Important Unsteady Flow Formulas PDF

Formulas
Examples
with Units

List of 37
Important Unsteady Flow Formulas

1) Discharge in Well Formulas

1.1) Discharge given Drawdown Formula

Evaluate Formula

Formula

$$Q = \frac{4 \cdot \pi \cdot F_c \cdot s_t}{W_u}$$

Example with Units

$$0.9993\,\text{m}^3/\text{s} = \frac{4 \cdot 3.1416 \cdot 0.80\,\text{m}^2/\text{s} \cdot 0.83\,\text{m}}{8.35}$$

1.2) Discharge given Formation Constant T Formula

Evaluate Formula

Formula

$$Q = \frac{F_c}{\frac{2.303}{4 \cdot \pi \cdot \Delta d}}$$

Example with Units

$$1.004\,\text{m}^3/\text{s} = \frac{0.80\,\text{m}^2/\text{s}}{\frac{2.303}{4 \cdot 3.1416 \cdot 0.23\,\text{m}}}$$

1.3) Discharge given Time at 1st and 2nd Instance Formula

Evaluate Formula

Formula

$$Q = \frac{\Delta d}{\frac{2.303 \cdot \log\left(\left(\frac{t_{2sec}}{t1}\right), 10\right)}{4 \cdot \pi \cdot t_{hr}}}$$

Example with Units

$$1.0732\,\text{m}^3/\text{s} = \frac{0.23\,\text{m}}{\frac{2.303 \cdot \log\left(\left(\frac{62\,\text{s}}{58.7\,\text{s}}\right), 10\right)}{4 \cdot 3.1416 \cdot 0.01\,\text{h}}}$$

2) Formation Constant Formulas

2.1) Constant dependent on Well Function given Formation Constant S Formula

Evaluate Formula

Formula

$$u = \frac{F_c}{\frac{4 \cdot T \cdot t_{days}}{\left(d_{radial}\right)^2}}$$

Example with Units

$$0.0567 = \frac{0.80\,\text{m}^2/\text{s}}{\frac{4 \cdot 0.0009\,\text{m}^2/\text{s} \cdot 0.500\,\text{d}}{\left(3.32\,\text{m}\right)^2}}$$

2.2) Formation Constant given Drawdown Formula

Evaluate Formula

Formula

$$F_c = \frac{Q \cdot W_u}{4 \cdot \pi \cdot s_t}$$

Example with Units

$$0.8086\,\text{m}^2/\text{s} = \frac{1.01\,\text{m}^3/\text{s} \cdot 8.35}{4 \cdot 3.1416 \cdot 0.83\,\text{m}}$$

2.3) Formation Constant S Formula

Evaluate Formula

Formula

$$F_c = \frac{4 \cdot u \cdot T \cdot t_{days}}{\left(d_{radial}\right)^2}$$

Example with Units

$$0.8042\,\text{m}^2/\text{s} = \frac{4 \cdot 0.057 \cdot 0.0009\,\text{m}^2/\text{s} \cdot 0.500\,\text{d}}{\left(3.32\,\text{m}\right)^2}$$

2.4) Formation Constant S given Radial Distance Formula

Evaluate Formula

Formula

$$F_{cr} = \frac{2.25 \cdot T \cdot t_{days}}{\left(d_{radial}\right)^2}$$

Example with Units

$$7.9366\,\text{m}^2/\text{s} = \frac{2.25 \cdot 0.0009\,\text{m}^2/\text{s} \cdot 0.500\,\text{d}}{\left(3.32\,\text{m}\right)^2}$$

2.5) Formation Constant T given Change in Drawdown Formula

Evaluate Formula

Formula

$$F_T = \frac{2.303 \cdot Q}{4 \cdot \pi \cdot \Delta d}$$

Example with Units

$$0.8048\,\text{m}^2/\text{s} = \frac{2.303 \cdot 1.01\,\text{m}^3/\text{s}}{4 \cdot 3.1416 \cdot 0.23\,\text{m}}$$

2.6) Formation Constant T given Formation Constant S Formula

Evaluate Formula

Formula

$$T = \frac{F_c}{\frac{4 \cdot u \cdot t_{days}}{\left(d_{radial}\right)^2}}$$

Example with Units

$$0.0009\,\text{m}^2/\text{s} = \frac{0.80\,\text{m}^2/\text{s}}{\frac{4 \cdot 0.057 \cdot 0.500\,\text{d}}{\left(3.32\,\text{m}\right)^2}}$$

2.7) Formation Constant T given Radial Distance Formula

Evaluate Formula

Formula

$$T = \frac{F_c}{\frac{2.25 \cdot t_{days}}{\left(d_{radial}\right)^2}}$$

Example with Units

$$9.1\text{E-}5\,\text{m}^2/\text{s} = \frac{0.80\,\text{m}^2/\text{s}}{\frac{2.25 \cdot 0.500\,\text{d}}{\left(3.32\,\text{m}\right)^2}}$$

3) Radial Distance Formulas

3.1) Radial Distance given Formation Constant S Formula

Evaluate Formula

Formula

$$d_{radial} = \sqrt{\frac{4 \cdot u \cdot T \cdot t_{days}}{F_c}}$$

Example with Units

$$3.3288\,\text{m} = \sqrt{\frac{4 \cdot 0.057 \cdot 0.0009\,\text{m}^2/\text{s} \cdot 0.500\,\text{d}}{0.80\,\text{m}^2/\text{s}}}$$

3.2) Radial Distance given Formation Constant T Formula

Evaluate Formula

Formula

$$d_{radial} = \sqrt{\frac{2.25 \cdot T \cdot t_{days}}{F_{cr}}}$$

Example with Units

$$3.3214\,\text{m} = \sqrt{\frac{2.25 \cdot 0.0009\,\text{m}^2/\text{s} \cdot 0.500\,\text{d}}{7.93\,\text{m}^2/\text{s}}}$$

4) Rate of Change of Height Formulas

4.1) Rate of Change of Height given Radius of Elementary Cylinder Formula

Evaluate Formula

Formula

$$\delta h \delta t = \frac{\delta V \delta t}{2 \cdot \pi \cdot r \cdot dr \cdot S}$$

Example with Units

$$0.0523\,\text{m/s} = \frac{0.92\,\text{cm}^3/\text{s}}{2 \cdot 3.1416 \cdot 3.33\,\text{m} \cdot 0.7\,\text{m} \cdot 1.2}$$

4.2) Rate of Change of Height given Rate of Change of Volume Formula

Evaluate Formula

Formula

$$\delta h \delta t = \frac{\delta V \delta t}{\left(A_q\right) \cdot S}$$

Example with Units

$$0.0153\,\text{m/s} = \frac{0.92\,\text{cm}^3/\text{s}}{\left(50\,\text{m}^2\right) \cdot 1.2}$$

5) Rate of Change of Volume Formulas

5.1) Area of Aquifer given Rate of Change of Volume Formula

Evaluate Formula

Formula

$$A_{aq} = \frac{\delta V \delta t}{\left(\delta h \delta t\right) \cdot S}$$

Example with Units

$$15.3333\,\text{m}^2 = \frac{0.92\,\text{cm}^3/\text{s}}{\left(0.05\,\text{m/s}\right) \cdot 1.2}$$

5.2) Change in Radius of Elementary Cylinder given Rate of change of Volume Formula

Evaluate Formula

Formula

$$dr = \frac{\delta V \delta t}{2 \cdot \pi \cdot r \cdot S \cdot \delta h \delta t}$$

Example with Units

$$0.7328\,\text{m} = \frac{0.92\,\text{cm}^3/\text{s}}{2 \cdot 3.1416 \cdot 3.33\,\text{m} \cdot 1.2 \cdot 0.05\,\text{m/s}}$$

5.3) Radius of Elementary Cylinder given Rate of change of Volume Formula

Evaluate Formula

Formula

$$r = \frac{\delta V \delta t}{2 \cdot \pi \cdot dr \cdot S \cdot \delta h \delta t}$$

Example with Units

$$3.4863\,\text{m} = \frac{0.92\,\text{cm}^3/\text{s}}{2 \cdot 3.1416 \cdot 0.7\,\text{m} \cdot 1.2 \cdot 0.05\,\text{m/s}}$$

5.4) Rate of Change of Volume given Radius of Elementary Cylinder Formula

Evaluate Formula

Formula

$$\delta V\delta t = \left(2 \cdot \pi \cdot r \cdot dr \cdot S \cdot \delta h\delta t\right)$$

Example with Units

$$0.8788\,\text{cm}^3/\text{s} = \left(2 \cdot 3.1416 \cdot 3.33\,\text{m} \cdot 0.7\,\text{m} \cdot 1.2 \cdot 0.05\,\text{m/s}\right)$$

5.5) Rate of Change of Volume given Storage Coefficient Formula

Evaluate Formula

Formula

$$\delta V\delta t = \left(\delta h\delta t\right) \cdot S \cdot A_{aq}$$

Example with Units

$$0.9198\,\text{cm}^3/\text{s} = \left(0.05\,\text{m/s}\right) \cdot 1.2 \cdot 15.33\,\text{m}^2$$

6) Storage Coefficient Formulas

6.1) Storage Coefficient given Radius of Elementary Cylinder Formula

Evaluate Formula

Formula

$$S = \frac{\delta V\delta t}{-\left(-2 \cdot \pi \cdot r \cdot dr \cdot \delta h\delta t\right)}$$

Example with Units

$$1.2563 = \frac{0.92\,\text{cm}^3/\text{s}}{-\left(-2 \cdot 3.1416 \cdot 3.33\,\text{m} \cdot 0.7\,\text{m} \cdot 0.05\,\text{m/s}\right)}$$

6.2) Storage Coefficient given Rate of Change of Volume Formula

Evaluate Formula

Formula

$$S = \frac{\delta V\delta t}{-\left(-\delta h\delta t\right) \cdot A_{aq}}$$

Example with Units

$$1.2003 = \frac{0.92\,\text{cm}^3/\text{s}}{-\left(-0.05\,\text{m/s}\right) \cdot 15.33\,\text{m}^2}$$

7) Chow's Function Formulas

7.1) Chow's Function given Constant dependent on Well Function Formula

Evaluate Formula

Formula

$$F_u = \frac{W_u \cdot \exp\left(u\right)}{2.303}$$

Example

$$3.8384 = \frac{8.35 \cdot \exp\left(0.057\right)}{2.303}$$

7.2) Chow's Function given Well Function Formula

Evaluate Formula

Formula

$$F_u = \frac{W_u}{2.303}$$

Example

$$3.6257 = \frac{8.35}{2.303}$$

8) Drawdown and Change in Drawdown Formulas

8.1) Change in Drawdown given Chow's Function Formula

Evaluate Formula

Formula

$$\Delta d = \frac{s_t}{F_u}$$

Example with Units

$$0.2167\,\text{m} = \frac{0.83\,\text{m}}{3.83}$$

8.2) Change in Drawdown given Formation Constant T Formula

Evaluate Formula

Formula

$$\Delta d = \frac{2.303 \cdot Q}{4 \cdot \pi \cdot F_c}$$

Example with Units

$$0.2314\,\text{m} = \frac{2.303 \cdot 1.01\,\text{m}^3/\text{s}}{4 \cdot 3.1416 \cdot 0.80\,\text{m}^2/\text{s}}$$

8.3) Change in Drawdown given Time at 1st and 2nd Instance Formula

Evaluate Formula

Formula

$$\Delta s = \frac{2.303 \cdot Q \cdot \log\left(\left(\frac{t2}{t_1}\right), 10\right)}{4 \cdot \pi \cdot t_{hr}}$$

Example with Units

$$0.0171\,\text{m} = \frac{2.303 \cdot 1.01\,\text{m}^3/\text{s} \cdot \log\left(\left(\frac{240\,\text{s}}{120\,\text{s}}\right), 10\right)}{4 \cdot 3.1416 \cdot 0.01\,\text{h}}$$

8.4) Chow's Function given Drawdown Formula

Evaluate Formula

Formula

$$F_u = \frac{s_t}{\Delta d}$$

Example with Units

$$3.6087 = \frac{0.83\,\text{m}}{0.23\,\text{m}}$$

8.5) Drawdown given Chow's Function Formula

Evaluate Formula

Formula

$$s_t = F_u \cdot \Delta d$$

Example with Units

$$0.8809\,\text{m} = 3.83 \cdot 0.23\,\text{m}$$

8.6) Drawdown given Well Function Formula

Evaluate Formula

Formula

$$s_t = \frac{Q \cdot W_u}{4 \cdot \pi \cdot F_c}$$

Example with Units

$$0.8389\,\text{m} = \frac{1.01\,\text{m}^3/\text{s} \cdot 8.35}{4 \cdot 3.1416 \cdot 0.80\,\text{m}^2/\text{s}}$$

9) Time of Flow Formulas

9.1) Time at 1st Instance since Pumping Started given Discharge Formula

Evaluate Formula

Formula

$$t1 = \frac{t2}{10^{\frac{\Delta s}{\frac{2.303 \cdot Q}{4 \cdot \pi \cdot t_{seconds}}}}}$$

Example with Units

$$59.5843\,\text{s} = \frac{240\,\text{s}}{10^{\frac{0.014\,\text{m}}{\frac{2.303 \cdot 1.01\,\text{m}^3/\text{s}}{4 \cdot 3.1416 \cdot 8\,\text{s}}}}}$$

9.2) Time at 2nd Instance since Pumping Started given Discharge Formula

Evaluate Formula

Formula

$$t2 = t1 \cdot 10^{\frac{\Delta s}{\frac{2.303 \cdot Q}{4 \cdot \pi \cdot t_{seconds}}}}$$

Example with Units

$$236.4383\,\text{s} = 58.7\,\text{s} \cdot 10^{\frac{0.014\,\text{m}}{\frac{2.303 \cdot 1.01\,\text{m}^3/\text{s}}{4 \cdot 3.1416 \cdot 8\,\text{s}}}}$$

9.3) Time given Formation Constant S Formula

Evaluate Formula

Formula

$$t_{days} = \frac{S_c}{\frac{4 \cdot u \cdot T}{\left(d_{radial}\right)^2}}$$

Example with Units

$$0.9326\,\text{d} = \frac{1.50}{\frac{4 \cdot 0.057 \cdot 0.0009\,\text{m}^2/\text{s}}{\left(3.32\,\text{m}\right)^2}}$$

9.4) Time in Days given Radial Distance Formula

Evaluate Formula

Formula

$$t_{days} = \frac{S_c}{\frac{2.25 \cdot T}{\left(d_{radial}\right)^2}}$$

Example with Units

$$0.0945\,\text{d} = \frac{1.50}{\frac{2.25 \cdot 0.0009\,\text{m}^2/\text{s}}{\left(3.32\,\text{m}\right)^2}}$$

9.5) Time in Hours given Time at 1st and 2nd Instance since Pumping Started Formula

Evaluate Formula

Formula

$$t_{hour} = \frac{2.303 \cdot Q \cdot \log\left(\left(\frac{t_{2sec}}{t1}\right), 10\right)}{4 \cdot \pi \cdot \Delta s}$$

Example with Units

$$0.1546\,\text{h} = \frac{2.303 \cdot 1.01\,\text{m}^3/\text{s} \cdot \log\left(\left(\frac{62\,\text{s}}{58.7\,\text{s}}\right), 10\right)}{4 \cdot 3.1416 \cdot 0.014\,\text{m}}$$

10) Well Function Formulas

10.1) Well Function given Chow's Function Formula

Evaluate Formula

Formula

$$W_u = F_u \cdot 2.303$$

Example

$$8.8205 = 3.83 \cdot 2.303$$

10.2) Well Function given Constant dependent on Well Function and Chow's Function Formula

Evaluate Formula

Formula

$$W_u = \frac{2.303 \cdot F_u}{\exp\left(u\right)}$$

Example

$$8.3318 = \frac{2.303 \cdot 3.83}{\exp\left(0.057\right)}$$

10.3) Well Function given Drawdown Formula

Evaluate Formula

Formula

$$W_u = \frac{4 \cdot \pi \cdot F_T \cdot s_t}{Q}$$

Example with Units

$$8.3028 = \frac{4 \cdot 3.1416 \cdot 0.804\,\text{m}^2/\text{s} \cdot 0.83\,\text{m}}{1.01\,\text{m}^3/\text{s}}$$

Variables used in list of Unsteady Flow Formulas above

- A_{aq} Aquifer Area *(Square Meter)*
- A_q Area of Aquifer *(Square Meter)*
- d_{radial} Radial Distance *(Meter)*
- **dr** Change in Radius of Elementary Cylinder *(Meter)*
- F_c Formation Constant for Unsteady Flow *(Square Meter per Second)*
- F_{cr} Formation Constant S given Radial Distance *(Square Meter per Second)*
- F_T Formation Constant T given Change in Drawdown *(Square Meter per Second)*
- F_u Chow's Function
- **Q** Discharge *(Cubic Meter per Second)*
- **r** Radius of Elementary Cylinder *(Meter)*
- **S** Storage Coefficient
- S_c Formation Constant S
- s_t Total Drawdown in Well *(Meter)*
- **T** Formation Constant T *(Square Meter per Second)*
- t_1 Time of Drawdown (t1) *(Second)*
- t_{2sec} Time of Drawdown (t2) in Wells *(Second)*
- t_{days} Time in Days *(Day)*
- t_{hour} Time in Hours *(Hour)*
- t_{hr} Time in Hours for Well Discharge *(Hour)*
- $t_{seconds}$ Time in Seconds *(Second)*
- **t1** Time of Drawdown (t1) in Wells *(Second)*
- **t2** Time of Drawdown *(Second)*
- **u** Well Function Constant
- W_u Well Function of u
- **Δd** Change in Drawdown *(Meter)*
- **δhδt** Rate of Change of Height *(Meter per Second)*
- **Δs** Difference in Drawdowns *(Meter)*

Constants, Functions, Measurements used in list of Unsteady Flow Formulas above

- constant(s): **pi**, 3.14159265358979323846264338327950288 *Archimedes' constant*
- Functions: **exp**, exp(Number) *n an exponential function, the value of the function changes by a constant factor for every unit change in the independent variable.*
- Functions: **log**, log(Base, Number) *Logarithmic function is an inverse function to exponentiation.*
- 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), Hour (h), Day (d) *Time Unit Conversion*
- Measurement: **Area** in Square Meter (m²) *Area Unit Conversion*
- Measurement: **Speed** in Meter per Second (m/s) *Speed Unit Conversion*
- Measurement: **Volumetric Flow Rate** in Cubic Meter per Second (m³/s), Cubic Centimeter per Second (cm³/s) *Volumetric Flow Rate Unit Conversion*
- Measurement: **Kinematic Viscosity** in Square Meter per Second (m²/s) *Kinematic Viscosity Unit Conversion*

- **δVδt** Rate of Change of Volume *(Cubic Centimeter per Second)*

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