Research on the improvement of hydrologic emergency monitoring capacity of barrier lake

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Abstract. Based on the analysis of the current situation of hydrologic emergency monitoring capability of barrier lake, and consider the actual needs of portability, environmental adaptability, technological advancement, accuracy suitability, reliability, etc. The overall structure of the improvement of hydrologic emergency monitoring capability of the barrier lake was designed, and the detailed program were carried out on data collection, data transmission, data processing and monitoring and guarantee. Through the improvement of emergency monitoring capacity, can provide better basic support for emergency disposal of barrier lake.

1. Introduction

In recent years, sudden water events caused by extreme weather, earthquakes, landslides, mudslides, etc. have been on the rise year by year, seriously threatening the safety of people's lives and property, and governments at all levels need hydrological data as the basis for decision-making when dealing with and handling these events. Hydrological emergency monitoring has become the norm[1].

In the last 10 years, sudden water events caused by the barrier lake have occurred frequently. According to incomplete statistics, there are as many as seven large-scale barrier lakes in China. If these lakes are not scientifically disposed of, they will form a larger secondary disaster on the upper and lower reaches, resulting in greater losses. China attaches great importance to the dammed lake, concentrates its superior forces, and establishes a professional team, by adopting engineering measures and non-engineering measures for dammed lake disposal, it has successfully lifted all previous dangerous situations. The hydrologic emergency monitoring in the whole emergency response work, plays the role of "eyes and ears", "sentry" and soon, for emergency disposal to provide precious first-hand hydrological monitoring data[2].

In April 2000, a huge landslide occurred in Bomi County, Tibet, blocking the YigongZangbu River to form a barrier lake. The Hydrological Department formed the Hydro science and Technology Rescue Team to carry out the emergency monitoring of the barrier lake, which pioneered the hydrologic emergency monitoring of the barrier lake. Tangjiashan Lake, formed in the 2008 "5.12 Wenchuan earthquake", is the most dangerous barrier lake. Hydrological Emergency Monitor overcoming difficulties such as poor communication and inadequate supplies and risked landslides, rolling stones, wood carrying out emergency monitoring, provides timely Hydrological data for the scene Commanding decision-making[3]. In February of 2008, the hydrological Department carried out the hydrologic emergency monitoring of the landslide in Tibet. It has laid a good foundation for emergency management. In 2010, a massive landslide occurred in Gansu province, and the hydrological department carried out emergency monitoring. It provides an important supporting role for disaster relief and
In 2018, four times barrier lakes occurred in Ya River and Jinsha River, the hydrological department responded positively, carrying out emergency monitoring, provide timely and reliable monitoring data for the disposal of the barrier lake.

2. Status and problems of hydrologic emergency monitoring

2.1. Status
In order to deal with all kinds of water emergency incidents in the basin, the Changjiang Water Resources Commission, relying on the Hydrological Bureau, has set up a hydro-emergency rescue team. When an emergency occurs, emergency monitoring is carried out according to the preset response mechanism. At the same time, every year for different regions in the basin, different types of natural disasters to carry out emergency drills, with better organization, technology and Human resources protection, accumulated a wealth of practical experience. In the hydrologic emergency monitoring of barrier lake, the geometric monitoring of the plug body, the monitoring of the hydrologic elements of the lake (water level, discharge, etc.) and the topographic survey of the downstream river channel were carried out. Hydrologic emergency monitoring mainly uses Ordinary equipment, no professional emergency monitoring equipment were used.

2.2. Problems
In the past emergency disposal of barrier lake, the hydrologic emergency monitoring has been carried out well, highlighting the basic support function of the hydrological work. However, in the practice of emergency monitoring, there are still many shortcomings, such as the relatively lack of research on emergency monitoring technology, the lack of emergency monitoring capacity, and the low utilization of new technologies. This is reflected in the following areas:

(1) The relative lack of technology research on emergency monitoring
In view of the special water situation with large water level variation, high sand content, large flow rate in the affected area of barrier lake, there is a relative lack of monitoring technology research on each element. Pressure self-remembering water meter in the water conditions of high-water level change rate data distortion, high-speed water flow, with a large number of floating objects in the case of how to effectively carry out flow testing and other technical problems have not yet the best solution.

(2) Insufficient emergency monitoring capabilities
The equipment to carry out emergency monitoring basically use daily production equipment, there is no relatively stable emergency equipment, equipment is relying on temporary patchwork, resulting in inadequate capacity for emergency monitoring, inefficiency. In addition, due to various restrictions, the patrol car can be used for emergency monitoring cannot be configured, such as in the "11.03" Baige emergency disposal, the vast majority of 19 vehicles are rented social vehicles, it has both safety risks and affect production efficiency.

(3) The low utilization of new technologies
Existing factor emergency monitoring methods are largely traditional methods. With the continuous development of sensing technology, computer control technology and information and communication technology, various high-tech technologies, such as drones, radar, artificial intelligence, etc., can further improve the timeliness of operation and reduce the risk of manual operation. However, in the existing emergency monitoring practice, the use of high-tech is obviously insufficient, innovation is not enough.

3. Demand analysis
Emergency monitoring emphasizes "emergency" and, unlike general monitoring, general monitoring requires "high accuracy and appropriate timeliness", while emergency monitoring requires ensuring the safety of personnel and equipment, it is often necessary to "be time-sensitive and appropriate accurate". Make full use of modern scientific and technological, developed emergency monitoring equipment to adapt to water level change large, high sand content, large flow, fast flow of barrier lake area, introduce contactless monitoring equipment, development the accurate, convenient, fast and safe monitoring.
methods, equipped with advanced high-performance all-weather transportation, communication tools to strengthen capacity-building for hydrological emergency monitoring. Therefore, the improvement of emergency monitoring capacity is particularly focused on safety, timeliness, accuracy, the specific requirements are as follows:

1. Easy to carry, high field environment adaptable.

The barrier lake is located, mostly in high mountain valleys, and traffic is very inconvenient, and in extreme cases, it is only accessible on foot. Therefore, emergency monitoring equipment should be small in size, lighter weight, easy to carry. At the same time, due to the harsh natural conditions in the location of the lake, the monitoring equipment is required to be adaptable to the environment, and can work normally in the high cold area.

2. Non-contact monitoring, improve job safety.

In the hydrologic emergency monitoring of barrier lake, non-contact monitoring should be used as much as possible to improve monitoring safety. Plug body after the collapse, the water level downstream will rise rapidly, which brings great difficulties to the hydrologic emergency monitoring. Such as 2018"11.03"Baige barrier lake after the dam broke, the maximum surface flow velocity was 10.3 meter per seconds, Yebatan Station, 56 Kilometre under the dam, the stage rose at most 3.53 meters per minute, the water ruler was washed away, automatic stage monitoring equipment cannot keep up with the stage change, 190km under the dam, the Batang Hydrological Station was flooded, the stage rises by 3.45 meters in 10 minutes. In such a special water situation, not only the operation is not convenient, but also has a greater security risk, should try to use non-contact observation.

3. Advanced technology and high degree of automation.

With the development of science and technology, hydrological instruments and equipment development towards intelligent, miniaturized, emergency monitoring equipment should be advanced of technology, intelligent, high degree of automation. Monitoring data is immediately available. At the same time, emergency monitoring equipment should be easy to operate, in the field environment, the easier to use, intelligent, the easier to improve the reliability and timeliness of operation.

4. The appropriate of accuracy and economical.

While designing hardware such as equipment and facilities, full attention should be paid to the development and research of application software, and the new technology and equipment should be demonstrated or confirmed by the experience of successful use in order to be technically reliable and economically reasonable.

5. Cross-related, moderately redundant.

The environment during emergency monitoring of barrier lake is often harsh, and the different monitoring methods of the hydrologic element shave some adaptability. A variety of testing methods and test facilities should be equipped to be available to each other to form a "hot backup". After one instrument or method fails, switch to another instrument or method in time to ensure the reliability of data collection. At the same time, there are many methods to measure the same elements, and the test results can be analysed and evaluated comprehensively to improve the accuracy of the monitoring.

4. Research on capability improvement technology

This article analyses the technical characteristics and requirements of the existing hydrological emergency monitoring of barrier lakes, and sorts out the experiences[4]. Based on extensive investigations, combined with the latest developments in hydrological monitoring technology and general scientific and technological developments, research was carried out to improve the hydrological emergency monitoring capabilities of barrier lake, and overall architecture design and detailed design of the scheme were carried out.

4.1. Architecture design

See Figure 1 for the overall architecture design for enhancing the hydrological emergency monitoring capabilities of barrier lake. It can be seen from the figure that the improvement of the emergency monitoring capacity is based on the full analysis of the status and needs, highlighting the key points, and
researching and designing the areas that need improvement.

4.2. Programme design

It can be seen from Figure 1 that the enhancement of the hydrological emergency monitoring capabilities of barrier lake includes data acquisition, data transmission, data processing, and monitoring guarantee. The detailed design is as follows:

4.2.1. Data collection. In hydrological emergency monitoring of barrier lakes, the focus is on stage, discharge and topography(section) measurements[5].

(1) State observation

Stage is one of the most important elements in the hydrological emergency monitoring of barrier lake. Regardless of the disposal and the hydrological forecast and analysis calculation of the barrier lake, it is necessary to collect the complete stage change process as much as possible. Traditional water level emergency monitoring uses self-recording or manual observation. When the self-recording instrument is unavailable, the prism-free total station can be used for stage observation. With the continuous development of drone technology and artificial intelligence technology, non-contact methods such as drones or video can also be used to observe stage[6].

Option 1: With the drone technology is constantly developing, its transportation and endurance capabilities are constantly improving. The drone platform is equipped with a global navigation satellite system (GNSS) receiver and a rangefinder, and the stage is monitored by the hovering altimetry. The measurement results are sent to the ground in real time through a wireless channel.

Option 2: With the continuous development of artificial intelligence, machine learning, neural networks and other technologies, video methods can be used for stage observation. This method is based on a deep learning algorithm and automatically and accurately obtains the current stage through image recognition. Video frames are extracted from the video, and the video frames are processed through a pre-trained neural network to determine the exact position of the stage line, and then the real-time stage is calculated.

Option 3: In the case where the adaptability of the above methods is not good, a fixed marker method can be used to observe the stage. Set a number of fixed marking points on the section line, and install

**Figure 1.** overall architecture design for enhancing the hydrological emergency monitoring capabilities of barrier lake.
lights on the marking points that glow when encountering water. When the stage reaches the marking point, record the stage and the time, so that the stage rising process can be recorded.

(2) Discharge measurements

Non-contact discharge measurement methods such as handheld radar, drone radar discharge measurement system, side scan radar online discharge measurement system, drone buoy method and aerial photography method can be used for the hydrological emergency monitoring discharge measurement of the barrier lake.

Option 1: The hand-held radar flowmeter (Figure 2) can transmit the measured velocity data in real time to the tablet device through wireless transmission in real time; the tablet device has built-in software to automatically convert the measured surface velocity to the sectional velocity. Calculate the flow based on the cross-sectional area.

![Figure 2. Handheld radar flow-meter.](image1)

![Figure 3. UAV radar measurement system.](image2)

Option 2: Unmanned aerial vehicle (UAV) radar current measurement system (Figure 3). Utilizing a drone equipped with a radar wave velocity meter, it can realize intelligent route planning, hovering on the vertical line; supporting multi-vertical discharge measurement; wireless transmission of velocity data to the ground control terminal. Simple operation, suitable for emergency flow measurement.

Option 3: The side scan radar (Figure 4) uses a radar transducer installed on the shore to obtain the water surface flow field by using the Doppler frequency shift principle, and calculates the discharge by the profile data[7]. This method has high accuracy when there are many floating objects on the water surface and the larger the flow rate. Therefore, under the premise of installation conditions, this method can be preferentially adopted.

![Figure 4. Side scan radar online flow measurement system.](image3)

Option 4: In the case where the above method is not suitable, a drone can be used to throw a buoy, and a polar coordinate method can be used for flow measurement.

Option 5: The aerial photography method can also be used for rapid flow test[8].

(3) Section measurement

The section measurement includes two parts: underwater and above water. The underwater part uses a drone to carry GNSS and an echo sounder; the above water part uses a drone to carry a three-dimensional laser scanner. It can also use surveying drones, adopt dual-frequency differential GNSS positioning. It can provide centimetre-level position data.
4.2.2. Data transmission. Most of the barrier lakes are located in mountainous areas, and public network signals are often interrupted. Data and voice transmission can be made using the "Tiantong No. 01 Star" independently developed in China. The Tiantong satellite communication technology is used to achieve full coverage of signals in China. As long as you can see the sky, you can make calls and send text messages throughout the day.

4.2.3. Data processing. Use mobile Internet technology to develop an APP that package, unify the common data processing programs, data calculation programs, data integration programs, etc. It can complete the data after the test is completed, and external distribution through smart terminals (based on the configured permissions) [9].

4.2.4. Monitoring guarantee. The improvement of guarantee capabilities includes transportation guarantee, power guarantee, and night vision guarantee.

(1) Traffic guarantee
The general traffic conditions at the location of barrier lake are bad, the road conditions are very poor, the slope is large, the road area is snowy and slippery, and ordinary cars cannot pass. Professional high-powered off-road vehicles are required to ensure driving safety. For example, during the disposal of the "11.03" barrier lake, some emergency monitoring vehicles were blocked in the plateau area, mainly due to insufficient power and insufficient off-road performance. After being towed by a professional off-road vehicle, they successfully escaped.

(2) Power guarantee
Emergency monitoring equipment are basically electronic products, and testing and data transmission depend on power supply. Therefore, it is necessary to equip portable hand-cranked generators, portable gasoline generators and solar power generators (Figure 5), and at the same time equipped with inverters, so that monitoring equipment will never lack power.

![Figure 5](image-url) Portable power supply system. (a) Hand-shaking (b) gasoline (c) solar energy.

(3) Guarantee of night vision
In the hydrological emergency monitoring of barrier lake, tests are often performed at night. Due to poor monitoring section conditions and poor night vision conditions, field searchlights and infrared night vision telescopes are required to facilitate field testing. The field searchlight should have a range of not less than 3,000 meters, and be equipped with a lithium battery, and have a mounting bracket; the night vision telescope needs to support day and night functions, high-definition photos and videos.

5. Conclusion
In the previous emergency treatment of barrier lakes, the emergency monitoring of hydrology highlighted the fundamental supporting role of hydrological work, and provided solid data source for the scientific treatment of barrier lakes. However, in the practice of emergency monitoring, there are still shortcomings such as the relative lack of research on emergency monitoring technology, insufficient emergency monitoring capabilities, and low utilization of new technologies. Based on the status quo analysis and needs analysis, combined with the latest developments in hydrological observation technology and general science and technology, this paper conducts research on the technology of improving the emergency monitoring capabilities of the barrier lake, which has high application value.
and good practical significance.

Acknowledgments
This work is supported by National Key R & D Program of China (2018YFC1508002), National Key R&D Program of China (2017YFC0405701).

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