

*Case Study on*  
*Quality Management System (QMS)*  
*in the Czech Hydrological Service*

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## **1. Czech Hydrological Service**

### **1.1 Historical Development of the Czech Hydrological Service**

The Czech Hydrological Service ranks among the oldest services in Europe. In Bohemia, an organised hydrological service was established in 1875, when the Hydrographic Commission for the Czech Kingdom was founded. At that time, the Czech Kingdom was part of the Austro-Hungarian Monarchy. After the Central Hydrographic Office was established in Vienna in 1893, the Hydrographic Departments for the Elbe, Morava and Odra River Basins were founded in the respective capitals of the Czech lands, i.e. in the cities of Prague, Brno and Opava.

After the demise of Austria-Hungary, the State Hydrological Institute was founded in 1920 and was later extended to the T. G. Masaryk Hydrological and Hydrotechnical State Research Institute to methodologically manage the Hydrographic Departments of the Provincial Offices as the units of operational hydrology. After the end of the World War II, the Water Research Institute was established in 1951, and one year later, the Water Development Centre was founded to include also the hydrological and hydrographic service.

A basic organisational change occurred in 1954, when the Hydrometeorological Institute with nationwide competences within the then Czechoslovak Republic was established through a governmental regulation. The meteorological and hydrological services were merged into one organisational unit, whose scope was extended by the field of air quality protection in 1967. After 1963, the construction of other hydrological centres in the cities of Ústí nad Labem, Hradec Králové, České Budějovice and Píseň was initiated to form, together with the offices in Prague, Brno and Ostrava, the basis of subsequent regional offices of the Institute. When the federal system of the state was introduced in 1969, the Czech Hydrometeorological Institute and the Slovak Hydrometeorological Institute were established with their registered offices in Prague and Bratislava, respectively. The split of Czechoslovakia in 1993 did not thus affect the organisational structure of the meteorological and hydrological services.

### **1.2 Current Position and Organisational Chart of the Czech Hydrometeorological Institute**

The Czech Hydrometeorological Institute (CHMI) is a state-funded organisation subordinate to the Ministry of the Environment. The basic purpose of the Institute is to perform the function of the central state institute of the Czech Republic in the fields of air quality, hydrology, water quality, climatology and meteorology, providing objective expert services primarily to the state administration.

The current Organisational Chart of the Institute is shown in Fig. 1. The Institute consists of the central divisions/departments and seven regional offices. The central divisions/departments are single-disciplinary (i.e. engaged in respective specific fields), and the regional offices are multi-disciplinary. The specialised central divisions/departments methodologically manage the relevant fields of specialisation at the regional offices. The regional offices operate monitoring networks, except for the professional meteorological stations and observatories. The Institute is headed by the Director, and the specialised and supporting sections (divisions/departments) are managed by the Deputy Directors. The regional offices are headed by the Regional Office Directors.

The Institute has a total of 692 employees, of whom almost 70% have reached a university education. In the central divisions/departments, there are 445 employees, and the regional offices have a total of 247 employees. The total costs in 2014 amounted to approximately CZK 710 million, (USD 28.4 million). The financial resources consisted of state contribution (57%), development projects and grants (19%) and revenues from commercial activities, such as sales of data, products and services (24%).

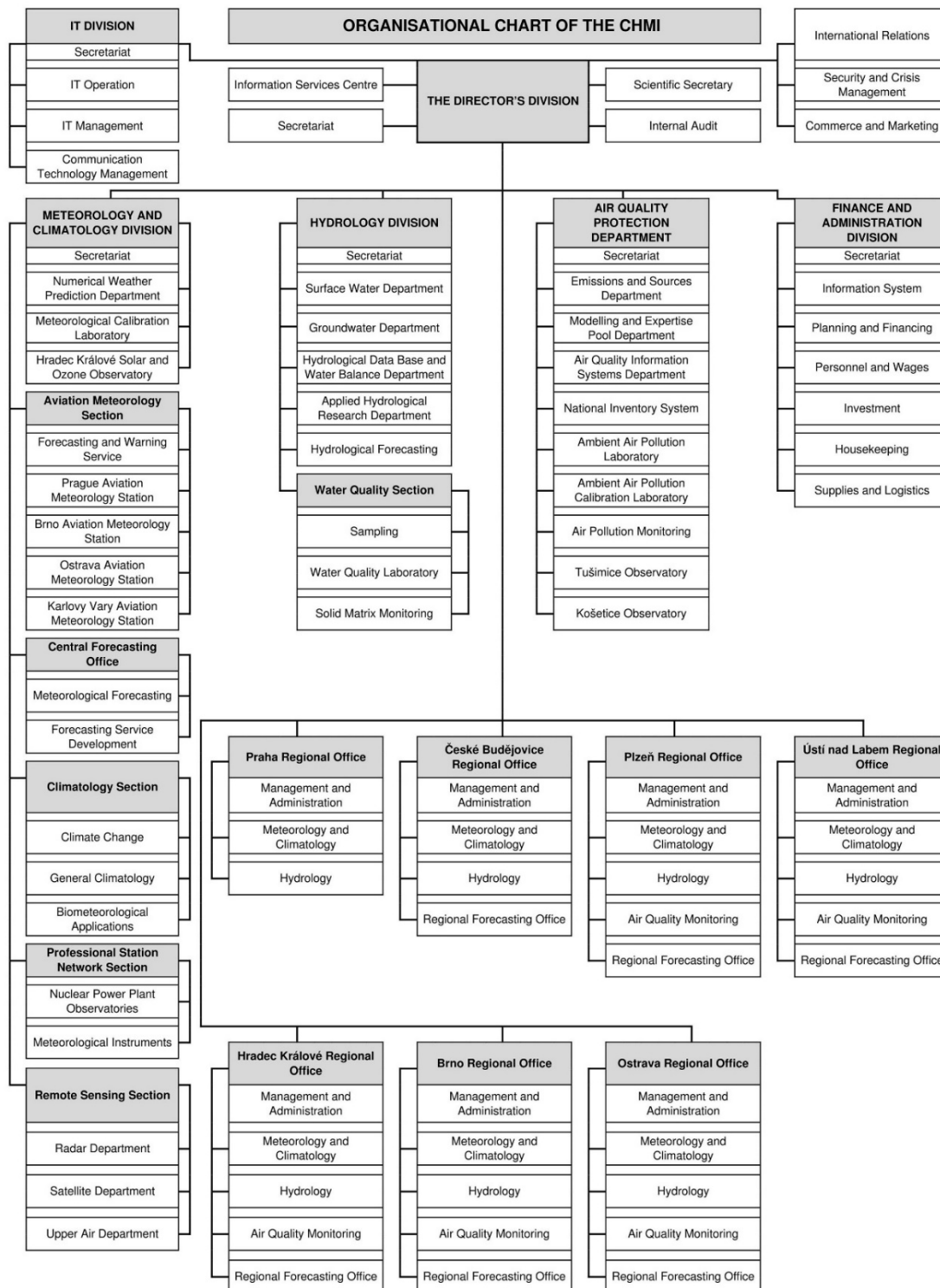


Fig. 1 – Organisational Chart of the Czech Hydrometeorological Institute

In the implementation of the ISO 9001 quality management standard, the Institute acts as a whole. The granted ISO certification applies to all the three fields, i.e. meteorology and climatology, hydrology and water quality, and air quality protection. However, this Case Study only concerns the quantitative hydrology, i.e. monitoring and evaluation of surface water and groundwater quantities.

In the field of hydrology, there are a total of 140 employees, of whom there are 70 employees in the hydrology departments of the regional offices, and 14 other hydrologists work in the regional forecast centres. The total annual costs of the hydrological service amounts to approximately CZK 205 million (USD 8.2 million), including the share in the Institute's overheads. As compared with the meteorology section, the hydrology section revenues from commercially provided products and hydrological studies are significantly lower and only amount to CZK 11 million (USD 0.5 million).

### **1.3 Legislative Basis for Hydrological Service**

The core activities of the Institute in the field of hydrology are based on the Institute Foundation Charter, issued through a Measure of the Ministry of the Environment in 2004, including particularly:

- establishing and operating the state monitoring and observation networks for monitoring the quantitative status of hydrosphere;
- processing professionally the observation, measurement and monitoring results;
- creating and administering the water quantity and quality databases;
- providing information on hydrosphere characteristics and regimes;
- providing operational information on the status of hydrosphere, forecasts and warnings about dangerous hydrological phenomena;
- performing scientific and research activities in the field of hydrology.

The main legislative documents that relate to the activities of the state hydrological service are as follows:

- Act 254/2001 Coll., on water and on amendments to some Acts (Water Act), as amended;
- Decree of the Ministry of Agriculture No. 431/2001 Coll., on the content of water balance, method of its compilation and data for the water balance;
- Decree of the Ministry of the Environment and the Ministry of Agriculture No. 5/2011 Coll., defining the hydrogeological zones and groundwater bodies, the method of groundwater stage assessment and the particulars of the programmes of groundwater stage survey and assessment;
- Decree of the Ministry of Agriculture No. 252/2013 Coll., on the scope of data in the records of the surface water and groundwater stage and on the method of processing, storing and reporting such data to the information systems of public administration.

The core activities are based on Section 21 of the Water Act, according to which the surface water and groundwater status shall be surveyed and assessed, and the information systems of public administration shall be operated by the river basin administrators and other expert bodies designated by the Ministry of Agriculture and Ministry of the Environment. According to the implementing regulations, the Czech Hydrometeorological Institute processes and

keeps data on hydrological catchments, hydrogeological zones, and surface water quantity and quality, groundwater quantity and quality, and compiles a hydrological balance every year.

Under Section 73 of the Water Act and in cooperation with the river basin administrators, the Czech Hydrometeorological Institute provides the flood forecasting service and also participates in providing the flood warning service. Details of performing the Flood Warning and Forecasting Service are regulated by a methodological guideline of the Ministry of the Environment. Under Section 76 of the Water Act, the Czech Hydrometeorological Institute keeps records of evaluated floods in terms of hydrology.

#### 1.4 Hydrological Monitoring Networks

The Czech Hydrometeorological Institute operates the following hydrological networks designed for the measurement of quantitative parameters (state as of 2014):

Measurement Station Type	Measured Parameter	Number of Stations
Hydrometric stations on surface water	water stage/discharge	505
	water temperature	170
	suspended load	40
Hydrometric stations on groundwater – springs	spring yield	325
Hydrometric stations on groundwater – boreholes	water level	1,487
Automated snow-gauging stations	snow depth/snow water equivalent	15

The hydrological measurement networks are operated by the personnel of the Hydrological Departments of the regional offices (i.e. Regional Hydrological Departments). For this purpose, they partly use voluntary observers, particularly at the groundwater stations. The hydrological service does not operate its own precipitation-gauge stations and uses data from the monitoring networks within the fields of meteorology and climatology.

The water stage is the basic monitored parameter at the hydrometric stations on streams. At present, all the measurement sites are equipped with automated gauging stations with remote data transmission systems. At most of the stations, two pressure sensors are installed to measure the water level. The water (staff) gauge is the basic etalon for measuring the water stage at each station.

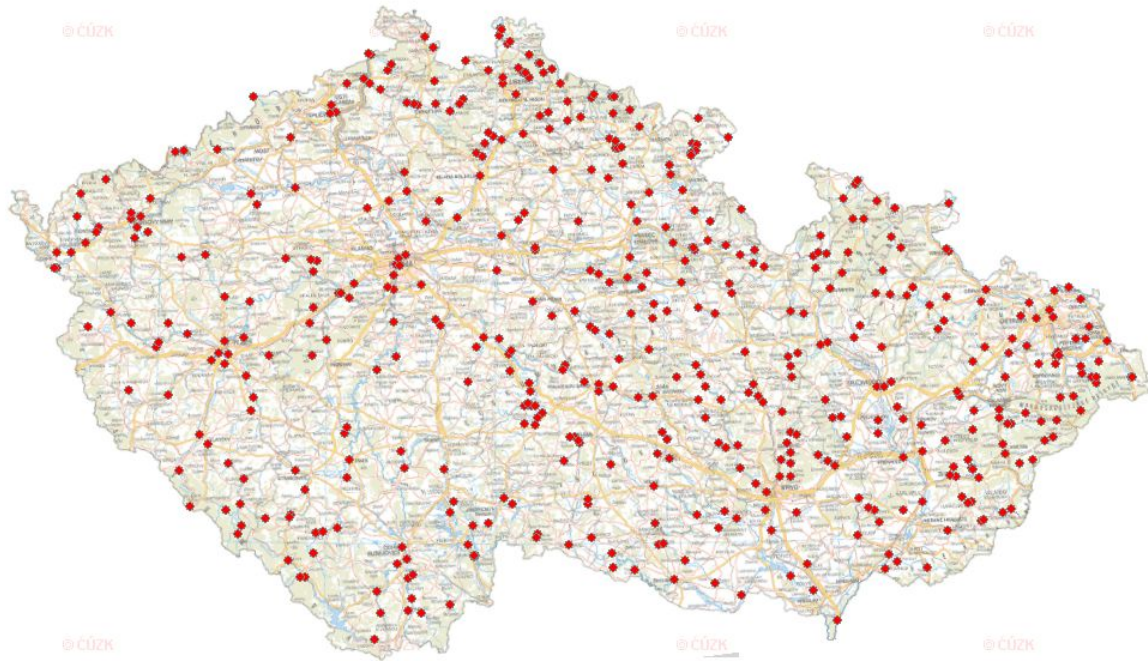


Fig. 2 – Monitoring network of surface water hydrometric stations

The discharge magnitude is derived from the water stage using a stage-discharge rating curve. Several times a year (in 2015 more than four times on average), direct discharge measurements are done at each station to check and update the rating curve. Conventional hydrometric propellers, ADCP (Acoustic Doppler Current Profilers) flow meters, and to a smaller extent, also acoustic or inductive point velocity gauges are used to measure the discharge.

To continuously and directly measure the discharge, the hydrological service of the CHMI operates its own stationary ultrasonic flow meters at two stations. The CHMI also takes measured data from the operators of similar stations within special-purpose networks, in particular from the Povodí (river basin) companies. It is planned to build further our own ultrasonic flow meters at several profiles where no stable stage-discharge curve can be derived. The Czech Hydrometeorological Institute does not measure the water level in any reservoirs or lakes.

The water temperature is measured at selected hydrometric stations using a thermometric sensor. In winter, this figure is used as a proxy indicator of occurrence of ice phenomena.

To determine the concentration of suspended load, samples are taken using an automatic sampler at 27 automated complex stations, and at the other profiles, manually once a day. The samples are analysed in our own laboratory in Prague.

At the groundwater stations, the spring yields are measured using a calibrated vessel or measuring weir, and in the case of larger yields, using a measuring flume. Approximately at a third of the gauging stations, the water level measurement on a measuring weir is automated using a pressure sensor, and at the other stations, the measurement is performed by voluntary observers once a week.

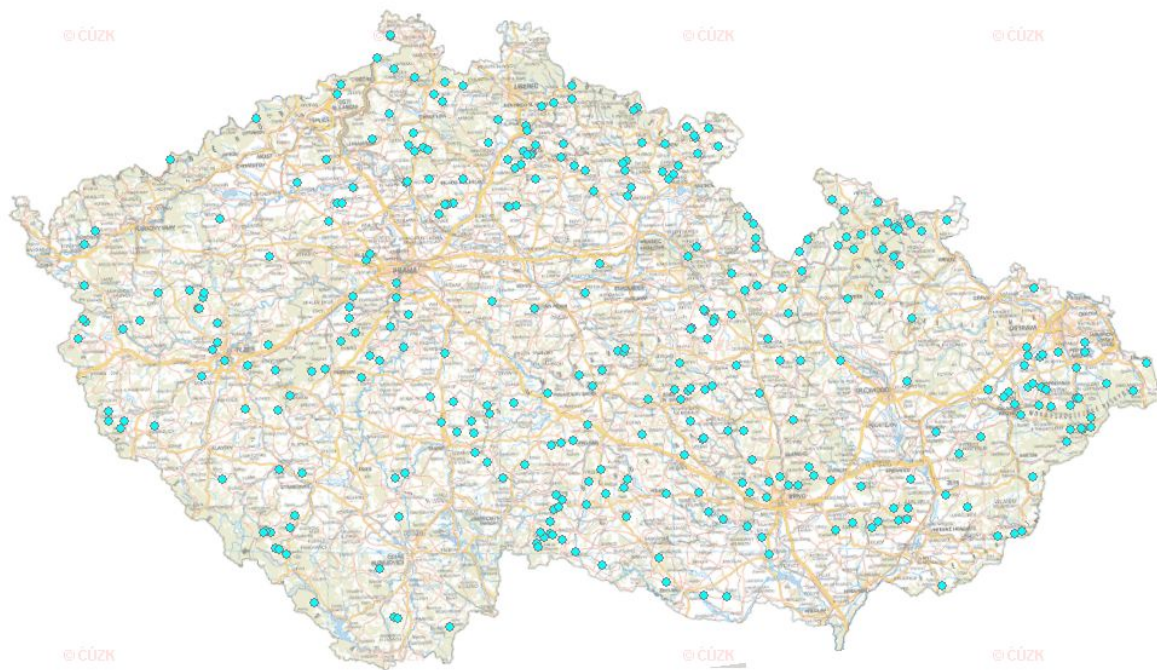


Fig. 3 – Groundwater monitoring network - springs

The water level in boreholes is measured automatically using a pressure sensor with records made in a datalogger. Approximately 820 stations are equipped with a remote data transmission system. Some of the boreholes that were historically established for monitoring the alluvial plains along the major streams in Moravia (so-called hydrogeologic profiles) are operated by voluntary observers once a week.

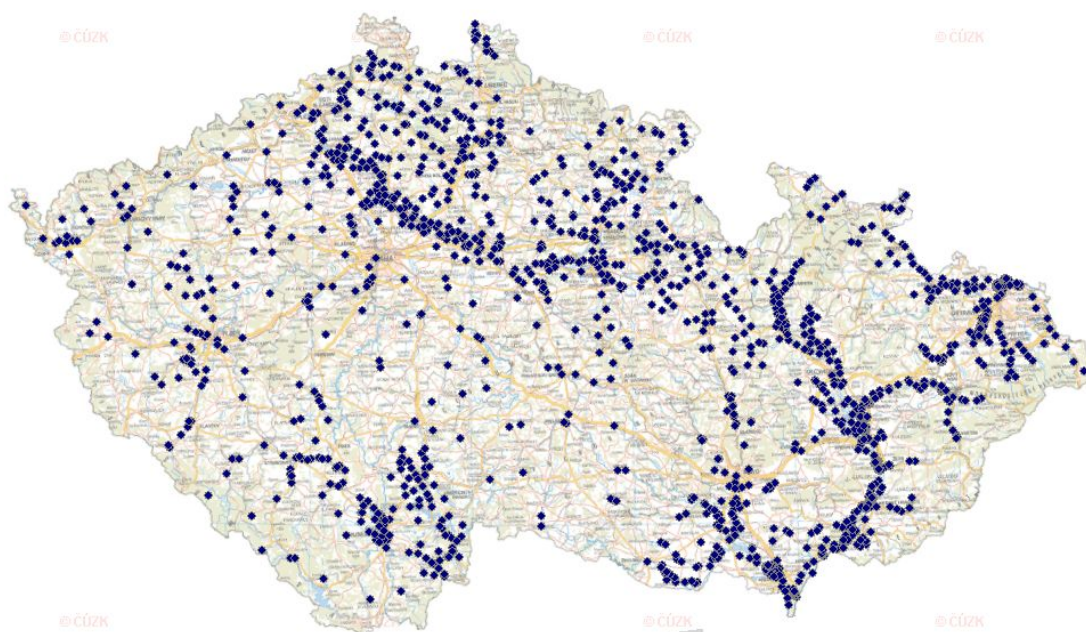


Fig. 4 – Groundwater monitoring network – boreholes



At the automated snow-gauging stations, the snow depth and the snow water equivalent are recorded in winter. The snow water equivalent is determined by weighing or measuring the snow layer pressure on the snow pillow. To ensure the measurement representativeness, it is important to carefully select the station site and perform manual control measurements. The data are used to calculate the water reserves in the snow cover at selected catchments and other territorial units, which is performed once a week. The calculation also uses the data from manual snow depth and snow water equivalent measurements, which are performed at 420 selected climate and precipitation-gauge stations.

The measured data from the surface water and groundwater stations are primarily processed at the regional offices, and during this process, the data are thoroughly checked under the supervision of the employee responsible for the relevant part of the network. The checked and authorised data are stored in the national hydrological database – Hydro-Fund.

### **1.5 Special-Purpose Monitoring Networks**

The special-purpose monitoring networks are considered to be measuring networks of other organisations that also measure the hydrological parameters for their specific purposes. Extensive automated networks of hydrometric stations on streams are operated by the Water Control Centres of the river basin administrators. They are state enterprises of Povodí Vltavy (Vltava River Basin Company), Povodí Labe (Elbe River Basin Company), Povodí Ohře (Ohře River Basin Company), Povodí Moravy (Morava River Basin Company) and Povodí Odry (Odra River Basin Company), which administer their respective streams and most important water management structures. Data from these networks are used to control the operations of water structures and their systems, as well as for other operational needs. Between the CHMI and the individual River Basin companies, there are agreements, on the basis of which measured data are mutually exchanged. The CHMI uses data from the Water Control Centres within the operations of its forecast centres. Such data do not undergo any primary processing and are not stored in the Hydro-Fund database.

The category of special-purpose monitoring networks also include hydrometric and precipitation-gauge stations established by some municipalities within their Local Warning Systems. These networks aim at drawing the attention of municipal flood authorities to the occurrence of torrential rainfalls and subsequent flash floods, which are not usually captured in the state observation networks of the CHMI or River Basin Companies. The hydrometric stations of local networks have not usually any stage-discharge rating curve. Data from these stations are less reliable and are not subject to any control process. However, in many cases, the forecast offices of the Czech Hydrometeorological Institute still take and use such data as additional rough information in flood events.

Special-purpose surface water and groundwater measuring networks are also created by some other institutions in experimental catchment areas and locations for the needs of hydrological research and solutions of water management and environmental tasks. For example, this includes the T. G. Masaryk Water Research Institute, Institute of Hydrodynamics of the Academy of Sciences, Czech Geological Survey etc. The Czech Hydrometeorological Institute does not usually use any data from those networks.

## 1.6 Providing Hydrological Data and Products

The Czech Hydrometeorological Institute provides operational information and regime information. The operational information reflects the actual surface water and groundwater stages, and possibly also their recent developments and short-term forecasts. It is used by a wide range of users who deal with water or who are affected by the water stage, as well as by the public. A considerable part of operational information is published within the Flood Warning and Forecasting Service. The main types of operational information are as follows:

- informative reports on the hydrometeorological situation (weekly, monthly, extraordinary);
- warnings about the occurrence of dangerous meteorological and hydrological phenomena, including extreme precipitation and flood water stages;
- water stage and discharge at the flood warning service stations;
- short-term hydrological forecasts at selected stations;
- water reserves in the snow cover for selected catchment areas (in winter);
- indicators of area water saturation and potentially dangerous precipitation totals for the emergence of flash floods (Flash Flood Guidance);
- assessment of the actual groundwater stage and spring yields as compared with long-term characteristics;
- evaluation of the hydrological drought as part of a comprehensive assessment of the actual state of drought (in terms of climate, soil and hydrology).

The operational information is processed based on measured data that has not undergone any primary processing. First of all, it is provided at the Institute's website, and to a limited extent, it is distributed electronically to direct addressees. All operational information is provided free of charge.

The regime information reflects long-term characteristics of the surface water and groundwater regime and is used for planning, studying, designing and other purposes. Hydrological data of surface water is processed and issued in accordance with the Czech National Standard ČSN 75 1400 (Hydrological Data on Surface Water). The standard hydrological data on surface water are as follows:

- catchment area and long-term annual average precipitation amount in the catchment;
- long-term average discharge;
- M-day discharges or p-percent daily discharges;
- N-year discharges with a recurrence interval of 2 to 500 years;
- theoretical and observed flood waves;
- observed or derived time series of daily, monthly, seasonal and annual average discharges;
- long-term characteristics of daily, monthly, seasonal and annual average discharges.

In the Czech Republic, standard hydrological data are provided only by the Czech Hydrometeorological Institute for any profile in the stream network, (in the case of derived discharges and their characteristics only for the profiles for which the hydrological analogy methods can be used). The other hydrological data are considered not to be standard and are processed through a hydrological study. For example, they include the N-year discharges with a recurrence interval longer than 500 years, N-year discharges and theoretical flood

waves affected by flood control measures (including retention reservoirs), N-year minimum discharges of a given duration, artificial discharge series etc. Non-standard hydrological data of surface water can also be processed by other expert offices.

Hydrological data of groundwater are provided in accordance with the Czech National Standard ČSN 75 1500 (Hydrological Data of Groundwater). As a standard, the following data for individual observation sites are processed and provided:

- time series of measured data (borehole water level, spring yield);
- statistical data processing (monthly, seasonal and annual averages, exceedance function);
- extreme value characteristics.

It is also possible to process and provide area characteristics of groundwater for a given catchment area or hydrogeological zones. The so-called base flow, which is the share of the underground runoff in the total runoff from the given area, is regularly evaluated. In the Czech Republic, 80% of the base flow magnitude is considered to be the exploitable groundwater reserves.

Regularly every year, the Czech Hydrometeorological Institute prepares a hydrological balance of water quantity, where the amounts of precipitation, runoff, evapotranspiration losses and differences in groundwater reserves are balanced for 74 individual catchment areas on a monthly basis. The Hydrological Balance outputs are published in a separate report and also in the Hydrological Yearbook. Both documents are available in electronic form at the Czech Hydrometeorological Institute's website. In addition, the N-year discharge and M-day discharge values for approximately 120 selected stations and the time series of monthly average discharges at the hydrological balance profiles are available at the website. Other hydrological regime data are provided by the CHMI for a consideration based on a purchase order or contract. The prices of hydrological data and products are determined under an internal pricelist.

## **2. Quality Management System**

### **2.1 Czech Hydrometeorological Institute's Quality Management System History**

Given that the basic hydrological activities have been decentralised to the regional offices of the Institute since the 1960s, the CHMI has always paid adequate attention to the unification of used methods, training of regional office personnel and checking of their results. In the field of hydrology, this was primarily achieved through methodological guidance applied by the central departments of the Hydrology Division towards relevant employee groups in the Hydrological Departments of the regional offices, (i.e. Regional Hydrological Departments). The methodological guidance included:

- preparing internal regulations (methodological guidelines) for the performance of individual hydrological activities;
- ensuring uniform instrumentation for the measurement of hydrological variables and staff training in its operation;
- organising methodological meetings related to the staff training in individual hydrological processes;

- after a broader deployment of computer technology – ensuring uniform software for implementing and supporting complex hydrological processes, such as processing of hydrometric measurement results, care for stage-discharge rating curves, primary processing of surface water data, discharge forecasting using forecasting models.

The above-mentioned activities were not formally recorded as the Quality Management System (QMS). However, they were coordinated at the level of the Head of Hydrological Service (Deputy Director of the Institute). It mostly included internal institute processes because the external possibilities of hydrologists' education and training were limited. Several hydrologists had the opportunity to attend a hydrological course conducted by UNESCO in Prague-Suchdol, and in the last century, a few individuals received a WMO's scholarship for the medium hydrological course in Delft.

We started to make efforts to obtain the Quality Management Certificate under ISO 9001 in 2003 on the initiative of the Meteorology and Climatology Division, which needed this certification for aeronautical meteorology. Through a decision taken by the Institute management, the introduction of the ISO 9001 QMS was extended to all the three fields of the Institute. Through the Director Order PR 2/2004, the preparation process was officially launched, the Quality Council and the Management Representative for Quality were designated and the Quality Policy was determined.

The preparation for the ISO 9001:2000 QMS certification and certification audit were ensured by the authorised firm Quality Austria Training, Certification and Evaluation. Based on the successful audit in March 2007, the Quality Certificate was granted on 22 March 2007. In the following years, the same auditor conducted surveillance audits, and once every three years, recertification audits in the CHMI . The last Certificate granted on the basis of the recertification audit in 2013 is valid until 25 March 2016.

Audit Type	Date	Standard	External Auditor
Certification	20 – 22/3/2007	EN ISO 9001:2000	Quality Austria Ltd.
Surveillance	25 – 26/3/2008	EN ISO 9001:2000	Quality Austria Ltd.
Surveillance	15 – 16/4/2009	EN ISO 9001:2008	Quality Austria Ltd.
Recertification	16 – 18/3/2010	EN ISO 9001:2008	Quality Austria Ltd.
Surveillance	21 – 22/3/2011	EN ISO 9001:2008	Quality Austria Ltd.
Surveillance	21 – 22/3/2012	EN ISO 9001:2008	Quality Austria Ltd.
Recertification	12 – 14/3/2013	EN ISO 9001:2008	Quality Austria Ltd.
Surveillance	13 – 14/3/2014	EN ISO 9001:2008	Quality Austria Ltd.
Surveillance	31/3 – 1/4/2015	EN ISO 9001:2008	Quality Austria Ltd.



Fig.5 – Certificate issued on the basis of the Recertification Audit in 2013

## 2.2 Quality Management System Documentation under ISO 9001

The Quality Management System (QMS) is built in accordance with the ISO 9001 standard, as amended, as a means of high-quality performance of the Institute’s activities in all three fields (meteorology and climatology, hydrology, air quality). The main QMS documents are therefore common. They are:

- Strategy and Main Objectives of the CHMI
- Quality Policy
- Quality Manual

These basic documents are not immutable, and are continuously amended and updated according to results of the QMS reviews and conclusions of completed audits. The Quality Strategy and the Quality Policy now apply in the 2012 version, and the valid Quality Manual now applies in its 9<sup>th</sup> version of 2015. The QMS documentation also includes the types of documentation that were used for managing the Institute and its activities before implementing the ISO 9001 standard, including:

- Institute Director Orders
- Institute Director Regulations
- Regional Office Director Orders and Regulations
- Methodological Guidelines and Instructions (issued by the specialised Deputy Directors)
- Work Instructions (usually issued by the central specialised Departments)

The introduction of a process-oriented approach was a new element that was brought by the ISO 9001 implementation. All processes (activities) of the Institute, including their inputs, outputs and mutual links, were described. This created a process map, which indicates the organisation functioning in an acceptable way. Basic categories of processes:

#### 1 Management Processes

- 11 Strategic Management
- 12 Operational Management
- 13 Infrastructure and Working Environment Management
- 14 Improvement
- 15 Safety/Reliability Management

#### 2 Implementation Processes

- 21 Cross-Sectional Processes
- 22 Meteorology and Climatology
- 23 Hydrology
- 24 Air Quality Protection
- 25 Process and Application Database

#### 3 Support Processes

- 31 Internal Resources Administration
- 32 Records Service Management
- 33 Human Resources Management
- 34 Audits – Internal and External
- 35 Process Monitoring
- 36 Acquisition of Tangible and Intangible Assets, Services and Other Supplier Activities
- 37 Document and Record Management
- 38 Documents and Processes Cancelled

The said basic processes are further broken down into sub-processes, which are divided into further levels of detail in the case of implementation processes, (in hydrology up to Level 7). The structure of the Hydrology implementation processes broken down to Level 5 of detail is described in Appendix 1. A processor (mostly an expert in the given field) and a process guarantor have been designated for each process. The process guarantors are the Institute senior management members (Institute Director and his Deputies). The processes are regularly monitored and evaluated.

### **2.3 Quality Objectives**

The main objective of the Institute in the QMS area is generally formulated in the Quality Strategy and is long-term fixed:

“Our objective is to obtain and process, on a long-term basis, data and information on the state of the atmosphere and hydrosphere in the Czech Republic and provide professional services in an efficient way to meet the needs of all users.”

This document also contains an essentially unchanging strategy to accomplish the above-mentioned objective. The main objective and the strategy to accomplish it are formulated jointly for all the branches of the Institute:

- Efficiently use and maintain all facilities and equipment of the Institute in good condition and continuously modernise the same so as to best meet the requirements of users and customers.
- Develop and use modern methods in accordance with applicable standards in all fields of the Institute's activity.
- Preferably perform information services to reduce losses of lives and property during emergencies and provide information to authorities engaged in crisis management and directly to citizens in time and in the required quality.
- Through adherence to high standard and quality of services, ensure a significant position of the Institute in all fields of its activity.
- Maintain and strengthen research in the fields covered by the Institute in cooperation with research institutes and universities.
- Carry out any and all activities to achieve the objectives efficiently and also economically.
- Cooperate with other organisations in the Czech Republic and abroad so as to continuously improve the level of knowledge of employees and the quality of the Institute activities and services.

Specific quality objectives for each year are issued in the form of a Director Order, and their accomplishment is regularly evaluated during an annual QMS review. The objectives include a continuous improvement process and are formulated by both the individual specified divisions and the regional offices. The Hydrology Division quality objectives for 2015 are set out in Appendix 2.

The Quality Management Systems under ISO 9001 are generally geared towards the needs of customers, and the measure of quality is the level of their satisfaction. In the case of the CHMI, which performs the function of state expert service, the measure of quality includes, in addition to the customer satisfaction, also meeting the requirements of its founder, i.e. representatives of the state (Ministry of the Environment). However, the CHMI also carries out activities to meet requirements of other sectors, e.g. Ministry of the Interior, Ministry of Transport, Ministry of Agriculture and others. Monitoring the customer satisfaction is therefore quite complex.

The basic elements of the Quality Management System, their responsibilities and powers are defined through the Director Order PR 2/2004. The position of the Management Representative for Quality is performed by the Deputy Director, Finance and Administration Division. The other Deputy Directors, who manage specialised divisions and departments, are members of the Quality Council, which is an advisory body of the Institute Director. The Quality Manager is appointed to accomplish operational tasks in the quality management area, and he devotes his full working capacity to this area. The Quality Policy intentions and Quality Objectives are communicated to all the employees through publication at ISOWEB (see the explanation below).

## **2.4 Quality Monitoring**

Monitoring the processes and parameters of their quality is used to ensure that the specified requirements for the CHMI products are met and fulfilled. The monitoring is based on internal audits, which are conducted according to the Annual Audit Plans. In the field of hydrology,

there are 6 internal auditors, who are specialised in individual kinds of hydrological activities (processes). In addition to their expertise in the relevant field of hydrology, the auditors are regularly trained in quality management. In the field of hydrology, 6 to 8 audits are conducted in central departments and regional offices every year. The Internal Audit Plan in Hydrology for 2015 is included in Appendix 3. If necessary, the Management Representative for Quality can order an extraordinary audit to be conducted, which has not yet happened in the case of hydrological implementation processes.

Regularly once a year, the QMS review is conducted for the last year. During such a review, the accomplishment of quality objectives, audit reports, implementation of measures aimed at remedying any deficiencies (nonconforming products), and customer satisfaction are evaluated. In the field of hydrology, which is not so commercially focused, the customer satisfaction is monitored through their comments or complaints.

During the QMS review, the indicators expressing the quality of individual implementation processes or groups of processes are also evaluated. Draft evaluation reports are prepared by the processors, who submit them to the process guarantors. The QMS Review Reports are a starting basis for conducting an external audit.

The external (surveillance or recertification) audit is conducted by an external auditor once a year. The last surveillance audit was conducted from 31 March to 1 April 2015. The Institute management prepares necessary input documents for the audit conduct, including particularly the QMS Review Report. The audit is conducted at several selected sites, and findings are discussed in detail with the Institute management. In particular, the Final Audit/Assessment Report includes:

- General (system definition – applicability, initial situation – development since the last audit, audit objectives in terms of the organisation)
- Overall impression
  - o Strategic statements made by the organisation
  - o Strong points
  - o Potential for improvement
  - o Statements on the audit objectives
  - o Process monitoring and measurement methodology
  - o Priorities and distinct interactions
  - o Statements on process measures
  - o Systematic processing of audit advice and recommendations
  - o Risk identification, assessment and management methodology
  - o Compliance with relevant legal regulations
- Audit result (major and minor deviations, further procedure)
- Advice and recommendations
  - o Organisation management responsibility
  - o Resources management
  - o Product implementation
  - o Measurement, analysis and improvement

As early as the beginning of the QMS implementation process, we acquired an ISOWEB software tool from an external company, which is a valuable tool for the Institute to manage and present all the QMS documents. ISOWEB enables defining the processes, including



their mutual links, and storing their descriptions in the database system. Furthermore, it helps to process and approve relevant documents, and also store them in the database system, including all previous versions. All employees thus have the opportunity to read all the QMS documentation, and the employees with appropriate access rights can edit relevant parts of the documents.

### **3. Specifics of the Implementation of Quality Management System under ISO 9001 in Hydrology**

#### **3.1 Benefits from the ISO 9001 Implementation**

The Czech Hydrological Service functioned well even before the QMS was certified under ISO 9001. The required quality and in particular, the uniformity of activities performed by the regional hydrological offices were ensured by the relevant central divisions/departments providing their methodological guidance, issuing internal methodological regulations, organising personnel training and deploying uniform instrumentation and software. The list of currently valid methodological guidelines in the field of quantitative hydrology is included in Appendix 4. During the implementation of the QMS under ISO 9001, these quality management elements were preserved and possibly further developed. The Institute management made efforts to sensitively introduce the procedures under ISO 9001, taking into account the specifics of the Institute as an institution providing state expert service in the fields of its competences, including also hydrology.

It is necessary to point out this Study only deals with the QMS in the field of quantitative hydrology of surface water and groundwater. In the area of water quality monitoring, the QMS issue is more complex because the water sampling and laboratory analyses are mostly ensured using services of external companies that are appropriately accredited for the relevant types of analyses. However, during the tendering procedures for such services, the CHMI does not require that the bidders are certified under ISO 9001.

The first QMS Certificate under ISO 9001 was obtained by the CHMI already 8 years ago. It is obvious that the quality of hydrological activities and products would have developed even without the ISO certification; nevertheless, its contribution can be estimated in the following paragraphs:

- A detailed hydrology process model is in place, including all major hydrological activities of the central and regional offices, their links and interrelationships. The block diagram depicts an interconnection of the processes with relevant implementing documents (instructions, guidelines). The process implementation method is therefore fixed, and may be uniformly implemented and monitored.
- The QMS documentation is in good order, and all relevant documents relating to the management, implementation and support processes are well-arranged at ISOWEB and are available to all employees.
- The level of inspecting activities has increased, and internal audits are regularly conducted with a focus on professional and formal aspects of the hydrological

implementation processes. When developing the Annual Audit Plans, regular rotation of audited processes and subjects is ensured.

- The regular evaluation of accomplishment of quality objectives and hydrological processes within the QMS reviews brings new impulses and ideas that may lead to improved quality of hydrological activities and products.
- The system of regular verification and calibration of measuring instruments is established, using activities of our own employees or services of accredited laboratories, which contributes to an improved measurement reliability and quality. The method is defined by the Institute's Metrological Rules and related Methodological Guideline for Metrological Security in the Field of Hydrology. An authorised employee – hydrology metrologist – supervises the compliance with these regulations.
- To operatively solve problems, particularly those with the use of computer technology and means of communication, the documented service of HelpDesk is established, working on the internal computer network of the Institute.

### **3.2 Problems and Deficiencies in the ISO 9001 Implementation**

Implementing the QMS under ISO 9001 is necessarily associated with some administrative burden, particularly for managers, processors and process guarantors. In addition, the standard itself is geared rather for manufacturing businesses, managing the quality of their products and customer satisfaction. The basis for the hydrological service of the CHMI is formed by the processes in the area of monitoring network operations and primary processing of measurement results, from which the processing of hydrological products unfolds. Since we work with natural phenomena, which cannot usually be described using unambiguous regularities, uncertainties enter into the processing of meteorological and hydrological data, which significantly affects the quality of final products.

For these reasons, there are some problems and deficiencies regarding the QMS in the hydrological service, chief among which are as follows:

- Not all descriptions of the hydrological implementation processes are sufficiently developed so as to be unambiguous guidance for their implementation and checking. Not all processes include quality criteria that would allow them to be objectively evaluated in terms of quantity.
- Some hydrological processes also take place at other entities (in particular, in the Povodí – River Basin Companies), which operate special-purpose measuring networks, and the CHMI takes some data from them. These entities have not usually established any control mechanisms within the primary data processing and rely on automatic software filters. Such data may only be used for operational purposes and do not enter the hydrological database.
- The QMS under ISO 9001 helps to identify problems and deficiencies in hydrological processes. However, if such problems and deficiencies are identified and solved, the process entitled "Control of Nonconforming Product" is not always formally followed, i.e. a nonconformity is not sufficiently recorded and the method of its remediation is

not documented. Nevertheless, the deficiency remediation and elimination usually takes place.

- Due to the wide range of users of hydrological data and products (customers), no systematic survey of their satisfaction is established. It is only the accuracy and reliability of hydrological forecasts that are consistently evaluated. Any customer complaints are dealt with on an ad hoc basis and the complaint settlement is not documented under the process entitled “Records and Settlement of Customer Complaints”. Some complaints about the quality of hydrological products indicate that the customers are not sufficiently aware of the natural uncertainty of hydrological data and products, or that the Institute does not sufficiently raise their awareness in this regard.
- The external (surveillance or recertification) audits are conducted particularly with regard to compliance with the formal rules of QMS under ISO 9001 without the knowledge of hydrological issues. The audit is preceded by quite an administratively demanding preparation, including the processing of inputs for the QMS Review Report. The main result of the audit is to obtain or maintain the ISO 9001 certification. Unlike the internal audits, the external audit professional contribution to hydrology is minimal.

### **3.3 Main Professional Issues of Quantitative Hydrology**

Professional issues encountered by the Czech Hydrological Service are not of course solved through the QMS implementation under ISO 9001, but the QMS can create conditions for their solution. To some extent, these include operational issues and problems, which are often caused by a lack of funds, instrumentation and capacity. Furthermore, there are methodological issues, whose solution consists in a constant development and improvement of the used procedures and software tools. The development is ensured by our own staff, who participate in various projects of applied research, as well as through our cooperation with research institutes, universities and other companies. To a limited extent, methodologies gained within the international cooperation (with the World Meteorological Organisation, partner hydrological services) are used. However, such methodologies are usually adapted to our local conditions. The main methodological issues of the Czech Hydrological Service currently include:

- Increasing the reliability and accuracy of stream discharge measurement, particularly under extreme conditions (floods and discharge minima). Verifying the reliability of ADCP flow meters and other modern instruments, for which no calibration similar to that of hydrometric propellers is performed.
- Introducing other new procedures in the system of care for stage-discharge rating curves, in particular, verifying and extrapolating the curves using hydraulic models, which must still be outsourced. Taking into account changes of rating curves in time and curve hysteresis.
- Processing the results of groundwater point measurements into area characteristics and expressing the exploitable groundwater reserves in various geological conditions.

- Collecting and keeping records of sources affecting the hydrological regime (water storage in reservoirs, water withdrawal, outlet and transfer) and including such records in the hydrological balance.
- Homogeneity of hydrological time series and influence of anthropogenic changes in catchment areas on deriving hydrological characteristics (regarding flood and minimum discharge values).
- Specifying hydrological forecasts and extending their lead time, introducing seasonal forecasts. Extending the issuance of probabilistic hydrological forecasts and educating customers about correct understanding of such forecasts.
- Further development of the Flash Flood Guidance and short-term flash flood forecasts.
- Deriving the methods for identifying and evaluating the hydrological drought following the climate (or soil) drought, introducing the drought intensity degrees, medium-term forecast of drought evolution.
- Influence of expected climate changes on the hydrological regime and deriving hydrological characteristics. This problem cannot yet be satisfactorily solved because of the uncertainty of input climate data, particularly on expected changes in the precipitation regime, for Central Europe.

From the professional perspective, the Institute is relatively well-equipped for solving many of the above-mentioned methodological issues, using its own hydrology staff, or in cooperation with meteorologists and climatologists. For the time being, the Institute does not have its own specialists in the hydraulic modelling of surface water and in particular, IT specialists for the creation of software for databases and related applications. In this regard, the Institute is almost completely dependent on external companies, which is expensive and causes problems in maintaining the established systems.

## Structure of Hydrology Implementation Processes

### 23 Hydrology

- 230 Saving the output documents, records and data from activities of the Division on Hydrology
- 231 Identifying the surface water and groundwater stage
  - o 2311 Surface water
    - 23111 Surface water observation
    - 23112 Inspection visit to the surface water hydrometric station
    - 23113 Discharge measurement
  - o 2312 Groundwater
    - 23121 Borehole observation
    - 23122 Spring observation
    - 23123 Inspection visit to the groundwater station
  - o 2313 Water quality monitoring
    - 23131 Surface water quality monitoring
    - 23132 Groundwater quality monitoring
- 232 Data processing and assessment
  - o 2321 Primary data processing
    - 23211 Primary surface water data processing, rating curve administration
    - 23212 Primary groundwater data processing
    - 23213 Primary data processing – water quality and suspended load regime
  - o 2322 Hydro-Fund
    - 23221 Hydro-Fund database administration
    - 23222 Database output processing (individual requirements)
    - 23223 Preparation of Hydrological Yearbook of the Czech Republic
    - 23224 Maps administration / processing
    - 23225 Processing of regularly provided outputs
  - o 2323 Regime data processing
    - 23231 Regime data processing – surface water
    - 23232 Regime data processing – groundwater
    - 23233 Regime data processing – water quality
- 233 Hydrological balance
  - o 2331 Water quantity balancing
    - 23311 Base flows
    - 23312 Hydrological balance of water quantity
  - o 2332 Water quality balancing
- 234 Processing of hydrological forecasts and warnings
  - o 2341 Processing of hydrological outputs – Central Forecast Office
    - 23411 Receipt and revision of operational data from regional offices
    - 23412 Warning Reports within the System of Integrated Warning Service
    - 23413 Evaluation of snow reserves in GIS
  - o 2342 Processing of hydrological outputs – Regional Forecast Offices
    - 23421 Receipt, checking and sending operational hydrological data
    - 23422 Processing of short-term hydrological forecast – manually
    - 23423 Processing of short-term hydrological forecast – using a model
    - 23424 Manual calculation of water reserves in snow
    - 23425 Preparation of Hydrological Information Report
- 235 Metrological security of the acquisition and operation of hydrological measurement networks
- 236 Applied hydrology
  - o 2361 Hydrological monitoring in experimental catchments

## Hydrology Quality Objectives in 2015 – Division of Hydrology

## Appendix 2

QUALITY OBJECTIVE	MEASURE	EVALUATION CRITERIA	RESPONSIBILITY
Improve the water status monitoring and evaluation procedures.	Commissioning the system of electronic records of collected solid matrix samples.	100% of solid matrix samples will be recorded in the electronic solid matrix system.	Head of Water Quality Department
	Introducing the system of long-term preservation of solid matrix samples.	Standard operating procedure for long-term preservation of solid matrix samples.	Head of Water Quality Department
	Improving the evaluation of hydrometric measurements.	Creating and implementing new software for the processing of hydrometric measurements and discharge calculation. Amending the Methodological Guideline and staff training. Processing of at least 50 measurements using a hydrometric propeller in the new software.	Head of Surface Water Department
Maintain and improve the quality of water monitoring and evaluation results.	Improving and specifying the monitoring and evaluation procedures and data in the Regional Hydrological Departments.	Determined by the regional offices.	Heads of Regional Hydrological Departments
Improving the inputs for informing the public administration and public.	Increase the number of pieces and frequency of information provided within the twitter account CHMI_Hydrology	Implementation of twitter rss feed into hydro.chmi.cz/hpps, loading of automatic tweets, total number of tweets in 2015 – at least 200.	Head of Hydrological Forecast Department
	Creating a mobile application for the presentation of operational hydrological data of the CHMI.	Existence of a functional application for the Android operating system.	Deputy Director for Hydrology

The said quality objectives are further specified by the individual regional offices particularly in the areas of monitoring network operations and improvement of water status monitoring and evaluation procedures.

## Internal Audit Plan in Hydrology for 2015

Scheduled Time	Process Number	Audit Subject	Audited Department (Person)	Authorised Auditor
Q1	124	Methodical management	Water Quality Department Kodeš	Zajíčková Hypš
Q1	126	External communication	Hydrological Forecast Department Čekal	Zajíčková Hypš
Q1	1531	Incident management	Surface Water Department Šercl	Hypš Zajíčková
Q1	2332	Water quality balancing	Water Quality Department Vejvodová	Količová Šercl
Q1	2321321	Receiving and processing the data from quantitative monitoring of suspended loads	Water Quality Department Petrová	Količová Doležal
Q2	232122	Processing of data from automated groundwater stations	Regional Hydrological Department in Ostrava Šustek	Soukalová Zajcev
Q2	232123	Groundwater data checking and sending to the Hydro-Fund database	Regional Hydrological Department in Ostrava Šustek	Soukalová Zajcev
Q2	232311	Processing of standard hydrological data	Regional Hydrological Department in České Budějovice Mátlová	Doležal Šercl
Q2	232312	Processing of non-standard hydrological data and hydrological studies	Regional Hydrological Department in České Budějovice Lett	Doležal Šercl

**List of Methodological Guidelines and Work Instructions  
in the Area of Quantitative Hydrology**

- MP NH 2007/02 Discharge Measurement and Evaluation Using the Velocity Field Method  
 MP NH 2007/03 Discharge Measurement and Evaluation Using the ADCP System  
 MP NH 2007/05 Flood Waves  
 MP NH 2007/05 Flood Waves – Appendix  
 MP NH 2007/16 Disposal of Idle Boreholes  
 MP NH 2010/14 Suspended Load Regime Observation  
 MP NH 2011/01 Operational Processing of Groundwater Data  
 MP NH 2011/04 Calculation of Water Reserves in Snow Cover in GIS  
 MP NH 2012/01 ADCP Calibration  
 MP NH 2012/02 Solid Matrix Sampling and Passive Sampling for Chemical Analyses  
 MP NH 2012/03 Hydrological Service Activity under Extreme Runoff Conditions  
 MP NH 2012/04 Ensuring the Flood Warning and Forecasting Service in the CHMI  
 MP NH 2013/01 Metrological Security in the Field of Hydrology  
 MP NH 2014/01 Deriving the N-year Discharges Affected by Flood Control Measures  
 MP NH 2014/02 Standard Operating Procedures for Surface Water Instrument Calibration  
 MP NH 2014/03 Standard Operating Procedures for Groundwater Instrument Calibration  
 MP NH 2014/06 Deriving the N-year Maximum Discharges  
 MP NH 2014/06 Deriving the N-year Maximum Discharges (Appendix)  
 MP NH 2014/07 Deriving the Theoretical Flood Waves as Standard Hydrological Data  
 MP NH 2014/07 Deriving the Theoretical Flood Waves as Standard Hydrological Data  
 (Appendix)  
 MP NH 2015/01 Updating the Central Regime Database of Groundwater Quantity  
 MP NH 2015/02 Primary Groundwater Data Processing  
 MP NH 2015/03 Primary Surface Water Data Processing  
 MP NH 2015/04 Updating the Central Regime Database of Surface Water Quantity  
 MP NH 2015/05 Stage-Discharge Curve Processing  
 MP NH 2015/05 Stage-Discharge Curve Processing (Appendix)  
 MP NH 2015/06 Creating the Adjusted Groundwater Time Series  
 MP NH 2015/08 Deriving the M-day Discharges  
 MP NH 2015/09 Archiving the Solid Matrix Samples for Chemical Analyses
- PN OPZV 2015/01 for Monitoring at Groundwater Profiles and Instructions for Groundwater  
 Observers  
 PN OPZV 2015/02 for Measurement of Spring Yield and Temperature and Instructions for  
 Groundwater Observers  
 PN OPZV 2015/03 Instructions for Groundwater Technician Work
- MP Methodological Guideline  
 PN Work Instruction  
 OPZV Department of Ground Water  
 ADCP Acoustic Doppler Current Profiler