Calculating Hydraulic Conductivity from Specific Capacity Information on Well Log Test Data

The specific capacity of a well is the discharge rate divided by the total drawdown during pumping. That information is information typically available on well drillers log in the Montana Bureau of Mines and Geology (MBMG) Groundwater Information Center (GWIC) (https://mbmggwic.mtech.edu/). When specific capacity of a well is acceptable to estimate hydraulic conductivity, the following equations and guidelines shall be used.

EQUATION #1 [Modified Cooper-Jacob Equation (Driscoll, 1986)]:

$$T = [(Q/s)(1500)] / 7.48$$

where:

T = transmissivity (feet^2/day)

Q = pumping rate (gallons per minute)

s = drawdown (feet). This is the difference between static water level and pumping water level on the well log. If the well log lists the drawdown during the test, use that value for drawdown. If drawdown is not recorded on the well log, the drawdown should be determined as follows:

- If the pumping water level is recorded, the drawdown is the pumping water level minus the static water level;
- If the pumping water level is not recorded, and only the pump depth or drill stem depth is recorded on the well log, then the pump depth or drill stem depth is conservatively estimated to be equal to the pumping water level. Drawdown is calculated as that estimated pumping water level minus the static water level; or
- If the pumping water level, pump depth and drill stem depth are not recorded, the pumping water level is conservatively estimated as one foot above the bottom of the well. Drawdown is calculated as that estimated pumping level minus the static water level.

1500 = factor used for unconfined aquifer. Use 2000 if the aquifer is confirmed as confined.

7.48 Unit conversion factor to provide T in feet^2/day.

Note- if the drawdown is less than 2-3 feet, the well log may not be suitable for calculation of transmissivity from specific capacity (with either method), due to potentially high relative error. Please verify with DEQ before proceeding.

EQUATION #2 [Razack - Huntley Equation (Razack and Huntley, 1991 as cited in Fetter, 1994)]:

This equation is designed only for use in unconsolidated geologic units (e.g. unconsolidated boulder, cobble, gravel, sand, silt, and clay units). It is not designed for and shall not be used for consolidated geologic units where flow is primarily through discrete fractures (e.g. rock and bedrock units).

$$\mathbf{T = (33.6)\left(\left[((Q)(192.5))/s\right]^{0.67}\right)}$$

where:

T = transmissivity (feet^2/day)
Q = pumping rate (gallons per minute).
s = drawdown (feet). See notes for calculating "s" in Equation #1.
192.5 = Pumping rate unit conversion factor to convert from gallons per minute to feet^3/day.
33.6 = Formula factor

EQUATION #3 [Convert T in above equations to hydraulic conductivity (K)]:

$$\mathbf{K = T/b}$$

where:

K = hydraulic conductivity (feet/day)
T = transmissivity (feet^2/day)
b = aquifer thickness (feet). Aquifer thickness is dependent on whether the well is completed with: 1) a perforated casing (or screen); 2) an open bottom (also known as an open casing); or, 3) an open hole. An open bottom well is completed by extending the well casing to the bottom of the borehole with no casing perforations, all water enters through the bottom of the casing. An open hole well is completed by continuing to drill a borehole beyond the bottom of the casing, this type of well is typically drilled into bedrock which allows the borehole to remain open without a casing. The aquifer thickness used for each type of well is listed as follows:

WELL COMPLETION	AQUIFER THICKNESS (b)
Perforated or Screened	Perforation/screen thickness (Morgan, et. al., 2007) – Minimum of 10 feet
Open Bottom	10 feet
Open Hole	Open hole length (distance from bottom of casing to bottom of borehole) – Minimum of 10 feet
Perforated/screen and open hole	Sum of the perforated/screen length and the open hole length – Minimum of 10 feet

Note that these estimates for aquifer thickness are only to be used for short test durations (up to several hours). Actual aquifer pumping tests (24 hours or more) require more detailed calculations (Weight and Sonderegger, 2001).

REFERENCES:

Driscoll, F.G., 1986. Groundwater and Wells, 2nd Edition. Johnson Screens, St. Paul, MN. 1089 p.

Fetter, C.W., 1994. Applied Hydrogeology, 3rd Edition. Prentice-Hall, Inc. 691 p.

Morgan, David S., Stephen R. Hinkle and Rodney J. Weick. 2007. Evaluation of Approaches for Managing Nitrate Loading from On-Site Wastewater Systems near LaPine, Oregon. USGS Scientific Investigations Report 2007-5237.

Razack, M. and D. Huntley. 1991. Assessing Transmissivity from Specific Capacity in a Large and Heterogeneous Alluvial Aquifer. Ground Water Vol 29, No. 6, pp.856-861.

Weight, W.D. and J.L. Sonderegger, 2001. Manual of Applied Field Hydrogeology. McGraw-Hill. 609 p.