0.6 \cdot \left(\frac{V_1^2}{2 \cdot g} - \frac{V_2^2}{2 \cdot g} \right)$$

Example with Units

$$0.5816 = 0.6 \cdot \left(\frac{10\,\text{m/s}^2}{2 \cdot 9.8\,\text{m/s}^2} - \frac{9\,\text{m/s}^2}{2 \cdot 9.8\,\text{m/s}^2} \right)$$

2.4.14.2) Eddy Loss for Abrupt Expansion Channel Transition Formula

Evaluate Formula

Formula

$$h_e = 0.8 \cdot \left(\frac{V_1^2}{2 \cdot g} - \frac{V_2^2}{2 \cdot g} \right)$$

Example with Units

$$0.7755 = 0.8 \cdot \left(\frac{10\,\text{m/s}^2}{2 \cdot 9.8\,\text{m/s}^2} - \frac{9\,\text{m/s}^2}{2 \cdot 9.8\,\text{m/s}^2} \right)$$

2.4.14.3) Eddy Loss for Gradual Contraction Channel Transition Formula

Evaluate Formula

Formula

$$h_e = 0.1 \cdot \left(\frac{V_1^2}{2 \cdot g} - \frac{V_2^2}{2 \cdot g} \right)$$

Example with Units

$$0.0969 = 0.1 \cdot \left(\frac{10\,\text{m/s}^2}{2 \cdot 9.8\,\text{m/s}^2} - \frac{9\,\text{m/s}^2}{2 \cdot 9.8\,\text{m/s}^2} \right)$$

2.4.14.4) Eddy Loss for Gradual Expansion Channel Transition Formula

Evaluate Formula

Formula

$$h_e = 0.3 \cdot \left(\frac{V_1^2}{2 \cdot g} - \frac{V_2^2}{2 \cdot g} \right)$$

Example with Units

$$0.2908 = 0.3 \cdot \left(\frac{10\,\text{m/s}^2}{2 \cdot 9.8\,\text{m/s}^2} - \frac{9\,\text{m/s}^2}{2 \cdot 9.8\,\text{m/s}^2} \right)$$

2.4.14.5) Eddy Loss for Non-uniform Flow Formula

Evaluate Formula

Formula

$$h_e = K_e \cdot \left(\frac{V_1^2}{2 \cdot g} - \frac{V_2^2}{2 \cdot g} \right)$$

Example with Units

$$0.95 = 0.98 \cdot \left(\frac{10\,\text{m/s}^2}{2 \cdot 9.8\,\text{m/s}^2} - \frac{9\,\text{m/s}^2}{2 \cdot 9.8\,\text{m/s}^2} \right)$$

2.4.14) Uniform Flow Formulas

2.4.14.1) Area of Channel with known Conveyance of Channel Formula

Evaluate Formula

Formula

$$A = \frac{K}{r_H^{\frac{2}{3}}} \cdot \left(\frac{1}{n} \right)$$

Example with Units

$$40.6615\,\text{m}^2 = \frac{8}{0.33\,\text{m}^{\frac{2}{3}}} \cdot \left(\frac{1}{0.412} \right)$$

2.4.14.2) Conveyance of Channel Formula

Evaluate Formula

Formula

$$K = \left(\frac{1}{n} \right) \cdot A \cdot r_H^{\frac{2}{3}}$$

Example with Units

$$13.9089 = \left(\frac{1}{0.412} \right) \cdot 12.0\,\text{m}^2 \cdot 0.33\,\text{m}^{\frac{2}{3}}$$

2.4.14.3) Conveyance of Channel given Energy Slope Formula

Evaluate Formula

Formula

$$K = \sqrt{\frac{Q^2}{S_f}}$$

Example with Units

$$8.0178 = \sqrt{\frac{3.0\,\text{m}^3/\text{s}^2}{0.140}}$$

2.4.14.4) Discharge for Uniform Flow given Energy Slope Formula

Evaluate Formula

Formula

$$Q = K \cdot \sqrt{S_f}$$

Example with Units

$$2.9933\,\text{m}^3/\text{s} = 8 \cdot \sqrt{0.140}$$

2.4.14.5) Energy Slope for Uniform Flow Formula

Evaluate Formula

Formula

$$S_f = \frac{Q^2}{K^2}$$

Example with Units

$$0.1406 = \frac{3.0\,\text{m}^3/\text{s}^2}{8^2}$$

2.4.14.6) Frictional Loss given Energy Slope Formula

Evaluate Formula

Formula

$$h_f = S_f \cdot L$$

Example with Units

$$14 = 0.140 \cdot 100\,\text{m}$$

2.4.14.7) Hydraulic Radius given Conveyance of Channel for Uniform Flow Formula

Evaluate Formula

Formula

$$r_H = \left(\frac{K}{\left(\frac{1}{n}\right) \cdot A} \right)^{\frac{3}{2}}$$

Example with Units

$$0.1439\,\text{m} = \left(\frac{8}{\left(\frac{1}{0.412}\right) \cdot 12.0\,\text{m}^2} \right)^{\frac{3}{2}}$$

2.4.14.8) Length of Reach by Manning's Formula for Uniform Flow Formula

Evaluate Formula

Formula

$$L = \frac{h_f}{S_f}$$

Example with Units

$$107.1429\,\text{m} = \frac{15}{0.140}$$

Variables used in list of Indirect Methods of Streamflow Measurement Formulas above

- **A** Cross-Sectional Area *(Square Meter)*
- A_1 Area of Channel Section 1 *(Square Meter)*
- A_2 Area of Channel Section 2 *(Square Meter)*
- **g** Acceleration due to Gravity *(Meter per Square Second)*
- **H** Head over Weir *(Meter)*
- h_1 Height above Datum at Section 1 *(Meter)*
- H_1 Upstream Water Surface Elevation *(Meter)*
- h_2 Height above Datum at Section 2 *(Meter)*
- H_2 Downstream Water Surface Elevation *(Meter)*
- h_e Eddy Loss
- h_f Frictional Loss
- h_l Head Loss in Reach *(Meter)*
- **k** System Constant k
- **K** Conveyance Function
- K_1 Conveyance of Channel at End Sections at (1)
- K_2 Conveyance of Channel at End Sections at (2)
- K_{avg} Average Conveyance of Channel
- K_e Eddy Loss Coefficient
- **L** Reach *(Meter)*
- **n** Manning's Roughness Coefficient
- n_{head} Exponent of Head *(Meter)*
- n_{system} System Constant n
- **Q** Discharge *(Cubic Meter per Second)*
- Q_1 Free Flow Discharge under Head H1 *(Cubic Meter per Second)*
- Q_f Flow Discharge *(Cubic Meter per Second)*
- Q_s Submerged Discharge *(Cubic Meter per Second)*
- R_1 Hydraulics Radius of Channel Section 1 *(Meter)*

Constants, Functions, Measurements used in list of Indirect Methods of Streamflow Measurement 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: **Area** in Square Meter (m²)
  Area Unit Conversion
- Measurement: **Speed** in Meter per Second (m/s)
  Speed Unit Conversion
- Measurement: **Acceleration** in Meter per Square Second (m/s²)
  Acceleration Unit Conversion
- Measurement: **Volumetric Flow Rate** in Cubic Meter per Second (m³/s)
  Volumetric Flow Rate Unit Conversion

- R_2 Hydraulics Radius of Channel Section 2 *(Meter)*
- r_H Hydraulic Radius *(Meter)*
- S_f Energy Slope
- S_{favg} Average Energy Slope
- V_1 Mean Velocity at End Sections at (1) *(Meter per Second)*
- V_2 Mean Velocity at End Sections at (2) *(Meter per Second)*
- y_1 Height above Channel Slope at 1 *(Meter)*
- y_2 Height above Channel Slope at 2 *(Meter)*
- Z_1 Static Heads at End Sections at (1) *(Meter)*
- Z_2 Static Head at End Sections at (2) *(Meter)*

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9/18/2024 | 12:05:00 PM UTC