QUALITY MANAGEMENT FOR DISCHARGE MEASUREMENTS IN BAVARIA

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Abstract

The hydrology of surface waters is based on the knowledge of the two main hydrological parameters, water level and discharge. These data are not only needed for almost every hydrological planning, but are very important for the management of high and low water.

Our long term goal is a complete registration of every natural runoff – covering everything from low to high water – at our 600 measuring stations using limited resources but at the same time achieving high reliability and quality. To this point we are currently enforcing the use of modern data acquisition technology for water level and discharge measurements. The new techniques enable a continuous registration of water levels, actual velocity and consequently the discharge. Currently we are using gauging methods like the well known bubble gauge and radar, while the ultrasonic systems become more and more frequent. The moving boat techniques using the ultrasonic-doppler-systems (e.g. ADCP, Q-Liner) are gradually substituting traditional methods for discharge measurement. In addition to that hydraulic methods (e. g. SIMK) are being incorporated in the measuring systems as well.

Since the start in the year 2000 almost all gauges have been equipped with data loggers and automatic data transmission systems. One of the outcomes of these investments is the online availability of hydrological data on our website (www.hnd.bayern.de). Needless to mention that this step requires high quality data and a lot of effort has to be made in order to guarantee these high standards. A highly efficient quality management system is therefore obligatory.

To achieve this goal, a new project has been initiated to improve the present rating curve. By means of hydraulic calculation the curve will be verified and if necessary adjusted to minimise deviations in the near future, which is of high importance especially for the forecast of flooding.

Keywords: hydrology, quality management, flooding, gauges, technical improvements.

1 INTRODUCTION

Water bodies provide water for important uses including drinking water, navigation, power generation, irrigation and recreation. Too much water causes problems for public safety as rivers overflow their banks and inundate critical infrastructure like hospitals. But flow data also have quite an impact on water quality. The amount of water available for different uses and for a low and high water management is dependent upon accurate measurements of the rate of flow under widely varying
conditions. The discharge measurement is one of the most important issues in hydrology. Besides that, discharge data also impact economy and social security. In the past, data logging and data control was based on time-consuming technologies and required a lot of manual work. But in times of limited resources especially in terms of manpower, new and more efficient technical equipment has to compensate these short comnes. Unlike in the past, the demand on hydrological data has changed as well. For our high water management system accurate data are needed right when they are generated. In an ideal scenario the measured water levels should be automatically transmitted from the gauging stations and converted on-line in to discharge values. These data must have already high quality, because they form the basis for flood forecasts and therefore the basis for disaster control. In addition they are an integral part of the highly priced flood protection planning. These facts make it even more important to define quality standards and to have a high quality management system in place. The approach taken by the Bavarian hydrology department to establish this quality standard will be highlighted subsequently. The major topic is on improving discharge measurements and the defining of the rating curve.

2 QUALITY IMPROVEMENTS IN WATER LEVEL CONTROL

A first step to reduce the need of resources is to improve the monitoring network. During a substantial revision of the water gauge system the water level registration has been adjusted to achieve state of the technology. Every gauge has been categorized into a quality classification system (A, B or C) based on its hydrological importance. According to this classification, the technical equipment of the gauge, the time needed for the analysis of the data and the data logging are the key criteria applied.

At present we have 600 stations for hydrological services. 200 of them belong to category A and 400 to category B. In addition to these, we operate about 200 of category C for other purpose.

Thanks to modern regionalization procedures it is now possible to improve region-wide forecasts. This optimisation of the water gauge stations in terms of measurement quality enabled a fine tuning of the network, which is currently ongoing.

The second step towards an improved water level registration is the optimization of the technical equipment both in terms of the measurement itself as well as the data recording and transmission. Therefore in Bavaria all hydrological station are now equipped with an additional transducer and data logger, so that the reliability - even under extreme circumstances like flooding - is guaranteed. With the on-line data processing of the measured data points the responsible hydrology department can easily identify data discrepancies and technical issues, which in turn allows for a fixation of the problem in more or less real time. Overall, the maintenance of the gauging stations became easier and more effectively managed as data control and comparison will be more and more automated.

3 QUALITY IMPROVEMENTS OF DISCHARGE MEASUREMENTS

A quality management in the water level data is the equivalent to quality management in discharge measurement. Despite the fact that improvements in the
water level registration have been made during the revision of the water gauge system, it is still difficult to predict discharge data. Especially in alpine regions considerable sediment transport during high waters negatively impacts the rating curve and therefore potentially causes false predictions. One of the major reasons for that can be found in the measurement technology used. In Bavaria the basic method for discharge measurement is still the traditional current meter. Direct measurements are taken at regular intervals across the river with mechanical meters from bridges or cableways. While this method under normal weather conditions fulfils its purpose, in case of flooding, the direct measurements of discharge by current meters are unreliable, unsafe or even straight out impossible because of high velocities, drifting logs, stumps and debris, to mention only a few. During such conditions discharge has to be determined indirectly by surveying high-water marks left by the flow and applying indirect discharge calculations. Another important aspect of the direct measurements is that only data from selected stations are captured. To comply with our modern high water management system requirements however, it is necessary to continuously monitor discharge.

In an effort to address these issues a project investigating new and emerging technologies has been initiated. The expectations from this initiative are that a more cost effective, accurate, safe and robust method of stream gauging will emerge eventually.

The project comprises:

- acoustic Doppler current profilers (ADCPs) and tracer sensors as alternative measurement techniques during flooding
- Reduction of current meter measurements in the river cross section
- Continuous measurement technologies like ultrasonic systems or stationary ultrasonic Doppler systems
- Measurements of point-velocities in combination with hydraulic calculations (e.g. SIMK)
- Hydraulic calculations of the rating curve

The above mentioned projects have been performed in close collaboration with the state water offices (WWA), the technical university of Munich and the Bavarian Environment Agency. Three of the above mentioned projects will be described in more detail.

### 3.1 Ultrasonic Doppler technologies

The most efficient technology for improving direct measurement is the use of ultrasonic Doppler systems. One representative of this technology is the moving-boat system which is used in Bavaria since the beginning of 2008.
The frequently used systems are the ADCPs (StreamPro or Workhorse RioGrande) - as shown in Fig.1 - and the QLiner. These sensors record water velocity through the water column by measuring the Doppler shift in the frequency of the acoustic signals reflected from materials suspended in and moving with the river flow. The most important improvement of this method is the possibility to measure velocity of the entire river cross section as compared to the single points captured by the mechanical current meter methods. Both ADCP (continuous measurement across the cross section) and QLiner (measurement in single verticals) allow an on-line control of the measurement data in less time and without a loss of accuracy. Due to the direct transmission of the measurement onto a pocket-pc via blue tooth a real time control of the result is enabled. If necessary, additional measurements can be performed quickly. The huge variety of sensors and boats allows discharge measurements in almost every river which contributes to the superior effect of the Ultrasonic Doppler technology.

In addition, the bottom track signal allows the determination and surveillance of the river bed as well. If additional GPS-antennas or similar equipment are used, discharge measurements by instable river bed or sediment transport are also possible. To this purpose a research project was ratified and initiated at the Inn River. A mapping of different river beds during low floods is exemplified in the figure below:
The third major advantage of the ultrasonic Doppler technology is the measurement of suspended solids. Experiments performed at the Versuchsanstalt der Technischen Universität München in Obernach (VAO), demonstrated an enormous increase of the echo signals and sound levels in a suspended solid cloud. Given an adequate calibration process of the signals a quantitative conclusion of the suspended solid concentration is therefore possible. Unfortunately an on-site experiment in a natural river couldn’t be carried out due to the absence of flooding.

3.2 Tracer sensors
A completely different kind of discharge measurement is the use of tracer sensors which are mainly used in mountain torrents to assess the velocity of the water flow. The inserted colour tracer is detected by the tracer sensors after having passed a sufficient drifting distance. The result is visible online on the display. Measurement failures can be detected immediately and the measurement itself repeated. First experiences evidenced that the discharge rating curve of the mountain torrents can be improved substantially by this method while testing is still ongoing.

3.3 Improvements of conventional measurements
Apart from the new technologies improvements of the discharge measurements are also achievable with the current conventional meters. One possibility is the adjustment of measuring programs and the amount of measuring points. In steady river cross-sections the reduction of these is possible. A pilot study carried out at a couple of gauging station demonstrated, that there is a close correlation between the middle velocity and the surface velocity, allowing to establish a functional relation between these two parameters. For this reason during flooding a measurement of the surface velocity is absolutely sufficient to determine the velocity of flow but it is still necessary, however, to control the relation to full measurement.
4 HYDRAULIC CALCULATION OF THE RATING CURVE

Another effort to increase the quality of discharge data is to improve the discharge rating curve itself. Despite all new technologies the measuring of extremes – both high and low water - will still be difficult also in the future due to inherent limitations. Therefore, the Bavarian Environment Agency in cooperation with the state water agencies initiated a project to improve the existing rating curve by incorporating hydraulic calculations. The result of the first 21 gauging stations didn’t come as a surprise: Almost every calculated curve showed particular variations if compared to the existing ones.

![Fig.3: Calculated rating curve (green colour) form the gauge Peißenberg / Loisach River (3)](image)

These variations clearly highlight the need for rating curve improvements. At present about 300 gauging stations are being recalculated hydraulically and about 2.5 Mio € will be invested in this project over the next 5 years.

5 CONCLUSION

There is sufficient evidence at this point that the current problems in discharge measurements can not be solved by addressing technology or hydraulic calculations individually. An improvement of hydrological data in the long run may be achieved by combining new technologies with optimized measuring programs, skilled personal and hydraulic models. The Bavarian water management administration is taking such an approach at present, using quality management as one of the modern tools to enhance the quality of information provided.
References


Technical University Munich – Fiedler, Katharina: „Operatives Entwicklungsvorhaben – Ermittlung des Abflusses an Pegeln mit bewegter Sohle“, 2008, unpublished