



## **Robust, non-invasive methods for metering groundwater well extraction in remote environments**

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Quantifying the rate of extraction from groundwater wells can be essential for regional scale groundwater management and impact assessment. This is especially the case in regions heavily dependent on groundwater such as the semi-arid Surat and Bowen Basins in Queensland, Australia. Of the 30 000+ groundwater wells in this area, the majority of which are used for stock watering and domestic purposes, almost none have flow metering devices installed. As part of a research project to estimate regional groundwater extraction, we have undertaken a small scale flow metering program on a selected set of wells. Conventional in-line flow meters were unsuitable for our project, as both non-invasiveness and adaptability / suitability to a variety of discharge pipe characteristics was critical. We describe the use of two metering technologies not widely used in groundwater applications, non-invasive, clamp-on ultrasonic transit time flow meters and tipping bucket flow meters, as semi-permanent installations on discharge pipes of various artesian and sub-artesian groundwater wells. We present examples of detailed extraction rate time-series, which are of particular value in developing predictive models of water well extraction in data limited areas where water use dynamics and drivers are poorly understood. We conclude by discussing future project trajectories, which include expansion of the monitoring network through development of novel metering techniques and telemetry across large areas of poor connectivity.