Research on Cloud Platform for Safety Supervision and Early Warning of Small Reservoirs

Youjie Jin¹2, Na Liu¹2*, Baibing Zhou¹2

¹ Nanjing Automation Institute of Water Conservancy and Hydrology, Ministry of Water Resource, Nanjing, Jiangsu Province, 210012, China
² Hydrology and Water Resources Engineering Research Center for Monitoring, Ministry of Water Resources, Nanjing, Jiangsu Province, 210012, China

*Corresponding author’s e-mail: 66507886@qq.com

Abstract. In order to meet the urgent needs of safety supervision and early warning of small reservoirs in China, and take the advantages of modern information technology in automation and intelligence, the overall design of cloud platform for safety supervision and early warning of small reservoirs is carried out from two aspects, one is based on cloud technology platform architecture, the other is the discussion of trusted operation mode. Small reservoirs have some daily management problems, such as limited funds, remote and complex environment, and weak technical force. This paper analyses and implements the core content and key technologies of platform construction, such as integrated intelligent monitoring system, platform business application system, and professional service. The informationization means and preliminary scheme for safety supervision and early warning of small reservoirs with high stability, high cost performance and scientific advancement are put forward.

1. Introduction
There are more than 93,000 small reservoirs in China, most of which were built in the 1950s to 1970s[1]. According to statistics, 96.4% of small and medium-sized reservoirs have experienced dam breaks since 1954, and the average risk rate is as high as 53.3%[2]. Low flood control standards, uneven engineering quality, limited management costs, and level of supervision and early warning to be promoted are important issues facing small reservoirs[3-4]. The present situation is that the safety risk of small reservoirs is much higher than that of large and medium reservoirs[5-6]. The safety supervision and early warning work of small reservoirs is a short board for the safety of water conservancy projects in China. It is urgent to strengthen industry supervision.

Based on cloud computing, big data, GIS and other new information technology, this paper sums up the characteristics and key points of small reservoir safety supervision, and discusses the small reservoir safety supervision and early warning mode. Using modern information technology, a cloud platform for safety supervision and early warning of small reservoirs is built, including automated monitoring system, data management platform, a set of professional application software, technical support services, etc., to overcome key technical problems. Supporting the whole process service of design, construction, operation and maintenance of information platform for small reservoirs. Realizing the whole chain supervision of intelligent monitoring, heterogeneous data fusion, integrated information management, analysis and early warning release and assistant decision-making for small
reservoirs. And providing a set of stable, efficient, scientific and advanced information supervision means and technical services.

2. Overall design of platform

2.1. Key Points of Platform Construction
The key points of safety supervision and early warning cloud platform construction for small reservoirs include three aspects (Figure 1). (1) To clarify the three main bodies of responsible persons: administration, technology and inspection. To refine the division of responsibilities by means of information technology, and to strengthen the supervision of responsibilities. (2) The core task is to prevent and warn dam-break in emergency state, and to warn and forecast in time to ensure the limited water level in flood season. (3) Regulate the daily supervision work, through the basic functions of reservoir safety responsibility supervision, comprehensive information monitoring, operation and maintenance management, early warning and forecasting information release, statistical analysis, etc. Strengthen the daily supervision with the combination of the means of information supervision and on-site reservoir manual management methods, and improve weak links of small reservoir supervision.

![Diagram of Platform Composition](image)

**Figure 1. Key Points of Safety Supervision and Early Warning for Small Reservoirs**

2.2. Overall framework
The construction of cloud platform for safety supervision and early warning of small reservoirs adopts the idea of standardized platform design. Five-tier platform architecture is designed (Figure 2).
2.3. Platform operation mode

The platform adopts the mixed cloud mode of public cloud and private cloud and takes scientific research institutes or information platform builders as the main body to establish the safe trusteeship operation mode of regional or watershed small reservoir groups. Using the advantages of mature public cloud service providers in mass data cloud storage and flexible management of computing resources, the massive monitoring data of small reservoir groups are connected to the cloud platform for dynamic storage. At the same time, small private clouds are established in research institutes to provide data security audit, business application, expert evaluation and other services on a more secure and professional platform.

Figure 2. Schematic diagram of cloud platform

Infrastructure layer constructs the basic cloud platform of intelligent supervision and early warning for small reservoir safety by using virtual technology and server cluster technology, which provides infrastructure guarantee for centralized storage of monitoring data and comprehensive information, information exchange and data communication, efficient calculation and analysis, and platform security protection. Monitoring and perception layer constructs integrated intelligent monitoring system of water regime-rain regime-project information-video elements by using intelligent micro-power measurement and control unit, sensor and emergency trigger response mechanism. The data resource layer is mainly composed of three parts: data resource catalogue, thematic database and standard system of complete data resources, so as to realize the construction of standardized data environment. The application support layer is divided into data resource support layer, public service support layer and business application support layer. On one side, it manages data receiving and gathering, realizes data resource integration and sharing. On the other side, it supports applications to provide system-wide information sharing services and realizes the integration and reuse of software resources. The service terminal layer includes online monitoring, monitoring and control, responsibility supervision, early warning and prediction, operation and maintenance, analysis and evaluation, assistant decision-making, document management and other functional applications. In addition, it supports workstations, network browsers, personal computers, mobile intelligent terminals and other terminal equipment applications.
Figure 3 shows that the data of each small reservoir automation monitoring system are transmitted to the remote central platform in real time by wireless communication. The reservoir site can also set up workstations (as optional facilities) to receive data synchronously. The manual observation data can be uploaded in the form of human-computer interaction at regular intervals, and the cloud platform can receive, store and manage monitoring data uniformly. At the same time, the cloud platform provides daily online monitoring, emergency monitoring, data analysis, report compilation, information subscription and push, expert assistant decision-making and other technical support services in the form of "remote monitoring + local service". It also provides on-site technical services such as system maintenance, inspection, fault treatment, observation and monitoring in various river basins or regions. Reservoir field personnel only need to ensure the management of the reservoir basic operation and the normal operation of the power supply automation system and burglar alarm system. Relevant responsible persons can make use of webpages, mobile phones and other terminals to clarify completion status of their responsibilities and tasks, and query reservoir comprehensive information and current status at any time. Under abnormal or emergency conditions of reservoir monitoring data, cloud platform actively pushes early warning information and monitoring data to relevant responsible persons to assist in strengthening supervision.

3. Key technologies research and implement of the platform

3.1. Integrative intelligent monitoring system

Deployment of small reservoir safety automatic monitoring system is an effective means to solve the problem of small reservoir safety supervision. However, due to the limitation of personnel, technology and funds, popularizing the construction of automated monitoring system is unreliable.
Figure 4. Integrative intelligent monitoring system

The core equipment of the system includes integrated monitoring device which can monitor water regime-rain regime-project information-video elements, installation bracket, standby battery, solar charger, lightning protection device, communication transmission equipment and so on (Figure 4). The multi-element integrated monitoring device provides standardized sensor interface, which can simultaneously connect various types of water level gauge, rainfall gauge, dam deformation monitoring sensor, seepage pressure gauge, and reservoir video camera, and shares communication transmission, lightning protection and power supply equipment, greatly improving the cost ratio of monitoring system. At the same time, the data acquisition process of the automation system makes full use of power control technology and system self-diagnosis technology, reduces the power consumption of the device, and improves the adaptability and stability of the system in complex environment. It minimizes the workload of daily manual operation and maintenance of the system. In addition, the system has set up a simple and easy-to-use visual interactive interface at the front end of the monitoring, which is convenient for people at different levels to use, and it has built-in self-protection mechanism for extreme conditions such as rainstorm, lightning, and earthquake. It realizes self-switching of monitoring frequency, monitoring items and monitoring modes, and has the advantages of high intelligence and easy operation.

3.2. Business application system

(1) Intelligent data acquisition system

Intelligent data acquisition system is mainly based on data acquisition network to automatically measure, control and collect reservoir safety monitoring information such as reservoir water level, rainfall, dam seepage, deformation, and video image, which are connected to each monitoring device. On the basis of conventional single reservoir safety monitoring, the intelligent data acquisition system optimizes the acquisition software in many aspects, such as multi-reservoir remote parallel data acquisition, remote setting and maintenance, autonomous intelligent monitoring under emergency conditions such as flood season, synchronous storage of massive data, and self-checking of system operation status. Enhance the stability, intellectualization, easy operation and maintenance of the acquisition software under the normal and emergency conditions.

(2) Integrated information management system

Depending on this system, management departments at all levels and reservoir managers can carry out their work in an orderly manner, timely and comprehensive grasp of the reservoir safety situation and operation behavior. And the system provides strong information service support for the daily supervision and emergency decision-making of small reservoirs. It includes many core functions such
as online monitoring, monitoring and control, responsibility supervision, operation and maintenance, early warning and forecasting, document management and platform monitoring.

(3) Early warning and forecasting system

Early warning and forecasting system is an important means to realize early warning and assistant decision-making of small reservoir safety monitoring based on cloud computing technology. The system realizes the early warning and prediction of flood and engineering safety of small reservoirs by means of information mining of big data, conversion of physical quantities, analysis and evaluation, simulation and so on, and provides users with auxiliary decision-making opinions in an intuitive and conclusive way. It mainly includes: reservoir flood forecasting analysis, comprehensive dispatching management, reservoir safety and health diagnosis, etc.

(4) Mobile terminal application system

Mobile terminal application system is another way of platform information publishing, and also an important means of online information exchange between different users. Mobile terminal application system mainly provides two service modes: Wechat service account and APP client. It has the advantage of mobile terminal being flexible and portable, and it can query monitoring information, patrol inspection, duty management, receive early warning information, read and download chart and interact with other users online anytime and anywhere.

3.3. Specialized services

In addition to the construction of platform hardware and application software, the small reservoir safety intelligent supervision and early warning cloud platform also includes the corresponding technology and service support.

(1) Daily surveillance: The platform trustee establishes a professional technical team to monitor the daily monitoring data of reservoirs and preliminarily evaluate anomalies. In the way of professional intervention, safety risks are detected in time and pushed to the relevant responsible person, system builder or expert team. After that, start abnormal diagnosis and troubleshooting process.

(2) Emergency decision-making: Emergency response mechanism should be established to realize online interaction and correspondence between reservoir site and central platform under special conditions such as rainstorm, typhoon and thunderstorm in flood season. Through online consultation of expert team, effective information of monitoring data can be mined in real time, and technical services such as early warning, forecasting and assistant decision-making can be provided.

(3) On-site operation and maintenance: The trustee deploys personnel to the site in different areas to provide technical support for the equipment, sensors and basic operation facilities such as power supply, lightning protection and communication in the automated monitoring system, and to attend the site for maintenance and problem investigation. In addition, it can provide professional technical team to complete professional services such as reservoir inspection, observation and monitoring, and maintenance.

(4) Remote technical support: Based on data center platform, new reservoir access and old reservoir maintenance are realized. The system remote debugging, account configuration management, data maintenance management, instrument measurement point management, chart results compilation, information release are 24 hours to provide services. To realize remote technical guidance and operation and maintenance operation by online consultation.

(5) Information subscription push: According to the rights, categories and needs of different reservoirs or managers, information subscription and automatic push services are set up and distributed, including daily briefing, abnormal information, task execution, annual report, etc.

4. Conclusions and outlook

In this paper, the framework of cloud platform for safety supervision and early warning of small reservoirs is designed, and the safe trusteeship operation mode of small reservoirs is discussed and put forward. Aiming at the characteristics and requirements of small reservoirs, the key technologies such as integrated intelligent monitoring system, business application system and professional service are
analyzed and implemented, and a safety supervision and early warning cloud platform for small reservoirs is built.

At the same time, the safety supervision and early warning of small reservoirs need further improvement. For example, cloud computing, Internet of things, and big data are deeply integrated with the business requirements of small reservoir safety monitoring, reservoir management, early warning and forecasting, emergency decision-making and so on. It is an important research direction in the future to improve the intelligent application level of information system and platform and reduce the cost of reservoir operation and maintenance by means of information technology.

Acknowledgments
This work was supported by Special funds for national key research and development program (2017YFC0405700).

References
[1] SUN J.H. (2018) Achievements of reservoir dam safety management in China and challenges. China Water Resources, 20:1-6.
[2] GAO X.C. (2018) Practice and discussion on dam safety management of small reservoirs. China Water Power and Electrification, 11:51-53.
[3] ZHANG X. (2019) Safety analysis of small reservoir dams. Agricultural Science-Technology and Information, 02:127-128.
[4] ZHANG K.Y. (2018) The mode exploration of small reservoir safety management. China Water Power and Electrification, 11:24-26.
[5] XU J.P., SONG W., LIU Y., et al. (2017) Design and application of communication early warning system for flood control of small reservoirs in Jiangsu. Yangtze River, S2:291-294.
[6] LIU H. (2015) Research on key technology of flood control forecast and early warning for small and medium-sized reservoirs. Yellow River, 07:37-40.