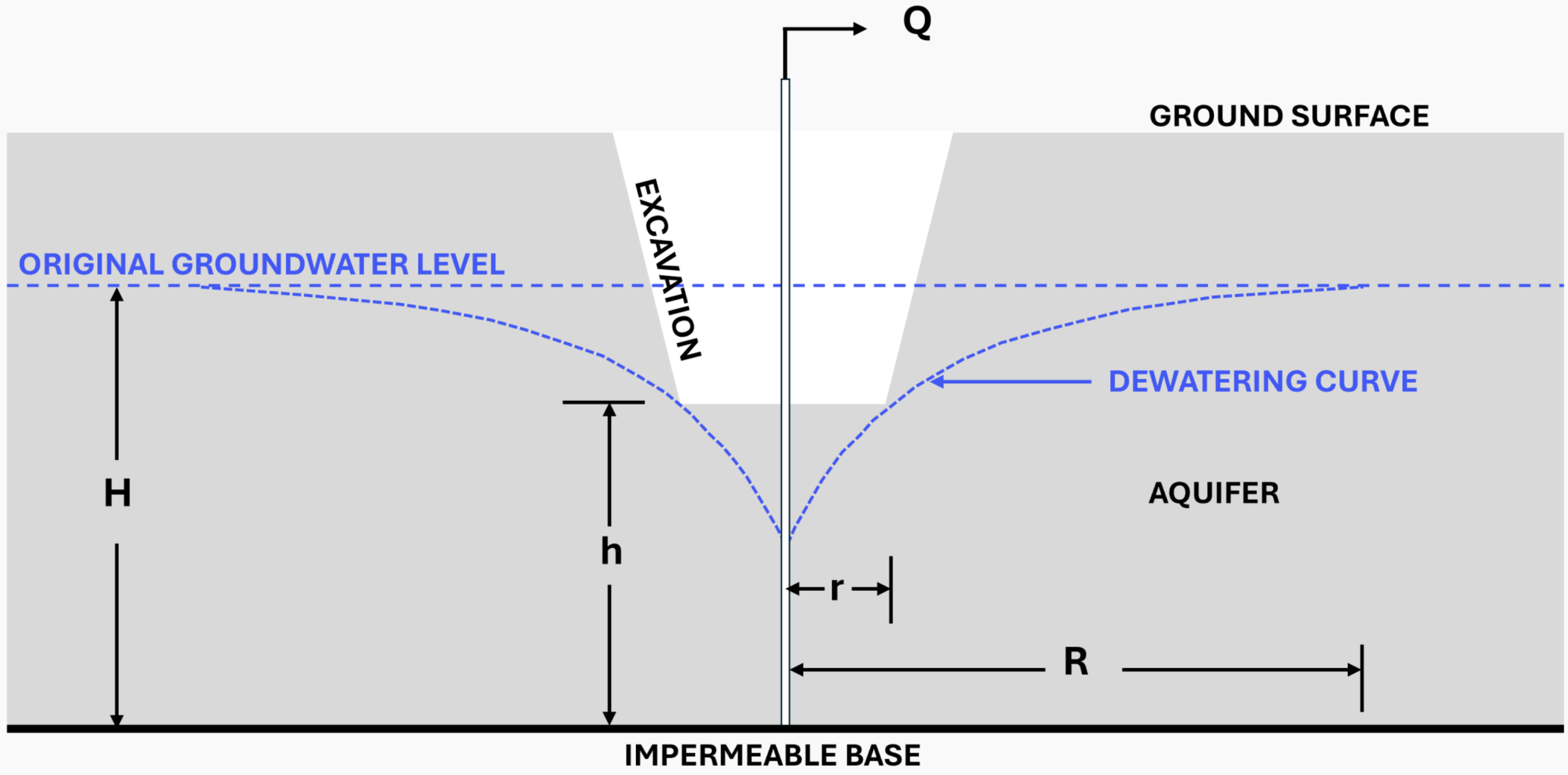
# Dewatering Model by Equivalent Well Method

## Application: Unconfined Aquifer




$$Q = \frac{\pi K \left(H^2 - h_r^2\right)}{\ln\left(\frac{R}{r}\right)}$$

### Flow Rate (Q)

Estimate pumping rate needed to control groundwater in excavation or pit.

### Dewatered Thickness (h)

Approximate the dewatered aquifer thickness at any distance beyond the pit.

$$h = \sqrt{H^2 - \frac{Q \ln\left(\frac{R}{r}\right)}{\pi K}}$$



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## When to use it

Use this method when you need a quick estimate of dewatering flow and groundwater level change around an excavation.

Typical applications include:

- Construction dewatering
- Quarries
- Open-Pit Mines

## Equivalent Well Method

This method is widely used in dewatering practice, although the original source is not credited.

It simplifies an excavation or pit as a large-diameter well inside a drawdown cone. While that geometry is not physically realistic, it can still give results that are close to actual field performance.

The method is usually presented only in steady-state form. In this cheat sheet, we extend it to transient conditions by introducing a time-dependent radius of influence, which makes it more useful for short-term dewatering problems.

## What you need

**Aquifer properties:**

- Hydraulic conductivity
- Specific yield for the transient calculation
- Saturated thickness and depth

**Excavation properties:**

- Length, width, and depth

## Limitations

- Applicable when an excavation or pit in an unconfined aquifer can be treated as a single-layer problem and simplified to an equivalent circle.
- It is best suited to excavations with a length-to-width ratio of about 1.5 or less.
- It can estimate groundwater level change around the excavation, but not inside it.
- A radius of influence must be defined, but that is not always straightforward because it changes with time and can be estimated in several ways.



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# Model Equations & Variables

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## Dewatered Thickness (h)

Approximate the dewatered aquifer thickness at any distance beyond the pit.

| Symbol | Units | Description |
|---|---|---|
| **H** | L | The initial aquifer thickness |
| **h** | L | The resulting dewatered aquifer thickness at distance ‘r’ |
| **r** | L | Any specified distance from centre of excavation |
| **R** | L | Radius of influence due to pumping |
| **K** | L/T | Hydraulic conductivity of the aquifer |
| **Q** | $L^3/T$ | Pumping rate |



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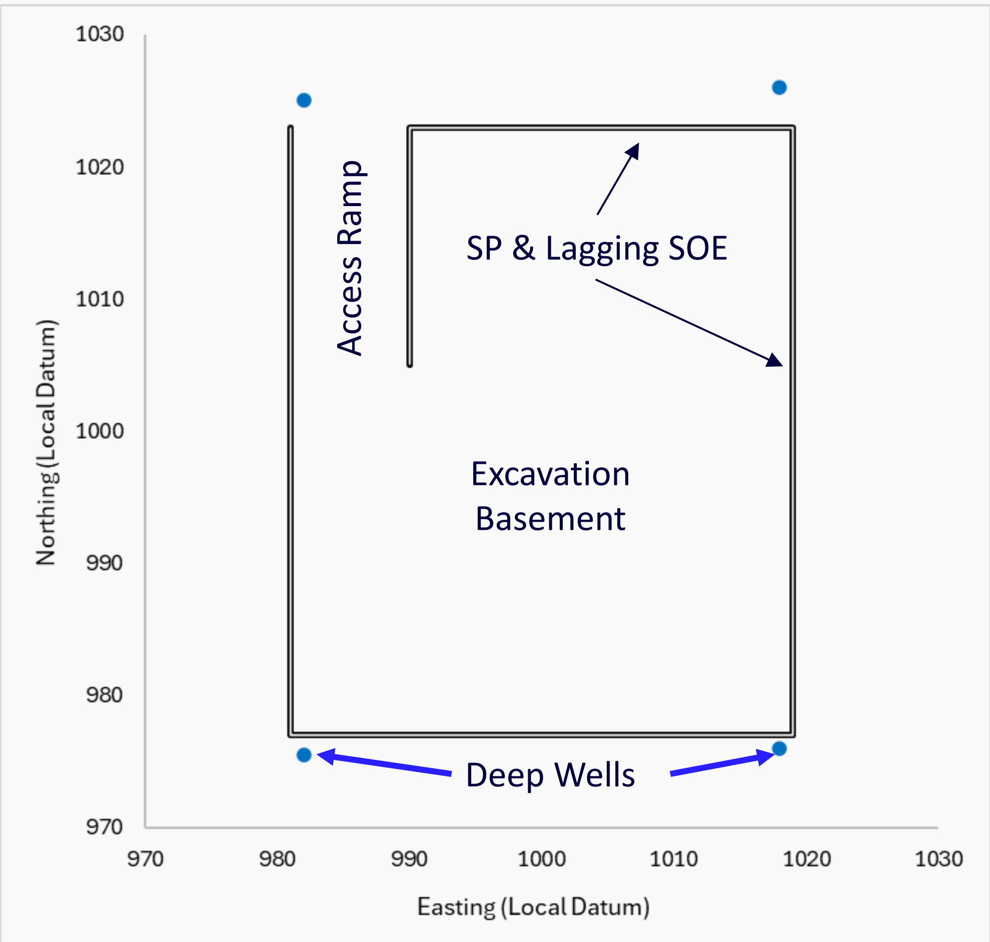
# Case study

This case study is based on a 2013 construction dewatering project in Washington State, USA. Although the original project used U.S. customary units, all values have been converted to SI units for this cheat sheet. The excavation was 46 m × 38 m and 11 m deep, with vertical walls supported by soldier pile and lagging. The site was dewatered using four deep wells with submersible pumps. Using a local datum with ground surface set at 100 m, the initial groundwater level was 98.3 m and the target dewatering level was 88.7 m.

The site was excavated in an unconfined gravel-and-sand aquifer with fines. A pumping test reported a transmissivity of 503 m²/d and a specific yield of 0.17. Because the full aquifer thickness was not confirmed by drilling, the gravel-and-sand unit thickness was estimated at about 30 m from regional surficial geology maps. This corresponds to an initial saturated thickness of about 28.3 m and an estimated hydraulic conductivity of about 17.8 m/d, based on the measured transmissivity.

## Site Layout:




## General Lithology:

| Elev. (m) | Visual Column | GW Elev. | Excavation Basement | Dewater Target Elev. | USCS Description | General Description |
|---|---|---|---|---|---|---|
| 100 | | | | | | |
| 97.9 | | ▽ 98.3 | | | GM | Gravel and sand with fines (Fill) |
| 72.6 | | | 89 | ▽ 88.7 | GM | Gravel and sand with fines |
| | EoH | | | | | |



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# Example Calculation – Pumping Rate on Day 15

**Step 1:** Calculate the equivalent well radius

$$\mathbf{A = L \times W = 46 \times 38 = 1748\ m^2}$$

$$\mathbf{r_{eq} = \sqrt{\frac{A}{\pi}} = \sqrt{\frac{1748}{\pi}} = 23.59\ m}$$

**Step 2:** Calculate the radius of influence at the selected time or use a steady-state radius of influence estimate. Example calculation uses the Weber formula – see notes.

$$\mathbf{R_{Day\_15} = 2.45\sqrt{\frac{(28.3)(17.77)(15)}{0.17}} = 516m}$$

*The radius of influence must be greater than the equivalent well radius, so early-time transient calculations are not possible, but the results can be extrapolated back in time.

**Step 3**: Calculate the pumping rate using the computed radius of influence.

$$\mathbf{Q_{Day\_15} = \frac{\pi(17.77)\left(28.3^2 - 18.7^2\right)}{\ln\left(\frac{516.10}{23.59}\right)} = 8160\ m^3/d}$$

**Optional Step 4:** Calculate groundwater head at the selected time for any point between the excavation and the radius of influence.

$$\mathbf{h = \sqrt{H^2 - \frac{Q\ \ln\left(\frac{R}{r}\right)}{\pi K}}}$$

# Results

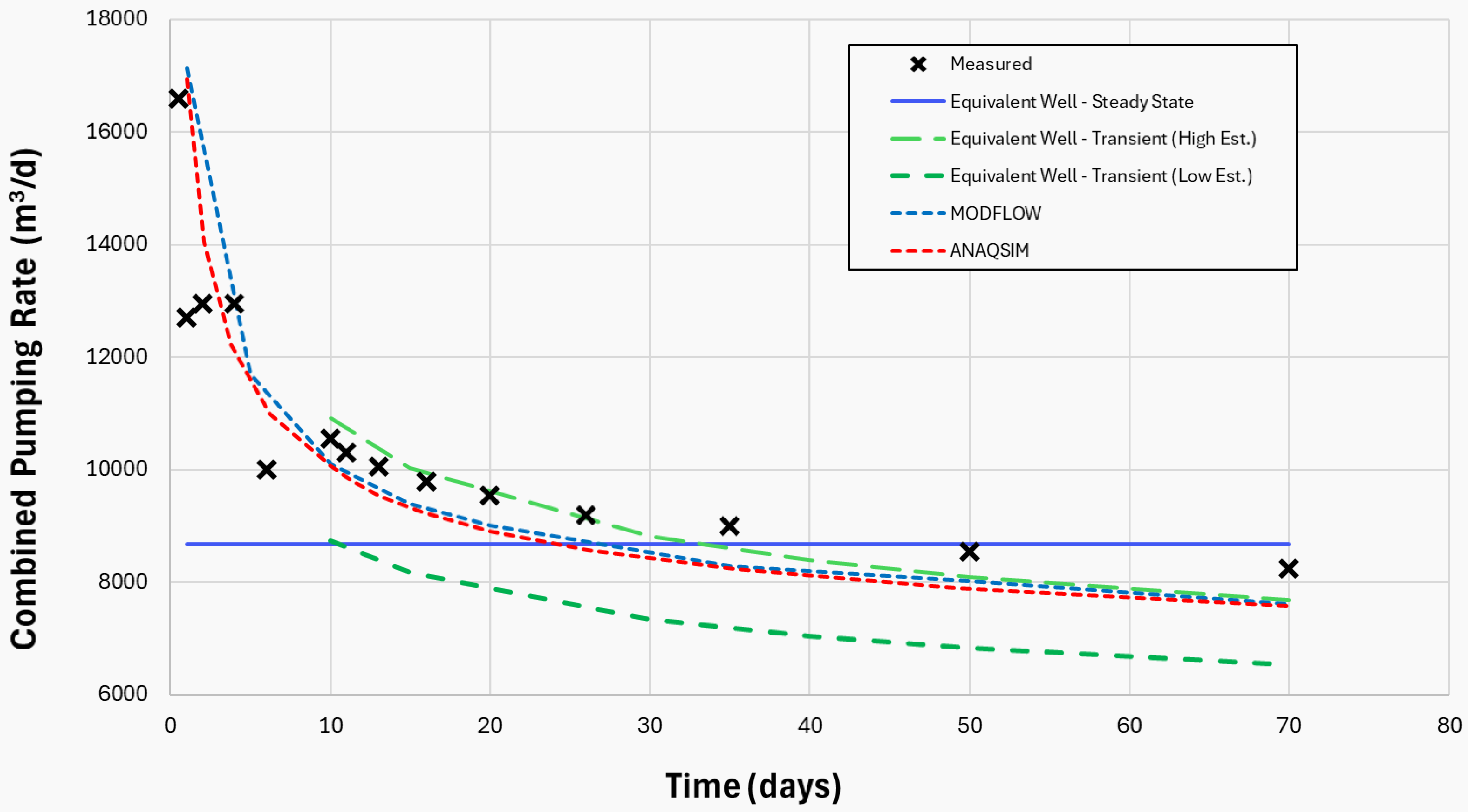
The graph on the next card compares the simulated change in pumping rate over time against the measured pumping rate from the field. The measured rate is the combined total from all four pumps.

**For the transient equivalent well method,** two lines are shown to represent the upper and lower range of results from several radius of influence equations. Presenting a range is a practical way to handle uncertainty in the radius of influence estimate. In this case study, the transient equivalent well method captures the measured pumping rates within the modelled range. These curves begin on day 10 because the transient results cannot be computed until the radius of influence becomes larger than the equivalent well radius. However, the plots can be extrapolated backward to estimate early-time pumping rates.

**The steady-state equivalent well method** substantially underestimates the initial pumping rate required to remove water from storage in this case study. It is therefore not well suited to well-field design or equipment sizing, but this is to be expected from a steady-state calculation. It becomes more reasonable as pumping continues and may still be useful for longer-term planning.

**For comparison, two numerical models were also included**. These show good agreement at early time but later underpredict pumping. According to the post-audit on the project, this underprediction likely reflects an increase in aquifer transmissivity to the east that became evident in the observation well data after about two weeks of pumping but was not identified in the original pumping test.

# Measured & Simulated Pumping Rate over time



# Notes

## Radius of influence (R)

There are many equations available to calculate the radius of influence. Exactly what the radius of influence represents in the real world is debatable, but in this dewatering model it is simply a mathematical boundary required for the calculation.

The following R equations were used in this case study example:

$$\text{Sichardt Equation: } R = 3000\, \mathrm{h}_w \sqrt{K} \text{ [steady state]}$$

$$\text{Weber Equation: } R = 2.45 \sqrt{\frac{HKt}{n_e}}$$

$$\text{Aarovin \& Numerov Equation: } R = \sqrt{1.9 \frac{HKt}{n_e}}$$

**Where:**

$K$ = hydraulic conductivity

$h_w$ = dewatered saturated thickness at the excavation edge

$H$ = initial aquifer thickness

$t$ = time

$n_e$ = specific yield of the aquifer

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