Technical Review of the Liulan Reservoir “7·6” Dam Failure Disaster in Hengzhou, Guangxi, China

— Overtopping and Local Breach Development under Extreme Rainfall and Above-Standard Flooding: Processes and Broader Lessons

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Note: This brief is an independent technical review of the Liulan Reservoir “7·6” dam failure disaster, based on State Council announcements, public reporting, engineering-document leads, pre- and post-event imagery, and professional discussion available through July 25, 2026. Data and mechanistic interpretations not yet confirmed by original project records or the formal investigation are explicitly identified as uncertain. This brief does not replace the State Council investigation and assessment, engineering safety appraisal, hydrologic reassessment, or determination of responsibility. The title and the term “dam failure disaster” follow the official designation used by the State Council investigation team; the process description continues to distinguish overtopping, local breach initiation, and breach enlargement.

Abstract

On July 6, 2026, Liulan Reservoir in Hengzhou, Nanning, Guangxi, China, experienced overtopping, local breach initiation, and rapid breach enlargement during typhoon-related extreme rainfall and rapidly increasing reservoir inflow. On July 24, the State Council established an investigation and assessment team for the Liulan Reservoir “7·6” dam failure disaster. Based on publicly available reports, the State Council announcement, pre- and post-event imagery, and professional discussions available through July 25, this brief provides a phased technical review of the project background, rainfall and inflow, reservoir operation, actual gate performance, emergency spillway facilities, overtopping and breach development, downstream impacts, and post-disaster recovery. Because the original hydrologic, gate-operation, design, and monitoring records have not yet been fully released, the numerical values and mechanistic interpretations presented here remain subject to confirmation by the formal investigation.

Public information indicates that staged gate releases began on the evening of July 5. When operators planned to fully open all five gates early on July 6, some gates and hoisting equipment did not reach the intended fully open position. The fuse-plug embankment at the entrance to the emergency spillway on the east side did not breach as intended and could not be activated manually in time; its exact design conditions and the reasons it did not activate remain under investigation. Operations were also constrained by the downstream safe release rate, evacuation progress, communications failures, and insufficient hydrologic data. The available evidence

more strongly supports the following provisional sequence: the reservoir reached the dam crest and overtopping began; concentrated erosion and an initial breach developed at or shortly after the east abutment; and a larger breach subsequently formed and expanded in the central portion of the dam. At present, it is not possible to determine precisely whether a clearly distinguishable time interval existed between the onset of overtopping and initial breaching at the east abutment.

The combined evidence indicates that extreme hydrologic loading was the primary external driver of the event. The available information supports the view that erosion of the homogeneous earthfill dam under sustained overtopping was likely one of the key mechanisms responsible for local breach initiation and rapid enlargement. Gate reliability, emergency spillway performance, local reservoir geometry and possible flow concentration near the dam, monitoring and forecasting, operational decisions, communications, and downstream exposure all influenced the risk chain. The event cannot be attributed to a single factor. The dam-safety community should both reassess design floods, discharge capacity, and engineering protection standards under nonstationary climate conditions and manage the residual risk that remains when design standards are exceeded. Dam safety should be evaluated on the basis of the current condition and remaining safety margin of the entire system, rather than the year of construction alone.

1. Project Overview and Functional Role: A Profile of Liulan Reservoir

Liulan Reservoir is located in Liulan Village, Xiaoyi Town, Hengzhou City, Nanning, Guangxi, China, and impounds runoff from the Zhenlong River, a first-order tributary of the Yu River that is also known as the Yunbiao River. Public sources report a drainage area of approximately 195 km² above the dam and a total storage capacity of about 93.19 million m³, although another published figure is approximately 95.52 million m³. The maximum dam height is about 42 m. The main dam is a homogeneous earthfill embankment constructed from 1958 to 1960. It is classified as a medium-sized reservoir serving irrigation, water supply, flood control, hydropower, ecological, and fishery functions. The principal publicly reported parameters are summarized in Appendix 1 (Appendix Table 1).

A homogeneous earthfill dam is constructed by placing and compacting cohesive soil in layers. Its safety cannot be judged simply by whether it is “new” or “old.” Unless specifically designed or protected for overtopping, an earthfill dam—regardless of age—generally cannot safely withstand sustained, high-volume flow over the crest. The more important implication of long service life is that the embankment materials, foundation, spillways, gate-hoisting systems, hydrologic design basis, monitoring facilities, maintenance capacity, and management arrangements may deteriorate or become inadequate at different rates.

Public reports indicate that the reservoir had previously experienced maintenance-related problems, including slope instability, seepage, and cracking, and that safety-rehabilitation works and standardized management upgrades had been implemented. Public interviews also indicate that a safety appraisal around 2020 generally concluded that the project was fit for safe operation, while noting problems involving rainfall and flood reporting, monitoring facilities, metal structures, or supporting management systems. These findings are not contradictory: the conclusion of a single appraisal does not mean that every component will thereafter maintain the same reliability, nor can it substitute for functional testing under extreme loading.

Liulan Reservoir irrigates approximately 157,300 mu (about 10,487 ha) of farmland and also supports water supply to nearby communities and a heavily funded irrigation-district modernization program. Public reporting indicates that the Yunbiao and Xiaoyi areas downstream are major jasmine-producing districts in Hengzhou, and that the flood damaged villages, flower fields, agricultural-supply businesses, roads, and water-supply facilities. Post-disaster decisions therefore should not be understood simply as "repairing the breach," nor should they assume in advance that the original project must be reconstructed in the same form. Options should be compared in terms of functional recovery, alternative water supplies, risk reduction, and long-term operation and maintenance.

2. Disaster Process: Extreme Inflow, Effective Discharge Capacity, and Earthfill-Dam Overtopping

2.1 Extreme Rainfall, Inflow Magnitude, and Pre-Event Storage

The event occurred under Typhoon "Maysak"-related extreme rainfall. Early public reports indicated that from 8:00 a.m. on July 5 to 8:00 a.m. on July 6, 24-hour rainfall totals at Shitang, Taoxu, and Xiaoyi in Hengzhou reached approximately 565.0, 445.0, and 411.5 mm, respectively; Bafeng Village in neighboring Binyang County recorded 713.3 mm. A July 17 expert interpretation published by China Daily further reported an average rainfall of about 749 mm over the Liulan Reservoir catchment and a maximum 24-hour rainfall of 862.5 mm at the Gulou station, and noted that antecedent soil moisture was already near saturation. These data show that the rainfall core was highly localized and concentrated over a short duration. Even when a regional heavy-rainfall threat is foreseeable, it may remain difficult to predict precisely which township, tributary catchment, or reservoir headwater area will receive the most intense rainfall (Source 41).

A preliminary order-of-magnitude estimate based only on early publicly reported point rainfall, a 195 km² drainage area, and an assumed runoff coefficient of 0.75–0.85 yields a 24-hour runoff volume of roughly 60–94 million m³; this is not a formal reservoir-inflow reconstruction. The July 17 expert interpretation reported that professional calculations produced a peak inflow of approximately 4,920 m³/s and a maximum 24-hour flood volume of about 135 million m³. These values were reported as approximately 2.8 times the 1,740 m³/s discharge capacity corresponding to the check-flood condition and 1.8 times the 73.15 million m³ 24-hour flood volume under that condition. This assessment is more complete than the early screening estimate, but it remains a publicly reported expert interpretation and should ultimately be verified using the rainfall, hydrologic, and reservoir-routing records adopted by the formal investigation (Source 41).

Public interviews reported that the reservoir held about 50 million m³ on the morning of July 5 and was below the flood-season limiting level; another public figure gives an effective storage capacity of about 66 million m³. This indicates that the reservoir was not "full" before the event. The July 17 expert interpretation further stated that the water level at 8:00 a.m. on July 5 was approximately 105.43 m—about 0.97 m below the 106.5 m spillway-crest elevation used in that analysis—so opening the gates at that time would not yet have produced gravity flow over the crest. This explanation still requires confirmation from design drawings, original water-level records, and gate-structure information. Total storage, effective storage, and the flood-control storage actually available at the onset of the storm are not the same concept and cannot be substituted by simply taking a difference between published capacities. A formal reconstruction must use the initial routing level, elevation–storage curve, flood-season limiting level, operating rules, and complete inflow hydrograph. Definitions of relevant water levels and structural elevations are provided in Appendix 2 (Appendix Table 2) (Sources 39 and 41).

2.2 Operational Timeline and Actual Gate Performance

Based on the reservoir manager's July 13 interview and other public reports, Table 1 summarizes several key points before and during the event. All times, water levels, discharges, and gate states remain subject to confirmation using original duty logs, automatic or manual water-level records, gate-operation records, and the formal investigation findings.

Publicly reported water-level data contain clear inconsistencies. One early account stated that the water level was 111.20 m at 2:30 a.m. on July 6 and was "0.91 m above the design flood level." A later interview stated that at 6:48 a.m., the water level reached 112.16 m and only then exceeded the design flood level by about 0.05 m. A gauge-room sign photographed by a Jiemian News reporter on July 8 showed a flood-season limiting level of 108.9 m, a design flood level of 112.11 m, and a check flood level of 113.51 m. The reservoir manager later explained that the emergency notice correctly recorded the water level as 111.20 m but that "above" should have read "below." Thus, 111.20 m was actually 0.91 m below the design flood level; the subsequent on-site sign and the manager's explanation support this correction (Sources 39 and 40). The reported water level at 10:10 p.m. on July 5 also appears in different circulated versions as either 109.42 m or 105.42 m. The July 17 expert interpretation reported a level of about 105.43 m at 8:00 a.m. on July 5 and a spillway-crest elevation of about 106.5 m, whereas the Southern Weekly account's 109.42 m at 10:10 p.m. is more consistent with its description that the water had reached or passed the tops of the gates. The 105.42 m figure may therefore reflect a time-point displacement, transcription error, or typesetting error. This brief provisionally uses 109.42 m, but the original water-level record is needed for confirmation. The distinctions among water-level names and structural elevations are explained in Appendix 2 (Sources 39–41).

The manager's interview indicates that operators planned or were directed to fully open all five gates, but the gates did not all reach the fully open position. Gate No. 5 malfunctioned during the early morning, and Gate No. 3 reportedly slid closed automatically. During the full-opening attempt, Gate No. 5 could be raised only about 2 m, compared with an approximate gate height of 2.9 m. The post-event gate positions cannot be used to infer the precise opening history throughout the event. Reporting on the Liulan Reservoir 2026 Flood-Season Operating Plan further indicated that the spillway originally had no gates and that five gates were added during the 2010 rehabilitation. If accurate, the gates and hoisting system that exhibited operating failures were only about 16 years old—far younger than the dam itself. This illustrates that the system component controlling risk need not be the component with the greatest calendar age and provides a concrete example of the "effective age" concept discussed in Section 8.5. The July 17 expert interpretation stated that the project passed acceptance for putting the main works into operation in December 2010 and that the completed works were rated qualified. This does not necessarily conflict with other reporting that final completion acceptance had not been finished, because the two statements may refer to different stages of acceptance; the complete project records are needed for clarification (Sources 39 and 41).

Table 1. Key Timeline of the Liulan Reservoir "7·6" Dam Failure Event (Compiled from Public Reports)

Time	Process Reported in Public Sources
After 3:00 p.m., July 5	Reservoir service-station staff began flood-routing preparations and went on full alert.
About 5:50 p.m.	A flood-routing warning was issued. Releases were originally planned to begin at 10:00 p.m., but the schedule was advanced because of rising water levels and upstream warnings.
About 8:30–8:40 p.m.	Emergency response was activated and staged gate opening began. Reported initial releases were controlled at approximately 50–200 m^3/s.
About 10:10 p.m.	The reported reservoir level was approximately 109.42 m and continued to rise.
About 2:22 a.m., July 6	Downstream townships were notified to prepare for evacuation under different scenarios. Communications, email, and road conditions were already being affected.
About 5:07 a.m.	After receiving instructions from the higher-level water authority, a warning was issued to fully open all five spillway gates.
About 5:45–5:50 a.m.	The reported level was approximately 111.61 m. During the attempt to fully open the gates, faults were found in some gates or hoisting equipment.
About 6:18 a.m.	Because of severe vibration in the gate structure and increasing safety risk, all control-room personnel were ordered to evacuate. Gate positions could no longer be adjusted thereafter.

Time	Process Reported in Public Sources
About 6:48 a.m.	The reported level was approximately 112.16 m and was said to be about 0.05 m above the design flood level.
About 8:00–8:30 a.m.	Multiple reports and eyewitness accounts described overtopping or clear flow over the dam crest.
About 9:00 a.m.	Reservoir work records were reported to show that an approximately 30 m breach first formed in the eastern section.
About 9:20 a.m.	Media reports cited a manually estimated level of approximately 116.26 m; both the value and elevation datum require formal confirmation.
About 10:20–10:30 a.m.	A larger breach developed in the central section and rapidly enlarged; reported width was approximately 100–110 m.

The reported downstream safe release rate of approximately 220 m^3/s helps explain why releases were initially increased in stages: suddenly opening all gates before downstream evacuation was complete could have caused earlier channel overflow and village inundation. Operations therefore faced a genuine tradeoff between controlling reservoir level and avoiding a sudden increase in downstream discharge before evacuation was complete. Whether a more effective pre-release or earlier evacuation strategy was possible can be determined only through complete reservoir-routing and emergency-response reconstruction, not from a few isolated time points. The July 17 expert interpretation also reported that recalculation showed overtopping by more than 0.9 m would still have occurred under the extreme rainfall even if the gates had been opened earlier. This was a public expert assessment rather than the formal investigation finding, but it preliminarily suggests that "earlier gate opening" might not have prevented overtopping itself, although it could have affected overtopping depth and duration and the downstream flood hydrograph—exactly the type of counterfactual question proposed in Section 8.1. The expert interpretation further reported that the reservoir rose by more than 9 m overnight and that the maximum rise during the final hour before breaching was 2.13 m (Source 41).

Public sources still conflict on the service-spillway parameters. Several reports describe it as a five-bay gated ogee spillway excavated through a natural saddle, with an entrance clear width of approximately 60 m. Some reports give a crest elevation of about 105.70 m; the July 17 expert interpretation used 106.5 m. Other early sources called 108.10 m the spillway-crest elevation, whereas the reservoir manager's interview identified 108.10 m as the flood-season limiting level. This brief does not treat any unverified key elevation or maximum discharge as conclusive. The parameters should be established from design drawings, operating rules, safety-appraisal records, and a common elevation datum (Sources 39 and 41).

2.3 Earthfill-Dam Overtopping, Local Breach Initiation, Breach Enlargement, and Emergency Spillway Facilities

The failure sequence at Liulan Reservoir is broadly consistent with the general mechanics of overtopping erosion of an earthfill dam. When the local reservoir surface reaches or exceeds the crest control elevation, water may pass over the crest and flow down the downstream slope. Once slope protection is damaged, embankment soil is exposed and concentrated gullies may migrate upstream. After erosion cuts into a critical embankment section, local slumping and rapid breach enlargement may occur. This general mechanism, however, cannot replace a site-specific investigation of the initial breach location, local elevations, abutment interfaces, and pre-existing project condition.

Based on public reports, eyewitness accounts, and information attributed to reservoir work records, the most defensible provisional description is as follows: at about 8:00 a.m., the water level began to reach the dam crest and overtopping appeared; concentrated erosion, local collapse, and an initial breach developed at the east abutment almost simultaneously or shortly thereafter; by about 8:30 a.m., floodwater was already discharging through the eastern breach; by about 9:00 a.m., the eastern breach was reportedly about 30 m wide; and between about 10:20 and 10:30 a.m., another, larger breach formed in the central section and rapidly expanded to approximately 100–110 m. Reports differ on the exact times, directions, and dimensions. It cannot yet be strictly demonstrated that overtopping continued for a distinct period before breaching began at the east abutment. A formal reconstruction should use dam-axis stationing, a common elevation datum, time-stamped continuous imagery, drone surveys, and cross-sectional investigations to establish the precise sequence and rate of development.

As shown in Figure 1, pre-event satellite imagery indicates an open bypass-like channel outside the east abutment. Public interviews and rehabilitation-document leads suggest that this feature was likely an emergency spillway whose entrance was closed by a fuse-plug embankment intended to breach at high reservoir levels, with manual blasting or mechanical excavation available if necessary. During this event, the main dam overtopped and breached, but the fuse-plug embankment did not breach as intended and could not be activated manually in time. Online water-conservancy gazetteer materials provide elevations for the fuse-plug crest, activation level, and dam crest that show certain numerical relationships to on-site signs and media estimates, but the source quality, elevation datum, and accuracy have not been reconciled. If all values use the same datum and are accurate, the failure of this facility to activate requires focused explanation in the formal investigation. At this stage, however, the exceedance above the control elevation cannot be quantified directly, and numerical proximity alone cannot establish the design relationship among these elevations (see the publicly reported values in Appendix Table 3 of Appendix 2).

Media reports citing 2009 rehabilitation information and satellite imagery suggested that timber processing, a village access road, repeated vehicle loading, soil densification, or local filling may have altered the control elevation and erodibility of the fuse plug. No blasting charges had been pre-positioned; manual blasting required approval; communications failed; and excavators could not reach the site because roads were damaged. These facts can help explain why manual activation was not achieved in time, but they do not prove that failure of the fuse plug was the sole cause of the main-dam breach. Design drawings, material testing, field elevation surveys, and counterfactual reservoir-routing calculations are needed to estimate how much timely activation would have reduced the peak reservoir level, delayed overtopping, and potentially changed the final outcome.

Figure 1. Pre-Event Layout of Liulan Reservoir and Satellite Image of the Channel Near the East Abutment. The open bypass-like channel outside the abutment is visible on the right. Public reporting has associated it with a fuse-plug emergency spillway, but its formal function, control elevation, and relationship to the initial breach remain to be confirmed from design records and the investigation. Image source: Google Maps (imagery credits shown in the figure).

Figure 2. Aerial View of the Dam Breach and Near-Dam Downstream Area after the Liulan Reservoir Failure. The image shows the large breach, sediment-laden outflow, and affected near-dam downstream area. It documents the overall post-event scene but cannot by itself establish the initial breach location, the precise sequence of overtopping and local breaching, peak discharge, or the specific failure mechanism. Image source: Red Star News, "The Critical 12 Hours before and after the Liulan Reservoir Breach: Those Trapped and Their Rescuers," July 11, 2026.

As shown by the planform in Figure 1, the reservoir shoreline and dam axis form a degree of planform convergence near the east abutment, where a hillside channel and suspected emergency spillway are also present. This geometry alone does not prove the existence of high-velocity “funnel-like” flow immediately upstream of the dam, because reservoir flow near the dam is normally dominated by storage and relatively low velocities. However, if the east abutment contained a locally low crest or road elevation, a microtopographic depression, an abutment interface, or a downstream flow-guiding channel, overtopping flow could have concentrated there first. Once an initial gully or local collapse formed, a positive feedback could have developed: lower elevation → greater flow concentration → accelerated erosion → breach enlargement. This remains a testable hypothesis and should be evaluated using detailed topographic surveys, continuous imagery, and coupled two- and three-dimensional hydraulic and erosion analysis.

2.4 Sediment Transport and Secondary Water-Quality Impacts

Reservoir overtopping and dam breaching release not only floodwater but potentially large quantities of watershed erosion sediment, reservoir deposits, and embankment soil. The yellow-brown floodwater in Figure 2 and thick mud deposits visible in other post-event imagery indicate substantial sediment deposition and erosion in downstream communities, farmland, roads, and channels.

Sediment-laden flooding can alter channel cross sections, block culverts and drainage systems, scour bridge foundations and roadbeds, and affect drinking-water sources, wells, agricultural topsoil, and aquatic ecosystems. Public reports also describe rescue boats threatened by submerged trees, broken poles, and building debris. Recovery should therefore treat sediment removal, classification and disposal of deposits, water-quality testing, bridge and culvert inspection, bank stabilization, and public river-recreation safety as priorities equal to treatment of the dam itself.

3. Basin Relationships and Attribution of Multiple Flood Sources

3.1 Combined Flooding from Liulan, Yunbiao, and the Wider Region

Yunbiao Reservoir lies approximately 5 km west of Liulan Reservoir. On July 6, both reservoirs overtopped and developed breaches, and their downstream channels converged near Naguang Village before entering the Yu River. Other small and medium reservoirs in the region also experienced emergencies during the same period. Public reports indicate that headwater flooding from the Zhenlong mountainous area, tributary inflows, breach outflows from both reservoirs, and high regional river levels jointly influenced inundation in Xiaoyi, Yunbiao, Maling, and the direction of Guigang.

Accordingly, without models and field measurements, the inundation depth, arrival time, and casualties at any particular downstream village or town cannot all be attributed to the single Liulan breach. Formal attribution should use one- and two-dimensional models with multiple inflow boundaries and should be calibrated against high-water marks, videos, remote-sensing inundation extents, and flood-arrival times.

3.2 Limits of Inference Regarding the Datengxia Project, the Pinglu Canal, and the May Earthquake

Floodwater from Liulan Reservoir enters the Yu River through the Zhenlong River and subsequently joins the Xi River system. The Datengxia Water Conservancy Project is located farther downstream on the Qian River. Based on presently available spatial information, elevation relationships, and public records, there is no evidence that Datengxia backwater extended to the area below Liulan Dam, and still less evidence that it contributed causally to overtopping of the reservoir.

The northern terminus of the Pinglu Canal begins at the Pingtang River mouth in the Xijin Reservoir area of Hengzhou, connecting with the Yu–Xi River system. The canal then crosses a drainage divide and reaches the Beibu Gulf through the Jiuzhou and Qin rivers; it is not a direct flood-conveyance route for Liulan Reservoir. Any assessment of whether trial water conveyance or operation of related control structures affected regional water levels or flows during the event must be based on contemporaneous operating records and regional hydraulic modeling, not on spatial proximity alone.

Post-earthquake inspections and pre-flood-season checks at Liulan Reservoir would have been appropriate following the May 2026 Guangxi earthquake. However, publicly available information has not shown that the earthquake caused abnormal settlement, cracking, seepage, pore-pressure changes, or damage to spillway facilities, and no evidence currently establishes a direct causal link between the earthquake and the July 6 breach. The formal investigation should still review site ground-motion estimates, post-earthquake inspection records, and any anomalies in embankment deformation, seepage, abutment interfaces, or gate-hoisting systems. On the evidence now available, however, the more clearly established direct sequence was extreme rainfall, rapidly increasing inflow, a continuing rise in reservoir level and overtopping, followed by erosion of the embankment and rapid initiation and enlargement of local breaches.

4. Water-Supply Source, Agricultural Production, and Basin Management

Liulan Reservoir is both an irrigation and regional water-supply project and is closely linked to Hengzhou’s jasmine industry and rural livelihoods. Public reports show that extensive jasmine fields, agricultural-supply shops, roads, village water-supply facilities, and homes in Yunbiao, Xiaoyi, and nearby areas were inundated. After the flood recedes, agricultural recovery must include not only drainage and replanting but also testing for soil salinity and contaminants, disease control, restoration of agricultural topsoil, and reconstruction of agricultural-input and processing chains.

Pre-existing soil erosion, nonpoint-source pollution, and drinking-water-source protection issues in the reservoir and upstream catchment are not part of the same direct causal chain as the overtopping event, but they can influence sediment yield, water quality, and recovery cost. Future management should integrate hillslope soil and water conservation, riparian buffers along inflowing streams, reservoir-bank stability, drinking-water protection, and extreme-flood safety.

5. Post-Disaster Recovery: From Emergency Response to Functional Reconstruction

5.1 Safety of the Dam and Infrastructure

The first post-disaster task is a safety assessment of the remaining embankment, breach side slopes, foundation, through-dam or adjacent structures, spillway, and gate systems. Based on topographic surveys, geologic investigation, seepage assessment, and stability analysis, temporary diversion, breach protection, and measures to prevent secondary collapse should be implemented. Rapid reservoir drawdown may also trigger reservoir-bank landslides, requiring parallel inspection of banks, roads, and structures near the reservoir.

Downstream roads, bridges, culverts, levees, power, communications, water-supply, and gas facilities should not be returned to service on visual appearance alone after scouring and inundation. Reports describe undermined roadbeds, damaged bridges and culverts, communications outages, and flooded water-supply facilities. Service should be restored through structural inspection, flushing and disinfection, electrical testing, and staged recommissioning.

5.2 Sediment Removal, Ecology, and Public Health

Sediment removal should distinguish among flood-conveyance sections of channels, village and town roads, homes, farmland, and potentially contaminated deposits. Drinking-water sources, temporary intake points, wells, and inundated water-supply facilities should be tested for microorganisms, turbidity, organic matter, and necessary chemical indicators. Submerged debris, deep holes, concealed channels, and unstable banks should be inspected and marked before water-contact recreation resumes. A concise downstream river-safety advisory is provided in Appendix 3.

5.3 Recovery of People, Industries, and Communities

The State Council announcement of July 24 stated that the dam failure disaster caused major casualties. According to CCTV News, The Beijing News, and other reports, the disaster statistics released by Nanning on July 9 stated that the Liulan Reservoir breach flood alone had caused 26 deaths and left 7 people missing, while the corresponding regional totals were 39 deaths and 9 missing. This was the first official separate statistical count for the Liulan Reservoir breach flood, but it may still change as identities are confirmed, missing persons are located, and disaster attribution is refined. Dynamic statistics for the broader regional rainstorm disaster should not be treated as the Liulan Reservoir event's standalone attributable toll. The final figures for deaths, missing persons, and losses should follow the State Council investigation and final official verification (Source 3).

Public reporting clearly shows that the consequences extended far beyond the dam itself, affecting housing, farmland, the jasmine industry, agricultural supplies and processing businesses, transportation, schools, water supply, and community confidence. Recovery should address resettlement, compensation, housing reconstruction, agricultural production, psychological support, risk communication, and transparent public engineering assessment.

6. Monitoring, Forecasting, Operations, Warning, and Evacuation Systems

Public interviews indicate that the problem was not simply that “the rainfall forecast was insufficiently accurate.” The event also exposed fragility in the data and communications chains: upstream hydrologic-station data stopped updating during the critical period; reservoir staff relied mainly on manual staff gauges and experience-based inflow estimates; automated monitoring and rainfall-reporting systems had experienced failures or transmission problems; power outages, network disruptions, road closures, and even email-storage limitations affected information receipt; and the reservoir station, township governments, villages, and evacuation operations lacked a confirmation loop that could remain functional under extreme conditions.

The “four forecasts” system—forecast, early warning, simulation, and contingency planning—should be upgraded from isolated equipment to an end-to-end operational chain: radar and numerical weather prediction → catchment-average rainfall → runoff generation, concentration, and reservoir inflow → reservoir routing → actual gate openings and outflow → downstream inundation prediction → confirmation that warnings were received → evacuation and rescue. Critical equipment should have backup power, offline recording, satellite or other emergency communications, and training and exercises for manual gauge reading, manual gate operation, and loss-of-power conditions.

Annual gate operation does not demonstrate reliability under extreme conditions. At high-consequence reservoirs, full-travel functional tests, braking and self-locking checks, hoisting-force tests, backup-power tests, and manual-operation verification should be performed periodically under safe conditions, with traceable opening-versus-time records retained. Emergency spillway facilities should likewise be checked regularly for control elevation, downstream conveyance, road encroachment, soil densification, and manual-activation requirements. “It has not been used for decades” must not be treated as evidence of reliability.

Operating plans should define actions at specific thresholds: when to pre-release, when to lower the flood-season limiting level, when to begin early evacuation, when to enter dam-preservation mode, when to activate emergency spillways, and who has decision authority and how authorization and execution are confirmed when communications and power fail. Optimal decisions during extreme floods are rarely the responsibility of a single discipline; they require joint judgment by hydrologists, hydraulic engineers, geotechnical and mechanical specialists, operators, emergency managers, and local government.

7. Recovery Options Based on Functional Needs and Risk Tradeoffs

Liulan Reservoir's irrigation and water-supply functions are highly important, but restoring those functions need not mean rebuilding the original project in the same form. Repair in place, upgrading standards, lowering the operating level, reclassification and restricted use, partial retirement, or construction of alternative water sources should be considered only after the cause of the disaster is established, downstream risk is updated, and life-cycle costs are compared. The principal consequences of lost functions, substitution options, and urgency of recovery are summarized in Table 2.

Table 2. Principal Functions of Liulan Reservoir, Substitution Options, and Recovery Urgency

Function	Principal Consequences if Not Restored	Potential Substitutes	Recovery Urgency
Irrigation	Water supply for approximately 157,300 mu of farmland would be affected, and benefits of existing irrigation-district improvements could not be fully realized.	Regional water transfers, pumping stations, ponds, and temporary sources may provide partial substitution, but complete short-term replacement would be difficult.	High
Water supply	Water-supply reliability and emergency-source capacity for nearby towns and villages would decline.	Alternative sources would require simultaneous construction of pipelines, pumping stations, and water-quality safeguards.	High
Flood control	Existing storage and regulation capacity would decline, while the safety margin of the previous system has also been called into question.	Alternatives should compare new storage, channel improvements, warning and evacuation, and downstream engineering measures.	Requires reassessment
Hydropower	Small-hydropower revenue and equipment would be lost or damaged.	The regional power system can provide substitution.	Relatively low

Function	Principal Consequences if Not Restored	Potential Substitutes	Recovery Urgency
Ecology, fisheries, and related industries	Aquatic ecology, fisheries, jasmine production, and related livelihoods would be affected.	Recovery can proceed gradually with water-source, farmland, and ecological restoration.	Medium to high

If repair in place is selected, the following questions require focused analysis: whether the design and check floods should be updated; whether service and emergency spillway capacities are adequate; whether gates should be replaced and redundant power added; whether crest and downstream-slope overtopping protection should be installed; whether the crest elevation and wave freeboard should be modified; whether seepage-control and drainage improvements are needed at the embankment, foundation, and structure interfaces; and how downstream flood-risk zones and evacuation routes should be redelineated.

8. Recommendations for Investigation, Research, and Engineering Reassessment

8.1 Reconstruction of the Hydrologic–Operational–Discharge Process

The formal investigation should establish a unified timeline and reconstruct catchment-average rainfall, upstream inflows, the reservoir-inflow hydrograph, reservoir levels and storage, actual opening of each gate, discharges through service and emergency spillways, breach initiation, and downstream water levels. It should distinguish among nominal design discharge, theoretical available discharge under the actual head and tailwater conditions, and actual discharge constrained by equipment malfunction, blockage, operations, and downstream limitations.

At least four counterfactual scenarios should be compared: actual operation; all gates operating normally according to the original plan; earlier pre-release combined with earlier completion of downstream evacuation; and activation of the fuse-plug emergency spillway as designed. For each scenario, the maximum reservoir level, onset and duration of overtopping, and downstream flood consequences should be calculated. Only then can the question be answered whether earlier gate opening or fuse-plug activation would have changed the outcome.

Once complete data are available, the actual sustained outflow and unit discharge per effective width, $q = Q/B$, can be calculated to evaluate hydraulic performance of the spillway facilities. This metric must be based on a verified total outflow hydrograph, effective flow width, gate openings, hydraulic head, and tailwater conditions; it cannot be obtained by simply dividing a nominal maximum design discharge.

8.2 Two-Dimensional Reservoir and Local Three-Dimensional Hydraulic Modeling of Overtopping-Flow Concentration

After reconstructing the overall water balance and reservoir routing, a two-dimensional hydraulic model of the reservoir should be developed using bathymetry, shoreline geometry, detailed near-dam elevations, crest microtopography, service and emergency spillway layouts, and inflow boundary conditions. The model should simulate flood propagation through the reservoir, the near-dam planform velocity field, local water-surface gradients, discharge allocation among outlets, and whether planform convergence at the east abutment could have combined with local low points to concentrate overtopping flow. One-dimensional routing or level-pool analysis is suitable for reconstructing the overall reservoir balance but cannot by itself resolve local flow direction and velocity distribution.

For the east abutment, service spillway, emergency spillway, abutment–embankment interfaces, and area of the initial breach, local three-dimensional hydraulic models should be considered to evaluate vertical circulation, local acceleration, recirculation, turbulence, wind waves or wind setup, crest overflow, and downstream-slope flow. Where necessary, these models should be coupled with soil erosion, slope-protection failure, and breach-enlargement models. Calibration should use measured water levels, gate openings, wind fields, videos, drone imagery, post-event topography, and high-water marks. Sensitivity and uncertainty analyses should address bathymetry, local elevations, roughness, and erosion parameters. Modeling should test mechanistic hypotheses, not replace field investigation.

8.3 Breach-Flood and Multiple-Source Inundation Modeling

A one- and two-dimensional hydraulic model should be developed for the Zhenlong River–Yu River corridor, including inflow boundaries from Liulan, Yunbiao, and other important sources. Key inputs should be disclosed or recorded: breach location, final width, invert elevation, development time, outflow hydrograph, digital elevation model accuracy, roughness, downstream boundary conditions, and bridge and culvert backwater effects.

The model must be calibrated against field high-water marks, remote-sensing inundation extent, flood-arrival times, media videos, drone imagery, and measured water levels. Sensitivity and uncertainty analyses should be conducted for breach parameters, roughness, and boundary conditions lacking field measurements. Uncalibrated animations may support communication, but they should not be presented as the actual flood process.

8.4 Design Standards, PMP/PMF, and Nonstationary Reassessment

The design flood, check flood, and extraordinary-operation flood standards used in the original design, rehabilitation projects, and operating plans should be reviewed. Based on applicable regulations, project scale, and downstream consequences, the investigation should determine whether probable maximum precipitation/probable maximum flood (PMP/PMF) analysis or other extreme-flood scenarios are required. Available information is insufficient to determine whether this event approached PMP, and “a one-in-a-thousand-year event" should not be treated as a confirmed conclusion. One local line of evidence for reassessment is the expert report that a surveyed flood mark at Zhenlong Hydrologic Station, approximately 15 km upstream, reached 139.81 m—7.05 m above the previously surveyed historical maximum flood level from 1935 (Source 41).

Under nonstationary climate conditions, design standards require adaptive reassessment, but higher standards cannot eliminate all risk. The first line of defense is to update the design flood, discharge capacity, crest freeboard, and overtopping protection. The second is to manage residual risk once standards are exceeded, including failure modes, warning and evacuation, emergency releases, cascading infrastructure impacts, and post-disaster functional recovery.

8.5 The "Effective Age" of the Dam System and Risk Prioritization

Calendar age is not the only measure of dam risk. Embankment materials, foundations, spillways, gates, monitoring systems, the hydrologic design basis, maintenance, and management arrangements may be viewed as multiple "clocks" running in parallel. Whichever component first exhausts its safety margin may become the controlling factor. This "effective age" concept is useful for risk communication and asset management, but it is not a single numerical indicator that can replace formal safety appraisal.

Regional risk prioritization should integrate dam height, storage, downstream population and assets, dam type, flood standards, effective discharge capacity, gate reliability, monitoring and communications, historical deficiencies, land-use change, and management capacity. Rehabilitation, inspection, full-travel gate testing, updated flood studies, and emergency exercises are, in effect, means of restoring the system's remaining safety margin. A long period of uneventful operation cannot substitute for assessment of current condition.

8.6 Comparison of Ecological, Public-Health, and Recovery Options

Recovery alternatives should be compared using multiple objectives, including life-cycle cost, risk-reduction benefit, irrigation and water-supply reliability, ecological impact, social acceptance, and operation and maintenance capacity. The assessment should also address downstream sediment, drinking-water safety, sand and silt deposition on farmland, recovery of jasmine and other industries, vector-borne disease, and mental health.

9. Conclusions and Broader Lessons: Design Standards, Residual Risk, and Collective Engineering Judgment

The Liulan Reservoir event demonstrates that extreme hydrologic loading, the overtopping vulnerability of earthfill dams, the actual reliability of spillway facilities, reservoir operations, and warning and evacuation are not independent of one another. The probability chain leading to severe consequences can be expressed conceptually as the probability of a flood exceeding the engineering design standard, multiplied by the conditional probability of overtopping under that flood, multiplied by the conditional probability that overtopping initiates and enlarges a breach, and finally multiplied by the conditional probability that people, assets, and infrastructure within the breach-flood impact area are exposed. Different engineering and management measures act on different links in this chain. To quantify risk more fully, this probability chain must be combined with the consequences of exposure, including casualties, economic losses, infrastructure disruption, and broader social impacts.

A “100-year event” does not mean that a project will necessarily remain safe for 100 years. Under the simplified assumption of an independent 1% annual exceedance probability, the probability of at least one event exceeding that standard in 50 years is approximately $1 - (0.99)^{50} \approx 39.5\%$. A design standard represents an engineering balance between risk and cost; it is not a guarantee of absolute safety.

The sector should advance two efforts simultaneously. First, engineering protection standards should be reassessed using updated hydrologic, climate, land-use, and downstream-exposure information. Second, regardless of whether standards are upgraded, residual risk beyond the standard must be managed. Relevant compound scenarios include gate or power failure, nonactivation of emergency spillway facilities, communications failure, road blockage, refusal to evacuate, and simultaneous emergencies at multiple reservoirs.

Dam safety is inherently multidisciplinary and multi-institutional. It requires participation by hydrologists, hydraulic engineers, geotechnical and structural engineers, mechanical and electrical specialists, reservoir operators, emergency managers, transportation and communications agencies, public-health professionals, and local communities. The formal investigation should avoid explaining the entire event from a single disciplinary perspective or by a single failure. Likewise, decades without an incident cannot be treated as proof that adequate safety margin remains.

The State Council investigation and assessment team called for a “comprehensive reconstruction of the disaster process, a full and factual determination of the causes, and an end-to-end examination of problems and responsibilities in disaster prevention, response, and emergency management.” The systems-risk framework used in this brief is consistent with that mandate. All provisional interpretations should ultimately be corrected or confirmed by the formal investigation findings (Source 9).

Sources, Methods, and Scope

This brief was prepared using official announcements, press-conference information, meteorological and hydrologic data, publicly available project-document leads, news interviews, satellite and aerial imagery, and professional discussions that could be obtained and cross-checked through July 25, 2026. The list below includes materials actually used or consulted for cross-checking. Where the same official announcement was republished by multiple outlets, preference is given to the official, original, or most complete version. News reports and professional discussions can provide valuable factual leads and research questions, but they cannot substitute for original hydrologic records, design documents, gate-operation records, field investigation, or the State Council’s formal investigation findings.

I. Official Announcements, Meteorological and Hydrologic Information, and Investigation Materials

1. Nanning Municipal Emergency Management Committee: July 6, 2026 briefing on flood-control conditions in Nanning, overtopping and breaches at Liulan and Yunbiao reservoirs, overtopping at Liuwang Reservoir in Binyang County, and escalation of the flood-control emergency response from Level III to Level I.

2. Nanning Municipal Emergency Management Committee, "Notice Declaring Certain Flood-Affected Areas to Be in an Emergency Flood-Control Period," July 6, 2026.

3. Public briefings from the first, second, and third Nanning flood-control and disaster-relief press conferences, July 6, July 7, and July 9, 2026.

4. Public briefing from the Guangxi Zhuang Autonomous Region emergency rescue and disaster-relief press conference, July 7, 2026.

5. Guangxi Meteorological Observatory and Nanning Meteorological Observatory: observed rainfall, forecasts, and historical extremes for Guangxi and Nanning during Typhoon "Maysak," July 3–7, 2026.

6. Guangxi Hydrological Center: public information on water conditions, stations above warning level, and flood warnings for the Yu River and other major rivers in Guangxi, July 5–8, 2026.

7. Guangxi Department of Water Resources, Ministry of Water Resources, and State Flood Control and Drought Relief Headquarters: public information on emergency flood-response levels, reservoir operations, and rescue activities during Typhoon "Maysak," July 6–8, 2026.

8. Hengzhou Liulan Reservoir Service Station: emergency notices concerning full opening of the spillway gates and related operating information, republished or shown by multiple media outlets, July 5–6, 2026.

9. Ministry of Emergency Management / Chinese Government website, "State Council Establishes Investigation and Assessment Team for the Liulan Reservoir '7·6' Dam Failure Disaster in Hengzhou, Nanning, Guangxi," July 24, 2026.

II. Project Information, Project Records, and Spatial Imagery

10. Local water-conservancy gazetteers and online engineering materials concerning Liulan Reservoir: construction dates, drainage area, dam type, dam height, crest elevation, spillway configuration, and nominal maximum discharge. The original editions and some parameters have not been independently verified; this brief treats them as subject to confirmation.

11. Public tender, design, and project-reporting materials for the Liulan Reservoir rehabilitation around 2009, together with publicly available information concerning the 2020 safety appraisal and subsequent repairs.

12. Publicly available information and media summaries on the continued upgrading and modernization of the Liulan Reservoir Irrigation District, including irrigated area, investment, and reservoir functions.

13. Google Maps satellite imagery, Imagery ©2026 CNES / Airbus, Maxar Technologies; used to identify the main dam, service spillway, open channel near the east abutment, and downstream spatial relationships.

III. Initial Reporting and Field Information, July 6–8, 2026

14. Xinhua News Agency, “Serious Emergency at Liulan Reservoir in Hengzhou, Nanning, Guangxi,” July 6, 2026.

15. Xinhua News Agency, “Multiple Reservoir Emergencies in Nanning, Guangxi; Local Authorities Organize Evacuations,” July 6, 2026.

16. Xinhua News Agency, “Hengzhou, Guangxi: Breach Develops in Reservoir Dam as Nearby Residents Are Urgently Evacuated,” July 6, 2026.

17. Xinhua News Agency, “Feature: Rescue in Liulan Village,” July 7, 2026.

18. CCTV.com, “Nanning, Guangxi Reports Flood Conditions: Overtopping and Breaches at Liulan and Yunbiao Reservoirs in Hengzhou; Overtopping at Liuwang Reservoir in Binyang,” July 6, 2026.

19. CCTV News app, “Multiple Reservoir Emergencies in Hengzhou, Guangxi; Flood-Control Response Raised to Level I,” July 6, 2026.

20. CCTV News app, “Drone View of Liulan Reservoir: Homes Inundated by Floodwater,” July 6, 2026.

21. CCTV News, “CCTV Reporter Visits the Core Emergency Area at Liulan Reservoir,” July 7, 2026.

22. The Paper, “Overtopping and Breaches at Liulan and Yunbiao Reservoirs in Hengzhou, Nanning; Overtopping at Liuwang Reservoir in Binyang,” July 6, 2026.

23. The Paper, “On Scene | Liulan Reservoir Breach Stabilized, Floodwater Receding, Residents Clear Mud and Rebuild,” July 7, 2026.

24. Yicai, “Reservoir Emergency in Hengzhou, Guangxi; DJI Drones Used to Evacuate Trapped Residents,” July 6, 2026.

25. Time Weekly, “Liulan Reservoir Dam Failure in Guangxi: Irrigation-District Modernization Began Three Years Earlier and Diversion Dam Was Reinforced,” July 6, 2026.

26. Qilu Evening News / Qilu One Point, “Video | Breach Develops in Liulan Reservoir Dam; Villager Reports Being Trapped at Home without Water or Electricity,” July 6, 2026.

27. Qilu Evening News / Qilu One Point, “Investigation | Reviewing the Liulan Reservoir Dam Failure: A Sixty-Six-Year-Old Earth Dam Meets Record Extreme Rainfall,” July 7, 2026.

28. Jimu News, “Breach Develops in Liulan Reservoir Dam in Hengzhou, Guangxi; Villagers Gather Supplies for Rescue Efforts,” July 6, 2026.

29. Jimu News, “Field Visit to Liulan Reservoir: Water Still Discharging through the Dam Breach; Villagers Spent the Night on a Mountain,” July 7, 2026.

30. Red Star News, “Liulan Reservoir Staff Recall the Moment of Failure: Water Far Above Design Level, All Staff on Duty and Gates Opened Early—‘It Was Rising Every Minute,’” July 7, 2026.

31. Red Star News, “Yabei Village Downstream of the Failed Reservoir: No Power or Network; Some Villagers Spent the Night on a Mountaintop as Hengzhou Organized Staged Evacuations,” July 7, 2026.

32. China Newsweek, “Liulan Reservoir Had Once Been Officially Called a ‘Problem Reservoir’; Villagers Say It Was Full the Day before the Emergency,” July 7, 2026. Residents’ recollections and the phrase “problem reservoir” are treated only as investigative leads, not as an official technical classification.

33. The Beijing News, “Liulan Reservoir Emergency in Two Minutes: Collapse Continued on Both Sides of the Breach; Rehabilitation Project Had Required Design for a 100-Year Flood,” July 7, 2026.

34. Southern Weekly, “Floodwater Submerges the ‘World Capital of Jasmine’: ‘We Had Never Seen the Entire Village Under Water,’” July 7, 2026.

35. Southern Window / Yan Finance, “Guangxi Floods Undermine the Supply Base of Luckin Coffee and Mixue,” July 8, 2026.

36. Tang Bohu, Phoenix News, “After Overtopping: An Exclusive In-Depth Review of the Liulan Reservoir Dam Failure in Hengzhou, Guangxi,” July 6, 2026. Order-of-magnitude estimates and preliminary mechanistic interpretations in the article are used only as early analytical references.

IV. Subsequent In-Depth Reporting, Interviews, and Analysis

37. Sanlian Lifeweek, “Thirty-Nine Dead in Guangxi Rainstorms: Lives Rapidly Overwhelmed by Flooding beyond Experience,” July 9, 2026. The figure 39 in the title refers to the regional rainstorm-disaster total and is not treated as the standalone toll from the Liulan Reservoir event.

38. Red Star News, “The Critical 12 Hours before and after the Liulan Reservoir Breach: Those Trapped and Their Rescuers,” July 11, 2026. Figure 2 in this brief is also from this report.

39. Southern Weekly, Zheng Dan and Su Luojie, “Liulan Reservoir Manager Describes the 24 Hours before the Breach,” July 14, 2026 (online edition; cited from a PDF copy retained by the author).

40. Jiemian News, “Seven Days after the Liulan Reservoir Overtopping: Operations, Evacuation, and Rescue,” July 14, 2026. Includes the reporter’s July 8 field record of the gauge-room markings at the dam crest: flood-season limiting level 108.9 m, design flood level 112.11 m, and check flood level 113.51 m.

41. China Daily website, “Water-Conservancy Expert Explains the Causes of Overtopping and Breaching at Liulan Reservoir in Hengzhou, Nanning,” July 17, 2026. The report cites hydrologic reassessment results by Xie Hailin, a professor-level senior engineer at the Guangxi Water and Power Design Institute, including catchment-average rainfall, peak inflow, 24-hour flood volume, discharge capacity under the check-flood condition, and an earlier-gate-opening scenario. This brief cites it as a public expert interpretation, subject to final confirmation by the formal investigation.

42. “Technical Review of the Liulan Reservoir ‘7·6’ Overtopping and Dam Failure—When a 66-Year-Old Homogeneous Earthfill Dam Met a ‘One-in-a-Thousand-Year’ Extreme Rainstorm,” July 2026. The article states that it was compiled using AI tools. Its “one-in-a-thousand-year” characterization, estimated discharges, and hydrographs are not used as factual evidence here because they are not supported by original records.

V. Professional Discussion and Methodological References

43. Professional discussions in water resources, hydrology, environmental engineering, and related fields following the original July 8 WeChat post, addressing PMP/PMF, reassessment of design standards, two-

dimensional inundation modeling, model calibration, and risk management. These comments were used only to frame research questions and refine the analytical framework, not as factual evidence about the event.

44. Professional discussions following the original July 8 LinkedIn post, addressing the "effective age" of dam systems, remaining safety margins, full-travel gate testing, multidisciplinary judgment, and unit discharge per effective width. These comments are used only as conceptual and methodological references.

Note: The list above is limited to materials actually used or consulted for cross-checking. Full-text republications of the same Xinhua, CCTV, or official notices on other platforms are not listed separately. When the formal investigation report, design documents, and original monitoring records become available, they should supersede provisional figures and secondary reporting.

Statement on Artificial-Intelligence Assistance: The author conceived and wrote this brief and is responsible for all content. Artificial-intelligence tools were used to assist with organizing attachments, locating and cross-checking public information, comparing reports, checking numerical consistency, and polishing language. All technical judgments, source selections, and final wording were reviewed by the author, who retains full responsibility for the document.

Appendix 1. Key Data for Liulan Reservoir (Compiled from Public Sources)

Appendix Table 1. Key Data for Liulan Reservoir (Public Information Available through July 25, 2026)

Item	Publicly Reported Data or Description
Location	Liulan Village, Xiaoyi Town, Hengzhou, Nanning, Guangxi
River system	Zhenlong River, a tributary of the Yu River in the Xi River system of the Pearl River Basin
Drainage area	Approximately 195 km²
Total storage	Approximately 93.19 million m³; another figure is approximately 95.52 million m³, pending verification from formal documents
Effective storage	Public reports give approximately 66 million m³; this is not the same as flood-control storage
Dam height and type	Maximum height approximately 42 m; homogeneous earthfill dam
Construction	Started in 1958 and completed in 1960

Item	Publicly Reported Data or Description
Service spillway	Public reports describe a five-bay gated ogee spillway with an entrance clear width of approximately 60 m. Key elevations and discharge capacity require confirmation from design documents. Gates were added during the 2010 rehabilitation.
Emergency spillway	Fuse-plug embankment at the entrance to an emergency spillway on the east side; it did not breach as intended during this event, and the cause remains under investigation
Principal functions	Irrigation, water supply, flood control, hydropower, ecology, and fisheries
Irrigated area	Approximately 157,300 mu
Catchment-average rainfall (expert interpretation)	Approximately 749 mm; maximum 24-hour rainfall of 862.5 mm at Gulou station (Source 41; pending formal investigation confirmation)
Peak reservoir inflow (expert calculation)	Approximately 4,920 m^3/s (Source 41; pending formal investigation confirmation)
Maximum 24-hour flood volume (expert calculation)	Approximately 135 million m^3 (Source 41; pending formal investigation confirmation)
Discharge capacity under check-flood condition (expert interpretation)	Approximately 1,740 m^3/s (Source 41; pending formal investigation confirmation)
Official event designation	State Council announcement of July 24, 2026: Liulan Reservoir “7·6” dam failure disaster

Appendix 2. Terminology for Principal Reservoir Water Levels and Structural Elevations

To avoid the confusion of different water-level and structural-elevation terms in public reporting, Appendix Table 2 defines the principal terms used in this brief. These terms represent different operating, design, or geometric concepts and are not interchangeable. Their precise definitions and values should follow applicable standards, design documents, operating rules, and the formal investigation record.

Appendix Table 2. Principal Reservoir Water-Level and Structural-Elevation Terms

Term	General Meaning and Engineering Function	Use and Cautions in This Brief
Flood-season limiting level	The upper operating level for conservation storage during the flood season, used to preserve flood-control	It is not an absolute safety limit that the reservoir may never exceed. The July 13 interview called 108.10 m the

Term	General Meaning and Engineering Function	Use and Cautions in This Brief
(flood-control limiting level)	storage and define the starting condition for flood operations.	flood-season limiting level; this must be distinguished from the spillway-crest elevation.
Normal pool level	The operating level used under normal conditions to satisfy irrigation, water-supply, hydropower, and other conservation purposes.	Its relationship to the flood-season limiting level depends on season and operating rules; during the flood season, the limiting level is often below the normal pool level.
Design flood level	The maximum reservoir level reached when the design flood is routed according to prescribed operating procedures.	It is not the level at which the spillway first begins to discharge, nor does reaching it imply that failure is inevitable. Published values for Liulan Reservoir still require confirmation using a common datum.
Check flood level	The maximum reservoir level expected under the check flood, used as an important control level for dam-safety verification under extraordinary operating conditions.	The on-site sign showed 113.51 m, but the value still requires confirmation from design documents and a common datum. It is not the measured peak level during this event.
Flood-control high water level	The maximum reservoir level reached when a reservoir performs downstream flood-control operations for the design flood of the protected area.	It applies only where the reservoir has the corresponding downstream flood-control function and should not be equated directly with the design flood level.
Spillway-crest elevation	The structural elevation of the spillway control section; it is a geometric parameter, not an operating water-level name.	For a gated spillway, the crest may be lower than the flood-season limiting or normal pool level. Whether discharge occurs and its magnitude also depend on gate opening, head, and tailwater.
Emergency-spillway control elevation	The control elevation at which an emergency spillway, fuse plug, or other auxiliary discharge facility is intended to activate.	The design elevation, activation condition, and reason for nonactivation of Liulan Reservoir's east-side fuse-plug facility should be established from design documents and field investigation.

Term	General Meaning and Engineering Function	Use and Cautions in This Brief
Dam-crest elevation	The structural elevation of the top of the dam. Local crest elevation may be affected by construction tolerances, settlement, road modifications, and differential deformation.	Overtopping may begin when the local water surface—where relevant including wind setup and wave runup—exceeds the local crest elevation. The lowest crest point, rather than only the nominal elevation, is important.

Using the terminology above, Appendix Table 3 compiles publicly reported values for the main elevations and water levels at Liulan Reservoir available through July 25, 2026. The sources vary in reliability and may not use a common datum. The values are presented only for cross-comparison and remain subject to design documents, operating rules, and the formal investigation.

Appendix Table 3. Publicly Reported Principal Elevations and Water Levels at Liulan Reservoir (Pending Formal Verification)

Elevation/Water-Level Item	**Publicly Reported Value (m)**	**Source and Explanation (All Pending Formal Verification)**
Spillway-crest elevation	Approximately 105.70; alternatively 106.5	Some reports and the manager's interview use approximately 105.70 m; the July 17 expert interpretation uses 106.5 m. Both require verification from design drawings and a common datum.
Flood-season limiting level	108.9 (alternative report: 108.10)	A Jiemian News reporter photographed 108.9 m on the dam-crest gauge-room sign on July 8; the manager's interview cited 108.10 m. Both remain in circulation.
Design flood level	112.11	Shown on the gauge-room sign; consistent with the manager's statement that the 6:48 a.m. level of 112.16 m was about 0.05 m above the design flood level.
Check flood level	113.51	Shown on the dam-crest gauge-room sign; not the measured peak level of this event and still subject to confirmation from design documents and a common datum.

Emergency spillway (fuse plug)	Crest approximately 113.5; activation approximately 113.17	Online water-conservancy gazetteer material; source and datum require verification. If these values share a datum with the on-site signs and event levels, the numerical relationship warrants investigation, but it cannot alone establish design correspondence or quantify exceedance depth.
Dam-crest elevation	114.38	Red Star News on July 11, citing a water-conservancy gazetteer; maximum dam height 42 m and foundation described as thick-bedded gray-green argillaceous shale.
Event peak water level	Approximately 116 (manual estimate: 116.26)	Media citation of a manual estimate; both the value and elevation datum require formal verification.

Note: Appendix Table 3 compiles public values from sources of differing reliability and should not be interpreted as a verified "elevation ladder." Published spillway-crest elevations include approximately 105.70 m and 106.5 m; reported flood-season limiting levels include 108.9 m and 108.10 m; and the fuse-plug and peak-event levels have not been verified from original records. Only after a common datum is confirmed and the values are checked against design documents, surveys, and monitoring records can they be used to determine relative elevations, activation conditions, and overtopping depth.

Special Note: Public sources conflict on whether 108.10 m represents an operating water level or a structural elevation. This brief lists the different reports but does not substitute this figure for formal design documentation. Reservoir water level, flood-season limiting level, design flood level, spillway-crest elevation, and dam-crest elevation all have distinct engineering meanings.

Appendix 3. Downstream River-Recreation Safety Advisory

- Altered channel bed: High-velocity flooding may create deep holes, concealed channels, abrupt drops, and zones of strong current that cannot be judged visually.
- Submerged hazards: Embankment soil, trees, reinforcing steel, building debris, electrical wires, and household waste may create collision and entanglement hazards.
- Water-quality hazards: Floodwater may carry pathogens, decaying organic matter, pesticides, and other contaminants.
- Bank collapse: After floodwater scours the toe of a bank, the bank may still collapse suddenly during recession.
- Infrastructure hazards: Bridges, culverts, levees, and roadbeds may have structural damage that is not readily visible.

Swimming, wading, boating, fishing, and approaching damaged bridges, culverts, or steep banks should be avoided until safety assessment, debris removal, sediment cleanup, and water-quality testing have been completed.

Overtopping and Local Breach of an Earth Dam under Floods Exceeding the Design Standard

A Technical Review and Industry Lessons from the Liulan Reservoir Event in Hengzhou, Guangxi, China

Qizhong Guo

July 8, 2026

Note on sources and scope: This article is a preliminary technical review based on public reports, official updates, and basic principles of hydraulic and water resources engineering available during July 6–8, 2026. It does not substitute for a governmental incident investigation, dam-safety assessment, or formal hydrologic review. Data related to water levels, storage capacity, breach width, flood volume, project condition, and reservoir operation process should be understood as preliminary estimates or reasonable inferences based on public information unless they have been confirmed by an official investigation.

Abstract

On July 6, 2026, Liulan Reservoir in Hengzhou, Nanning, Guangxi, experienced overtopping and breach openings in its dam during a historically rare extreme rainfall event, creating a severe flood emergency. From the perspective of hydraulic and water resources engineering, this article provides a preliminary review of the engineering background, possible hazard mechanisms, reservoir-release constraints, overtopping failure mechanism of the earth dam, secondary sediment and water-quality impacts, post-disaster recovery needs, and directions for improving forecasting and warning systems.

Based on currently available public information, the direct trigger of the event was an above-design-standard inflow flood caused by typhoon rainfall. The vulnerability of an aging homogeneous earth dam to overtopping flow, together with the imbalance between spillway/release capacity and the incoming flood peak, formed an important engineering context for the rapid escalation of the emergency. High downstream exposure of population and infrastructure was also a major factor contributing to the severity of the disaster consequences. This article emphasizes that such events should not be attributed to a single cause before the completion of an official investigation. Instead, hydrologic reconstruction, operation review, dam-safety assessment, and basin-scale risk evaluation should be used to promote a transition in aging-reservoir management from design-standard-based engineering protection to risk-based system management.

1. Project Overview and Functional Role: Basic Profile of Liulan Reservoir

Liulan Reservoir is located in Liulan Village, Xiaoyi Town, Hengzhou City, Nanning, Guangxi, at approximately 22°56′N and 109°12′E. The reservoir impounds runoff from Zhenlong River, a first-order tributary of the Yujiang River; the upstream reach is also referred to as Yunbiao River. The drainage area above the dam site is approximately 195 km². Publicly reported total storage capacity is approximately 93.19 million m³, although another public source gives approximately 95.52 million m³. The dam height is approximately 42 m. It is a medium-sized reservoir serving flood control, irrigation, water supply, and other multipurpose functions.

From an engineering-structural perspective, public information indicates that the main dam of Liulan Reservoir is a homogeneous earth dam, meaning that the dam body was formed by placing and compacting cohesive soil materials in layers. Construction reportedly began in 1958 and was completed in 1960, so the project has been in operation for more than 60 years. Homogeneous earth dams are relatively low-cost and comparatively simple to construct, but they generally are not designed to withstand sustained overtopping flow. Once floodwater flows over the crest, concentrated flow on the downstream slope may rapidly erode and remove dam materials, leading to breach initiation and enlargement.

Public information also mentions that the reservoir historically experienced safety issues such as upstream-slope sliding, locally loose soil, and seepage, and that dam-safety reinforcement works had been undertaken. This article treats such information only as engineering background. The specific condition of historical deficiencies, the scope and quality of reinforcement, and their relationship, if any, to the present event should be determined by formal engineering assessment and official investigation.

In terms of beneficial-use functions, Liulan Reservoir supports agricultural irrigation in Xiaoyi, Yunbiao, Maling, Hengzhou, and other townships. The reported benefited farmland area is about 157,300 mu, and the reservoir is also related to local water supply, irrigation-district modernization, ecological uses, and fishery management. A modernization project for the irrigation district reportedly began in 2023, with a total investment of about RMB 383 million. Local media reported in April 2026 that approximately RMB 290 million had been completed and that civil-works completion had reached about 95%. Improved irrigation water-use efficiency, water-source reliability, and source-water protection are therefore closely connected to reservoir operation. This shows that Liulan Reservoir is not a single-purpose flood-control project but an important node in the regional agricultural, water-resources, and livelihood system.

During recent severe droughts, Liulan Reservoir reportedly released water to support spring irrigation. This fact indicates that post-disaster decisions on whether and how to repair the reservoir cannot be limited to closing the breach. They should also consider regional water supply and demand, irrigation-district investments, alternative water sources, engineering safety, and acceptable risk from multiple perspectives.

2. Hazard Mechanisms: Above-Design Floods and Overtopping Vulnerability of an Earth Dam

2.1 Extreme rainfall and inflow-magnitude assessment

The direct trigger of this emergency was extreme rainfall associated with Typhoon Maysak, the tenth typhoon of the year. Public reports indicate that from 08:00 on July 5 to 08:00 on July 6, 2026, Nanning and surrounding areas experienced rainstorms to extreme rainstorms. The 24-hour rainfall reached 565.0 mm at Shitang Town, 445.0 mm at Taoxu Town, and 411.5 mm at Xiaoyi Town in Hengzhou. At Bafeng Village, Luxu Town, Binyang County, the 24-hour rainfall reached 713.3 mm; its 3-hour, 6-hour, 12-hour, and 24-hour rainfall totals all broke historical records for Nanning, and the 24-hour total ranked second in the historical record for Guangxi. The Hengzhou–Binyang–Guigang area was near the center of the intense rainfall, and regional river levels rose rapidly.

Using the approximately 195 km^2 drainage area of Liulan Reservoir for an order-of-magnitude estimate, it should be noted that the Shitang station may not be within the reservoir catchment or may be located only near its edge; the measured rainfall at Xiaoyi Town, closer to the core of the catchment, was 411.5 mm. If 411.5–565 mm is used as a representative rainfall range, then the 24-hour total rainfall volume over the catchment would be approximately 80 to 110 million m^3. Under conditions of near-saturated antecedent soil, extremely high rainfall intensity, and high runoff efficiency, assuming a runoff coefficient of 0.75–0.85 could yield an inflow volume of approximately 60 to 94 million m^3. This magnitude approaches, and may even reach, the total storage capacity of the reservoir.

It must be emphasized that the above calculation is only a rough order-of-magnitude assessment based on point rainfall and a simplified runoff coefficient. It cannot substitute for a formal hydrologic reconstruction. Subsequent review should incorporate basin-average rainfall, radar rainfall, antecedent soil moisture, measured stage-storage relationships, inflow hydrographs, outflow rating curves, and gate-operation records.

2.2 Water-level rise, release capacity, and operation constraints

Public reports indicate that before the incident the water level of Liulan Reservoir had exceeded the design flood level. According to media summaries, the reservoir station had conducted two flood-regulation releases before the event and had all personnel on standby on the afternoon of July 5. Around 02:30 on July 6, the reservoir reportedly exceeded the flood-control limit level and issued multiple release warnings. At 06:00 the gates were fully opened, and at around 10:20 the dam was overtopped and breach openings appeared. Another report stated that the reservoir water level reached 111.20 m at around 02:30 on July 6, exceeding the design flood level by 0.91 m. That value is not an official record and should be verified against gate-operation records and automatic water-level data. Despite full-gate release, the water level continued to rise and ultimately overtopping occurred. This indicates that, at least during this extreme event, there was a significant imbalance between the inflow-flood magnitude and the project's release capacity.

Reservoir operation should not be simplified as "opening gates earlier would necessarily have prevented overtopping." The maximum discharge capacity of gates, spillways, and outlet works is jointly constrained by opening size, crest elevation, gate condition, hydraulic head, and downstream conveyance capacity. If the inflow hydrograph far exceeds the project's release capacity, earlier and larger releases can reduce or delay water-level rise but may not fully prevent overtopping. According to water-conservancy gazetteer-type materials circulated online, the normal spillway of Liulan Reservoir may be a shoulder-side-channel practical weir with a crest elevation of 108.10 m and a maximum discharge of about 2,240 m^3/s. These parameters have not been officially confirmed, and "design maximum discharge" is not equivalent to the actual usable discharge capacity during this flood event. A later review should verify the actual discharge-capacity curve using design and safety-assessment documents, measured reservoir stage, downstream water levels, gate condition, and any inlet or outlet blockage or obstacles.

At the same time, the possibility of operational optimization cannot be ruled out in the absence of complete operation records. Key questions for review include whether the pre-event reservoir level was relatively high, whether pre-releases had been conducted based on typhoon forecasts, whether maximum discharge capacity was fully used, whether downstream channels and Yujiang River water levels constrained pre-release, and whether downstream warnings and evacuation were coordinated with reservoir operation.

2.3 Overtopping failure mechanism of a homogeneous earth dam

From the perspective of earth-dam engineering, the development of the Liulan Reservoir emergency is consistent with the general pattern of overtopping failure of earth dams. The downstream slope of a homogeneous earth dam is typically protected by grass cover, dry masonry, or other slope-protection measures against rainfall erosion and small surface runoff. Such measures are not designed to withstand sustained, high-discharge overtopping flow.

A possible failure process includes four stages. First, after the reservoir water level exceeds or approaches the dam-crest control elevation, water flows over the crest and down the downstream slope. Second, high-velocity flow damages the slope protection and exposes the dam-fill material. Third, concentrated erosion forms rills and gullies on the slope; these gullies headcut upstream and deepen continuously. Fourth, when a gully cuts through a critical section of the dam body, the remaining dam mass cannot resist the upstream water pressure, and local sliding and breach enlargement follow.

According to public images and reports, at around 10:20 on July 6, two breach openings appeared at the eastern dam head and on the left-side dam section near the power station, with an initial combined length reported at about 50 m. By the evening of the same day, media cited reservoir staff as saying that the breach had expanded to about 100 m wide and that both sides were still collapsing. According to a July 7 report by Guangxi Daily, the overtopping breach at Liulan Reservoir had become stable and was no longer expanding. The precise location, width, bottom elevation, development duration, and stage-by-stage enlargement rate of the breach—as well as whether it was related to dam abutment connections, through-dam structures, a suspected emergency-spillway facility, or local fill quality—should be confirmed by field survey, UAV imagery, dam cross sections, material testing, and operation records. Special attention is needed because media expressions such as "eastern dam head" and "left-side dam section near the power station" involve two different coordinate references: cardinal directions and left/right bank (or observer perspective). By the hydraulic convention of facing downstream, the left bank at this dam site roughly corresponds to the east bank; however, if an eyewitness was looking from the upstream reservoir side, "left side" would be opposite to the hydraulic left bank. Existing text alone cannot close the positional relationship between the two breach openings. A formal review should locate the two breaches using the dam-axis stationing system from design drawings to avoid ambiguity caused by mixing east/west with left/right terminology.

Another issue that should be carefully verified in the formal investigation is the engineering nature and actual operating condition of the open bypass channel outside the east-bank dam shoulder. Pre-breach satellite imagery shows that a normal spillway can be identified near the right-bank dam shoulder of Liulan Reservoir. At the same time, there is another distinct open bypass channel outside the east-bank dam shoulder, with artificial shaping and features suggestive of an auxiliary release channel or emergency spillway channel (see figure). Because satellite imagery does not provide control elevation, crest structure, design discharge, or activation conditions, this article does not determine the engineering function of that facility. Online sources have also mentioned that Liulan Reservoir may have a fuse-plug-type emergency spillway facility, but its location, elevation, activation criteria, current condition, and relationship to the present breach have not been confirmed by authoritative sources. Subsequent investigation should determine whether this east-bank channel is an auxiliary spillway, emergency spillway, or another engineering feature; whether its design function, actual discharge capacity, and current condition meet design requirements; whether the highest water level in this event reached its activation condition; whether the downstream floodway has been occupied or obstructed; and whether it has any direct relationship with the breach openings. This article does not use this issue to characterize the event; it identifies it only as an important issue for subsequent engineering review.

Figure: Pre-event satellite imagery of Liulan Reservoir engineering layout (Google Maps; imagery source: Imagery ©2026 CNES / Airbus, Maxar Technologies)

Therefore, this article prefers to describe the event as "overtopping and localized dam breach openings" or "local breach following overtopping of an earth dam." Before official investigation conclusions are released, directly characterizing it as a full dam failure or a single engineering-quality problem would be overly simplistic.

2.4 Sediment transport and secondary water-quality impacts

Overtopping and dam-breach openings not only release floodwater but may also transport large quantities of sediment, organic matter, nutrients, and other pollutants. Images from the site show yellow-brown flow, indicating that the floodwater may have had a high suspended-sediment concentration. Possible sources include watershed surface erosion, resuspension of reservoir sediments, and erosion of dam-fill material.

Under intense rainfall, sloping farmland, disturbed forest areas, road slopes, exposed ground surfaces, and channel banks within the watershed may all become sediment sources. If the reservoir water level drops rapidly after breach formation, reservoir shoals and loose bottom sediments may also be re-eroded and transported downstream. The dam material itself, eroded during overtopping, directly adds to the sediment concentration in the released flow.

Such sediment-laden floodwater may deposit in downstream channels, farmland, roads, and low-lying village or town areas, affecting flood conveyance sections, cultivated soil layers, intake operation, water-quality protection, and ecosystem recovery. Therefore, post-disaster dredging, sediment handling, water-quality monitoring, environmental sanitation, and necessary public-health disinfection should be incorporated into the recovery plan together with dam repair.

3. Basin Relationships and Related-Project Clarifications

3.1 Flood superposition with Yunbiao Reservoir and simultaneous multi-reservoir emergencies

Yunbiao Reservoir is located about 5 km west of Liulan Reservoir. Official updates indicate that on the morning of July 6, both reservoirs experienced overtopping and breach openings, and their downstream channels merge near Naguang Village before entering the Yujiang River. On the same day, Sanchakou Reservoir and Chayuan Reservoir in Hengzhou also experienced emergencies, and Liuwang Reservoir in Binyang County experienced overtopping of the embankment.

This means that inundation in some downstream towns and villages was the result of superposed flood sources from two or more reservoirs. For example, a village official in Nankang Village, Yunbiao Town, told the media that approximately 6,390 people in the village were affected by floodwater associated with overtopping and breach openings at the two reservoirs, and nearly 1,700 people were at one point surrounded by floodwater. Therefore, in disaster attribution, inundation reconstruction, and loss assessment, downstream flooding should not be simply attributed to a single breach source from Liulan Reservoir. The fact that multiple reservoirs in the same region experienced emergencies on the same day is itself important evidence for the “systemic risk” argument presented in Section 9.

3.2 Relationship with the Datengxia Water Control Project

Liulan Reservoir is located upstream on Zhenlong River, a tributary of the Yujiang River. Floodwater from the reservoir enters Zhenlong River, then the Yujiang River, and eventually the Xijiang River system. The Datengxia Water Control Project is located on the Qianjiang mainstem in Guiping City. The two projects are hydrologically connected within the same basin, but they are not in a close upstream–downstream relationship.

From the perspective of hydraulic propagation, backwater from the Datengxia reservoir area could not propagate upstream to the river reach below Liulan Reservoir and cause this event. The river distance is long, and the Liulan emergency occurred at the upstream tributary reservoir itself. Public information indicates that Datengxia undertook regulation and flood-peak attenuation during this regional flood process. The specific flood volume retained, peak-reduction effect, and operational role should be determined by water-authority operation reports.

3.3 Relationship with the Pinglu Canal

The starting point of the Pinglu Canal is located in the Xijin reservoir area of the Yujiang mainstem within Hengzhou. It is in the same regional Yujiang water-system context as Liulan Reservoir, but the two are not on the same direct flood-conveyance path. Floodwater from Liulan Reservoir enters the Yujiang via Zhenlong River and then generally propagates downstream along the Xijiang River system; the Pinglu Canal is an artificial channel connecting the Yujiang southward to the Beibu Gulf.

The actual hydraulic role of the Pinglu Canal during this flood cannot be determined merely from geographic proximity. Whether it affected local water levels, flow distribution, or flood-conveyance conditions should be evaluated using canal-control operation records, Yujiang stage-discharge hydrographs, and hydrodynamic modeling. This article only notes the regional water-system connection and does not treat the Pinglu Canal as a cause of the Liulan Reservoir emergency.

3.4 Reconsideration of earthquake influence

After the May 2026 earthquake in Liuzhou, Guangxi, some members of the public raised concerns about whether seismic activity may have affected regional reservoir safety. Such concern is reasonable. For the Liulan Reservoir event, however, public information has not indicated that the earthquake was a direct or major cause of the dam-breach openings. The direct trigger of this emergency remains extreme rainfall and the resulting above-design-standard flood and overtopping process.

Nevertheless, the combined risk of seismic and flood conditions deserves attention. For aging earth dams, earthquakes may create microcracks, local loosening, or changes in seepage conditions. Under extremely high reservoir levels, increased seepage pressure may accelerate piping or local instability along such weak zones. Although these effects may not have been the primary cause in this event, they remind the industry that old reservoirs, deficient reservoirs, and projects in complex geological areas require special attention during pre-flood inspections, post-earthquake inspections, and risk reassessment before intense rainfall.

4. Source-Water Protection, Water Quality, and Watershed Management

In addition to irrigation and flood-control functions, Liulan Reservoir is also an important regional water source. Some public materials have mentioned source-water management issues in the reservoir area and upstream watershed, including elevated total nitrogen, fertilizer input to the reservoir, soil erosion, and fast-growing eucalyptus plantations. These issues are not part of the same causal chain as the present dam-breach openings, but they are related to runoff generation, sediment production, water-quality risk, and post-disaster recovery under extreme rainfall, and they deserve continued attention in long-term watershed management.

During extreme rainfall, watershed nonpoint-source pollution, resuspension of reservoir sediments, and wash-off of pollutants from farmland, villages, and towns may all increase downstream water-quality risk. Post-disaster recovery should therefore not focus only on structural dam repair. It should also include inspection of source-water protection zones, monitoring of sediments and pollutants, reservoir-bank stability checks, restoration of ecological buffer zones along inflowing rivers, and upstream hillslope soil-and-water conservation measures.

5. Post-Disaster Recovery: A System Project Beyond Breach Repair

5.1 Repair of hydraulic works and infrastructure

Post-disaster recovery should first include dam-safety assessment and breach treatment. For a breach on the order of about 100 m, topographic survey, geotechnical investigation, residual-dam stability analysis, seepage analysis, and emergency diversion planning should be conducted before determining temporary closure, permanent repair, dam raising, or construction of new flood-release facilities.

At the same time, rapid reservoir drawdown may induce reservoir-bank instability. Reservoir-bank failures, slope cracks, road damage, and risks to structures around the reservoir should be inspected. Downstream channels may experience severe sediment deposition, bank erosion, local scour at bridge piers, culvert blockage, roadbed undermining, and damage to weak levee sections; all of these require systematic safety assessment.

Power supply, water supply, communications, roads, and bridges form the basis of post-disaster life recovery. Transformers, pumping stations, cables, communication facilities, and water-supply pipelines that were inundated by floodwater should not simply be returned to service. They should be safety-tested, disinfected, flushed, and put through trial operation before gradual restoration.

5.2 Dredging, ecological recovery, and public-health restoration

After sediment-laden floodwater deposits in downstream farmland, towns and villages, roads, and channels, it may affect cultivated soil layers, drainage capacity, and public health. Dredging should distinguish among flood-conveyance dredging in channels, road and village/town cleanup, farmland topsoil restoration, and disposal of potentially contaminated sediments. Not all sediment should be treated simply as ordinary silt.

If reservoir-bottom sediment contains relatively high organic matter, nitrogen, phosphorus, or other pollutants, post-disaster water-quality and sediment monitoring should also be conducted. Drinking-water sources, temporary intakes, wells, and inundated water-supply facilities should be tested for microorganisms, turbidity, organic matter, and necessary chemical indicators to ensure public-health safety.

5.3 Assistance, compensation, and rebuilding public confidence

According to the Nanning flood-control and disaster-relief press conference on July 7, as of that morning, Hengzhou had 4 deaths, 8 missing persons, 84,700 affected people, and 53,808 people urgently evacuated and relocated; Binyang County had 8,606 affected people, and all persons requiring evacuation had been evacuated and relocated. The evening Guangxi regional emergency-response press conference on July 7 further reported that 375,000 people across the region had been affected, 6 had died, 11 were missing, and 130,000 had been urgently evacuated and relocated. These figures are dynamic statistics, and final values should be based on official verification.

In the short term, disaster assistance should focus on shelter, drinking water, hot meals, medical care, disinfection, transportation restoration, and delivery of relief supplies. In the medium term, it should focus on housing, farmland, roads, hydraulic facilities, and public-service systems. In the long term, the focus should be risk communication, disclosure of engineering safety assessments, repair-scheme evaluation, and clarification of responsibility boundaries.

Rebuilding public confidence cannot rely only on explaining that “this was caused by extreme weather.” More important is allowing affected communities to see concrete actions in dredging, emergency repair, compensation, relocation support, risk assessment, and long-term governance. The role of professional media and technical experts is to help the public understand complex causality and avoid reducing the event to either a single engineering responsibility or a single natural disaster.

5.4 Public water-contact safety warning

After the flood from the breach recedes, the downstream river channel does not immediately become safe. High-velocity flow may form deep pits, submerged grooves, and abrupt drops in the channel bed. Large amounts of dam material, trees, building debris, and household waste may be deposited underwater. Riverbank toes may have been scoured and remain unstable. Bridges, culverts, and levees may also contain hidden damage.

Therefore, local emergency-management and water-resources authorities should issue clear channel-safety warnings, place visible warning signs at dangerous reaches, and repeatedly notify residents through village broadcasts, new media, schools, and community channels. Before systematic safety assessment, debris removal, and water-quality testing are completed, swimming, wading, boating, fishing, and activities near damaged bridges or culverts should be strictly prohibited. Safety education for children and adolescents should be especially strengthened.

6. Forecasting and Warning System: The “Four Pre-” Direction and Improvement Needs

This event indicates that traditional reservoir-operation and risk-communication systems still have shortcomings when facing extreme events that exceed design standards. Many aging reservoirs have limited monitoring intelligence, and data-transmission stability may decline during extreme weather. Samples of above-design-standard floods are rare, hydrologic forecasting is difficult, and whether warnings can reach threatened populations rapidly and accurately directly affects evacuation outcomes.

In recent years, the water sector in China has emphasized the “four pre-” system: forecasting, warning, rehearsal/simulation, and emergency plans. For aging reservoirs and small-to-medium watersheds, the key is not merely installing more sensors, but building an integrated chain from rainfall forecasting, watershed runoff generation and routing, reservoir inflow, reservoir operation, downstream inundation, population evacuation, and emergency response.

Technically, radar rainfall, numerical weather prediction, automatic water-level and rainfall stations, watershed hydrologic models, reservoir-operation models, machine learning, and digital-twin platforms can be integrated to improve linked forecasting of extreme rainfall, floods, and reservoir operations. AI and large-model technologies should be treated as supporting tools, with emphasis on data integration, scenario rehearsal, risk identification, and emergency-information organization, rather than on simple claims of fixed-percentage improvements in forecast accuracy.

Institutionally, clearer graded response procedures should be developed for floods exceeding the design standard: when to pre-release, when to lower the flood-control limit level, when to initiate downstream evacuation, when to enter dam-protection emergency mode, and when to use emergency spillway facilities or temporary flood-diversion measures. Emergency plans should be exercised regularly and linked to evacuation routes for townships, villages, schools, elderly-care institutions, and transport nodes.

7. Repair Necessity and Scheme Comparison Based on Functional Tradeoffs

Liulan Reservoir has multiple functions, including irrigation, water supply, flood control, power generation, ecology, and fisheries. Discussion of whether and how to repair the reservoir should not be simplified as a question of restoring the original condition. A more reasonable approach is to compare schemes based on functional redundancy, feasibility of alternative projects, downstream risk, and future climate pressure.

Function	Main consequences if not repaired	Feasibility of alternatives	Repair urgency
Irrigation	Water-source security for about 157,300 mu of farmland would be affected, and the benefits of completed irrigation-district modernization investments would be difficult to realize.	Regional water transfers, ponds, pumping stations, or temporary water sources could partially substitute, but complete short-term substitution would be difficult.	Extremely high
Water supply	Water-supply security and emergency water-source capacity for surrounding townships would decline.	Switching to or constructing alternative water sources is possible, but supporting pipelines, pumping stations, and water-quality safeguards would be required.	High
Flood control	Upstream regulation and storage capacity would be weakened; however, this event also exposed the inadequacy of the original flood-control capacity.	Flood-control standards, emergency spillway facilities, downstream levees, and warning/evacuation systems would need to be reassessed.	Requires reassessment
Power generation	Small hydropower revenue would be lost.	The regional energy system can substitute; this function has relatively low priority.	Low
Ecology and fisheries	The aquatic ecosystem and management practices such as "using fish to improve water quality" would be interrupted.	They can be gradually rebuilt as the reservoir and water quality recover.	Moderate

The above framework indicates that Liulan Reservoir has a very high need for repair, mainly because its irrigation and water-supply functions are difficult to fully replace in the short term. However, repair should not simply restore the original condition. Instead, the event should be treated as a window of opportunity for functional reallocation, standard improvement, and risk transfer.

At least three options should be compared. Scheme A would repair the reservoir at the original site while improving flood-control and overtopping-resistance capacity. Scheme B would repair the reservoir but adjust its functional role, lower high-risk beneficial-use water levels, or operate it at a downgraded level. Scheme C would partially abandon the existing reservoir and build alternative water-supply or alternative storage/regulation works. The final choice should comprehensively consider engineering safety, economics, downstream population risk, irrigation and water-supply security, ecological impacts, and long-term operation and maintenance capacity.

If the original-site repair option is selected and the reservoir continues to serve important water-supply and irrigation functions, key issues should include whether to raise the dam crest and increase wave freeboard, whether to expand or construct spillways, whether to review the reliability, control elevations, activation conditions, and downstream land-use controls of existing spillway facilities and suspected emergency spillway facilities, whether emergency spillway facilities and erosion-resistant linings should be rebuilt, expanded, or added, whether cutoff walls, drainage prisms, and slope reinforcement should be adopted, whether automatic rainfall and water-level monitoring and remote gate-control systems should be upgraded, and whether downstream flood-risk zones and emergency evacuation routes should be redelineated.

8. Subsequent Research and Work Recommendations

The research and technical work listed in this section directly supports the repair-necessity assessment and scheme comparison in Section 7. Whether the final decision is original-site repair, downgraded operation, or an alternative scheme, the following hydrodynamic reconstruction, risk-chain analysis, risk ranking, and multi-objective comparison studies are needed as a basis for decision-making.

8.1 Quantitative simulation of breach-flood propagation

A one-dimensional/two-dimensional hydrodynamic model should be established for the reach from Zhenlong River to the Yujiang River, using HEC-RAS, MIKE, or a similar model. Because Yunbiao Reservoir also experienced overtopping and breach openings on the same day, and because the downstream channels of the two reservoirs merge, the model should use dual-source inflow boundaries for Liulan and Yunbiao, and multi-source boundaries if necessary. Otherwise, inundation reconstruction for Xiaoyi, Yunbiao, Maling, and nearby downstream areas may contain systematic bias. The model should use measured or verified storage curves, breach width, breach invert elevation, breach development time, and water-level process to back-calculate breach-flood hydrographs and quantitatively evaluate inundation extent, depth, velocity, and arrival time in downstream townships.

If conditions permit, the model should further couple a sediment-transport module to assess deposition of sediment-laden floodwater in channels, farmland, and villages/towns. This would provide quantitative support for channel dredging, bridge and culvert inspections, and farmland recovery.

8.2 Severe-consequence risk chain and nonstationary frequency analysis

A complete risk-chain analysis framework should be established, for example: P(severe consequences) = P(flood exceeds design standard) × P(overtopping | above-design flood) × P(breach formation | overtopping) × P(exposure of people and property | flood release). Such a framework helps place “extreme rainfall,” “engineering vulnerability,” “operation capability,” and “downstream exposure” within a unified risk-management system.

Under climate change, traditional “100-year return period” frequency estimates may no longer satisfy nonstationary extreme-rainfall conditions. Regional rainfall records, changes in typhoon tracks, extreme short-duration rainfall intensity, and future climate scenarios should be used to conduct nonstationary frequency analysis and adaptive assessment of flood-control standards.

8.3 Risk ranking of aging earth dams and reinforcement pathways

A regional risk-ranking inventory for aging earth dams should be established using indicators such as dam height, storage capacity, downstream population, project age, dam type, release capacity, historical deficiencies, geological conditions, sensitivity to intense rainfall, and management capacity. For projects with high risk levels, safety assessment, flood-regulation capacity review, spillway-capacity assessment, and downstream flood-risk mapping should be prioritized.

Reinforcement pathways should not be limited to seepage control of the dam body. They should also include improving release capacity, dam-crest wave protection and anti-overtopping measures, erosion-resistant downstream slope protection, monitoring automation, gate reliability improvement, and emergency access construction. For small projects with low necessity or unacceptably high risk, downgraded operation, retirement, or replacement should also be considered.

8.4 Strategic comparison of repair schemes

The post-disaster repair of Liulan Reservoir should involve systematic scheme comparison. Original-site repair with increased standards would help preserve irrigation and water-supply functions, but it would require substantial investment and renewed assessment of above-design flood risk. Downgraded operation could lower beneficial-use water levels and downstream risk, but it may weaken water supply and irrigation capacity. Construction of alternative water sources or alternative storage/regulation projects would have a long cycle and high coordination difficulty.

Multi-objective decision analysis should use criteria such as life-cycle cost, risk-reduction benefits, functional-security capacity, ecological impacts, social acceptability, and operation and maintenance capacity.

8.5 Ecological and public-health impact assessment

Post-disaster ecological and public-health impact assessment should be conducted. Key issues include the effects of downstream sediment deposition on benthic organisms and fish habitat, sediment-cover thickness on farmland and changes in soil fertility, release risks from nitrogen, phosphorus, organic matter, and possible pollutants in reservoir-bottom sediments, and drinking-water safety and vector-borne disease risks in affected areas.

9. Industry Lessons: From Design Standards to Risk Management

The core lesson of the Liulan Reservoir event is that an aging homogeneous earth dam encountered extreme rainfall exceeding its design standard, and its flood-regulation capacity, resistance to overtopping, and downstream emergency-response system were all tested under limiting conditions. Extreme rainfall was the direct trigger; overtopping vulnerability of the earth dam was a key engineering mechanism; and reservoir operation, anti-overtopping capacity, downstream warning and evacuation, and post-disaster recovery systems jointly determined the event consequences. During the same typhoon rainstorm, several reservoirs, including Yunbiao, Sanchakou, Chayuan, and Liuwang, experienced emergencies on the same day. This further indicates that the event was not an isolated single-reservoir incident but a manifestation of regional water-infrastructure systems under above-design loading. According to the Guangxi regional press conference on the evening of July 7, at that time there were still 341 reservoirs above flood-control limit levels and 56 hydrologic stations on 41 rivers above warning levels. This illustrates the overall stress on the regional water system.

A “100-year” design standard does not mean that a project will necessarily be safe for 100 years. If it is interpreted in simplified terms as a 1% annual exceedance probability, then a project designed for a 100-year event has approximately a $1 - (0.99)^{50} \approx 39.5\%$ probability of experiencing an event exceeding that standard during a 50-year operating life. Therefore, a design standard is the result of engineering-economic and risk tradeoffs, not an absolute safety guarantee.

When a flood exceeding the design standard occurs, reservoir operation objectives shift from normal beneficial use, flood control, and safe release to the extraordinary objectives of dam protection, loss reduction, warning, and population evacuation. For aging earth dams, response pathways for above-design floods must be clarified in advance. These include pre-release rules, emergency spillway measures, emergency materials, emergency transportation, power supply, downstream evacuation thresholds, and public risk communication.

Against the background of climate change and intensified extreme weather, hydraulic-infrastructure safety management needs to shift from “probability-based engineering design” to “risk-based system management.” This means the industry should not only ask whether a project meets existing design standards, but also how it will fail when those standards are exceeded, how floodwater will propagate after failure, how downstream people will evacuate, how infrastructure will recover, and whether there are lower-cost risk-transfer pathways.

For the large number of homogeneous earth dams and small-to-medium reservoirs built across China in the 1950s–1970s, the Liulan Reservoir event provides an important warning. Future safety reinforcement should not remain at the minimum level of "filling gaps." It should incorporate new evidence on extreme rainfall, downstream socioeconomic exposure, and digital monitoring capacity to reassess safety redundancy, flood-regulation capacity, and emergency resilience.

Sources

The information in this article is mainly from official updates, publicly released meteorological and water-authority information, and domestic public media reports from July 6–8, 2026, including Xinhua News Agency, CCTV, The Paper, Jimu News, Yicai, Red Star News, Southern Wind, Qilu Evening News, and Time Weekly. Engineering parameters related to the spillway, the suspected emergency spillway facility, and discharge capacity are taken from water-conservancy gazetteer-type materials circulated online and remain to be verified. Engineering and disaster data in this article may be revised as formal investigation reports become available.

AI-Assisted Writing Statement

This article was conceived and written by the author, who is responsible for all content. Artificial intelligence tools were used during the writing process to assist with public-information retrieval, fact checking, order-of-magnitude estimate verification, and language revision. All technical judgments and conclusions in the article were reviewed and confirmed by the author, who bears full responsibility for the text.

Appendix 1. Key Data for Liulan Reservoir (Compiled from Public Information)

Item	**Data or description**
Location	Liulan Village, Xiaoyi Town, Hengzhou City, Nanning, Guangxi
Geographic coordinates	Approximately 22°56′N, 109°12′E; the intake coordinates are separately reported in public materials as 109°16′10″E, 22°56′02″N
Water system	Zhenlong River, a tributary of Yujiang River in the Xijiang River system of the Pearl River Basin
Drainage area	Approximately 195 km²
Total storage capacity	Public sources report two values, approximately 93.19 million m³ and approximately 95.52 million m³. These may correspond to different statistical or assessment versions and should be confirmed by formal documents.
Dam height	Approximately 42 m
Dam type	Homogeneous earth dam
Construction period	Construction began in 1958 and was completed in 1960
Design standard	Public sources describe it as a 100-year design standard; the specific standard and review results should be confirmed by design and safety-assessment documents.
Main functions	Irrigation, water supply, flood control, and other multipurpose uses
Irrigated area	Approximately 157,300 mu

Water-supply service population	Public sources state approximately 210,000 people; another official wording says the reservoir "benefits more than 170,000 people." The difference may reflect different statistical categories (water-supply service versus irrigation beneficiaries) and should be verified against local water-supply system data.
Hydropower capacity	Public sources state approximately 1,300 kW

Appendix 2. Public Water-Contact Safety Warning for Downstream Channels

- **Changed riverbed:** High-velocity floodwater may form deep pits, submerged grooves, and abrupt drops that are difficult to see and can easily lead to drowning.
- **Underwater deposits:** Dam material, broken trees, building debris, and household waste may create underwater obstacles and entanglement hazards.
- **Water-quality pollution:** Floodwater may carry bacteria, viruses, pesticide residues, and decaying organic matter. Contact may cause skin disease or gastrointestinal infection.
- **Riverbank collapse:** After floodwater scours the bank toe, riverbanks may still collapse suddenly during the drawdown period.
- **Damaged infrastructure:** Bridges, culverts, levees, and roadbeds may have hidden damage and should not be approached without authorization.

Before systematic safety assessment, debris removal, dredging, and water-quality testing are completed, residents along the river should not enter the channel for swimming, boating, fishing, or playing in the water. Schools, village committees, and communities should strengthen safety education for children.