In-Situ Inc.

Innovations in Water Monitoring

Technical Note

Calculating Barometric Efficiency in a Confined Aquifer

Using a BaroTROLL® Instrument with a gauged (vented) Level TROLL® Instrument to calculate and correct water levels influenced by barometric efficiency

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Why Measure Barometric (Atmospheric) Pressure When Using Gauged (Vented) Pressure Loggers?

Gauged (vented) pressure loggers are preferred for groundwater level monitoring to obtain higher accuracy and stable measurements, and to obtain a single water level measurement without the time-consuming need for post-compensation of data. There are, however, some situations when separate measurement of barometric pressure can help you investigate anomalous water level fluctuations. Adding this single correction factor to data from a gauged sensor, instead of the dual correction needed with data from an absolute sensor, allows for a higher level of accuracy in the resulting measurements.

Water levels measured in wells penetrating confined aquifers at depth can incorrectly record the real piezometric pressure in the aquifer adjacent to the well screen. This is due to the difference in pressure being transmitted directly to the free surface of a well and the pressure being transmitted to groundwater in the aquifer itself (Ferris et al. 1962). When barometric pressure increases over an aquifer penetrated by a tightly cased well, the water level in the well decreases. Conversely, when the barometric pressure decreases over the same aquifer, the water level increases (Landmeyer 1996). Similar effects can be observed in shallow unconfined aquifers (Chow 1964), however, these are usually less significant, though they can be investigated using similar methodology.

The most commonly used method to correct for the barometric pressure effect on groundwater level is through the calculation of "barometric efficiency." This requires data from concurrent barometric and gauged sensor measurements. In practice, estimates can be determined in a few days. By recording both level and barometric pressure changes, the groundwater level data can be post-corrected for accuracy using the methods described below.

What is Barometric Efficiency?

Barometric efficiency can be described as the ratio of well water level change to barometric pressure change. Barometric efficiency is expressed by the equation:

$$BE = \Delta h/(\Delta Pa/\rho g)$$

Where:

- **BE** = barometric efficiency
- **Δh** = change in piezometric water level
- **ΔPa** = change in atmospheric pressure
- **ρg** = density of fluid

Theoretically, a well with a full response to changes in barometric pressure would have a barometric efficiency of 100 percent and a well unaffected by changes in barometric pressure would have a barometric efficiency of 0 percent. Typically, barometric efficiency values range from 20 to 70 percent (Todd 1980).

How Can I Calculate Barometric Efficiency?

In its simplest form, barometric efficiency can be determined by plotting the incremental atmospheric pressure changes on the x-axis and the incremental water level changes on the y-axis. The water level changes are those recorded directly using a gauged logger. The slope of the resulting line is the barometric efficiency (Gonthier 2007). Figure 1 shows an example of this method for a well in Marietta, Georgia (Gonthier 2007). In some cases, a delay in the response of the water level to the barometric pressure change (time lag) may occur and will require an additional time shift adjustment in the two sets of data.

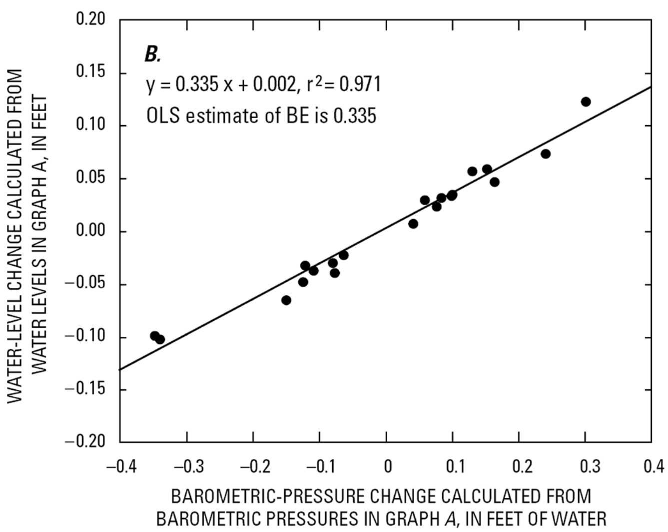

Figure 1. Plot of water changes vs. barometric pressure changes. The slope, or barometric efficiency, equals 0.335 (Gonthier 2007).

Figures 2 and 3 show examples of uncorrected and corrected water level data. Data was collected with Level TROLL and BaroTROLL Instruments. The Environment Canterbury Regional Council in New Zealand granted In-Situ Inc. permission to publish these data plots (see References for more information).

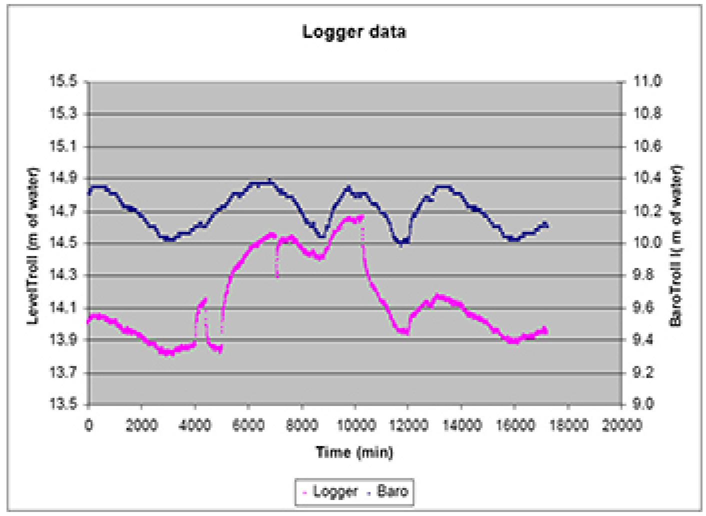

Figure 2. Plot of logger records from a Level TROLL (pink) and a BaroTROLL (blue). Level data has not been corrected for barometric pressure fluctuations.

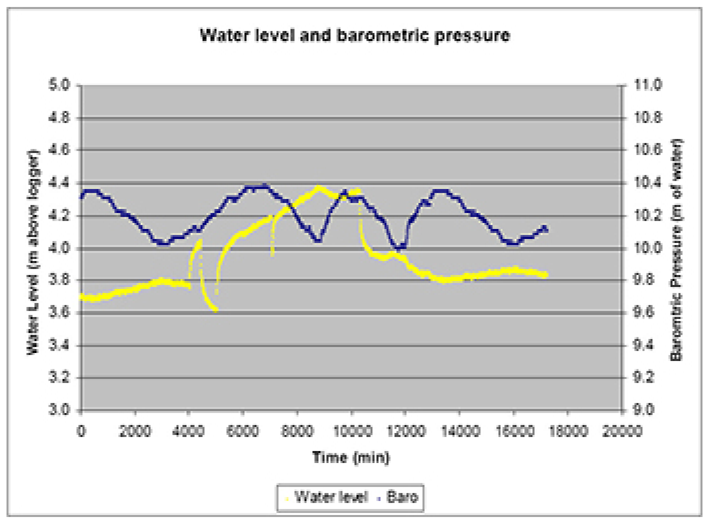

Figure 3. Plot of water level data (yellow) that has been corrected for barometric efficiency.

What Do I Do With This Number?

Assuming that barometric efficiency is constant, uncorrected data can be corrected by the following equations (Gonthier 2007):

$$W_{(t)corr} = W_{(t)uncorrt} - BE(p_0 - p_{(t)}) / \rho g$$

Where:

- **$W_{(t)corr}$** = Water level, at time t, corrected for barometric pressure
- **$W_{(t)uncorrt}$** = Uncorrected water level, at time t
- **BE** = barometric efficiency
- **ρg** = density of fluid

Conclusion

Barometric pressure changes can adversely affect water levels recorded in monitoring wells in confined aquifers, even when using gauged (vented) pressure loggers. To correct for the effect of barometric efficiency, barometric pressure changes should be measured concurrently with water level changes over a trial period of at least a few days. These data can then be used to calculate a value for barometric efficiency for a particular well.

The concurrent use of a gauged device (e.g., Level TROLL 500 Instrument) and a BaroTROLL Instrument can provide data for the calculation of barometric efficiency. This coefficient can then be used to post-correct existing level data from that specific well.

References

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