

WORLD METEOROLOGICAL ORGANIZATION

Guidelines for Implementing a Quality Management System in Hydrology

August 2013

WORLD METEOROLOGICAL ORGANIZATION



Introduction

Quality management is a process for ensuring that all the activities necessary to design, develop, and deliver a product or service are conducted effectively and efficiently. It typically involves one or more of the following elements: quality planning, quality control, quality assurance and quality improvement. Thus, it focuses not only on product and service quality, but also on the means to achieve it. By utilizing quality assurance and control of functions as well as of products, it is possible to achieve more consistent quality. Although quality control and quality assurance have long been familiar tools within National Meteorological and Hydrological Services (NMHSs) for ensuring data accuracy and consistency, the broader concept of a Quality Management System (QMS), which also incorporates quality planning and quality improvement, may be less familiar and less widely utilized.

The World Meteorological Organization (WMO) has established, documented, implemented and maintains a quality management framework (QMF). It provides a comprehensive system of recommended procedures and practices that can be included in quality management systems to direct and control basic and specialized meteorological and hydrological services with regard to quality of data, products and services. The basis for the WMO QMF is given in Resolution 27 (Cg-XIV), which stipulates:

WMO should work toward a Quality Management Framework (QMF) for NMSs that would eventually include and develop the following distinct though related elements, which could be addressed, possibly on a phased basis:

- (1) WMO technical standards;*
- (2) Quality management system(s) including quality control; and*
- (3) Certification procedure(s);*

while recognizing that the tasks associated with the development of such a framework had yet to be assessed.

The development of a WMO Quality Management Framework should enable the provision of early and continuing relevant advice to Members on developing their quality management system.

For a more complete description of the WMO Quality Management Framework see the [WMO explanatory circular](#). WMO's policy on quality management is stated in [Volume IV of the Technical Regulations](#) (WMO-No. 49) as follows: "WMO is dedicated to ensuring optimum affordable quality for all meteorological, climatological, hydrological, marine and related environmental data, products and services, especially those supporting the protection of life and property, safety on land, at sea and in the air, sustainable economic development and protection of the environment."

WORLD METEOROLOGICAL ORGANIZATION

At the Thirteenth Session of the Commission for Hydrology (CHy-XIII) in 2008, the Commission adopted a Quality Management Framework – Hydrology providing an overall strategy, advice, guidance and tools for National Hydrological Services (NHSs) to attain efficiency, quality and effectiveness in their functioning; and encouraged NHSs to design and implement quality management systems, based on the WMO Quality Management Framework and the principles of the International Standards Organization (ISO) or other relevant quality management standards, as appropriate to their situations. CHy also requested that the Advisory Working Group prepare and publish guidelines for implementing a Quality Management System (QMS) in NHSs. This document is the response to that request.

Definitions

Quality Management Framework (QMF): the strategy, advice, guidance and tools necessary for an organization (such as a National Hydrological Service) to attain quality, efficiency, and effectiveness in performing its mission responsibilities.

Quality Management System (QMS): a management tool consisting of a set of rules to direct and control an organization with regard to quality, which is intended to assist in establishing policy and objectives and in achieving those objectives. It is a dynamic process that brings resources, activities and behavior together to focus on the achievement of success.

Quality Management: the coordinated activities to direct and control an organization with respect to quality.

Quality: the degree to which a set of inherent characteristics fulfills requirements.

Quality Assurance: that part of quality management focused on providing confidence that quality requirements will be fulfilled.

Quality Policy: the course or principle defining the commitment to quality by an organization's senior management, including a framework for setting quality objectives.

Quality Objectives: performance indicators for measuring the progress of the quality system; for example, the number of hours of staff training per year, the number of discharge measurements made, etc.

Quality Manual: document that defines the scope of the Quality Management System and that outlines documentation related to the standard to be achieved. It includes or references documented procedures and describes how processes interact to form the QMS. It can be either a high level document with little detail regarding how work is performed, or it may include considerable detail.

Why Have a Quality Management Framework – Hydrology?

Reliable hydrological data and information are key inputs to the sound and wise management of water resources. Particularly within the context of integrated water resources management, where decisions are increasingly being made in coordination with relevant stakeholders, it is imperative that accurate data and information be accessible in a timely manner to facilitate informed decision-making. The value of such data and information increases when they are provided by organizations that have established and adhere to quality management principles.

WORLD METEOROLOGICAL ORGANIZATION

Decisions in various sectors of the economy are becoming increasingly reliant on hydrological information. Depending upon a country's particular circumstances, it is possible that multiple agencies collect hydrological data within a basin. In such instances, a lack of standard procedures for obtaining measurements, storing and manipulating data, protocols for data and metadata exchange, as well as acceptable analytical methodologies for transferring data into information, can result in conflicting materials being made available to users. Such a situation can lead to disagreements, generate reluctance to cooperate and can undermine the importance and credibility of the work of the National Hydrological Service (NHS). In transboundary basins, the situation is even more complicated and requires greater assurance among riparian countries that data and products meet a certain standard of quality.

Given the complexity intrinsic to hydrological processes and the impracticality of completely eliminating uncertainty in observed data and derived products, it is useful to make users aware of the various uncertainties. Further, research on the global water cycle and the effects of climatic variability and change on the availability of water resources requires the sharing and use of data among numerous countries. To support such analyses, it is essential that the data be compatible, comparable and of known quality.

Quality Management Framework and National Hydrological Services

To accomplish their mission and achieve their strategic directions, NHSs must ensure that the core activities of hydrological data acquisition and delivery of services and products are performed efficiently and effectively. It is also beneficial to have in place quality management procedures so that assurances can be provided that the stated data quality is being attained. Implementation of quality management systems will assist NHSs in the provision of good management practices and ultimately will enhance confidence in the quality of their data, products and services. This can enhance the reputability of the NHS among clients, users and stakeholders, and possibly raise awareness of the need for financial and human resources to manage and operate the NHS.

It is worth noting that quality management is useful to an NHS even if there is no intention by the Service to enter into a formal certification process, as the adoption of quality management principles, approaches and practices facilitates the efficient and effective management and operation of a Service. Therefore, NHSs from both developing and developed countries that may lack sufficient funds for obtaining third-party certification can still greatly benefit by adopting quality management principles, even in the absence of certification.

National Quality Management Framework

It is common in hydrology to have multiple organizations performing similar activities with different objectives or at different geographical scales within a country. At the same time, overall responsibility for maintaining and improving the quality of hydrological observations, products and services may rest with a central authority, typically the country's National Hydrological Service. Such a central authority should strive to establish and support the quality-related structures and processes of the various other hydrological organizations operating within the country, including the private sector when possible.

Accordingly, it is most desirable that the NHS and each organization involved in the provision of hydrological data, products and services within a country or a basin establish a QMS to support the continuous improvement process of all monitoring and information delivery activities. An authorized organization, normally the NHS, should be able to guide such a process by defining the

WORLD METEOROLOGICAL ORGANIZATION

national QMF. In other words, in the case of a country with multiple hydrology-related organizations, the NHS would be responsible for the national QMF, with each Hydrological Service developing and adopting its own QMS under the umbrella of the national QMF.

The national QMF has to be supported by an accepted statement articulating the objectives, policy and values of the NHS concerning the maintenance and improvement of the quality of the hydrological information that it provides. It is important to ensure that policies and objectives are relevant to the stated policy of the NHS, and consistent with the circumstances and conditions within the country.

Typically, the compilation and documentation of the quality system is undertaken through a quality manual, which forms an important part of the process of building, consolidating and clarifying the quality management framework. Describing the framework in a single document helps reflect a coherent and integrated overall quality management strategy. The manual, in addition to the details of the specific elements of the quality system, should describe the broader content of the quality management system, including policy, objectives, organization, quality improvement and service standards. This manual may also show linkages to the WMO QMF and WMO publications. This document could also summarize what actions have been taken to satisfy the requirements of a QMS based on ISO 9000 requirements or a similar system.

What is a Quality Management System (QMS)?

“A quality management system is a management tool consisting of a set of rules to direct and control an organization with regard to quality, which is intended to assist in establishing policy and objectives and in achieving those objectives. It is a dynamic process that brings resources, activities and behaviour together to focus on the achievement of success”. ([WMO, 2006, p. 36](#))

A QMS should exist within the context of the policy and structures of its corresponding QMF. In practical terms, the QMS will reflect the existing political, administrative, legal and socio-economic environment within which a country's National Hydrological Service, and any other hydrological organizations operate.

To support a complex professional organization like an NHS, the QMS must incorporate specific operational elements of quality assurance by establishing acceptable practices and exercising control checks on these practices (Hudson et al., 1999). Indeed, the purpose of a QMS is to control the quality and standards across all organizational processes and to support the staff engaged in the various components in achieving the quality policy objectives. To accomplish this, it is necessary to define clearly the responsibility, authority and interactions of all staff whose work affects the quality of data, products and services, as well as the approaches and verifications that are needed within the system.

The quality management system guides the entire process that guarantees the quality of the final data, products and services. It should also be extended to include other, non-technical NHS activities such as accounting practices and performance appraisals. The QMS thereby ensures that the NHS is able to inform “clients that its data, products and services meet the standards of quality that have been defined for them”, both accurately and reliably ([WMO, 2006, p. 36](#)).

Fundamental to any quality management system are the following key principles:

- Quality is built into the observation and data/information production process, rather than relying on post-production audits or checks;

WORLD METEOROLOGICAL ORGANIZATION

- Each person in the process has clearly defined and properly communicated responsibilities;
- An *efficient* results-based control process exists (too many controls results in no control);
- Stakeholders are involved in performance assessment; and
- Practitioners (e.g., hydrographers, technicians, etc.) participate in the continuous evolution of the quality management system.

Continuous improvement activities are integral to every quality management system. There are many possible mechanisms for quality improvement and each hydrological service will need to develop approaches best suited to its own circumstances. A continuous improvement process typically contains six activities that operate synergistically. They are:

- Formal documentation of standards and expected practices and procedures;
- Development of activities that build staff awareness of and competencies in standard procedures and practices and their expectations;
- Assessment of product or process quality against established indicators;
- Studies that propose improvements to practices and procedures;
- Development of an inventory of improvement initiatives and a plan to assist in their implementation; and
- Identification and documentation of lessons learned.

The Eight Principles of Quality Management

The WMO QMF is founded on the eight principles of quality management. These principles are designed to underpin the achievement of objectives and the enhancement of capacity building activities for Members. They were developed by ISO Technical Committee ISO/TC176/SC2/WG15 and are listed as follows:

1. User/customer focus: Members should identify, document and understand the current and future needs of their users/customers for meteorological, hydrological, marine, aviation, marine and related environmental data, products and services. The means to achieve this may include conducting regular customer satisfaction surveys, liaison meetings, and visits to users/customers;

2. Leadership: the WMO Congress and the Executive Council provide overall leadership in establishing the purpose and direction of the Organization based on the WMO Convention (article 2) and strategic planning process. The Congress, Executive Council, and Secretary-General maintain the organizational environment in which all Members, WMO constituent and working bodies are fully involved in achieving organizational objectives. In turn, the senior management of each of the Members should clearly establish the direction of the organization and the environment within which staff members are encouraged to work toward that direction and the objectives;

3. Involvement of people: the full involvement of members of Technical Commissions, Regional Associations, and experts from Members should be used for the implementation of the Members QMSs. As staff members are the essence of an organization, their full involvement enables their abilities to be used for the benefit of the Members;

4. Process approach: a process is a set of interrelated or interacting activities that transform inputs into outputs. The desired results are achieved more efficiently when programme activities are managed as processes. The activities and related resources of Members should also be managed as processes. Processes may be operational, scientific, or administrative; and they provide the mechanism to achieve customer satisfaction;

WORLD METEOROLOGICAL ORGANIZATION

5. *System approach to management*: Members are encouraged to identify, understand, and manage interrelated processes as a system to achieve effectiveness and efficiency in fulfilling their objectives. An example is the identification and management of the linked processes associated with making and recording observations, issuing forecast products and services, and disseminating and archiving records;

6. *Continual improvement*: continual improvement in the quality of observations, records, and reports on weather, water resources, climate and related natural environment, operational forecasts, and warning services should be a permanent objective of all Members. The effectiveness and suitability of the QMS, in particular, should be evaluated and areas for improvement should be identified and rectified. Regular management reviews should be conducted and mechanisms for staff members to suggest improvements should be encouraged;

7. *Factual approach to decision making*: effective decisions should be based on the analysis of data and information. They should never be based on unsubstantiated beliefs or suppositions; and

8. *Mutually beneficial supplier relationships*: Mutually beneficial relations with other international and national organizations will enhance the ability to create value-added meteorological, hydrological, marine, aviation, and related environmental products and services. The Members and their suppliers are interdependent and a mutually beneficial relationship enhances the ability of both to create value. Suppliers should be evaluated and selected on the basis of their ability to meet requirements, as well as on their past performance.

Development and Implementation of a Quality Management System (QMS)

Members should develop and implement a properly organized quality system comprised of the procedures, processes, and resources necessary to improve the efficiency and effectiveness of delivering meteorological, climatological, hydrological, marine, and related environment data and products.

It is recommended that the quality system established meet the requirements of the appropriate Standard of the ISO 9000 Quality Management Standard series, or other internationally recognized practices and procedures, to fulfill the prevailing national and regional regulatory requirements and to meet customer needs.

The ISO 9001 Quality Management Systems – Requirements. This international Standard specifies requirements for a quality management system that can be used by internal and external parties, including third party (external) certification bodies, to assess an organization's ability to meet customer, regulatory, and the organization's own requirements. It focuses on the effectiveness of the quality management system in meeting customer requirements. Members are strongly encouraged wherever possible to adopt this approach to quality management.

The ISO 9004 Managing for the sustained success of an organization – A quality management approach focuses on meeting the needs and expectations of customers. It will prove useful to Members who wish to pursue ongoing improvement, as measured through the satisfaction of customers and other stakeholders. It is not subject to external (third party) certification and uses a formal self-assessment process. Although it may be used as a stand-alone QMS, it is primarily used by organizations pursuing ongoing improvement following third party certification under ISO 9001.

Although certification may be the ideal arrangement, an efficient and effective quality management system can be implemented and operated successfully without going through formal ISO 9001

WORLD METEOROLOGICAL ORGANIZATION

certification. A number of NHSs have successfully operated rigorous quality management systems for decades without ever pursuing certification by an internationally recognized body such as ISO. To do so, however, these Services have consistently followed procedures that are nearly identical to those required to receive ISO 9001 certification and recertification. The following section outlines the recommended steps for ensuring the development and implementation of a quality system that complies with the ISO 9001 requirements, even though certification may not be a Service's ultimate objective.

Steps Involved

- Obtain a copy of the ISO 9001 Standard and study it to understand what is needed to transform its requirements into practical working language for daily activities.
- Designate a senior person to oversee development of the QMS, ensuring that this person receives adequate training.
- Form a small task team, possibly including an external expert, to evaluate the adequacy of existing quality procedures and the need for new procedures based on ISO 9001 requirements.
- Senior management prepares and publishes the *Quality Policy*, *Quality Objectives*, and *Action Plan* for implementing the QMS.
- Promote leadership within the organization by creating and sustaining employee awareness and motivation by involving staff in developing and improving the system.
- Assess organizational structure by identifying critical competencies needed within the Service.
- Develop *Documented Procedures* (for control of documents, control of records, internal audit, control of nonconforming products, corrective action, and preventive action) describing how the Service carries out its work. Flowcharts may be used to describe core and support processes. Procedures should be reviewed continuously and staff should be trained to implement them.
- Prepare and publish the *Quality Manual* describing the overall system in broad terms. Keep it simple and distribute it to clients and cooperators, all employees, and to suppliers. The quality manual must include a description of the system to control documents.
- Launch the QMS and continually audit and improve it. Even if certification is not being sought, this step provides valuable insight into system performance.
- Establish review mechanisms to verify whether the Service is complying with all requirements set by the Standard.
- Establish *corrective* as well as *preventive action* systems to prevent problems from recurring, as well as a system to measure customer/cooperator satisfaction, process effectiveness, and product conformity.
- Select and hire a recognized and respected certification body to carry out the certification assessment (if certification is planned).
- Start the certification assessment (if certification is planned).

WORLD METEOROLOGICAL ORGANIZATION

It could take 12 to 18 months to complete all of these steps, depending upon the scope of the certification, complexity of processes, staff skills and workload, availability of resources and, above all, the level of management commitment.

Obtaining NHS Certification – A Case Study

In 2004, WMO prepared a short guide entitled [Quality Management System for National Meteorological and Hydrological Services](#). Its purpose was to explain why an NMHS should spend time and money implementing a certified QMS. The report included practical information based on the experience of a medium size NMHS that had undergone certification and recertification processes, and that had a broad scope covering the Service's Headquarters, regional centers, observation networks, and telecommunication networks. That generic example, modified slightly to appear more hydrology oriented, follows.

Summary of the statement of Mission, Vision and Quality Policy

Mission: To provide reliable hydrological information to the society such that decision making processes associated with the development of the country are positively affected.

Vision: To be a major contributor in developing and using hydrology both nationally and internationally through innovation and partnership with social and economic sectors of the society.

Quality Policy: Seek recognition, trust and high user satisfaction through the efficient monitoring of hydrological conditions, use of modern hydrological forecasting tools, and timely delivery of required products and services.

The stated reasons for implementing a QMS

- Obtain national recognition through the ISO certification;
- Seek excellence through continuous improvement of activities, processes, products, services and customer satisfaction;
- Use and expand the knowledge of hydrology;
- Involve staff in all processes, from data collection to delivery of products; and
- Have an integrated view of the organization.

Utility of a QMS

- Standardization and implementation of documented procedures for the development of products, services, and processes, all based on government regulations, WMO standards, and the national ISO 9001:2000 standard;
- Structuring of the processes and services to ensure customer satisfaction and continuous improvement; and
- Management of processes using quality objective indicators and the continuous monitoring of activities.

Perception of what needed to be done to fulfill the requirement of ISO 9001

- Commitment and involvement of top management;
- Statement of a Quality Policy, Mission and Vision;
- Writing a Quality Manual;

WORLD METEOROLOGICAL ORGANIZATION

- Writing and implementing Procedures, Instructions and Manual/Guides;
- Management review of the QMS twice a year; and
- Internal and external auditing twice a year.

How it was done

- Hired a recognized consulting firm that specializes in quality management;
- Established a high level Quality Committee;
- Designated a Quality representative;
- Created a Quality Control section within the Service;
- Prepared the documentation;
- Trained those who would become QMS trainers;
- Obtained certification through an internationally accredited company; and
- Obtained recertification three years later.

Composition of the Documentation

- Strategic – The Quality Manual, including the statement of Mission, Vision and Quality Policy;
- Tactical – Documented Procedures; and
- Operational – Working instructions.

The staff structure

- Quality representative of senior management at Headquarters;
- Head of Quality section at Headquarters;
- Internal auditor(s) at Headquarters;
- Lead auditor(s) at Headquarters;
- Quality Engineer; and
- Quality representative at each regional centre.

Number of Quality Procedures

- Fourteen Documented Procedures were implemented, including the six that were mandatory.

Examples of Quality Indicators

- Number of hours of staff training per year;
- Success index (accuracy) of the hydrological forecasts for each region of the country;
- Provision of hydrological data;
- Availability of the hydrological data base;
- Number of messages (feedback) received;
- Number of automated data collection platforms;
- Number of stream gauging stations inspected; and
- Number of station-days operated per site without loss of data.

Monitoring forms and tools

- Daily reports of nonconformity, inconsistency, or trouble/error detection;
- Monthly reports covering nonconformities; and
- Quarterly: Internal and external audits; requests for preventive/corrective actions; and meeting of the high level Quality committee.

WORLD METEOROLOGICAL ORGANIZATION

In reviewing this case study, it is important to remember that the listed elements were performed to achieve *certification*. Significantly, however, *certification* is not the primary objective, *quality* is; and a fully functional and successful quality management system can be developed, implemented, and operated for many years without ever having received a third party certification. The crux of the issue is for the Service first to understand that quality is in their best interest, and second to develop a quality-oriented process for conducting business as appropriate to their circumstances. It is not an all or nothing venture. A long-term strategy for gradually making incremental improvements in monitoring, data review, products, management, and all other processes within an NHS is acceptable.

Summary

A properly designed and implemented quality management system can improve efficiency and effectiveness and can assist National Hydrological Services demonstrate that they are high performance organizations that deliver high quality products and services critical to societal health and safety. Although the “cost of quality” (implicitly, high quality) is commonly perceived to be high, the “cost of lack of quality” may well be higher. A Service that finds that the observations it has made for several years are worthless because of a previously unrecognized fault in an instrument, or the Service that finds that it must completely reprocess a flow record because a weir was incorrectly rated, incurs a much higher cost than would have been involved in checking the instrument or the rating. As in so many other situations, the cost of doing something now is obvious, but the long-term or future benefits are much less so. The management of a Hydrological Service should consider very carefully the Service’s need for a systematic approach to product quality.

References

Hudson, H.R., McMillan, D.A., and Pearson, C.P., 1999. *Quality assurance in hydrological measurement*: Hydrological Sciences Journal, v. 44, pp. 825-834.

[Wellens-Mensah, J., 2008. *Capacity-building needs for National Hydrological Services*: World Meteorological Organization Bulletin, v. 57, pp. 152-158.](#)

[WMO, 2004. *Quality Management System for National Meteorological and Hydrological Services*. World Meteorological Organization, Geneva.](#)

[WMO, 2006. *Guidelines on the Role, Operation and Management of National Hydrological Services*. Operational Hydrology Report No. 49, World Meteorological Organization, Geneva.](#)

[WMO, 2010. *Technical Regulations Volume IV Quality Management*. World Meteorological Organization, Geneva.](#)