Hydrologic Aspects of the 2022 Addendum to the Environmental Impact Statement for the DPM Lead-Zinc Mine, North Sumatra, Indonesia

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LIGHTNING SUMMARY

PT. Dairi Prima Mineral (DPM), an Indonesian company with majority ownership by a Chinese state-owned company, has submitted a 2022 Addendum to the Environmental Impact Statement (EIS) for a proposed underground lead-zinc mine in North Sumatra, Indonesia. Compared with the 2021 Addendum, the only significant changes to the hydrologic aspects are the increase in the height of the tailings dam from 25 to 28 meters and the increase in the tailings storage from 1.2 to 1.67 million cubic meters. Based on the latest industry guidance, it is not possible to backfill 75% of the tailings, so that the actual aboveground tailings storage would be closer to 2.5 million cubic meters. Based upon the population at risk, the design of the tailings dam for a 100-year flood is inconsistent with recent guidance by the Australian Committee on Large Dams (ANCOLD) and the International Commission on Large Dams (ICOLD) that require design for the Probable Maximum Flood (PMF), while the proximity to populated areas would be illegal according to Chinese regulations. The updated Addendum contains less rainfall and baseline data than previous versions and even contradicts data in previous versions.

EXECUTIVE SUMMARY

PT. Dairi Prima Mineral (DPM), an Indonesian company with majority ownership by a Chinese state-owned company, has submitted a 2022 Addendum to the Environmental Impact Statement (EIS) for a proposed underground lead-zinc mine in North Sumatra, Indonesia. Compared with the 2019 and 2022 Addenda, the only significant change in the hydrologic aspects of the proposal are the increase in the height of the tailings dam from 25 to 28 meters and the increase in the tailings storage volume from 1.2 to 1.67 million cubic meters. A review of the 2022 Environmental Feasibility Decree by the Ministry of Environment and Forestry also did not reveal any other significant changes. Previous reports by the author evaluated the shortcomings of the 2019 and 2021 Addenda in terms of the hydrologic aspects. These shortcomings included the following:

1) the location of the tailings dam less than 1000 meters upstream from numerous homes and houses of worship and about 1800 meters upstream from Parongil village (population 2010);
2) the design of the tailings dam to accommodate only the monthly rainfall with a return period of 100 years, as opposed to international guidelines that require design for the Probable Maximum Flood or the 10,000-year flood, based upon the population at risk;
3) the short duration of local rainfall data that could be used to estimate the monthly rainfall with a return period of 100 years;
4) the lack of explanation as to how 75% of the tailings could be backfilled into the mine, which affects the height and storage volume of the tailings dam;

5) the measurement of baseline water quality without consideration of potential contaminants or the likely sites of emergence of contaminated groundwater;
6) the measurement of baseline surface water and groundwater discharge over short durations and on non-representative dates together with claims that trends existed that were not statistically significant;
7) the lack of discussion of the impact of water consumption on downstream users;
8) the lack of an adequate and detailed plan for the closure of the tailings dam
9) a closure plan that would allow the flow of untreated mine wastewater through the dam spillway 15% of the time;
10) the lack of an adequate and detailed plan for the prevention of acid mine drainage;
11) the assumption that the waste rock that will be used to construct the dam will be non-acid generating (NAG) based upon only two samples from the footwall and two from the hanging wall;
12) the numerous examples of contradictory data among tables, graphs and maps.

The objective of this report is to evaluate the hydrologic aspects of the 2022 Addendum both in terms of updated information, as well as in terms of recent mining industry guidance and regulations that shed new light on the plans in the 2019 and 2021 Addenda.

The plan for the DPM mine is to use cement paste fill (CPF) to return 70-75% of the tailings to the underground mine. The 2022 Society for Mining, Metallurgy and Exploration (SME) Tailings Management Handbook and the 2023 SME Underground Mining Handbook clarify that, even with CPF, no more than 50-60% of the tailings can be returned to exhausted underground mine workings. The processes of pressure release, blasting, crushing, and mixing with water (collectively called bulking) increase the volume of the ore body by an average factor of 1.8. The paste (a mixture of tailings, water and cement) has a typical solids content of about 70% by mass, although the plan at the DPM mine is for a solids content of only 65% by mass. Because the paste is discharged into the mine workings by gravity and water does not separate from the paste, all void spaces cannot be filled. Some attempts to fill all void spaces have resulted in over-pressurization of the walls with fatalities in some cases. Finally, problems in the coordination of extraction and backfill reduce the volume of tailings that can be backfilled. As a consequence, the volume of tailings that will require permanent aboveground storage, which is the basis for the tailings dam design, has been greatly underestimated and is probably closer to 2.5 million cubic meters. Thus, the tailings dam will be considerably taller than projected, which reinforces the concern that there might not be enough NAG waste rock to construct the dam.

The 2022 Addendum claims to follow the 2019 guidelines of the Australian Committee on Large Dams (ANCOLD). However, although there has been no analysis of the consequence of tailings dam failure at the DPM mine (which should be required according to the ANCOLD guidelines), it should be assumed that the population at risk will exceed 1000, so that, based on the ANCOLD guidelines, the Severity Level will be Major or Catastrophic and the consequence category will be Extreme. The Extreme consequence category should require design for the Probable Maximum Flood (PMF), so that the design for the monthly rainfall with a return period of 100 years falls far short of the guidelines. In the same way, due to the population at risk in the event of dam failure, according to the 2022 guidelines of the International Commission on Large Dams (ICOLD), the consequence category will be Extreme and the tailings dam should be designed to withstand the PMF. Although a publication by the Indonesian Ministry of Public Works and People's Housing states that all dams should be designed to withstand the PMF, regardless of the consequences of dam failure, it is not clear that this concept has been codified in Indonesian regulations. The Chinese tailings dam regulations are relevant since PT. Dairi Prima Mineral (DPM) has majority ownership by a Chinese state-owned company. These regulations would prohibit the construction of a tailings dam within 1000 meters of a populated area, so that the tailings dam site would be illegal within China, regardless of the selected design flood or any other safety standard.

Although critiques by the author of the 2019 and 2021 EIS Addenda emphasized the lack of rainfall and baseline data, the 2022 Addendum did not present any new data, but rather even fewer data than previous versions. For example, although the 2022 Addendum presents monthly rainfall data for 2009 – 2018, which would be insufficient to estimate even a 100-year extreme event, the 2021 Addendum presented monthly rainfall data for 2008 – 2019. Moreover, some of the data in the 2022 Addendum contradict the data in previous versions without any explanation. In general, although the author critiqued the short duration of surface water and groundwater discharge data that were used to show either the presence or absence of trends in the 2019 and 2021 Addenda, the same data were shown in the 2022 Addendum with no updating of either the data or the interpretation.

The recommendation of this report is still that the proposal for the DPM lead-zinc mine should be rejected without any further consideration.

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OVERVIEW

The Indonesian mining company PT. Dairi Prima Mineral (DPM) has now submitted the third Environmental Impact Statement (EIS) Addendum for a proposed underground lead-zinc mine in North Sumatra (Sumatera Utara), Indonesia (DPM, 2019, 2021, 2022). The proposed mine is called *Proyek Anjing Hitam* [Black Dog Project] in DPM (2019, 2021, 2022), but is more commonly referred to as the DPM mine, which is the name that will be used in this report. The majority owner of PT. DPM is China Nonferrous Metal Industry's Foreign Engineering and Construction Co., a part of the China Nonferrous Metal Mining Group, which is a Chinese state-owned company. The minority owner is Bumi Resource Minerals, the non-coal subsidiary of the Indonesian mining company Bumi Resources. The mine would operate for eight years and would process one million metric tons of ore annually, resulting in the annual export of 103,000 metric tons of lead concentrate (64% lead) and 225,000 metric tons of zinc concentrate (54% zinc). The plan is to store 70-75% of the tailings underground as cement paste backfill with the remaining 25-30% (1,344,000 – 1,612,800 metric tons) permanently stored aboveground as a tailings deposit confined by a tailings dam. Non-acid-generating (NAG) waste rock would be used to construct the tailings dam and to confine any potentially acid-generating (PAG) waste rock in a free-standing waste dump.

The hydrologic aspects of the 2019 Addendum (DPM, 2019) were reviewed by Emerman (2020) who made the following observations:

1) The plan to store 70-75% of the tailings underground as cement paste backfill would represent a theoretical maximum percentage and was not justified in terms of the mining sequence.
2) The tailings dam would be located less than 1000 meters upstream from numerous homes and houses of worship, as well as 1800 meters upstream from Parongil village (population 2010), which would make the project illegal in China.
3) The tailings dam would be designed to accommodate only a 100-year flood, although, according to internationally-recognized guidelines and Indonesian regulations, due to the probable loss of life in the event of dam failure, the dam should be designed to withstand either the 10,000-year flood or the Probable Maximum Flood (PMF), which is significantly rarer than even a 10,000-year flood.
4) There is no basis for determining even the 100-year flood since the closest weather station to the tailings dam with at least 30 years of rainfall data is 102 kilometers to the northeast with an elevation 545 meters lower than the dam.
5) The sites for measurements of baseline water quality were only in the southeastern portion of the mine project and were chosen without consideration of the likely sites of emergence of contaminated groundwater.
6) Water quality parameters were chosen without a geochemical analysis of tailings and waste rock and, thus, without consideration for potential contaminants.
7) Baseline surface water and groundwater discharge measurements were also made only in the southeastern portion of the mine project and on dates that were not shown to be representative. Claims that groundwater discharge has been decreasing were not statistically significant and could be used to claim that future decreases in groundwater discharge were unrelated to mining activity.
8) There was no discussion of the source of water for the mine, the rate of water consumption, or how water consumption could impact downstream users. However, based on global

trends in lead-zinc mining, the projected annual water consumption is 0.5-5 million cubic meters, or 6-66% of the discharge of the stream that supplies water to Parongil village.

9) The 2019 Addendum acknowledged the likelihood of acid mine drainage, but did not include adequate or detailed plans for the prevention of groundwater or surface water contamination. In particular, although the non-acid-generating (NAG) waste rock had a key role in constructing the dam for the potentially acid-generating (PAG) tailings and for confining the PAG waste rock in a waste dump, there was no indication that any NAG waste rock existed.
10) The 2019 Addendum was devoid of any contingency plans, in contrast to almost any other mining project.
11) The 2019 Addendum included no quantitative predictions of adverse impacts on the environment that are likely to occur despite the use of environmental controls, with the lack of attention to the environmental impact of dewatering of the underground mine being just one of many examples.
12) The 2019 Addendum contained numerous examples of contradictory data among tables, graphs and maps.

In response to the preceding observations, Emerman (2020) recommended rejection of the proposal without any further consideration.

In April 2021 PT. Dairi Prima Mineral submitted an updated EIS Addendum (DPM, 2021). The 2021 Addendum did not alter any of the hydrologic aspects of the project, but presented additional detail as to how certain decisions had been made. In particular, the 2019 Addendum clarified that the 100-year flood did not refer to a single storm (with a duration in the range 24-72 hours), but to the rainy period with a duration of 30 days and a return period of 100 years. Based on the additional detail in the 2021 Addendum, Emerman (2021) made the following additional observations:

1) The design of the tailings dam at the DPM mine to withstand a 100-year flood based on rainy periods with duration of 30 days is not a conservative design (not protective of people and the environment). Historic daily precipitation data from the Polonia weather station (102 kilometers northeast of the mine site) illustrates the principle that storms of duration 24-72 hours are much more extreme, relative to average precipitation, than month-long rainy periods. In particular, the ratio of the 100-year precipitation to the average precipitation at Polonia is 153.2, 83.1, 56.7, 26.8, and 9.8 for storms with durations of 24 hours, 48 hours, 72 hours, 7 days and 30 days, respectively.
2) The design of the tailings storage facility was based upon only 12 years (2008-2019) of monthly rainfall data.
3) Based on the design overflow monthly rainfall and monthly precipitation data from the mine site, following closure of the tailings dam, the flow of toxic and acidic tailings pond water through the emergency spillway and into downstream water bodies without treatment for removal of contaminants will be occurring 15% of the time. Such a frequent discharge of untreated mine wastewater into downstream water bodies must be regarded as unacceptable by any standard.
4) The conclusion that non-acid-generating (NAG) waste rock will be available for construction of the tailings dam and for confining the potentially acid-generating (PAG) waste rock in a free-standing waste dump was based upon only four rock samples. Since the waste rock would include acid-generating sulfide minerals such as pyrite, galena, and sphalerite, the acid-generating status would depend upon the sulfide concentration in a

particular sample. Based on standard practice, the fraction of waste rock that would be NAG or PAG should be determined from hundreds of samples. Thus, it is not known whether there will be enough NAG waste rock to construct the tailings dam or to confine the PAG waste rock in a free-standing waste dump. There are no contingency plans for the non-availability of sufficient NAG waste rock, although the consequences could be severe.

5) More detail showed that there were even more contradictions among the tables, graphs and maps in the updated Addendum, as well as arithmetic errors.

In response to the preceding observations, Emerman (2021) again recommended rejection of the proposal without any further consideration.

In terms of the hydrologic aspects of the mining project, the only significant change in the 2022 Addendum is the increase of the height of the tailings dam from 25 to 28 meters and the increase in the tailings storage volume from 1.2 million to 1.67 million cubic meters (DPM, 2022). Nothing in the 2022 Addendum explains why the dimensions of the tailings storage facility have been increased. The same annual rates of extraction of ore and export of lead and zinc concentrates as in the previous Addenda (DPM, 2019, 2021) are repeated in the 2022 Environmental Feasibility Decree (Ministry of Environment and Forestry, 2022). Although none of the EIS Addenda have analyzed the consequences of tailings dam failure, it should be clear that the consequences should increase as the dam height increases and as the stored volume of tailings increases. A complete review of the 2022 Environmental Feasibility Decree by the Ministry of Environment and Forestry also did not reveal any other significant changes.

In the absence of significant changes in the project design that could have potential hydrologic impacts, it is worthwhile asking whether there has been recent mining industry guidance that could influence the evaluation of the project. In particular, the project design can now be compared with the SME (Society for Mining, Metallurgy and Exploitation) Tailings Management Handbook: A Life-Cycle Approach that was released in February 2022 (Morrison, 2022), the ICOLD (International Commission on Large Dams) Bulletin 194: Tailings Dam Safety that was released in November 2022 (ICOLD, 2022), and the SME Underground Mining Handbook that was released in February 2023 (Darling, 2023a). One change in the mine proposal is that DPM now states that they are following the guidelines of the Australian Committee on Large Dams (ANCOLD), although not necessarily in all respects. According to DPM (2022), "*Kajian stabilitas TSF PT DPM telah dilakukan study oleh Nerin Engineering yang mengacu kepada kriteria dari ANCOLD (Australia National Committee on Large Dams, 2012)*" [The TSF [Tailings Storage Facility] stability study for PT DPM has been carried out by Nerin Engineering, which refers to the criteria from ANCOLD (Australian National Committee on Large Dams, 2012)]. Although DPM (2022) refers to the 2012 version of the ANCOLD Guidelines on Tailings Dams—Planning, Design, Construction, Operation and Closure, these guidelines were updated in July 2019 (ANCOLD, 2012, 2019).

It is also worth asking whether recent mining regulations could influence the evaluation of the project. The latest regulations from the Indonesian government (Ministry of Environment and Forestry, 2020; Government of the Republic of Indonesia, 2021) are certainly relevant. Since DPM has majority ownership by a Chinese state-owned company, it is also worth asking whether the proposed mining project would be legal within China. Although the Chinese tailings dam regulations were discussed in a previous report (Emerman, 2020) based upon English-language news articles (Zhang and Daly, 2019; Zhang and Singh, 2020), the complete regulations have now been translated by the author (see translation of Safety Regulations for Tailings Ponds (National Standards of the People's Republic of China, 2020) in Appendix A and Work Plan for the Prevention and Resolution of Tailings Pond Safety Risks (Department of Basics for Production Safety, 2020) in Appendix B), so that they can be compared with the proposal for the DPM mine in greater detail. A final point of re-evaluation of the proposal for the DPM mine is that, in light of the previous critiques of the short duration of rainfall and other baseline data in the previous Addenda (Emerman, 2020, 2021), it could be asked whether DPM has taken advantage of the additional three years (2019-2022) to add more data and to alter the project design or the assessment of the potential hydrologic impacts as necessary.

In summary, the objective of this report is to answer the following three questions:

1) Is the plan to backfill 70-75% of the tailings consistent with recent mining industry guidance?
2) Is the plan to design the tailings dam to withstand the monthly rainfall with a 100-year return period consistent with recent mining industry guidance?
3) Has the 2022 Addendum increased the amount of rainfall and other baseline data in comparison to the 2019 and 2021 Addenda?

EVALUATIONS

It is not Possible to Backfill 70-75% of Tailings

The opening chapter of the SME Underground Mining Handbook mocked the concept of backfilling all of the mine waste and much of the argument could be applied to backfilling even a large fraction of the mine waste. According to Darling (2023b), "Some regulators have advocated returning *all* the waste to where it came from, which is an argument that does not survive even cursory scrutiny, although there are examples where some percentages of inactive tailings facilities are consumed via paste backfill (e.g. Meikle and Leeville). In underground mining, this would mean changing the whole mining sequence to ensure backfilling could *never* interfere or be a consideration if a change in technology, commodity price, or reserve horizons presented itself. Furthermore, whole development and access drives would have to be kept open, safe, and gas-free far longer than previously considered necessary. And there is then the whole question of how to backfill, which will be both expensive and time-consuming" (emphasis in original) (Darling, 2023b).

Emerman (2020) also drew on the work by Yilmaz and Fall (2017) to emphasize the conflicting needs and schedules of underground mine backfill with ongoing ore extraction. According to Emerman (2020), "The underground storage of 60% of the tailings is a typically accepted maximum (Yilmaz and Fall, 2017). The underground storage of 70-75% of the tailings could be theoretically possible if all of the following conditions were met (Yilmaz and Fall, 2017): … Mining starts at the deepest and/or farthest point of the underground mine … However, it would be unusual (and generally uneconomical) to start mining at the deepest and/or farthest point of the underground mine. DPM (2019) does not describe such a plan or give any other indication as to the sequence of mining. Therefore, the intention to store 70-75% of the tailings underground cannot be seen as justified based on the present information."

The most important factor limiting the percentage of tailings that can be returned to the mine is the expansion (also called bulking) that occurs throughout all of the processes that are involved in the conversion of an underground ore body into a commodity of value (such as lead or zinc concentrate) and tailings. These processes include the pressure release due to the removal of the overlying rock, blasting, crushing (also called comminution), and flotation (mixing with water and reagents to remove the commodity of value). The preceding quote by Darling (2023b) continues, “In addition, such a notion [returning *all* the waste to where it came from] does not take into account the bulking that occurs when rock is blasted and processed.” The most bulking results from comminution. According to the SME Tailings Management Handbook, “Comminution not only reduces the size of the ore particles but also increases the volume that those particles occupy (usually more than 1.8 times the volume of the in situ rock). This means that even after removing the economic minerals, it is impossible to place the remaining tailings volume back into the UG [Underground] void it previously occupied” (Veenstra, 2022).

Cement paste fill (CPF), which would be used at the DPM mine, is often contrasted with the older method of hydraulic fill (HF) (Stone, 2023). In the hydraulic fill method, the tailings are cycloned to separate the coarser tailings, which are then pumped to the exhausted mine workings (called stopes) as a slurry with a solids content of 55-65% by mass. The slurry is discharged from the top of the stope so that it fills the stope by gravity, after which the excess water drains out of the tailings and is pumped back into the mining operation. The tailings are not compacted into the stope, which limits the mass of tailings that can occupy a stope. The hydraulic fill can include a cement that will bind the tailings together as the mixture cures within the stope.

In the cement paste fill method, the whole tailings (without removal of finer tailings) are combined with water and cement to achieve a mixture with a solids content that is typically in the range 68-72% by mass (Stone, 2023). Because of the inclusion of the finer tailings, water will not separate from the mixture after discharge into a stope. According to Stone (2023), “The term paste, as it applies to mine backfills, refers to a suspension of solids in a carrier fluid (typically water or process water) that is not subject to segregation or settling and has a measurable yield stress.” A cement paste fill also flows or is pumped to the stope, from where it is discharged from the top of the stope so that it fills the stope by gravity. In the case of a paste, the presence of the finer tailings improves the pumpability or flowability of the mixture. The cement paste fill method increases the mass of tailings that can be placed into a given stope, although that mass is still limited by the permanent inclusion of water within the material that fills the void space, as well as by the lack of mechanical compaction. Stone (2023) continues, “The higher solids content in the paste translates into a higher density, and hence into a higher proportion of tailings being returned underground in a paste backfill. A typical HF can only achieve a 40%-50% replacement rate, whereas paste fills can achieve 50%-60%.”

Another limitation on the mass of tailings that can be backfilled into a stope using the cement paste fill method is the inability of a paste that is discharged from the top of a stope to fill all void space by gravity. According to Stone (2023), “It is important to recognize that most paste operations cannot achieve a tight fill to the back of the stope above. This is because the placement of paste involves an angle of repose from the discharge point, typically in the 2%-3% slope range, depending on the yield stress of the paste. This will ultimately leave a gap at the top of the paste pour under the back of the stope being filled.” Efforts to completely fill all void spaces have sometimes ended in tragedy through over-pressurization of the walls. According to Veenstra (2022), “Wall failures have occurred in the past that led to an onrush of backfill into the UG workings and, in some cases, fatalities (Revell and Sainsbury 2007; Gray 2019). Figure 8.5 shows before and after photographs of UG backfill wall failures from two operations. Both failed while tight filling their respective stopes. Tight filling occurs when the stope is filled as completely as possible. Because of these failures, it is becoming increasingly common for operations to instrument walls to determine the loading pressure on the wall …”

Although the DPM mine would use the cement paste fill method, the solids content in the fill would be more typical of a hydraulic fill. According to DPM (2022), "*Tailing akan dipompakan dari pabrik pengolahan menuju TSF menggunakan pipa diameter 8 inchi sepanjang kurang lebih 3,2 km, pada saat pengaliran tailing slurry memiliki kadar padatan direncanakan 65%* [Tailings will be pumped from the processing plant to the TSF using an 8-inch diameter pipe of approximately 3.2 km in length, while the tailings slurry has a planned solids content of 65%]. There is no explanation as to why the solids content would be so low, but it is probably related to the length of the pipe. According to Stone (2023), "The most significant limitation with paste is the ability to pump the material horizontally … it is generally accepted that paste cannot be pumped horizontally more than about 2 km, and even less if it goes uphill. The majority of paste systems today are designed to rely on gravity for paste distribution with only a nominal horizontal pump to reach distant outlying stopes."

In summary, based upon the most recent mining industry guidance, the plan at the DPM mine to backfill 70-75% of the tailings is completely unrealistic. A typical cement paste fill operation should be able to backfill 50-60% of the tailings. However, since the solids content of the cement paste fill that would be used at the DPM mine (65%) would have a solids content at the upper end of what would be typical for a hydraulic fill operation (55-65%), the maximum possible backfill at the DPM mine would probably be at the upper end of what is typical for a hydraulic fill operation, that is, 50% of the tailings. On that basis, the volume of tailings that would require permanent aboveground storage is probably closer to 1.5 times the predicted volume, that is, closer to 2.5 million cubic meters. Thus, the design basis for the tailings storage facility, which is the required volume of tailings storage, is fundamentally flawed.

If the true volume of tailings that will require permanent aboveground storage is closer to 2.5 million cubic meters than the projected 1.67 million cubic meters, then the tailings dam will need to be considerably taller than the projected 28 meters. It is not possible to predict the actual height without knowing the stage-volume relationship of the tailings pond (which is not provided in any of the Addenda), but the final height might be on the order of 40 meters. The taller tailings dam reinforces the concern that there might be enough NAG waste rock (or any NAG waste rock) to construct the dam. A taller tailings dam and greater tailings storage volume will also increase the consequences of tailings dam failure, even though there has been no such analysis for any height or storage volume.

Design for 100-Year Flood is Inconsistent with all Guidelines and Regulations

Comparison with ANCOLD Guidelines

Although there has been no analysis of the consequences of failure of the tailings dam at the DPM mine, the need for such an analysis (also called a dam break study or dam breach study or inundation study) is strongly emphasized by ANCOLD (2019). According to ANCOLD (2019), "The Dam Failure Consequence Category is determined by evaluating the consequences of dam failure with release of water and tailings through a risk assessment process. This will lead to selection of appropriate design parameters to manage the risks. The assessment is undertaken by considering the potential failure modes of the facility and the resulting consequences to the business, the social and natural environment and the potential for loss of life …" ANCOLD (2019) also emphasizes that the dam break study is an essential component of the emergency plan, which should be updated annually. According to ANCOLD (2019), "A Dam Safety

Emergency Plan (DSEP), in conjunction with appropriate emergency authority planning, should be prepared for tailings dams where any persons, infrastructure or environmental values could be at risk should the dam collapse or fail … The DSEP should include an appropriate dam break study with the conservative assumption of liquid tailings flow in the event of dam failure unless a more sophisticated analysis of water and/or tailings flow can be justified. DSEP's are to be updated annually and tested at regular intervals." By contrast, the plan for the DPM mine includes neither a dam break study nor any kind of dam safety emergency plan.

Emerman (2020) showed that numerous homes and houses of worship are present within 1000 meters downslope of the tailings dam at the proposed DPM mine. The significance of houses of worship is that they are locations where very large gatherings of people could occur. In addition, Parongil village (population 2010) is only 1800 meters downstream of the site of the tailings dam. On that basis, even without a rigorous dam break study, it should be clear that the population at risk in the event of dam failure will be in excess of 1000 people.

According to the ANCOLD guidelines, if fewer than 1000 people will be affected by tailings dam failure for more than one month, the Severity Level is Major (see Fig. 1a). If more than 10,000 people will be affected for over one year, the Severity Level is Catastrophic (see Fig. 1a). Thus, the Severity Level will be either Major or Catastrophic or somewhere in between. However, based upon the population at risk of greater than 1000, the consequence category will be Extreme, whether the Severity Level is either Major or Catastrophic (see Fig. 1b).

Tailings dams in the Extreme consequence category should be designed to withstand the Probable Maximum Flood (PMF) (see Fig. 1c). The PMF is defined as "the largest flood hydrograph resulting from PMP [Probable Maximum Precipitation] and … coupled with the worst flood-producing catchment conditions that can be realistically expected in the prevailing meteorological conditions," for which the PMP is defined as "the theoretical greatest depth of precipitation for a given duration that is physically possible over a particular catchment" (ANCOLD, 2019). According to the U.S. Army Corps of Engineers "the PMF does not incorporate a specific exceedance probability, but is generally thought to be well beyond the 10,000 year recurrence interval" (USACE-HEC, 2003). The ANCOLD (2019) guidelines also do not state a return period for the PMF, but Table 6 in ANCOLD (2019) [Fig. 1c in this report] implies that the PMF could be regarded as having a return period greater than 100,000 years. Based upon the preceding, it should be clear that the design of the tailings dam at the DPM mine to accommodate the monthly rainfall with a 100-year return period is entirely inadequate. In fact, according to the ANCOLD guidelines, design for the 100-year flood would be appropriate only for the Low consequence category, which would require, at a minimum, that not a single person will be at risk in the event of dam failure (compare Figs. 1b-c).

Table 1 Severity Level impacts assessment - summary from ANCOLD Consequence Guidelines (2012)

DAMAGE TYPE	MINOR	MEDIUM	MAJOR	CATASTROPHIC
Infrastructure (dam, houses, commerce, farms, community)	<$10M	$10M-$100M	$100M-$1B	>$1B
Business importance	Some restrictions	Significant impacts	Severe to crippling	Business dissolution, bankruptcy
Public health	<100 people affected	100-1000 people affected	<1000 people affected for more than one month	>10,000 people affected for over one year
Social dislocation	<100 person or <20 business months	100-1000 person months or 20-2000 business months	>1000 person months or >200 business months	>10,000 person months or numerous business failures
Impact Area	$<1km^2$	$<5km^2$	$<20km^2$	$>20km^2$
Impact Duration	<1 (wet) year	<5 years	<20 years	>20 years
Impact on natural environment	Damage limited to items of low conservation value (e.g. degraded or cleared land, ephemeral streams, non-endangered flora and fauna). Remediation possible.	Significant effects on rural land and local flora & fauna. Limited effects on: A. Item(s) of local & state natural heritage. B. Native flora and fauna within forestry, aquatic and conservation reserves, or recognised habitat corridors, wetlands or fish breeding areas.	Extensive rural effects. Significant effects on river system and areas A & B. Limited effects on: C. Item(s) of National or World natural heritage. D. Native flora and fauna within national parks, recognised wilderness areas, RAMSAR wetlands and nationally protected aquatic reserves. Remediation difficult	Extensively affects areas A & B. Significantly affects areas C & D. Remediation involves significantly altered ecosystems.

Figure 1a. Although there has been no analysis of the consequence of tailings dam failure at the DPM mine, due to the presence of numerous homes and houses of worship within 1000 meters downstream of the tailings dam and the presence of Parongil village (population 2010) about 1800 meters downstream of the dam, it should be assumed that the number of affected people will exceed 1000, so that the Severity Level will be Major or Catastrophic according to the ANCOLD (2019) guidelines. Table from ANCOLD (2019).

Table 2 Recommended consequence category

(Adapted from the ANCOLD Consequence Guidelines Table 3 - the worst case of the Severity Level of Damage and Loss- from Table 1, combined with the Population at Risk determines the Consequence Category)

Note: A, B and C are subdivisions within the HIGH Consequence Category level with A being highest and C being lowest.

Population at Risk	Severity of Damage and Loss			
	Minor	Medium	Major	Catastrophic
<1	Very Low	Low	Significant	High C
>1 to 10	Significant (Note 2)	Significant (Note 2)	High C	High B
>10 to 100	High C	High C	High B	High A
>100 to 1,000	(Note 1)	High B	High A	Extreme
>1,000		(Note 1)	Extreme	Extreme

Note 1: With a PAR in excess of 100, it is unlikely Damage will be minor. Similarly with a PAR in excess of 1,000 it is unlikely Damage will be classified as Medium.

Note 2: Change to "High C" where there is the potential of one or more lives being lost. The potential for loss of life is determined by the characteristics of the flood area, particularly the depth and velocity of flow.

Figure 1b. Although there has been no analysis of the consequence of tailings dam failure at the DPM mine, due to the presence of numerous homes and houses of worship within 1000 meters downstream of the tailings dam and the presence of Parongil village (population 2010) about 1800 meters downstream of the dam, it should be assumed that the population at risk will exceed 1000, so that the consequence category will be Extreme according to the ANCOLD (2019) guidelines. Table from ANCOLD (2019).

Table 6 Recommended minimum design floods for spillway design and wave-freeboard allowance during operation phase

Dam Failure Consequence Category	Design Flood AEP (Note 1)	Wave Freeboard Allowance
Low	1:100	Wave run-up for 1:10 AEP wind
Significant	1:1000	Wave run-up for 1:10 AEP wind
High	1:100,000	Wave run-up for 1:10 AEP wind
or	PMF	None
Extreme	PMF	To be determined by risk assessment

Figure 1c. Although the tailings dam at the DPM mine would be designed to accommodate only the monthly rainfall with a return period of 100 years, due to the Extreme consequence category (see Fig. 1b). according to the ANCOLD (2019) guidelines, the dam should be designed to accommodate the Probable Maximum Flood (PMF). Table from ANCOLD (2019).

Table 4.1
Tailings dam consequence classification

Dam Failure Consequence Classification	Incremental Losses				
	Population at Risk[1]	Potential Loss of Life[2]	Environment[3, 4]	Health, Social & Cultural	Infrastructure and Economics [5]
Low	none	none	Minimal short-term loss of environmental values. No expected impact on livestock / fauna drinking water. Limited area of impact and restoration feasible in short term.	Minimal effects and disruption of business and livelihood. No measurable effects on human health. No disruption of heritage, recreation, community or cultural assets	Low economic losses: area contains limited infrastructure or services - <US$1M.
Significant	1-10	none	Limited loss or deterioration of environmental values. Potential contamination of livestock/fauna water supply. Potential area of impact < 5 km^2. Restoration possible in <5 years.	Limited effects and disruption of business and livelihood (<500 people affected). No measurable effects on human health. Limited loss of regional heritage, recreation, community, or cultural assets.	Losses to recreational facilities, seasonal workplaces, and infrequently used transportation routes. - <US$10M
High	10-100	1 - 10	Significant loss or deterioration of critical environmental values. Potential contamination of livestock/fauna water supply. Potential area of impact 5 km2 – 20 km2. Restoration possible but difficult and could take > 5 years	500 - 1,000 people affected by disruption of business, services, or social dislocation. Significant loss of regional heritage, recreation, community, or cultural assets. Potential for Some short-term human health effects.	High economic losses affecting infrastructure public transportation, and commercial facilities, or employment. Moderate relocation / compensation to communities. <US$100M

Figure 2a. Although there has been no analysis of the consequence of tailings dam failure at the DPM mine, due to the presence of numerous homes and houses of worship within 1000 meters downstream of the tailings dam and the presence of Parongil village (population 2010) about 1800 meters downstream of the dam, it should be assumed that the population at risk will exceed 1000, so that neither the Low, Significant, nor High consequence categories of the ICOLD (2022) guidelines would be appropriate. Table from ICOLD (2022).

Dam Failure Consequence Classification	Incremental Losses				
	Population at Risk[1]	Potential Loss of Life[2]	Environment[3, 4]	Health, Social & Cultural	Infrastructure and Economics [5]
Very High	100-1000	10 to 100	Major loss or deterioration of critical environmental values including rare and endangered species of high significance. Potential area of impact >20 km^2. Restoration or compensation possible but very difficult and requires a long time (5 years to 20 years).	> 1,000 people affected by disruption of business, services, or social dislocation for more than one year. Significant loss of national heritage, recreation, or community facilities or cultural assets. Significant long-term human health effects.	Very high economic losses affecting important infrastructure or services (e.g. highway, industrial facilities, storage facilities for dangerous substances), or employment. High relocation/compensation to communities. <US$1B
Extreme	> 1000	> 100	Catastrophic loss of critical environmental values including rare and endangered species of high significance. - Potential area of impact > 20 km^2. Restoration or compensation in kind impossible or requires a very long time (>20 years).	> 5,000 people affected by disruption of business, services, or social dislocation for years. Significant National heritage or community facilities or cultural assets destroyed. Potential for Severe and/or long-term human health effects	Extreme economic losses affecting critical infrastructure or services (e.g. hospital, major industrial complex, major storage facilities for dangerous substances or employment. Very high relocation/compensation to communities and very high social readjustment costs. > US$1B

Notes:

1. Population at Risk: Includes allowance for people who may be within the inundation zone on a short-term or intermittent basis (e.g. seasonal or recreational visitors, temporary travelers or workers)
2. Potential Loss of Life: There are several methods used to estimate PLL – refer to references
3. Environmental values: Include aquatic and terrestrial habitat and life, the presence of rare and endangered species, and ecosystem integrity.
4. The potential effects due to released tailings or process water consider the geochemical properties, restoration time, and the effectiveness of restoration.
5. Infrastructure and economics: Include indirect and tangible losses. Costs are indicative only.

Figure 2b. Since the population at risk from failure of the tailings dam at the DPM mine will exceed 1000, the consequence category will be Extreme according to the ICOLD (2022) guidelines. Table from ICOLD (2022).

Comparison with ICOLD Guidelines

ICOLD (2022) emphasizes not only the importance of a dam failure consequence analysis, but that such analyses are now standard practice in most of the world. According to ICOLD (2022), "Tailings dams are classified according to the potential consequences of failure of the dam with respect to population, environment, societal and economic impacts. This form of classification has been operating in various countries for many years." Similar to the guidelines of ANCOLD (2019), according to the guidelines of ICOLD (2022), a population at risk in excess of 1000 places a tailings dam into the Extreme consequence category (see Figs. 2a-b). Just as in the ANCOLD (2019) guidelines, the ICOLD (2022) guidelines require that tailings dams in the Extreme consequence category should be designed to withstand the PMF (see Fig. 2c). Again it should be clear that the design of the tailings dam at the DPM mine to accommodate the monthly rainfall with a 100-year return period is entirely inadequate.

Table 7.2

Suggested minimum flood design criteria for operating and active care phases

Consequence Classification	Flood Criteria -- Annual Exceedance Probability (AEP)[1] Operations and Active Care Closure
Low	1/200
Significant	1/1,000
High	1/3rd between 1/1,000 and PMF
Very High	2/3rd between 1/1,000 and PMF
Extreme	PMF

Note: 1) The criteria presented is guidance for suggested minimum criteria.

Figure 2c. Although the tailings dam at the DPM mine would be designed to accommodate only the monthly rainfall with a return period of 100 years, due to the Extreme consequence category (see Fig. 2b), according to the ICOLD (2022) guidelines, the dam should be designed to accommodate the Probable Maximum Flood (PMF). Table from ICOLD (2022).

A difference between the ANCOLD (2019) and ICOLD (2022) guidelines is that, in the ICOLD (2022) guidelines, the design for only the 100-year flood is never appropriate. Even a tailings dam in the Low consequence category, for which not a single person would be at risk should be designed to withstand a 200-year flood (compare Figs. 2a and 2c). Moreover, even a tailings dam in the Significant consequence category, for which fewer than 10 people would be at risk and the potential loss of life is zero (see Fig. 2a) should be designed to withstand a 1000-year flood (see Fig. 2c). ICOLD (2022) clarifies that "Life safety can be assessed in terms of Population at Risk (PAR) and Potential Loss of Life (PLL). The PAR in an inundation area (due to the dam breach) provides an indication of the number of people that could be exposed to the hazard. This includes persons who live in the inundation area, together with an allowance for people who may be there on a short-term or intermittent basis (e.g. seasonal or recreational visitors and temporary travelers) … The PLL in the inundation area (due to the dam breach) is an assessment of potential fatalities from within the PAR and depends on many factors such as depth of flow, velocity, time of day, advanced warning, topography, transportation routes, mobility, etc."

Comparison with Indonesian Regulations

A source of confusion in the Indonesian regulations is that there appears to be a strong dam safety standard that has been adopted in practice, but which has not yet been codified into regulations. According to a 2015 publication by employees of the Dam Safety Unit of the Indonesian Ministry of Public Works and People's Housing, "So in this paper, it will going to explain the dam safety in Indonesia based on Water Law No. 11 of 1974 and Ministerial Regulation Number 72/PRT/1997 about Dam Safety … Nowadays dam safety concept in Indonesia was adopted by dam safety concept from Swiss Dam … The dam, including dam body, appurtenance structure, reservoir and foundation, should be safe for: - All possible loading, include earthquake and flood. Consequently, the design must be based on the largest possible events at the site when it comes to the natural hazards of flood and earthquake" (Mayangsari and Adji, 2015). In other words, based upon the preceding quote, all dams in Indonesia, with no exception for tailings dams, should be designed to withstand the Probable Maximum Flood (PMF) and the Maximum Credible Earthquake (MCE).

The requirement for design of all dams to withstand the PMF and MCE, regardless of the consequences of dam failure, would give Indonesia the strongest dam safety standards in the world. Switzerland is generally regarded as having the strongest dam safety standards in the world. Although Mayangsari and Adji (2015) refer to Swiss regulations, no explicit connection is made between any particular Swiss and Indonesian dam safety regulations. In the case of tailings dams in particular, it is quite reasonable to require the strongest standards for flood design, regardless of the consequences of dam failure. As a general rule, unless the tailings can be moved to a safe location or if, in some other way, all credible failure modes can be eliminated, a closed tailings dam must be monitored, inspected, maintained, and reviewed in perpetuity, unlike a water-retention dam that can be completely removed (decommissioned) when it is no longer needed or can no longer be maintained (Morrill et al., 2022). Thus, in light of all of the possible ways in which the social, economic, and environmental context of a tailings dam could change indefinitely into the future, for the protection of future generations, the Global Industry Standard on Tailings Management (GISTM) requires that closed tailings dams be designed so as to withstand the 10,000-year flood, regardless of the consequences of failure that could be foreseen at the time of closure (ICMM-UNEP-PRI, 2020). The most effective way to convert a tailings dam into a dam that can withstand the 10,000-year flood at closure is to require the ability to withstand the 10,000-year flood throughout the operating phase of the tailings dam.

Mayangsari and Adji (2015) do not clarify how or whether the requirement to design all dams to withstand the PMF is connected with the regulations they mentioned, which were Water Law No. 11 of 1974 and Ministerial Regulation Number 72/PRT/1997. In fact, the requirement of a particular flood return period for dam design is not mentioned in any of the relevant Indonesian regulations (Government of the Republic of Indonesia, 2007, 2009, 2010a-b, 2021; Ministry of Public Works and People's Housing, 2015; Ministry of Environment and Forestry, 2022). The most likely regulations in which a required flood return period would be mentioned, if it existed, would be the two versions of *Tentang Bendungan* [Regarding Dams] (Government of the Republic of Indonesia, 2010a; Ministry of Public Works and People's Housing, 2015). Thus, at the present time, it is unclear how the design for a monthly rainfall with a return period of 100 years is connected with Indonesian regulations, although such a design is certainly inconsistent with what the Ministry of Public Works and People's Housing believes to be the current practice in Indonesia.

Comparison with Chinese Regulations

Tailings dam regulations in China differ from those in most of the rest of the world in that the dam safety standards depend upon the height and storage volume of the dam, not upon the consequences of failure. The Chinese approach has not been to apply strong safety standards to tailings dams with high or extreme consequences, but simply to prohibit the construction of tailings dams at locations where the consequences of failure would be unacceptable. The tailings dam at the DPM mine would have a height of 28 meters and storage volume of 1.67 million cubic meters, so that it would be a Class V dam based on the height and a Class IV dam based on the storage volume (see Table 1; National Standards of the People's Republic of China (2020)). According to National Standards of the People's Republic of China (2020), "当按尾矿库的全库容和尾矿坝高分别确定的尾矿库等别的等差为一等时, 应以高者为准; 当等差大于一等时, 应按高者降一等确定" [When the difference between the class of a tailings pond determined based on the total storage capacity and the class determined based on the tailings dam height is a single class, the higher class one shall prevail. When the class difference is greater than a single class, the higher class shall be reduced by one]. Thus, the tailings dam at the DPM mine would be classified in China as a Class IV dam, which should be designed to withstand a flood with a return period of 100 – 200 years (see Table 2; National Standards of the People's Republic of China (2020). On that very superficial basis, the hydrologic design of the tailings dam would seem to be acceptable in China. Note that even if the storage volume were increased to 2.5 million cubic meters and the height were increased to 40 meters, taking into account the current overestimation of the volume of tailings that can be backfilled, the projected tailings dam at the DPM mine would still be classified as a Class IV dam in China.

Table 1. Design classes of tailings ponds for a given service period

Design Class	Total Storage Capacity, *V* (10^4 m^3)	Tailings Dam Height, *H* (m)
I	$V \geq 50{,}000$	$H \geq 200$
II	$10{,}000 \leq V < 50{,}000$	$100 \leq H < 200$
III	$1000 \leq V < 10{,}000$	$60 \leq H < 100$
IV	$100 \leq V < 1000$	$30 \leq H < 60$
V	$V < 100$	$H < 30$

[1]English translation of Table 1 in Department of Basics for Production Safety (China) (2020) (see Appendix A).

Table 2. Flood control standards for tailings ponds (unit is years)[1]

Tailings Pond Class for Given Service Period	I	II	III	IV	V
Flood Return Period	1000 - 5000 or PMF	500 - 1000	200 - 500	100 - 200	100
Note: PMF is the Probable Maximum Flood.					

[1]English translation of Table 9 in Department of Basics for Production Safety (China) (2020) (see Appendix A).

The essential point is that the tailings dam would simply be illegal in China, regardless of its design flood. Department of Basics for Production Safety (2020) defines "overhead ponds" [头顶库] as "初期坝坡脚起至下游尾矿流经路径 1 公里范围内有居民或重要设施的尾矿库" [tailings ponds with residents or important facilities within 1 km from the toe of the embankment of the starter dam along the downstream tailings flow path]. Thus, because of the numerous homes and houses of worship within 1000 meters downslope from the tailings dam, the tailings dam at the DPM mine would certainly be classified as an "overhead pond" in China. Department of Basics for Production Safety (2020) then clarifies that new tailings dams within 1000 meters of populated areas ("overhead ponds") are illegal. According to Department of Basics for Production Safety (2020), "严禁新建"头顶库", 总坝高超过 200 米的尾矿库, 严禁在距离长江和黄河干流岸线 3 公里, 重要支流岸线 1 公里范围内新（改, 扩）建尾矿库" [It is strictly forbidden to build new "overhead ponds" and tailings ponds with a total dam height of more than 200 meters. It is strictly forbidden to build new (or modified or expanded) tailings ponds within 3 kilometers from the banks of the main streams of the Yangtze River and the Yellow River, and 1 kilometer from the banks of their important tributaries].

The preceding quote helps to illustrate the importance of reading the two Chinese tailings dam regulations, National Standards of the People's Republic of China (2020) (see Appendix A) and Department of Basics for Production Safety (2020) (see Appendix B), together. Although Table 1 states that a tailings dam with a height greater than 200 meters is a Class I dam and Table 2 states that the design flood for a Class I dam is either the PMF or the flood with a return period in the range 1000-5000 years, Department of Basics for Production Safety (2020) states that new tailings dams taller than 200 meters are illegal. A Class I dam could be legal only if it had a storage volume in excess of 500 million cubic meters and with a height in the range 100-200 meters (see Table 1).

Hydrometeorological Data have not been Updated and Contradict Earlier Data

The 2022 Addendum could have updated the rainfall and other baseline data through at least 2021. Such updates would have been highly appropriate since earlier reports by the author (Emerman, 2020, 2021) critiqued the short duration of rainfall data that was used to determine the monthly rainfall with a 100-year return period, as well as the identification of either the presence or the absence of temporal trends based upon datasets of very short duration. However, in most cases, the 2022 Addendum simply repeated the baseline data from the 2021 Addendum. For example, the 2021 Addendum claimed that there were no temporal trends in surface water discharge based on 19 measurements carried out over less than four years and these same claims based on the same data were repeated in the 2022 Addendum (see Fig. 3a). In the same way, the 2021 Addendum claimed that there was a temporal trend in groundwater discharge based on 19 measurements carried out over less than four years. Although Emerman (2021) showed that the trend was not statistically significant, that same claim with the same data was repeated in the 2022 Addendum (see Fig. 3b).

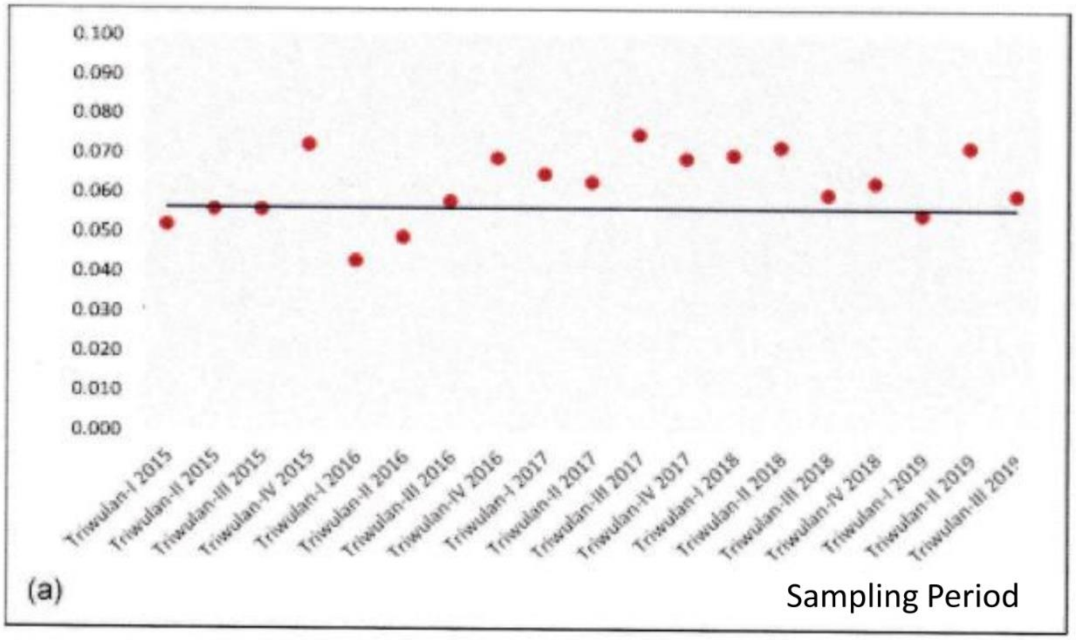

Figure 4.34 Monitoring Results of Surface Water and Groundwater Discharge of the Lae Sopokomil Irrigation Canal (LSIR)

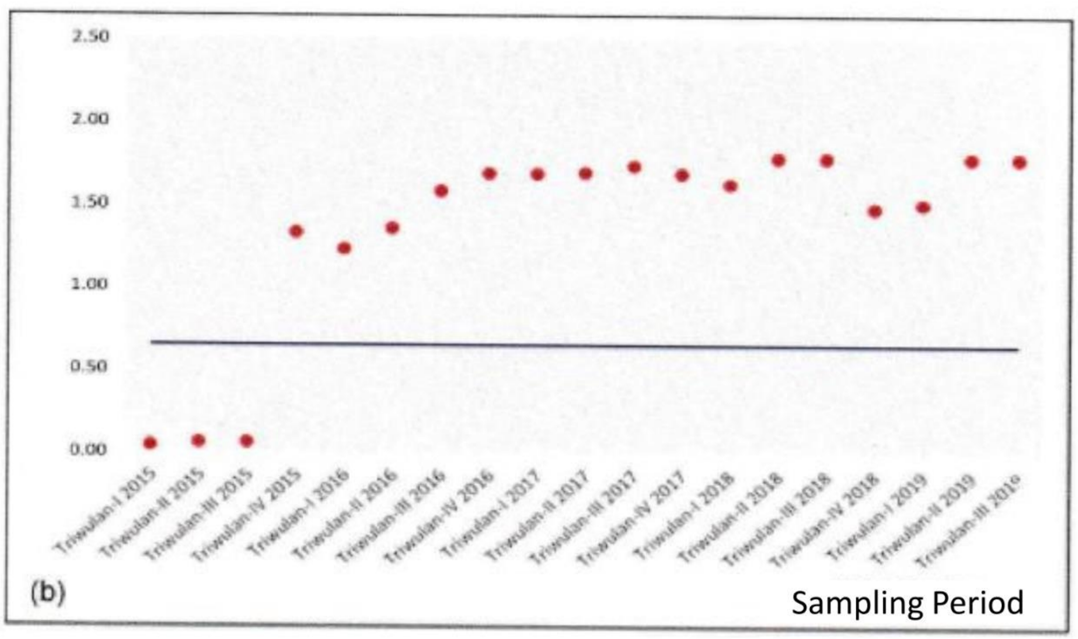

Figure 4.4 Monitoring Results of Surface Water and Groundwater Discharge of Lae Sopokomil, 100 m upstream from the bridge to Sopokomil (LSSB)

Figure 3a. Although critiques of the 2019 and 2021 EIS Addenda emphasized the lack of baseline data that was used to show a lack of trends (19 measurements over less than four years), the 2022 Addendum reports the same data with no updating. Figure from DPM (2022) with overlay of English labels.

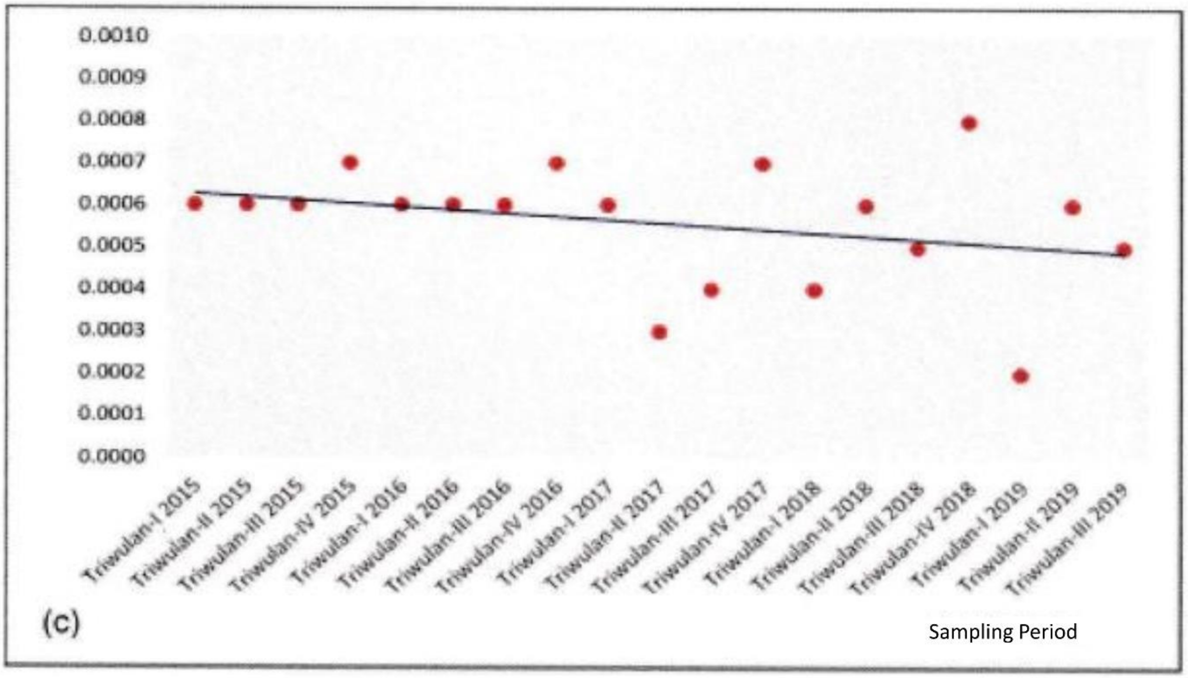

Figure 4.5 Monitoring Results of Surface Water and Groundwater Discharge of Borehole SOP 58 (GW58)

Figure 3b. Although critiques of the 2019 and 2021 EIS Addenda emphasized the paucity of baseline data that was used to show a temporal trend (19 measurements over less than four years), the 2022 Addendum reports the same data with no updating. Figure from DPM (2022) with overlay of English labels.

In some cases, the 2022 Addendum contains even fewer data than the 2021 Addendum. For example, while the 2022 Addendum presents monthly rainfall data from January 2009 through December 2018, the 2021 Addendum presented monthly rainfall data from April 2008 through August 2019 (compare Figs. 4a-b). In these cases, the 2022 Addendum does not provide any explanation as to why fewer data are now available. In some cases, not only does the 2022 Addendum have fewer data than the 2021 Addendum, but different data. For example, while the 2022 Addendum reports 134 mm and 334 mm of rainfall for July 2012 and November 2012, respectively, the 2021 Addendum reports 194 mm and 394 mm for the same respective months (see red ellipses in Figs. 4a-b). These changes are not simply typographical errors, but actual changes in data, since for both tables, the averages for July and November rainfall are consistent with the numbers that are stated in the tables (see Figs. 4a-b).

Table 3.1 Monthly Rainfall Data for the Years 2009-2018

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average	BB	BK
2009	365	89	204	172	303	78	82	303,5	152	380	329	159	218,0	9	0
2010	251	166	254	214	94	236	136	161	273	276,5	408,5	121	215,9	11	0
2011	222	249,7	402,5	220,5	220,5	112,9	148	105,6	291,2	401,9	247,3	247	239,1	12	0
2012	78,4	79	133	262	162	81	134	172	101	336	334	365	186,5	9	0
2013	488	79	133	158	141,5	233	41	111	135	403	395	171	207,4	10	1
2014	79	45	109	527	215	127	93	236	231	306	334	288	215,8	9	1
2015	210	99	129	135	178	114	122	109	234	360	375	129	182,8	11	0
2016	160	79	133	158	158	119	113	236	249	101	320	0	152,2	10	0
2017	211	76	135	124	97	154	87	177	181	91	183	315	152,6	9	0
2018	146	160	88	234	94	90	161	111	185	298	301	359	185,6	8	0
Rata-rata	221,0	112,2	172,1	220,5	166,3	134,5	111,7	172,2	203,2	295,3	322,7	215,4	195,6	9,8	0,2

Description: BB = Dry Month, BK = Wet Month

Table 3.2 Number of Rainy Days per Month Years 2009-2018

Month	Rainy Days (Days)										Average
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	
January	15	15	22	16	19	6	18	11	15	15	15,2
February	11	15	19	8	8	4	7	8	9	13	10,2
March	17	16	21	11	11	10	10	11	14	13	13,4
April	17	15	20	18	13	23	18	13	18	16	17,1
May	16	11	23	15	15	12	17	13	10	9	14,1
June	6	20	19	6	15	7	10	11	11	9	11,4
July	11	16	16	15	3	7	12	9	9	16	11,4
August	25	17	20	19	7	15	11	13	18	14	15,9
September	11	21	18	10	12	20	20	17	19	15	16,3
October	22	13	23	24	13	27	23	10	5	23	18,3
November	24	26	20	24	22	26	26	26	17	24	23,5
December	18	19	21	26	13	23	12	0	22	23	17,7
Total	193	204	242	192	151	180	184	142	167	190	184,5
Average	16,08	17	20,16	16	12,58	15	15,3	11,83	13,91	15,83	15,37

Source: PT DPM, 2019

Figure 4a. Although critiques of the 2019 and 2021 EIS Addenda emphasized the lack of rainfall data, the 2022 Addendum did not present any new data, but even fewer data than previous versions. For example, although the 2022 Addendum presents rainfall data for 2009 – 2018, the 2021 Addendum presented rainfall data for 2008 – 2019 (see Fig. 4b). Moreover, the data in the 2022 Addendum contradict the data in previous versions without explanation. For example, while the 2022 Addendum reports 134 mm and 334 mm of rainfall for July 2012 and November 2012, respectively (shown in red ellipses), the 2021 Addendum reports 194 mm and 394 mm for the same respective months (see Fig. 4b). Figure from DPM (2022) with overlay of English labels.

The previous reviews by Emerman (2020, 2021) documented numerous examples of contradictory data, including the following types of contradictions:

1) contradictions between maps and tables of coordinates;
2) contradictions between data in tables and data in graphs;
3) contradictions between lists of numbers and totals and averages of those numbers;
4) contradictions between annual tables and summary tables.

No attempt was made in those reports or in this report to inspect every table, graph and map for consistency, as this was not the primary objective of the previous or present reports.

The standard practice is to reject a dataset when it involves a significant contradiction, such as a contradiction between a list of numbers and the average of those numbers. Of course, some judgment can be involved as to whether a contradiction is significant or whether it can be resolved by correcting a typographical error. At this point, the contradictions among the data that have been used by PT. DPM to develop the various Addenda to the EIS are so overwhelming that all of those environmental data should be rejected and it should be assumed that there are no environmental data. Even without all of the other shortcomings, the proposal for the DPM mine could be rejected on this basis alone.

Table 4.7 Monthly Rainfall (mm/month) from 2008 to 2019

Year	Monthly Rainfall (mm/month)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	-	-	-	241,5	60	82.5	193	406	167	0	503	228
2009	365	89	204	172	303	78	82	303,5	152	380	329	159
2010	251	166	254	214	94	236	136	161	273	276,5	408,5	121
2011	222	249,7	402,5	220,5	220,5	112,9	148	105,6	291.2	401,9	247,3	247
2012	78,4	79	133	262	162	81	194	172	101	336	394	365
2013	488	79	133	158	141,5	233	41	111	135	403	395	171
2014	79	45	109	527	215	127	93	236	231	306	334	288
2015	210	99	129	135	178	114	122	109	234	360	375	129
2016	160	79	133	158	158	119	113	236	249	101	320	0
2017	211	76	135	124	97	154	87	177	181	91	183	315
2018	146	160	88	234	94	90	161	111	185	298	301	359
2019	340	277	270	202	170	162	122	84	-	-	-	-
Total	2.550,4	1.398,7	1.990,5	2.648	1.893	1.589,4	1.492	2.212,1	2.199,2	2.953,4	3.789,8	2.382
Average	212,5	116,6	165,9	220,7	157,8	132,5	124,3	184,3	199,9	268,5	344,5	216,5

Figure 4b. Although critiques of the 2019 and 2021 EIS Addenda emphasized the lack of rainfall data, the 2022 Addendum did not present any new data, but rather even fewer data than previous versions. For example, although the 2022 Addendum presents rainfall data for 2009 – 2018 (see Fig. 4a), the 2021 Addendum presented rainfall data for 2008 – 2019. Moreover, the data in the 2022 Addendum contradict the data in previous versions without explanation. For example, while the 2022 Addendum reports 134 mm and 334 mm of rainfall for July 2012 and November 2012 (see Fig. 4a), respectively, the 2021 Addendum reports 194 mm and 394 mm for the same respective months (shown in red ellipses). Figure from DPM (2021) with overlay of English labels.

SUMMARY CONCLUSIONS

The three questions that were posed as the objective of this report are now repeated followed by very brief responses. More complete responses can be found in the preceding section.

1) ***Is the plan to backfill 70-75% of the tailings consistent with recent mining industry guidance?***

   No, according to recent mining industry guidance, no more than 60% of the tailings can be returned to the underground mine. In the case of the DPM mine, the percentage of backfilled tailings will be closer to 50%.

2) ***Is the plan to design the tailings dam to withstand the monthly rainfall with a 100-year return period consistent with recent mining industry guidance?***

   No, according to the recent guidelines from the Australian Committee on Large Dams (ANCOLD) and the International Commission on Large Dams (ICOLD), the tailings dam should be designed to withstand the Probable Maximum Flood (PMF), which is generally regarded as significantly more rare than even a 10,000-year flood.

3) ***Has the 2022 Addendum increased the amount of rainfall and other baseline data in comparison to the 2019 and 2021 Addenda?***

No, the 2022 Addendum includes even fewer environmental data and has changed some of the previous data without explanation.

RECOMMENDATIONS

The recommendation of this report is that the proposal for the DPM lead-zinc mine should be rejected without any further consideration.

ABOUT THE AUTHOR

Dr. Steven H. Emerman has a B.S. in Mathematics from The Ohio State University, M.A. in Geophysics from Princeton University, and Ph.D. in Geophysics from Cornell University. Dr. Emerman has 31 years of experience teaching hydrology and geophysics, including teaching as a Fulbright Professor in Ecuador and Nepal, and has over 70 peer-reviewed publications in these areas. Since 2018 Dr. Emerman has been the owner of Malach Consulting, which specializes in evaluating the environmental impacts of mining for mining companies, as well as governmental and nongovernmental organizations. Dr. Emerman has evaluated proposed and existing tailings storage facilities in North America, South America, Europe, Africa, Asia and Oceania, and has testified on tailings storage facilities before the U.S. House of Representatives Subcommittee on Indigenous Peoples of the United States, the European Parliament, the United Nations Permanent Forum on Indigenous Issues, and the United Nations Environment Assembly. Dr. Emerman is the Chair of the Body of Knowledge Subcommittee of the U.S. Society on Dams and one of the authors of Safety First: Guidelines for Responsible Mine Tailings Management.

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APPENDIX A:

TRANSLATION OF CHINESE SAFETY REGULATIONS FOR TAILINGS PONDS

ICS 73
Z 61
GB
National Standards of the People's Republic of China
GB 39496-2020
Replaces AQ 2006-2005

Translator's Note: Section 3 Terms and Definitions includes English equivalents for Chinese technical terms. Some of the English equivalents are not correct. In those cases, the incorrect English vocabulary from the Chinese document is stated followed by the correct English vocabulary in square brackets. The correct English vocabulary is used throughout the translation of this document except where the correct English usage would drastically change the meaning of the document.

SAFETY REGULATIONS FOR TAILINGS PONDS

Published on October 11, 2020
Implementation on September 1, 2021
National Market Supervision and Administration
National Standardized Management Committee
Release

Table of Contents

Preface

This standard was drafted in accordance with the rules given in GB/T 1.1-2009. This standard replaces AQ 2006-2005 "Technical Regulations for Safety of Tailings Ponds." Compared with AQ 2006-2005, except for structural and editorial changes, the main technical changes are as follows:

- Some normative references have been deleted and only GB 16423, GB 50135 and GB 50191 have been quoted (see Chapter 2 of this document, Chapter 2 of AQ2006-2005);
- Terms and definitions for tailings ponds have been modified (see Chapter 3 of this document, Chapter 3 of AQ 2006-2005), wet and dry tailings ponds have been added;
- Grading standards for first-class tailings ponds and second-class tailings ponds have been revised (see 4.5 of this document, 4.1 of AQ 2006-2005);
- The simplified Bishop method and the corresponding minimum factor of safety have been added to the analysis methods for the stability of tailings dam slopes against sliding (see 5.3.16);
- Relevant requirements for dynamic seismic calculations of tailings dam stability have been added (see 5.3.17);
- The flood control standards for tailings ponds have been modified (see 5.4.1 of this document, 5.4.2 of AQ 2006-2005);
- The contents of "Safety of Tailings Ponds" and "Utilization of Tailings Ponds and Reuse of Tailings Ponds after Closure" have been deleted (see Chapters 8 and 10 of AQ 2006-2005)
- "Tailings Pond Remining" and "Emergency Management of Production and Operation Units" have been added (see Chapters 7 and 10)

This standard is proposed and managed by the Ministry of Emergency Management of the People's Republic of China. This standard is published for the first time.

1. Scope

This standard specifies the safety requirements for the construction, production and operation, remining, closure, inspection, emergency management of production and operation units, and safety evaluation of tailings ponds. This standard applies to tailings ponds within the territory of the People's Republic of China.

2. Normative References

The following documents are essential for the application of this document. For dated references, only the dated version applies to this document. For undated references, the latest edition (including all amendments) applies to this document.

GB 16423 Safety Regulations for Metallic and Non-Metallic Mines
GB 50135 Design Standard for Tall Single Structures
GB 50191 Code for Seismic Design of Structures

3. Terms and Definitions

The following terms and definitions apply to this document:

3.1 Tailings Pond

A place used to store ore rejects and tailings from metallic and non-metallic mines.

3.2 Wet Tailings Pond

The tailings in the tailings pond have the ability to flow and the tailings are hydraulically discharged into the tailings pond.

3.3 Dry Tailings Pond

The tailings in the tailings pond do not have the ability to flow, the tailings are emplaced into the tailings pond mechanically, and the tailings pond does not store water under non-flood conditions.

3.4 Whole Storage Capacity

The volume of space enclosed by the elevation level of the dam crest, below the slope of the tailings dam body, and above the bottom of the reservoir (excluding the dam body that was not constructed from tailings).

3.5 **Effective Storage Capacity**

The volume of space below the outer surface of the tailings dam and above the bottom of the reservoir for storing tailings (including suspended tailings slurry).

3.6 Flood Regulation Storage Capacity

The volume of space that can store floods above the initial flood level and below the design flood level.

3.7 Total Storage Capacity

The full capacity of the final state of the design.

3.8 Tailings Dam

A tailings pond peripheral structure that impounds tailings and water.

3.9 Starter Dam

A dam built from soil, rock, etc., as a drainage or support structure for a multi-stage tailings dam.

3.10 Tailings Embankment

A dam constructed from tailings from the production process.

3.11 Water Dam of Tailings Pond

A dam for which there is no effective dry beach behind the dam so that the dam is in direct contact with water.

3.12 Tailings Collection Dam

A dam built downstream of the tailings discharge in order to capture tailings that are entrained in stormwater.

3.13 Upstream Embankment Method

A dam construction method for a wet tailings pond in which tailings dikes are raised in the upstream direction from the starter dam. Its characteristic is that the axis of the successive dikes gradually moves upstream of the starter dam.

3.14 Centerline Embankment Method

A dam construction method for a wet tailings pond in which coarser tailings are separated by equipment such as cyclones on the starter dam axis. Its characteristic is that the axis of the dam of successive dikes remains unchanged.

3.15 Downstream Embankment Method

A dam construction method for a wet tailings pond in which coarser tailings are separated by equipment such as cyclones and deposited in the downstream direction of the starter dam. The characteristic is that the axis of the successive dikes gradually moves downstream of the starter dam.

3.16 One-Step Constructed Dam [Single-Stage Dam]

A tailings dam that is constructed at one time or in stages with all dam-building materials other than tailings.

3.17 Upstream Discharge Tailings Stack Method

The tailings entering the dry tailings pond are discharged and rolled from the front of the starter dam to the toe of the pond. The dam construction method of layered tension and compression is adopted in the area that affects the stability of the slope of the dam body.

3.18 Surrounding Discharge Tailings Stack Method [Peripheral Discharge Tailings Stack Method]

The tailings entering the dry tailings pond are discharged and rolled from the periphery of the pond to the middle of the pond. The tailings are compacted in the area that affects the stability of the slope of the dam body.

3.19 Center Discharge Tailings Stack Method

The tailings entering the dry tailings pond are discharged and rolled from the middle of the pond to the periphery of the pond. The tailings are compacted in the area that affects the stability of the slope of the dam body.

3.20 Downstream Discharge Tailings Stack Method

The tailings entering the dry tailings pond are discharged and rolled from the rear of the pond to the front of the pond. The tailings are compacted in the area that affects the stability of the slope of the dam body.

3.21 Tailings Dam Height

For a dry tailings pond, the tailings dam height is the height difference between the highest point on the top of the tailings dam and the lowest point at the toe of the dam. When the tailings dam has a starter dam or tailings collection dam as the support body, the tailings dam height is the height difference between the highest point on the top of the tailings dam and the original ground at the axis of the starter dam or tailings collection dam. For a wet tailings pond using the upstream embankment method, the tailings dam height is the height difference between the dam crest and the original ground at the axis of the starter dam. For other construction methods, the tailings dam height is the height difference between the dam crest and the original ground at the dam axis.

3.22 Total Dam Height

The height of the dam in the final design state.

3.23 Embankment Height or Accumulation Height

For a dry tailings pond, the embankment height is the height difference between the highest point on the top of the tailings dam and the lowest point at the toe of the dam. When the tailings dam has a starter dam or tailings collection dam as the support body, the embankment height is the height difference between the highest point on the top of the tailings dam and the top of the starter dam or tailings collection dam. For an upstream tailings dam, the embankment height is the height difference between the crest of the highest raise and the crest of the starter dam. For centerline and downstream tailings dams, the embankment height is the height difference between the crest of the highest raise and the original ground elevation at the axis of the dam crest.

3.24 Criticaled Position of the Phreatic Line [Critical Position of the Phreatic Line]

The phreatic surface within the dam body at which the factor of safety for stability against sliding can meet the minimum requirements of this regulation

3.25 Controled Position of the Phreatic Line [Control Position of the Phreatic Line]

The highest phreatic line of the dam body that meets the requirements of the critical phreatic line and the minimum depth of the phreatic line below the surface in the outer embankment of a multi-stage tailings dam.

3.26 Normal Production Water Level

The water level in the tailings pond that can meet the requirements of recycling into the production process, tailings discharge, and flood control.

3.27 Deposited Beach [Tailings Beach]

The surface layer of the sedimentary body formed by the hydraulic discharge of tailings. The tailings beach is divided into two parts, above water and below water, based on the water surface within the reservoir.

3.28 Beach Crest

The line of intersection between the surface of the tailings beach and the outer embankment of the dam.

3.29 Beach Width

The horizontal distance from the edge of the water in the reservoir to the crest of the beach.

3.30 Flood Control Dam Width

The horizontal distance from the edge of the water in the reservoir to the line of intersection of the water surface in the reservoir and the outer embankment of the dam under the flood operating condition of a dry tailings pond.

3.31 Flood Regulation Height

The height difference between the initial water level of flood regulation and the design flood level.

3.32 Flood Control Height

For a wet tailings pond, the flood control height is the height difference between the initial water level of flood regulation and the dam crest. For a dry tailings pond, the flood control height is the height difference between the initial water level of flood regulation and the dam crest.

3.33 Free Height [Freeboard]

For both single-stage and multi-stage tailings dams, under non-seismic operating conditions, the freeboard is the height difference between the dam crest elevation and the sum of the design flood level plus the maximum wave run-up plus the maximum wind-driven water surface height. For multi-stage tailings dams, under seismic operating conditions, the freeboard is the height difference between the elevation of the beach crest and the sum of the normal production water level plus seismic settlement plus seismic wave height plus the maximum wave run-up plus the maximum wind-driven water surface height. For single-stage tailings dams, under seismic operating conditions, the freeboard is the height difference between the elevation of the dam crest and the sum of the normal production water level plus seismic settlement plus seismic wave height plus the maximum wave run-up plus the maximum wind-driven water surface height.

4. Basic Regulations

4.1 Tailings pond construction, remining and closure projects shall be subject to approval of site investigation, safety evaluation, design, construction and closure.

4.2 Tailings ponds are divided into wet tailings ponds and dry tailings ponds according to the flow-like behavior of the incoming tailings combined with the water in the reservoir. The typical parameters of tailings ponds are shown in Appendix A. Dry and wet tailings should not be discharged together.

4.3 Tailings dam construction is divided into construction of the starter dam and construction of the raises, with possible differences in dam construction materials. The tailings impoundment method of the wet tailings pond is based upon the dam-raising method. The shift in the dam axis is divided into the upstream tailings dam construction method, the centerline tailings dam construction method, and the downstream tailings dam construction method. The tailings discharge and dam construction methods for dry tailings ponds can be divided into the upstream discharge tailings stack method, the peripheral discharge tailings stack method, the center discharge tailings stack method, and the downstream discharge tailings stack method.

4.4 In the process of tailings pond construction and production and operation, scientific and technological research is encouraged on safe production and the application of advanced safety technologies to improve the safety level of tailings ponds. When adopting new processes, new technologies, new material or using new equipment, it is necessary to understand and master their safety technical characteristics, take effective safety protection measures, and conduct special safety education and training for employees.

4.5 The classification of tailings ponds shall be determined according to the following principles:

- A tailings pond class shall be determined according to Table 1 based on the total storage capacity and total dam height of the tailings pond. The design class of the tailings pond during the service period shall be determined according to Table 1 based on the total storage capacity and tailings dam height of the period. When the difference between the class of a tailings pond determined based on the total storage capacity and the class determined based on the tailings dam height is a single class, the higher class one shall prevail. When the class difference is greater than a single class, the higher class shall be reduced by one. Caution should be exercised.
- When an abandoned open pit is used to store tailings, and there is no tailings dam built around the pit, the classification should be not applicable; when a tailings dam is built around the pit, the classification of the tailings dam should be determined according to the height of the dam and the storage capacity.

Table 1. **Design classes of tailings ponds for a given service period**

Design Class	Total Storage Capacity, V (10^4 m^3)	Tailings Dam Height, H (m)
I	$V \geq 50{,}000$	$H \geq 200$
II	$10{,}000 \leq V < 50{,}000$	$100 \leq H < 200$
III	$1000 \leq V < 10{,}000$	$60 \leq H < 100$
IV	$100 \leq V < 1000$	$30 \leq H < 60$
V	$V < 100$	$H < 30$

4.6 The classes of tailings pond structures other than the auxiliary dam of the tailings pond shall be determined according to the design class of the tailings pond and the importance of the tailings pond structure for each service period according to Table 2. The class of the auxiliary dam of the tailings pond shall be determined from Table 1 based on the dam height and its corresponding storage capacity.

Table 2. Levels of tailings pond structures

Tailings Pond	Level of the Structure		
	Primary Structure	Secondary Structure	Temporary Structure
I	1	3	4
II	2	3	4
III	3	5	5
IV	4	5	5
V	5	5	5

Note 1: The primary structures refer to the structures that will cause downstream disasters after the failure of tailings dams, drainage structures, etc.
Note 2: Secondary structures refer to permanent structures other than primary structures.
Note 3: Temporary structures refer to structures temporarily used during construction.

5. Tailings Pond Construction

5.1 *Site Investigation for Tailings Ponds*

5.1.1 Geotechnical investigation shall be carried out for new construction, reconstruction and expansion of tailings ponds according to standard construction procedures.

5.1.2 The geotechnical engineering investigation of tailings ponds shall comply with the requirements of relevant national standards, correctly reflect the engineering geological and hydrogeological conditions, identify adverse geological effects, geological hazards and impacts on tailings ponds, and the range of unfavorable factors for the safety of structures, and put forward engineering measures and recommendations, as well as site investigation reports with complete data, correct evaluations and rational recommendations.

5.1.3 The detailed site investigation for new construction, reconstruction and expansion of tailings ponds shall carry out the following requirements:

- Identify the engineering geological and hydrogeological conditions of the dam site, dam abutment, reservoir area and reservoir hillslopes;
- Provide regional geological structure and seismic geological data, analyze site seismic effects, and provide relevant parameters for seismic design;
- Identify the distribution range of adverse geological effects such as landslides, potentially unstable hillslopes, and debris flows that may threaten the safety of tailings ponds, tailings dams and flood discharge facilities, and propose control measures;
- Identify the geotechnical composition, distribution characteristics and engineering characteristics of the dam foundation, dam abutment and the sections of each proposed structure and provide the strength and deformation parameters of rock and soil;
- Analyze and evaluate the stability of the dam foundation, dam abutment, reservoir hillslopes, flood discharge facility site, etc., and propose treatment measures for potentially unstable factors;
- Analyze and evaluate the seepage potential of the dam foundation, dam watershed and reservoir area and its impact on safety, and propose measures to prevent seepage;
- Analyze and evaluate the strength and deformation characteristics of the foundation (underlying rock) of flood discharge structures such as flood discharge tunnels, drainage

wells, drainage chutes, drainage pipes and micro-flood ditches. Recommendations on ground treatment measures should be put forward for when the foundation is established;
- Determine the corrosiveness of water and soil to structural materials;
- Determine the origin of the dam construction materials and ascertain the nature and reserves of dam construction materials.

5.1.4 For the reconstruction and expansion of the tailings pond, the geotechnical investigation of the tailings raises shall also be carried out, and the investigation shall carry out the following requirements:
- Determine the mineralogical composition, grain size distribution, compactness, stratification and seepage characteristics of the tailings raises;
- Identify the engineering characteristics of the tailings raises;
- Determine the position and functional dependance of the phreatic surface within the tailings dam body;
- Analyze the stability of the tailings dam body during operation;
- Analyze the stability of the tailings dam under earthquake conditions and the possibility of seismic liquefaction of the tailings.

5.2 *General Requirements for Tailings Pond Design*

5.2.1 Tailings ponds shall not be located in the following areas:
- Wherever the construction of tailings ponds is prohibited by national laws and regulations;
- Wherever the failure of the tailings pond will seriously threaten the downstream important towns, industrial and mining enterprises, main railway lines or highways.

5.2.2 The selection of the tailings pond site shall be comprehensively determined based on factors such as catchment area, engineering geology and hydrogeology, reservoir length, and the surrounding environment of the reservoir area through technical and economic comparison of multiple sites, and shall meet the following requirements:
- The watershed should be small and have sufficient storage capacity;
- Areas with severe adverse geological phenomena should be avoided;
- An upstream tailings pond should have sufficient initial and final pond lengths;
- The average longitudinal slope of the base of an upstream tailings pond shall not exceed 20%.

5.2.3 Reliable control measures shall be taken for the design of tailings ponds under poor engineering geological conditions.

5.2.4 When two or more tailings ponds are constructed in the same valley, corresponding safety precautions should be taken according to the mutual relationship and influence between the tailings ponds in the design of the subsequent ponds to ensure the safety of each tailings pond.

5.2.5 When storing tailings in abandoned open pits and depressions, reliable technical and engineering measures shall be taken for the slopes, the tailings pond facility, and the surrounding environment that affect the safety of the tailings pond.

5.2.6 The design of dry tailings ponds shall meet the following requirements:

- In areas where the average annual rainfall value at the site exceeds 800 mm or the average annual maximum 24-hour rainfall value at the site exceeds 65 mm, the center discharge tailings stack method shall not be used;
- The moisture content of a tailings stack should meet the requirements for tailings emplacement and dam construction; namely, the moisture content of saline and less ductile tailings should not be greater than 22%, and the moisture content of ductile tailings should not be greater than the plastic limit;
- Reliable preventive measures should be taken against the impact of adverse climatic conditions on the safety of the operation process;
- Under normal operating conditions, no water should be stored in the tailings stack.

5.2.7 The tailings pond shall be equipped with dam construction machinery, conveyance systems, engineering vehicles, traffic roads, and duty rooms according to factors such as the amount of dam construction work in the production process, the type of drainage structures and operational requirements, as well as the distances between the reservoir area and the plant area, the emergency equipment warehouse, and the communication and lighting facilities.

5.2.8 Reconstruction and expansion projects of tailings ponds for greater height shall meet the following requirements:

- Except for first-class tailings ponds, the flood control standard shall be raised on the basis of the flood control standard determined in accordance with 5.4.1;
- Reliable seepage and drainage facilities should be set up so that the depth below the surface of the control position of the phreatic line of the tailings dam shall not be less than 1.2 times the control phreatic line determined by calculation;
- The reliability of the existing flood discharge structures should be checked according to the requirements of increased height and capacity, and the flood discharge structures that have been terminated should be reliably sealed;
- The height of the tailings pond shall not be raised more than 50 m at a time.

5.2.9 The tailings pond design document shall specify the following safe operation control parameters in addition to the stockpiling process and dam construction method:

- Classification of tailings pond, design elevation of final raise, total dam height, total storage capacity, effective storage capacity
- Tailings volume, tailings specific gravity, distribution of particle sizes, tailings discharge method;
- Dam type, dam height, dam crest width, upstream and downstream slopes, and dam construction materials for the starter dam, primary dam, secondary dam, and tailings collection dam;
- Foundation treatment;
- Height and upstream and downstream slopes for each dam raise;
- Types of flood discharge systems and main parameters of flood discharge structures;
- Seepage type of tailings dam;
- Depth below surface of the control phreatic line for each operation period and each section of the tailings dam;

5.2.10 In addition to the safe operation control parameters in 5.2.9, the wet tailings pond design documents should also provide the following safe operation control parameters:

- Concentration of incoming tailings;
- The stacking slope of the temporary side slopes for centerline and downstream tailings dams, the design particle size, and the yield and concentration of tailings for dam construction;
- The normal production water level, flood regulation height, freeboard, flood control height, tailings beach slope, dry beach length at normal production water level, minimum dry beach length, etc.

5.2.11 In addition to the safe operation control parameters in 5.2.9, dry tailings pond design documents should also provide the following safe operation control parameters:

- Moisture content, lift thickness, area affecting the stability of the dam body, and tailings compaction index;
- The tailings stack slopes, and step heights and step widths of the temporary side slopes of the tailings stack;
- Aspect and slope of the outer surface of the dam body;
- The initial water level, flood regulation height, flood control height, freeboard and minimum flood control width in a reservoir.

5.3 Tailings Dam Design

5.3.1 The selection of the tailings pond site should be based on the principle of avoiding adverse engineering geological and hydrogeological conditions, combined with considerations of the tailings pond watershed, in terms of flood control and storage. The tailings pond filling and other factors should be comprehensively determined.

5.3.2 The starter dam type should be comprehensively determined according to the tailings storage method, the tailings dam construction method, the seismic design intensity and other factors. In terms of earthquake design, when the upstream construction method is adopted, regardless of the seismic design intensity, the starter dam should be built with well-graded soil or rock materials with good seismic performance and stable permeability. When the starter dam is constructed out of impervious materials, a reliable dam body drainage method should be adopted.

5.3.3 The determination of the starter dam height shall meet the following requirements:

- The most important is that the starter dam should be able to store the volume of tailings from the mineral processing plant for at least six months after it is put into operation;
- The height should be great enough that the tailings water will be clarified;
- When the beach behind the starter dam is flush with the crest of the starter dam, the flood control requirements of the tailings pond class shall be met;
- The requirements for remining in winter shall be met in permafrost areas;
- The requirements of the raising rate of the intended dam raises shall be met;
- The ratio of the starter dam height to the total dam height of an upstream tailings dam shall not be less than 1/8.

5.3.4 In the following situations, the tailings dam foundation shall be especially investigated and treated:

- Crushed stone ringwall foundation that is prone to seepage and damage;
- Liquefiable soils, soft clays, ice formations, permafrost and collapsible loess foundations;
- Foundations with karst development;
- Spring, mine shafts, waste from old mine workings, etc.

5.3.5 Wet tailings ponds with tailings dam raises shall meet the following requirements:

- When the seismic design intensity is IX or higher, the tailings embankment height or accumulation height for an upstream dam shall not be higher than 30 m;
- For upstream tailings dam construction, an experimental study on tailings dam construction should be carried out whenever the mass concentration of the tailings slurry is greater than 35%;
- For upstream tailings dam construction, an experimental study on tailings dam construction should be carried out whenever the particle content of tailings with $d < 0.074$ mm is greater than 85% by mass or the particle content of tailings with $d < 0.005$ mm is greater than 15% by mass;
- For centerline or downstream tailings dam construction, an experimental study on tailings dam construction should be carried out whenever the particle content of tailings with $d > 0.074$ mm is less than 75% by mass and the particle content of tailings with $d < 0.02$ mm is greater than 10% by mass;
- The raising rate of dam construction should meet the requirements of the raising rate of the tailings beach.

5.3.6 The tailings discharge and dam construction of dry tailings ponds shall meet the following requirements:

- During tailings emplacement and dam construction, the tailings should be rolled during stacking. The slope of the top surface of the stack should meet the requirements for drainage and no reverse slope should occur during stacking. When the top surface of the dam is inclined toward the outer slope of the stack or the stormwater diversion channel around the reservoir, the slope of the top surface of the stack shall not be greater than 2%.
- Steps should be set up during the construction of the stack. The height of the steps for the processes of tailings discharge, rolling and layering should not exceed 10 m. The width of the steps should not be less than 1.5 m and should not be less than 5 m when the steps will be used for vehicular traffic. The height of the steps for promoting carbon emission should not exceed 5 m and the width of the steps should not be less than 5 m. The slopes of the steps during operation should meet the stability requirements.
- The lift thickness of ductile and less ductile tailings shall not exceed 0.8 m, and the lift thickness of ductile tailings shall not exceed 0.5 m.
- In the process of tailings discharge and depending upon the rate of tailings production, permanent slopes should be formed in stages as quickly as possible. The areas that affect the stability of the final outer slope of the stack should be used for the formation of permanent slopes. For layered high-pressure discharge operations, the degree of compaction shall not be less than 0.92.

5.3.7 The tailings pond retaining dam shall meet the requirements of the corresponding reservoir dam design specifications according to the dam type, and the flood control standard shall not be lower than the provisions of this standard.

5.3.8 The height difference between the crest of the tailings beach and the design flood level of the upstream tailings dam shall comply with the minimum safe freeboard value in Table 3. The distance from the crest of the beach to the edge of the water at the design flood level shall meet the requirements of the minimum dry beach length in Table 3.

Table 3. Minimum safe freeboard and minimum dry beach length for upstream tailings dams (unit is meters)

Dam Level	1	2	3	4	5
Minimum Safe Freeboard	1.5	1.0	0.7	0.5	0.4
Minimum Dry Beach Length	150	100	70	50	40

When tailings dams of Levels 3, 4 and 5 are shown to be safe through seepage and stability analyses, the minimum dry beach length in the table can be reduced by up to 30%.
The minimum dry beach length in seismic areas shall comply with the relevant provisions of GB 50191.

5.3.9 For downstream and centerline tailings dams, the distance from the outer edge of the dam crest to the edge of the water at the design flood level shall meet the requirements in Table 4. The height difference at the design flood level shall meet the requirements of the minimum safe freeboard value in Table 3.

Table 4. Minimum dry beach lengths for downstream and centerline tailings dams (unit is meters)

Dam Level	1	2	3	4	5
Minimum Dry Beach Length	100	70	50	35	25

The minimum dry beach length in seismic areas shall comply with the relevant provisions of GB 50191.

5.3.10 For dry tailings ponds under flood operating conditions, the flood control width between the tailings dam and the water behind the dam shall comply with the provisions in Table 5. The height difference between the elevation and the design flood level shall comply with the minimum safe freeboard value in Table 3.

Table 5. Minimum flood protection width of tailings dams for dry tailings ponds (unit is meters)

Dam Level	1	2	3	4	5
Minimum Flood Protection Width	100	70	50	35	25

5.3.11 The height difference between the tailings pond retaining dam crest and the design flood level shall not be less than the sum of the minimum safe freeboard value in Table 3, the maximum water wave surface height and the maximum wave run-up.

5.3.12 For multi-stage dams constructed from tailings in seismic zones where the design earthquake horizontal acceleration is not less than 0.05g, the height difference between the design seismic water level and the normal production water level shall not be less than the sum of the minimum safe freeboard value in Table 3, the seismic subsidence value and the seismic wave height. The height difference between the top of the retaining dam and the normal production water level shall not be less than the sum of the minimum safe freeboard value in Table 3, the seismic subsidence value, the seismic wave height, the maximum wind-driven water wave surface height, and the maximum wave run-up.

5.3.13 Seepage calculations should be carried out for tailings dams, and the influence of tailings production rates, precipitation and other factors on the phreatic line of tailings dams should be analyzed in seepage calculations. The seepage of Level 1 and Level 2 tailings dams shall be determined by 3-D numerical simulation calculations or by experiments on physical models.

5.3.14 The minimum depth below the surface of the phreatic line on the downstream slope of the multi-stage dam constructed from tailings shall meet the requirements of Table 6 in addition to the conditions for stability of the dam embankment against sliding.

Table 6. Minimum depth below the surface of the phreatic line on the downstream slope of multi-stage dams constructed from tailings (unit is meters)

Accumulation Height, H	H ≥150	150>H≥100	100> H≥60	60>H≥30	H<30
Minimum Depth of Phreatic Line	10 ~ 8	8 ~ 6	6 ~ 4	4 ~ 2	2

The height of the tailings dam should be based on the vertical dam axis of each raise.
The relevant height of the multi-stage dam located in the starter dam section is taken as the accumulation height. The accumulation height of the multi-stage tailings dam located in the remaining dam sections shall be the height difference between the dam crest of the multi-stage dam and the toe of the embankment.
The minimum depth below the surface of the phreatic line of the tailings dam at any height can be determined by linear interpolation.

Table 7. Minimum factor of safety against sliding for dam embankment

Calculation Method	**Operating Conditions**	**Dam Level**			
		1	2	3	4-5
Simplified Bishop's Method	**Normal**	1.50	1.35	1.30	1.25
	Flood	1.30	1.25	1.20	1.15
	Extraordinary	1.20	1.15	1.15	1.10
Swedish Circle Method	**Normal**	1.30	1.25	1.20	1.15
	Flood	1.20	1.15	1.10	1.05
	Extraordinary	1.10	1.05	1.05	1.05

5.3.15 The tailings dam shall meet the requirements for seepage control, and the seepage control measures of the tailings dam shall ensure that the phreatic surface is lower than the control phreatic surface.

5.3.16 The tailings dam shall meet static and dynamic stability requirements and the stability of the tailings dam shall be calculated. The factor of safety for stability of the dam embankment against sliding shall not be less than the value specified in Table 7. Tailings dams should include reliable measures against seismic failure.

5.3.17 The stability against sliding of the starter dam and multi-stage dam of the tailings pond shall be determined and calculated based on the physical and mechanical properties of the dam body material and the dam foundation. The calculation method shall adopt the simplified Bishop's method or the Swedish circle method, and the response to seismic loading shall be calculated based on the pseudostatic method. The calculations shall confirm the stability of the tailings pond retaining dam according to the relevant codes. The dynamic seismic calculation of tailings dams shall be carried out according to the following requirements:

- For the seismic stability analysis of tailings dams of Levels 1 and 2, in addition to the pseudostatic method, a comprehensive dynamic seismic calculation should be carried out. The dynamic seismic calculation should include the analysis of seismic liquefaction, seismic stability and permanent seismic deformation.
- For a Level 3 tailings dam located in an area with an earthquake design intensity of VI and above or a Level 4 or 5 tailings dam in an area with a design intensity of VI and above, the analysis of seismic liquefaction can rely on simplified calculation and analysis methods. For Level 3 tailings dams, when the results of the seismic liquefaction analysis results are unfavorable, the dynamic seismic calculation should also be carried out.
- For a tailings dam of all levels located in an area with an earthquake design intensity of IX or higher or tailings dams of Levels 1, 2 or 3 located in any area, the seismic stability analysis should use not only the pseudostatic method, but also a program of dynamic analysis.

5.3.18 The loads calculated for the stability of the tailings dam shall be combined according to Table 8 based on different operating conditions.

Table 8. Load combinations for stability calculation of tailings dams

Operating Conditions	Calculation Method	Load Category				
		1	2	3	4	5
Normal Conditions	**Total Stress**	yes	yes	—	—	—
	Effective Stress	yes	yes	yes	—	—
Flood Conditions	**Total Stress**	—	yes	—	yes	—
	Effective Stress	—	yes	yes	yes	—
Extraordinary Conditions	**Total Stress**	yes	yes	—	—	yes
	Effective Stress	yes	yes	yes	—	yes

Note 1: Load category 1 refers to the stable hydrostatic pressure at normal reservoir water level during operation.
Note 2: Load category 2 refers to the dead weight of the dam body.
Note 3: Load category 3 refers to the pore water pressure in the dam body and dam foundation.
Note 4: Load category 4 refers to the stable seepage pressure that may be formed at the design flood level.
Note 5: Load category 5 refers to seismic loads.

5.3.19 The cross section used in the tailings dam stability calculation shall be generalized and partitioned based on the particle size and degree of consolidation of the tailings, and the tailings of the generalized partition shall be specified. The name shall be specified in accordance with Appendix B. For new tailings ponds, the generalized division of the tailings dam into sections for purposes of calculation and the physical and mechanical properties of the tailings in each section should be comprehensively determined with reference to data from investigations of similar tailings dams. The physical and mechanical properties of tailings in each section should be determined based on the data from the investigations.

5.3.20 The average slope of a multi-stage dam constructed from tailings shall not exceed 1V:3H. Maintenance facilities shall be set up on the final downstream slope of the tailings dam, and the maintenance facilities shall meet the following requirements:

- A trafficable road should be constructed with the height difference between two adjacent levels of the road not greater than 15 m and the width of the road not less than 1.5 m. The width shall not be less than 5 m when driving is required;
- Rock, earth, or wood should be used for slope protection. If rock or earth is used for slope protection, grass or shrubs should be planted on the slope;
- For construction of the drainage system, the dam abutment intercepting ditch should be set at the junction of the downstream slope and the slopes on both banks. Longitudinal drainage channels shall be constructed on the inner sides of each raise of a multi-stage dam or at the toe of the downstream slope of each raise of an upstream tailings dam, and herringbone ditches or vertical drainage ditches shall be provided on the slope.
- Once the steps are set, the distance between the steps along the dam axis shall not be greater than 500 m.

5.3.21 The dam body structure of a centerline or downstream tailings dam shall meet the following requirements:

- A starter dam and a sand bar for filtering water should be set up, and seepage drainage facilities should be installed within the scope of the dam foundation between the starter dam and the sand bar;
- The width of the crest of a tailings dam shall meet the needs of grading equipment, pipeline installation and traffic.

5.4 *Flood Drainage Design*

5.4.1 The flood control standards for tailings ponds shall meet the following requirements:

- The flood control standard for each service period of a tailings pond shall be determined according to Table 9 based on factors such as the class of the tailings pond during the service period, the storage capacity, the dam height, the service life, and possible damage to downstream areas;
- When the determined storage capacity or dam height of the tailings pond is less than the upper limit for a given class and either the service life of the tailings pond is long or the accident will cause serious harm to downstream areas, the flood control standard should be taken as the upper limit or higher;
- When abandoned open mine pits are used for storing tailings, and no tailings dams are built around the pits, the flood control standard should be the 100-year flood. When

tailings dams are constructed, the class of the tailings pond and the flood control standard should be determined according to the height of the dam and its corresponding storage capacity;
- For tailings ponds built with centerline or downstream tailings dams, the flood control standard for the dam area should not be less than a 50-year flood;
- The flood control standard for tailings dam diversion and intercepting canals outside the tailings reservoir flood drainage system and for drainage canals on the dam surface should not be less than the average annual maximum 24-hour rainfall.

Table 9. Flood control standards for tailings ponds (unit is years)

Tailings Pond Class for Given Service Period	I	II	III	IV	V
Flood Return Period	1000 ~ 5000 or PMF	500 ~ 1000	200 ~ 500	100 ~ 200	100

Note: PMF is the Probable Maximum Flood.

5.4.2 The tailings pond shall be provided with flood discharge facilities, and the flood discharge capacity of the flood discharge facilities shall not include the flood discharge capacity of pump-driven flood discharge.

5.4.3 Except for the dry-type tailings ponds for mine tailings discharge, the first-class, second-class and third-class tailings ponds shall not use flood intercepting ditches for flood discharge. For tailings ponds with centerline or downstream tailings dams, if the flood in the watershed of the tailings pond cannot seep out of the tailings pond through the tailings collection dam, flood drainage facilities should be installed behind the tailings collection dam.

5.4.4 The flood discharge design of tailings ponds with external and internal tailings dams should meet the following requirements:

- A permanent interception system should be set up around the tailings pond in the design final state. When the height of the designed multi-stage tailings dam constructed from tailings exceeds 60 m, an intermediate flood intercepting ditch shall be constructed;
- The downstream side of the outer slope of a multi-stage tailings dam constructed from tailings shall be provided with a tailings collection dam, and the storage capacity formed shall be sufficient to store the mud and sand washed by the secondary flood;
- Drainage facilities should be installed behind the tailings collection dam. The drainage inlet should be 0.5 m higher than the sedimentation level, and the silt behind the dam should be removed in a timely manner.
- During the operation of the tailings pond, a temporary drainage ditch shall be set up in the tailings accumulation area to drain the floodwater toward the downstream side of the tailings pond, and the flood shall not be discharged in an uncontrolled manner onto the outer embankment of a multi-stage tailings dam.

5.4.5 The tailings pond flood calculation should be carried out according to the hydrological atlas for each province or a calculation method based on micro-watersheds as suggested by the relevant departments. When using national formulae, local hydrological parameters should be used. The rainfall duration of the design flood should be 24 hours.

5.4.6 The calculation of flood regulation for tailings ponds shall be calculated using the water balance method. The flood discharge time of the tailings pond should be less than 72 hours.

5.4.7 Engineering measures should be undertaken to prevent mudslides, landslides, tree debris, etc. from affecting the flood discharge capacity of tailings ponds.

5.4.8 The type and size of the flood discharge structure of the tailings pond shall be determined based on hydraulic and flood control calculations, and shall meet the design flow regime, routine inspection and maintenance, and flood control safety requirements. For particularly complex flood drainage systems, hydraulic models or simulation tests shall be carried out for verification.

5.4.9 Structural calculations shall be carried out for the flood discharge structures of the tailings dam, and the structural calculations shall meet the requirements of the corresponding hydraulic structure design specifications. The preceding also applies to the drainage wells. The relevant requirements of GB 50135 should be met. Since tailings, tailings water, the rock and soil mass of tailings ponds, and the groundwater of tailings ponds have a corrosive effect on flood discharge structures, anti-corrosion measures shall be taken for the flood discharge structures.

5.4.10 The design maximum flow velocity of the flood discharge structure shall not be greater than the allowable flow velocity that will avoid scouring of the structure material. A stilling well shall be provided at the bottom of the drainage well. Energy dissipation and scour prevention measures should be taken according to specific conditions at slope breaks, turns, and outlets of drainage pipes or tunnels.

5.4.11 Poor engineering geological conditions or recharge areas should be avoided as foundations for flood discharge structures. If they cannot be avoided, foundation treatment shall be designed and carried out. Flood discharge structures shall not be located directly on the tailings beach.

5.4.12 Underground flood discharge structures other than tunnels shall adopt reinforced concrete structures, and their foundations shall be placed on foundations with sufficient bearing capacity. For foundations with insufficient bearing capacity, engineering measures that meet the requirements for foundation bearing capacity should be undertaken.

5.4.13 When the flood drainage facilities are closed, they should be sealed in a timely manner, and the safety and security of the permanent structures downstream of the sealed section should be ensured at the same time as the sealing. The seepage stability and safety of the multi-stage tailings dam upstream of the sealed section and the safety of the adjacent drainage structures should be ensured. The sealing body of the drainage well shall not be arranged on the top and body of the well.

5.5 Design of Safety Monitoring Facilities

5.5.1 The tailings pond should be equipped with safety monitoring facilities combining manual safety monitoring and online safety monitoring. The monitoring points of manual safety monitoring and online safety monitoring should be the same or close, and the same reference values should be adopted. The cross-section of the monitoring facility should be arranged in coordination with the section layout for the stability calculation of the tailings dam, and the layout of the monitoring facility should also meet the following principles:

- The layout should fully reflect the operating status of the tailings pond;
- The layout of the displacement monitoring points of a tailings dam should extend to a certain range beyond the dam toe in accordance with the stability calculation results;
- Monitoring facilities should be added if necessary at the dam abutment, bedrock faults, and buried pipes within the dam.

5.5.2 For wet tailings ponds, monitored parameters should include dam body displacement, phreatic surface, dry beach length and slope, precipitation, reservoir water level, geological landslide displacement in the reservoir area, and videos of important features such as the dam body and the inlets and outlets of the flood drainage system. For dry tailings ponds, monitored parameters should include the dam body displacement, the phreatic surface of the largest section of the dam body, precipitation, and video monitoring of important features such as the dam body and the inlets and outlets of the flood drainage system. For first-class, second-class and third-class wet tailings ponds, the pore water pressure, water volume, and rate of water injection should also be monitored when necessary.

5.5.3 The tailings pond online safety monitoring system shall meet the following requirements:

- It should have the functions of automatic survey and response measurements;
- It should have the functionality for self-diagnosis of sensors, acquisition equipment, power supply system, and communication network failures;
- It should have lightning protection and anti-interference functions;
- It should have the functions of data background processing, database management, data backup, early warning, monitoring graphics and report production, and monitoring information query and response;
- There should be an interface with on-site inspections and manual safety monitoring to conduct data supplementary measurements, comparison measurements and recording.

5.5.4 Tailings pond safety monitoring and early warnings should be divided into four levels from low level to high level: blue early warning, yellow early warning, orange early warning, and red early warning. The design unit should give the early warning reading values of each monitored parameter at each level. The determination of the early warning levels of each monitored parameter and the safety status of the tailings pond should be carried out accordingly. The following requirements should be met:

- When a monitoring point registers four blue warnings, the monitoring project should be a yellow warning; when it registers three yellow warnings, the project should be an orange warning; when it registers two orange warnings, the project should be a red warning;
- When a monitored parameter registers four blue warnings, the monitoring project should be counted as one yellow warning. When a monitored parameter registers three yellow warnings, the monitoring project should be counted as one orange warning. When a monitored parameter registers two orange warnings, the monitoring project should be counted as one red warning.

- The early warning of the tailings pond safety status should be determined by the highest early warning level of the tailings pond safety monitoring project.

5.6 Tailings Pond Construction and Approval

5.6.1 The unit undertaking the construction should establish a sound quality and safety management system, and formulate measures to ensure quality and safety.

5.6.2 The construction of tailings facilities shall be carried out according to the facility design and construction drawings. When the actual situation is inconsistent with the engineering investigation or design, and the design is modified, the written consent of the investigation and design unit shall be obtained.

5.6.3 For the construction of tailings facilities, the construction organization design and special construction plan shall be well prepared, and the construction sequence shall be arranged reasonably.

5.6.4 During the construction of tailings facilities, the original control points on the construction site should be reviewed and checked, and the deficiencies should be supplemented. At the same time, a ground measurement control network should be established.

5.6.5 The materials, equipment and components used in the construction of tailings facilities shall meet the design requirements and product standards, and shall have legal certification documents and product qualification certificates, and shall not use materials and equipment that have been ordered by the state to be eliminated.

5.6.6 Technical files should be established during the construction of tailings facilities. For approval of the project, the original construction records, the various test records, the quality inspection records, the confidential project approval records, and the as-built drawings should be available. The as-built drawings should be completed by the construction unit, and design drawings cannot be used instead.

5.6.7 The construction unit shall organize completion inspection and approval in accordance with relevant national laws and administrative regulations after the completion of the project.

6. Tailings Pond Production and Operation

6.1 General Provisions

6.1.1 The production and operation unit should establish and improve the safe production responsibility system for all employees of the tailings pond, establish and improve safe production rules and regulations and safe technical operation procedures, and implement effective safety management for the tailings pond.

6.1.2 The production and operation unit shall prepare the annual and quarterly operation plans and detailed operation charts of the tailings pond, strictly follow the operation plan for production and operation, prepare good records and keep them for an extended period of time.

6.1.3 Production and operation units should carry out safety risk identification, establish a safety risk management and control system at different levels, establish and improve the investigation and management system for hidden hazards for tailings pond production accidents, and carry out timely discovery and elimination of hidden hazards for accidents. The investigation and management of hazards for accidents shall be truthfully recorded and reported to practitioners.

6.1.4 The production and operation unit shall formulate a plan for the safe use of tailings ponds, and propose new construction, reconstruction, expansion, safety review during operation, and closure of the pond. For engineered tailings facilities such as tailings ponds, stacks or reservoirs constructed using the upstream method, it is necessary to understand the stability of the upstream projects and take necessary precautionary measures.

6.1.5 Engineering facilities such as dam bodies, seepage drainage facilities, flood drainage facilities and their sealing facilities, as well as monitoring facilities for the operation period of the tailings pond, shall be designed with construction drawings.

6.1.6 According to the requirements of 5.6.2~5.6.6, the construction data shall be checked and confirmed by the technical personnel in charge for seepage drainage facilities pre-buried within the dam body for raises constructed using the upstream method, the centerline method, and the downstream method. The same shall apply to dry tailings ponds where the final stability of the outer embankment could be affected.

6.1.7 Production and operation units should set up clearly visible safety warning signs in the tailings pond area.

6.1.8 Tailings ponds shall conduct safety status evaluations at least once every three years.

6.1.9 For tailings ponds involving tailings dams, a comprehensive safety review of the tailings dams should be conducted during the operation period to verify the stability of the final dam body and determine the necessary treatment measures. Before the tailings dam safety review, a comprehensive geotechnical investigation should be carried out on the tailings dam, and the safety review work should be completed by the design unit according to the results of the investigation. The safety review should meet the following principles:

- A comprehensive safety review shall be carried out on third-class, forth-class and fifth-class tailings ponds when the facility has reached one-half to two-thirds of the total dam height of the final design. A comprehensive safety review shall be carried out on first-class and second-class tailings ponds when the facility has reached one-third to one-half and one-half to two-thirds of the total dam height of the final design, respectively;
- After a first-class tailings pond by design achieves first-class status in reality, a comprehensive safety review of the dam body should be carried out every time the dam height increases by 20 m;

- When the nature of the tailings or the ore-processing method is quite different from the design, a comprehensive safety review of the tailings dam should be carried out.

6.1.10 The tailings ponds should be provided with emergency roads leading to the dam crest and near the flood drainage system. The emergency roads should meet the needs of traffic and transportation of emergency materials during emergency rescue, and should avoid areas that may be affected by safety accidents and should not be set on the outer embankment of the tailings dam.

6.2 *Measurement of Properties of Incoming Tailings*

6.2.1 The production and operation unit should be equipped with necessary testing facilities and personnel according to the tailings stockpiling method and dam construction method, so as to meet the needs of regular testing of the corresponding properties of the tailings entering the tailings pond.

6.2.2 According to the stockpiling method and dam construction method, the incoming tailings shall be subject to necessary testing according to the parameters required by the design document, and the testing shall at least include the following parameters:

- For tailings impounded using the upstream construction method, the specific gravity, concentration and particle size of the tailings;
- For tailings impounded using the centerline and downstream construction methods, the specific gravity, concentration and particle size of the tailings;
- For dry tailings ponds, the specific gravity, moisture content and degree of compaction of the tailings after the tailings have been compacted.

6.2.3 The testing frequency of tailings parameters entering wet tailings ponds should not be less than once a week, and the testing frequency of tailings parameters entering dry tailings ponds should not be less than once a week. The testing frequency could be less than once a day if there are clear requirements for such a testing frequency in the design documents, in which case the testing frequency should meet the design requirements. When the deviation of the parameter measurement from the design exceeds 5%, the frequency of testing should be increased, the reasons for the deviation should be analyzed, and the existing problems should be resolved in a timely manner. When the deviation between the measured parameter and the design parameter exceeds 10%, the discharge should be stopped, and the discharge can be resumed after the problem has been resolved.

6.3 Dam Construction and Tailings Discharge

6.3.1 Tailings dam construction and tailings discharge include embankment slope clearing, tailings discharge, dam body construction, dam surface maintenance, seepage drainage facility construction and quality inspection. Steps should be carried out in accordance with the design requirements and work plan, and records should be made.

6.3.2 Embankment slope treatment shall be carried out before starter dams and raises are constructed, and all trees, tree roots, turf, tombs and other structures shall be removed. The cleared debris shall not be stockpiled on the spot and shall be transported outside the tailings pond site. If there are springs, wells, tunnels, karst caves or caves, etc., they should be treated according to the design requirements.

6.3.3 The discharge of tailings into wet tailings ponds shall meet the following requirements:

- The tailings should be discharged according to the design requirements, and the elevation of the crest of the beach should meet the requirements of production, corrosion prevention, remining, and water recycling in winter. For single-stage tailings ponds, the elevation of the tailings in the tailings reservoir and the elevation of the discharge point of the tailings must not exceed the design elevations;
- The discharge of tailings slurry shall not scour the starter dam or raises, and the flow of tailings slurry along the toe of the upstream slope of a raise shall not scour the dam body;
- The spacing, location, opening quantity and time of discharge outlets shall be carried out according to the design requirements and operation plan, and the ore processing records shall be kept.

6.3.4 In addition to meeting the requirements in 6.3.3, tailings discharge from wet tailings ponds using tailings dams should also meet the following requirements:

- The tailings discharge should result in uniform dispersion of the tailings and the beach surface should be maintained to rise smoothly and uniformly. There should be no side slopes, fan-shaped slopes or fine-grained tailings concentrated on one end or one side of the beach surface;
- The dam crest and tailings beach surface should be even and flat, and the length of the tailings beach and the minimum elevation of the crest of the beach should meet the flood control design requirements;
- There shall be no puddles on the surface of the tailings beach.

6.3.5 The raises of the wet tailings pond and the post-raise compaction shall meet the following requirements:

- The slopes of the tailings dam raises shall meet the design requirements;
- After each phase of dam construction is completed, quality inspection shall be carried out. The main inspection items shall include the dam axis position, the length of the dam body, the height of the dam body, the width of the dam crest, the slopes of upstream and downstream embankments, the elevation of the beach surface at the dam crest and upstream dam toe, the water level in the reservoir, the quality of dam construction, etc.;
- When the upstream tailings dam construction method requires sand to be stacked in the reservoir to construct a raise, the straight-line distance between the position of sand collection and the upstream dam toe of the current raise shall not be less than twice the height of the current raise, and the stacking shall be on the beach surface along the direction of the dam axis. Sand should be collected evenly and should not be collected from the beach.
- For centerline and downstream tailings dam construction, during the operation period there should an appropriate balance between the volume of sand-sized tailings in the dam and the storage volume in the reservoir;

- When the underflow tailings of the cyclone are used to directly construct the dam, the concentration of the underflow slurry should be greater than the concentration without size segregation.

6.3.6 Tests shall be conducted before tailings discharge and stacking in dry tailings ponds, and the operation procedures for stockpiling tailings shall be determined according to the test results and design requirements. The test items should include the following:

- Physical and mechanical testing of tailings under natural consolidation without mechanical compaction;
- Lab compaction testing;
- Rolling tests with different lift thicknesses and rolling times under the condition of the design moisture content;
- Measurement of physical and mechanical parameters of tailings after compaction.

6.3.7 When using vehicles to transport and discharge tailings into dry tailings ponds, the following regulations shall be met:

- The transportation road to the point of deposition should meet the safety requirements of vehicles. The unloading platform should be set at the end of the road, and its size should meet the safety requirements for the transportation vehicles to enter and exit;
- The unloading platform in each operation period should be arranged to meet the requirement of placing the tailings in the entire reservoir area under the condition of mechanical compaction;
- Transport vehicles moving or unloading near the slope of the tailings stack shall keep a sufficient safety distance from the edge of the slope of the tailings stack;
- When encountering bad weather such as heavy rain and freezing, the transportation operation should be stopped. After the bad weather, it is necessary to evaluate the road, unloading platform and other operations. Operations can be resumed only after the safety conditions of the area have been met.

6.3.8 When using a conveyor belt to transport and discharge tailings into a dry tailings pond, the following regulations shall be met:

- The length, quantity and layout of the belts in each operation period shall meet the requirement of placing the tailings in the entire reservoir area under the condition of mechanical compaction;
- The end of the belt should have the proper elevation angle and height to meet the safety distance of mechanical operation;
- When belt transportation is used in cold regions, measures for prevention of freezing should be carried out.

6.3.9 During tailings discharge and dam construction of dry-type tailings ponds, the setting of tailings discharge steps, the construction of barrier dams, and the degree of compaction of tailings shall meet the design requirements. The link between tailings discharge and dam construction shall be strictly controlled according to the design requirements. For the area of the dry tailings pond, the discharge operation method, lift thickness for compaction, number of rolling times and rolling range, degree of compaction, etc. should meet the design requirements, and effective measures should be taken to prevent the operating machinery from damaging the dam body and drainage structures.

6.3.10 During the operation of the dry tailings pond, the tailings discharge operation plan should be adjusted in accordance with the climate, and the following measures should be undertaken:

- The tailings of the tailings reservoirs should be rolled in a timely manner, and measures should be taken to prevent the moisture content of unrolled tailings from increasing;
- When the tailings cannot be emplaced into the tailings pond in a normal manner, the dry tailings should be temporarily stored at an emergency site;
- When normal operation resumes, unrolled tailings should be compacted and rolled again in accordance with the change in moisture content, taking measures such as compaction, drying or other measures to adjust the moisture content;
- The dam body stacking that affects the stable area of the dam body slope should be completed before the rainy season;
- In cold regions, the dam body stacking that affects the stable area of the dam slope should be completed before winter.

6.3.11 The maintenance work on the downstream embankment of the dam shall be carried out according to the design requirements, and there shall be no puddles on the downstream embankment of the tailings dam. When gullies, cracks, field pits and other phenomena appear in the dam body, they should be addressed in a timely manner.

6.3.12 During the operation of the tailings pond, the seepage drainage facilities shall be constructed according to the design requirements, and the proper seepage drainage shall be verified after construction.

6.4 *Reservoir Water Level Control and Flood Prevention*

6.4.1 The production and operation unit shall control the reservoir water level and prevent flooding according to the design requirements.

6.4.2 The production and operation unit should entrust the design unit to carry out flood control calculations based on the measured topographic map of the tailings pond, the water level, and the annual measured variation in the tailings beach. The design unit should also review the flood control capacity of the tailings pond, and determine the operating water level, as well as the operation control parameters for safe operation such as dry beach length and safe freeboard.

6.4.3 The water level control in the wet tailings pond shall follow the following principles:

- Under the premise of meeting the requirements of flood control safety, and the quality and quantity of return water, the water level in the reservoir should be reduced as much as possible;
- When the water level of the reservoir affects the safety of the tailings pond, the principle of safety first should be adhered to and the water level inside the pond should be reduced;
- When discharging the stored water in the reservoir or greatly reducing the water level in the reservoir, attention should be paid to controlling the flow rate, and no sudden drop is allowed in non-emergency situations;

- For tailings ponds in areas where karst or fissures are developed, the water depth in the pond shall be controlled to prevent leakage;
- Dam raises shall not be used to retain water.

6.4.4 The water level control in a dry tailings pond shall follow the following principles:
- The tailings stack shall not store water under normal operating conditions;
- Any flood in a tailings stack shall be discharged out of the stack within 72 hours.

6.4.5 A clear and easily visible water level observation scale should be set in the tailings pond. During the rainy season, the inspection of flood discharge facilities should be strengthened to ensure unimpeded flow through flood discharge facilities.

6.4.6 The manufacture and installation of the prefabricated parts of the flood drainage structure shall meet the following requirements:
- The prefabricated parts shall be manufactured according to the design requirements and properly maintained;
- The surface of the inner wall of prefabricated parts shall be flat and smooth, the height of local convex ridges shall not be greater than 5 mm, and shall be ground according to a slope of 1:10. The allowable deviation of the length shall be ±3 mm and the thickness shall not have a measured negative value;
- Before installation, the strength and surface smoothness of the prefabricated parts should be inspected to ensure that the quality of the prefabricated parts used for installation meets the design requirements;
- Prefabricated parts should be installed according to the design requirements and the installation quality should be ensured.

6.4.7 After a flood, a comprehensive inspection of the dam body and flood drainage facilities shall be carried out, and any problems shall be dealt with in a timely manner.

6.4.8 When the flood discharge structures of the tailings dam are closed, they shall be sealed in a timely manner in strict accordance with the design requirements, and the construction quality shall be ensured.

6.5 *Seepage Control*

6.5.1 During the operation of the tailings pond, the monitoring of the phreatic surface should be strengthened, and the depth of the phreatic surface should be controlled strictly according to the design requirements.

6.5.2 During the operation of the tailings pond, if the depth below the surface of the phreatic line of the dam body is less than the control depth below the surface, seepage drainage facilities shall be added or updated.

6.6 *Seismic Resistance*

6.6.1 When the original design seismic standard of the tailings dam is lower than the current standard, reliable measures should be taken to improve the seismic performance of the tailings dam so that it meets the requirements of the current standard. Commonly used measures are as follows:

- Adding a soil and rock buttress at the toe of the downstream slope;
- Cutting the downstream slope in order to decrease the seismic velocity;
- Increasing the compaction of the dam body;
- Reducing the water level in the reservoir or adding seepage drainage facilities to lower the phreatic surface within the dam body.

6.6.2 After an earthquake, the production and operation units should conduct safety inspections and repair the damaged safety facilities in a timely manner.

6.7 *Tailings Pond Safety Monitoring*

6.7.1 When the tailings dam is in operation, manual safety monitoring facilities and online safety monitoring systems should be set up in a timely manner according to the design, and the range of monitoring should be carried out regularly according to the design.

6.7.2 Tailings ponds should be inspected daily and real-time inspections should be conducted on-site during heavy rain or rainstorms. Manual safety monitoring facilities should be monitored once every half a month at the initial stage of installation and should be monitored no less than once a month after six months. In case of any of the following situations, the frequency of monitoring should be increased:

- Rainy season;
- After an earthquake, rain for several consecutive days, heavy rain, or typhoon;
- When the safety status of the tailings pond is at the level of yellow warning, orange warning or red warning;
- Before and after the construction of flood drainage facilities and dam body reinforcement;
- During other conditions that affect the safe operation of the tailings pond.

6.7.3 Manual safety monitoring shall meet the following requirements:

- A consistent observation pattern, observation route and observation method shall be adopted;
- For a single parameter, a consistent set of monitoring instruments and equipment shall be used;
- The data shall be processed in a consistent manner;
- There shall be no less than two professional technicians for each inspection.

6.7.4 The online safety monitoring frequency shall meet the following requirements:

- When a tailings pond is in a normal state, the online safety monitoring frequency should be in the range once every 10 minutes to once every 24 hours;
- When the safety status of the tailings pond is abnormal, the online safety monitoring frequency should be in the range once every five minutes to once every 30 minutes.

6.7.5 The monitoring results of tailings pond online safety monitoring and manual safety monitoring should be compared and analyzed regularly. It should be done once a year. Normal and in-depth data analysis should be added in the following cases:

- When the tailings pond is completed and approved;
- When assessing the status quo of tailings pond safety;
- When the tailings pond is closed;
- When an abnormal or dangerous situation occurs.

6.7.6 After the safety monitoring system is commissioned and running normally, the results of online safety monitoring and manual safety monitoring should be basically consistent, and the difference between online safety monitoring results and manual safety monitoring results at the same monitoring point at the same monitoring time should not be greater than twice the uncertainty in the measurement.

6.7.7 The management and maintenance of the online safety monitoring system for tailings ponds should be assigned specialized technical personnel.

6.7.8 The online safety monitoring system for tailings ponds should operate continuously and normally around the clock. When a failure occurs in the system, it should be eliminated as soon as possible, and the troubleshooting time should not exceed seven days. During the troubleshooting period, the failure-free monitoring equipment should be kept in normal operation, and manual monitoring should be strengthened. During the reconstruction and expansion of the monitoring system, the normal operation of the existing system should not be affected.

6.7.9 The tailings pond safety monitoring data should be analyzed in a timely manner and, if there is any abnormality, the reason should be analyzed in a timely manner and countermeasures should be taken. Analysis, management and release of safety monitoring information should be carried out by integrating the results of on-site inspection, manual safety monitoring and online safety monitoring.

6.8 *Requirements for the Reservoir Area and Surrounding Environment*

6.8.1 Buildings and structures irrelevant to the operation of the tailings pond shall not be built on the tailings dam or in the tailings pond area.

6.8.2 Illegal mining, indiscriminate digging and illegal blasting shall not be carried out on the tailings dam or in areas that would have a safety impact on the tailings pond.

6.9 *Hidden Hazards of Tailings Ponds and Handling of Major Dangerous Situations*

6.9.1 When the tailings pond is in one of the following categories of general production safety accident hazards, the situation shall be rectified within a short period of time to eliminate the accident hazards:

- The flood control storage capacity of the tailings reservoir is insufficient, so that the design flood level cannot simultaneously meet the requirements of the safe freeboard and dry beach length specified in the design;
- Cracks, corrosion or abrasions are present that do not affect the safe use of the flood discharge facilities;
- According to empirical calculations, the minimum factor of safety for stability of the dam body against sliding meets the specified values in Table 7, but local instability may occur due to the density of failure surfaces intersecting the outer embankment at some elevations;
- The depth below the surface of the phreatic line of the dam body is less than 1.1 times the depth below the surface of the control phreatic line;
- Partial longitudinal or transverse cracks appear on the dam surface;
- The water content of tailings in dry stacking is too high, so that it is difficult to implement dry stacking, and there are no reliable measures for mitigation;
- Drainage ditches were not set up on the dam surface according to the design, resulting in serious erosion with many or large gullies;
- A dam abutment has no diversion channel, so that stormwater from surrounding slopes contacts the dam abutment;
- Maintenance facilities were not installed according to the design on the outer embankment of a multi-stage dam constructed from tailings;
- Other abnormal conditions exist that do not affect the basic safe production conditions of the tailings pond.

6.9.2 Production should be stopped immediately, and the production and operation unit should formulate and implement major accident hazard management plans to eliminate accident hazards when the tailings pond is in one of the following major production safety accident hazards:

- There are mining, excavation, blasting and other activities not in accordance with the approved design plan in the reservoir area and tailings dam;
- A large area of longitudinal cracks has appeared in the dam body with the release of a large amount of seepage water at a high level and the formation of a large swampy area downstream;
- The slope of the outer embankment of a dam is greater than the design slope;
- The dam body exceeds the design dam height or the tailings are stored beyond the design storage capacity;
- The raising rate of a multi-stage dam constructed from tailings is greater than the design raising rate;
- According to empirical calculations, the minimum factor of safety for stability of the dam body against sliding is less than 0.98 times the specified value in Table 7;
- The depth below the surface of the phreatic line of the dam body is less than the depth below the surface of the control phreatic line;
- The flood control storage capacity of the tailings reservoir is insufficient, and neither the safe freeboard nor the dry beach length meet the design requirements for the design flood level;

- A part of the flood drainage facilities is blocked or the remining area and drainage wells are tilted, so that the drainage capacity is reduced and cannot meet the design requirements;
- The dry stacked tailings have a large water content, so that it is difficult to implement dry stacking, and there are no reliable measures for mitigation;
- A variety of tailings with different properties are mixed and discharged together, and the discharge is not carried out according to the design requirements;
- There is a failure to use under-ice remining operations in accordance with the design requirements in winter;
- There are incoming tailings, waste or wastewater that are inconsistent with the design;
- Other situations exist that endanger the safe operation of the tailings pond.

6.9.3 When one of the following major dangers occurs in the tailings pond, the production and operation unit should stop production immediately, activate the emergency plan, and carry out emergency rescue:

- Severe piping, soil flow and other phenomena appear in the dam body;
- Signs of severe cracks, crevasses and slippage appear in the dam body;
- According to empirical calculation, the minimum factor of safety for stability of the dam body against sliding is less than 0.95 times the specified value in Table 7;
- The tailings pond's flood control storage capacity is seriously insufficient. The safe freeboard and the length of the dry beach do not meet the design requirements for the design flood level, and flooding may occur;
- The drainage well is significantly tilted, and there are signs of collapse;
- The flood drainage system is seriously blocked or cut off, unable to drain or the drainage capacity is sharply reduced;
- The water content of tailings in dry stacking is too high, so that dry stacking is basically impossible, and reliable measures for mitigation cannot be carried out;
- Other major dangers exist that endanger the safety of the tailings pond.

7. Tailings Pond Remining

7.1 The grades and related requirements of each stage of tailings pond recovery shall be implemented in accordance with the following regulations:

- The class of the tailings pond shall be determined according to the full storage capacity and dam height of the tailings pond in 4.5;
- The stability of a tailings dam shall meet the requirements of 5.3.16;
- The flood control of the tailings pond shall meet the relevant requirements of 5.4.

7.2 The remining of tailings ponds shall meet the following requirements:

- The primary mining method shall be technically reasonable, safe and reliable;
- The reliability of the safety facilities of the tailings pond should be guaranteed during the remining process;
- The remining sequence should follow the principle of mining one area at a time "from the inside to the outside, from the reservoir to the dam, from the top to the bottom";

- For tailings ponds using combined dry and wet remining, the treatment plan for the connection between the two methods should be clarified;
- The recovery and discharge of tailings shall not be carried out at the same time in the same tailings pond;
- The new tailings produced by the remining of a tailings pond should be reused or stored in another tailings pool.

7.3 The remining design of the tailings pond should include the following main components:

- The scale, mining range, service life and corresponding reliable mining safety measures for the tailings pond;
- The planning and sequence of recovery of the tailings ponds, including recovery technology, transportation methods, equipment configuration, and utilization and protection of existing facilities;
- The stability analysis and safety measures of the tailings dam and the mining slopes in the reservoir during remining;
- The flood control standards, flood control calculations and flood control safety measures for the tailings ponds during remining;
- The monitoring facilities for the tailings ponds during primary mining;
- The disposal plan for the tailings pond after primary mining.

7.4 Flood drainage facilities shall be installed during the whole process of tailings pond remining, and the flood drainage facilities shall meet the following requirements:

- If the existing flood discharge facilities are to be used continuously, the reliability of their structure shall be ensured;
- Flood discharge channels should be set up between the primary mining area and the flood discharge facilities;
- Measures shall be taken to protect and prevent clogging of flood discharge facilities;
- Reliable measures should be taken to seal the flood drainage facilities that are not in use.

7.5 When a partition dam needs to be reserved or constructed during the recovery process of the tailings pond, the following requirements shall be met:

- A partition dam shall be designed as a temporary structure;
- The crest elevation of the partition dam shall not be higher than the elevation at which remining is taking place;
- For dry mining, the partition dam shall not be higher than 3 m from the base to the top of the dam.

7.6 Dry mining shall meet the following requirements:

- The height of single-layer mining shall not be greater than 3 m, and the slope angle of the steps shall be determined according to the mechanical properties of the tailings;
- The selection of equipment should be determined according to the bearing capacity of the foundation, and corresponding foundation reinforcement measures should be taken if necessary;
- A reasonable transportation route should be set up at the remining operation site;

- Remining facilities shall be located in a safe zone, and measures to prevent landslides and debris flows shall be taken if necessary.

7.7 The depth of the mining pit for wet mining shall not be greater than 6 m, and the height of the slope above the water surface shall not be greater than 3 m. The angle of the slope above the water shall be less than 25°, and angle of the slope of the underwater portion shall be less than 20°.

7.8 The production and operation of tailings pond remining should meet the following requirements:

- A tailings remining production unit shall establish a remining safety management system, prepare remining operation plans and emergency rescue plans for mining accidents, and do a good job in remining safety management;
- The tailings within 15 m from the drainage wells, drainage chutes, drainage culverts and other facilities in the tailings pond shall not be mined by excavating machinery and shall be lowered uniformly and synchronously;
- In the process of remining tailings, corresponding protection measures should be taken for the impermeable layers of the starter dam and reservoir area;
- No remining operation should be carried out during heavy rain, heavy snow, strong winds, heavy fog and other severe weather, and daily safety precautions should be taken;
- In the freezing season of tailings ponds in cold regions, hydraulic mining shall not be adopted;
- Effective measures should be taken in the remining area to prevent disasters such as landslides and mud-rock flows.

7.9 The excavation operation, road transportation, belt conveyor transportation, hydraulic mining, dredger mining and electrical facilities involved in the tailings pond recovery project shall be implemented in accordance with the relevant regulations of GB 16423.

7.10 If the tailings pond continues to receive tailings after the suspension or completion of remining, re-evaluation and re-design shall be carried out, and the regulations for rebuilding the tailings pond shall be followed. Otherwise, the tailings pond should be closed, and the closure should be implemented in accordance with the regulations on the closure of tailings dams.

8. Tailings Pond Closure

8.1 If there are hidden dangers of production safety accidents in the tailings inventory, the closed storage design should include control measures for the hidden dangers of production safety accidents.

8.2 For tailings pond closure, in addition to tailings pond investigation, adverse geological phenomena that could affect the safety of tailings ponds should also be investigated.

8.3 For first-class and second-class tailings ponds that have not been subjected to special dynamic seismic calculations, special dynamic seismic calculations shall be performed during the closing stage.

8.4 The design of the closed storage should analyze the safety of the tailings pond before and after the closed storage, and should propose corresponding closed storage engineering measures. The design focus should include the following:

- Dam stability analysis and engineering measures for tailings dam closure;
- Review of the flood control capacity of the tailings pond and the closure engineering measures for the flood drainage system;
- Closed storage engineering measures in the surrounding environment that could affect the safety of the tailings storage;
- Engineering measures for monitoring the closed facilities.

8.5 The engineering measures for tailings dam closure shall include the following contents:

- If the stability of a dam body is insufficient, measures such as strengthening the dam body and lowering the phreatic surface shall be taken to ensure that the stability of the dam body meets the requirements of this standard;
- Sinkholes, cracks and gullies in the dam body should be remediated;
- Improvements should be made regarding the drainage ditches on the dam surface, soil and rock covers, vegetative covers, dam abutment diversion channels, monitoring facilities, etc.

8.6 The closed storage engineering measures for the flood drainage system shall include the following:

- The flood control capacity of the tailings pond should be reviewed in accordance with the flood control standards. When the flood control capacity is insufficient, measures such as increasing the flood control storage capacity or building additional flood drainage systems should be taken, and if necessary, additional surface flood drainage facilities such as spillways should be added;
- When the structural strength of the original flood discharge facilities cannot meet the requirements or the damage is serious, reinforcement treatment should be carried out. If necessary, new flood discharge facilities should be constructed, and the original flood discharge facilities should be sealed at the same time.

8.7 After the tailings pond is closed, there should be no water in the pond under normal operating conditions.

9. Safety Inspection of Production and Operation Units

9.1 *General Provisions*

9.1.1 The production and operation unit should regularly organize relevant personnel to conduct safety inspections on the tailings pond. Safety inspections should be conducted no less than four times per year, and records should be kept. Inspections should be focused on before and after the rainy season, and before the freezing period in cold areas.

9.1.2 The safety inspection shall not be replaced by the daily inspection results of the production and operation unit and of the safety monitoring data. If it is necessary to use instruments for measurement, measurements shall be carried out according to the requirements of the manual safety monitoring, and the accuracy of the measuring instruments shall not be less than that of the daily manual safety monitoring instruments.

9.1.3 After the safety inspection, the inspection records should be compiled and analyzed, the conclusions of the analysis should be addressed, and the inspection process data should be archived.

9.2 ***Safety Inspection of Flood Control***

9.2.1 The main content of flood control safety inspections shall include flood control standards, main control indicators of flood control safety operation management, and safety inspection of flood discharge structures, etc.

9.2.2 The safety inspection of flood control standards for tailings ponds shall determine whether the flood control standards comply with the provisions of this standard. When the flood control standard is lower than this standard, the flood calculation and flood regulation calculation should be re-performed, the control parameters should be adjusted according to the calculation results, and flood drainage facilities should be added if necessary.

9.2.3 The safety inspection of the main control indicators of flood control safety operation management shall include inspection of tailings reservoir water level, inlet weir crest elevation, dam (beach) crest elevation, dry beach length, and dry beach slope inspection, and shall meet the following requirements:

- The measuring points for water level detection of a tailings reservoir shall be selected to represent the stable water level in the reservoir, and the number of measuring points shall not be less than two.
- The measuring points for the elevation measurement of the inlet weir crest should be able to reflect the actual situation of the inlet weir, and the number of measuring points should not be less than three.
- For the measurement of the height of the crest of the dam (beach) of a tailings reservoir, measuring points should be arranged along the direction of the crest of the dam (beach) for actual measurement. The total number of measuring points shall not be less than three, and one to two measuring points shall be selected at the lower part for every 100 m of dam length. When the crest of the dam (beach) is higher at one end and lower at the other, the measuring points shall be selected at the lower elevation section. One to three measuring points should be set at the lower elevation. The elevation of the lowest point among the measuring points should be selected as the elevation of the crest of the dam (beach) of the tailings reservoir.
- For the measurement of the dry beach length of the tailings pond, depending on the length of the dam and the curvature of the edge of the water, one to three sections should be arranged at the shorter dry beach length. The measuring section should be arranged perpendicular to the axis of the dam, and the minimum value should be selected as the length of the dry tailings beach of the tailings pond.
- For the measurement of the average slope of the dry tailings beach of the tailings reservoir, depending on the flatness of the dry tailings beach, one to three sections should be arranged for every 100 m of dam length. The measuring section should be arranged

perpendicular to the axis of the dam, the measuring points should be arranged at each slope break as far as possible, and the distance between measuring points should not be greater than 10 m to 20 m (the maximum value should be used for older dry beaches). The average slope of the dry tailings beach of the tailings reservoir should be calculated as the weighted average of the average slopes of the dry tailings beach at each measurement section.

9.2.4 Based on the actual topography, water level, and difficulty of tailings deposition in the tailings pond, the flood control capacity of the tailings pond should be reviewed to determine whether the safe freeboard of the tailings pond, the length of the dry beach and the slope of the dry beach meet the design requirements.

9.2.5 The main items for the safety inspection of flood discharge structures shall include consideration as to whether the structures show deformation, displacement, damage, silting, and whether the drainage capacity meets the design requirements.

9.2.6 The inspection items for the drainage well shall include inner diameter, opening size and position, residual corrosion, flaking, seepage through the well wall, width of maximum crack development, inclination and displacement of the sides, the connection position of the well and the pipe, the placement and fracture of the arch plates, the width of maximum crack development in the arch plates, impermeable fillings and sand leakage between the arch plates and between the arch plates and the well wall, floating objects on the water surface of the water inlet, sealing methods and measures for out-of-service wells, and auxiliary facilities for the installation of arch plates in drainage wells.

9.2.7 The inspection items for the drainage chute shall include the section size, the deformation, damage and size of the chute body, the width of maximum crack development, the cover plate placement and fracture, the width of maximum crack development in the cover plates, the gap between the cover plates and the gap between the cover plates and the tank walls, impermeable filling, sand leakage, silting in the chute, etc.

9.2.8 The inspection items for drainage pipes shall include section size, deformation, damage, fracture, abrasion, width of maximum crack development, seals and filling between pipes, tailings seepage into pipes, silting in pipes, etc.

9.2.10 The inspection items for spillways and flood diversion channels shall include cross-sectional dimensions, landslides along the slopes, field squares, lining deformation, damage, fracture, abrasion, silting in channels, etc. For the spillway, the top elevation of the overflow sill, the stilling pool and the stilling sill should also be inspected.

9.2.11 There should be image data for the inspection of flood discharge structures. When recording or photographing important components such as cracks, holes, bulges, drainage well bases, and diversion wells, tools such as measuring rulers should be used to make detailed measurements and mark the measurement sites.

9.2.12 Inspectors should be equipped with low-voltage lighting equipment with strong light, oxygen supply facilities, safety helmets, wireless communication and other necessary equipment according to the operational environment of the inspection. There should be safety protective equipment and a protective plan for limited space operations. The number of people involved should not be less than two.

9.3 *Safety Inspection of Tailings Dam*

9.3.1 The main items for the tailings dam safety inspection shall include the dimensions of the dam perimeter, deformation, cracks, landslides and seepage, dam surface maintenance facilities, etc.

9.3.2 When measuring the slope of the outer embankment of the dam, sections with the maximum dam height and sections with the maximum dam slope should be selected, and there should be no less than two sections for every 100 m of the dam length.

9.3.3 When inspecting the displacement of the dam body, the displacement monitoring points set on the dam body shall be comprehensively measured, and the position of the dam shall be analyzed in combination with the daily monitoring data. The variation in the displacement of the dam should be uniform, without abrupt changes, and should decrease year by year. When the displacement changes abruptly or tends to increase, the cause should be discovered and addressed immediately.

9.3.4 When inspecting the dam body for cracks and landslides, the dam body should be checked for signs of longitudinal and transverse cracks and landslides. When cracks are found in the dam body, the length, width, depth, direction, shape and cause of the cracks should be determined and the degree of damage should be determined. When signs of landslides are found in the dam body, the location, scope and shape of the potential landslide should be determined, as well as the dynamics of the landslide trend.

9.3.5 When inspecting the seepage from the dam body, the seepage surface of the dam body, the slope of the dam body, the downstream seepage, and the seepage drainage facilities of the dam body shall be included. The position and shape of the seepage surface should be determined in the inspection of the dam body seepage line. The seepage inspection of the dam body slope and downstream area should determine whether there are seepage points on the dam body slope and downstream area, and the location, shape and flow rates of the seepage points should be determined, as well as the sand content, etc. The inspection of the seepage drainage facilities of the dam body should determine whether the seepage drainage facilities are in good condition, as well as the effects of the seepage and the seepage water quality.

9.3.6 When inspecting the dam surface maintenance facilities, the inspection should include the sectional dimensions of the dam abutment diversion channels and the dam slope drainage ditches, the deformation, damage, fracture and abrasion of the lining, the silting in the ditches, and the stability of the hillsides. The implementation of slope protection such as rock coverings on dam slopes should also be inspected.

9.4 ***Safety Inspection of Tailings Pond Remining***

9.4.1 The safety inspection of remining of the tailings pond should focus on determining whether the remining and dam construction methods meet the design requirements. For tailings ponds in cold regions, it should also be determined as to whether remining is taking place in winter and whether the conditions exist for normal operation in winter.

9.4.2 The safety inspection of the tailings discharge operation of a dry tailings pond shall include the following items:

- Determine whether the safety conditions of tailings transportation roads and inspection roads meet the safety requirements;
- Determine whether the operation of mechanical equipment meets the safety requirements;
- Determine whether the method of tailings drainage and dam construction meets the design requirements;
- Determine whether the construction of tailings discharge steps, construction of barrier dams, drainage slope and slope aspect meet the design requirements.

9.5 ***Safety Inspection of Tailings Reservoir Area***

9.5.1 The main items for the safety inspection of the tailings reservoir area shall include the stability of the surrounding mountains, illegal buildings, illegal construction and illegal mining and prospecting operations, etc.

9.5.2 When inspecting the surrounding site for landslides and debris flows, etc., it is necessary to observe in detail whether there are abnormalities and sudden changes in the surrounding mountains, and investigate the rock and soil. The engineering site investigation report should analyze the possibility of landslides in the surrounding mountains.

9.5.3 The existence of possible behaviors that would endanger the safety of the tailings pond within the reservoir area should be investigated. The main items should include illegal blasting, illegal quarrying and construction, illegal tailings remining, illegal water extraction, tailings, waste rock, wastewater and waste discharge from another operation, grazing and house construction, etc.

9.5.4 The safety inspection of the tailings reservoir area should also include the reliability inspection of the drainage facilities and facilities for controlling seepage in the reservoir area, whether the production roads in the reservoir area are unobstructed, and whether the setting of temporary and permanent safety warning signs is complete and clear.

9.6 ***Safety Inspection of Monitoring Systems***

9.6.1 The main items for the safety inspection of the tailings pond monitoring system should include the monitored parameters, the layout of the monitoring facilities and the maintenance of the monitoring facilities.

9.6.2 The safety inspection should determine whether the monitored parameters and the setting of monitoring warning values meet the design requirements. The inspection should determine whether the placement of the monitoring facilities meet the requirements of the facilities, whether the monitoring facilities are damaged, and whether they are operating normally.

9.6.3 The safety inspection should determine whether the monitoring facilities are regularly inspected and maintained, as well as the reliability and integrity of the monitoring facilities and personnel. The safety inspection should determine whether the manual monitoring facilities and online monitoring facilities are regularly compared and corrected.

9.7 *Safety Inspection of Other Facilities*

9.7.1 The main items for safety inspection of other facilities shall include lighting facilities, management stations, communication facilities, emergency management facilities, etc.

9.7.2 When inspecting the lighting facilities of the tailings pond, it should be determined as to whether the lighting facilities meet the requirements for safe production and use at night, and the lighting circuits and equipment should be inspected. The inspection should determine whether the layout is safe and standardized.

9.7.3 The safety inspection of the tailings pond management station should include the location and specifications of the tailings pond management station, records of duty shifts and daily safety inspections. The safety inspection should determine whether the management station and operations, management personnel and external communication facilities are unimpeded.

9.7.4 When inspecting the emergency management facilities of the tailings pond, the inspection should include the supply of emergency rescue materials and determine whether the emergency road is unblocked.

10. Emergency Management of Production and Operation Units

10.1 The production and operation unit should implement the main responsibility for tailings pond emergency management, establish and improve the emergency work responsibility system and emergency management rules and regulations for production safety accidents in tailings ponds, formulate emergency rescue plans, and distribute them to all departments, positions and emergency response departments of tailings ponds in a timely manner.

10.2 The following factors should be considered when preparing the emergency rescue plan:

- The existence of a relict tailings dam;
- Deep-seated sliding of the dam embankment;
- Overtopping by flooding;
- The water level exceeding the warning line;
- A damaged flood drainage facility;
- A blockage of the flood drainage system;
- The occurrence of heavy rain, flash floods, mudslides, landslides, earthquakes and other disasters.

10.3 The emergency rescue plan should include:

- Composition and responsibilities of emergency response agencies;
- Emergency rescue plan system;
- Tailings pond risk description;
- Early warning and information report;
- Emergency response and emergency communication support;
- Preparation of personnel, funds and materials for emergency teaching aids;
- Emergency rescue plan management.

10.4 The production and operation unit shall conduct at least one emergency rescue drill every year before the review. The drill plan, records, summary evaluation reports and other materials should be kept for a long time.

10.5 The production and operation unit shall evaluate the emergency rescue plan every three years and revise the plan in a timely manner if any of the following situations occurs:

- Significant changes have taken place in the laws, regulations, rules, and standards on which the contingency plan is based;
- There has been an adjustment of the emergency command organization and its responsibilities;
- There has been a major change in the potential risks faced by the production and operation of the tailings pond;
- Significant changes have occurred in important emergency resources;
- Major problems that require revision of the plan were found in the plan or emergency rescue drill;
- Other situations have arisen that should be reviewed.

10.6 The production and operation unit shall establish an emergency shift system, equip emergency shift personnel, and implement a 24-hour shift schedule.

10.7 The production and operation unit should establish an emergency rescue team that meets the requirements of national laws and regulations, and emergency rescue personnel should be trained on a regular basis.

10.8 The production and operation unit should set up an emergency material storehouse for tailings ponds for storage of emergency rescue equipment and other equipment and materials that meet the requirements of the plan. Regular inspections, maintenance and updates should be carried out. The layout of the construction site of the emergency material storehouse shall follow the following principles:

- It should be built near the tailings dam and in an area with stable foundation;
- It shall be directly connected with the emergency road;
- It should not be built directly on the tailings dam or downstream of the tailings pond.

10.9 After a dangerous situation or accident occurs in the tailings pond, the production and operation unit should immediately initiate the emergency rescue plan, scientifically organize the emergency rescue, and report the accident according to relevant regulations.

11. Safety Evaluation of Tailings Pond

11.1 *General Provisions*

11.1.1 Safety pre-evaluation and safety approval evaluation should be carried out for new construction, reconstruction, expansion projects and remining construction projects for tailings ponds. Safety status evaluation should be carried out during the production and operation period of tailings ponds and before closure.

11.1.2 On-site reconnaissance should be carried out in the early stage of the tailings pond safety evaluation. The reconnaissance items should include topography, adverse geological phenomena, and the surrounding human and geographical environment. The safety approval evaluation should also include project construction, supervision and trial operation. The safety status evaluation should also include the operation of the tailings dam, the integrity of the flood discharge facilities, and the operation of the safety monitoring facilities.

11.1.3 The production and operation unit shall provide the following materials to the evaluation unit according to the purpose and requirements of each evaluation:

- A current topographic map of the tailings pond and relevant upstream and downstream data;
- Hydrometeorological data;
- A tailings reservoir geotechnical investigation report;
- Design materials for safety facilities for the tailings pond;
- Construction data for tailings pond safety facilities;
- Tailings pond operation management data, including safety management and accidents and their handling, safety risk management and control, hidden danger investigation and treatment, and monitoring;
- Other relevant information.

11.2 *Safety Pre-Evaluation*

11.2.1 The safety pre-evaluation shall evaluate the safety and reliability of the construction scheme proposed in the feasibility study report, and the evaluation focus shall include:

- The rational evaluation of reservoir site selection, including the safety impact of the tailings reservoir on downstream residents and the surrounding environment, such as important facilities, as well as the natural environment. The focus shall also include the impact of the surrounding environment, such as geological or environmental disasters and the human environment, on the safety of the tailings ponds;
- The rational evaluation of the tailings dam site and dam type selection, the quantitative calculation of the stability of the dam against seepage and against sliding, and an analysis and judgment as to the tailings dam safety status;

- The rationality of the layout of the flood drainage system and the evaluation of the reliability of the flood drainage capacity, using the water volume balance method to carry out flood control calculations, and an analysis and judgment as to the safety status of the flood control and drainage;
- The evaluation of the integrity and reliability of the tailings pond safety monitoring system;
- The identification of the main dangerous and harmful factors that exist in the operation process of the tailings pond after it is put into production and operation, and an analysis of the causative factors, and the possibility and severity of the accident that may result;
- The evaluation of the reliability of the prevention and control measures of dangerous and harmful factors in the feasibility study report.

11.2.2 The safety pre-evaluation report should have clear evaluation conclusions, and the evaluation conclusions should include:

- A listing of the main dangerous and harmful factors, emphasizing the major dangerous and harmful factors that should be avoided in the construction project, and specifying the safety factors to which attention should be paid, as well as suggestions for countermeasures;
- A feasibility study report on the compliance with national laws, regulations, rules, standards and norms related to production safety;
- A clarification as to whether the potential dangers and harmful factors of the construction project can be controlled after carrying out safety countermeasures and taking into consideration the degree of control.

11.3 *Safety Approval Evaluation*

11.3.1 The safety approval evaluation shall evaluate whether the construction project meets the safety approval conditions, and the key points of the evaluation shall include:

- A determination as to whether the safety facilities are designed and will be constructed and put into production and use at the same time as the overall project;
- A determination as to whether the safety facilities conform with the approved safety facility design and construction drawings and whether they are reliable for ensuring safe production;
- The establishment of the work safety responsibility system, the safety management organization and safety management personnel, the work safety system, and the emergency rescue plan for accidents, as well as a determination as to whether the content related to safety management meets the requirements of relevant safe production laws, regulations, rules, standards, and normative documents and their implementation;
- The identification and analysis of the dangerous and harmful factors that could cause the safety facilities and components of the completed construction projects to fail, and determine their degree of risk;
- A determination as to whether there are complete concealed engineering records confirmed by the supervisor and the owner;
- A determination as to whether the construction parameters and quality of each individual project meet the national and industry norms, regulations and design requirements;
- A proposal for reasonable and feasible safety countermeasures and suggestions.

11.3.2 The safety approval evaluation report should have clear evaluation conclusions, and the evaluation conclusions should include:

- An evaluation of the conformity and validity of the safety facilities of the construction project with the design of the safety facilities and the construction drawings;
- An evaluation of dangerous and harmful factors that could cause the safety facilities and components of the completed construction project to fail, as well as their degree of risk.
- A clear conclusion as to whether the construction project meets the safety approval conditions.

11.4 ***Safety Status Evaluation***

11.4.1 The safety status evaluation should assess the tailings pond operation and management status, and the focus of the evaluation should include:

- An explanation and evaluation of the natural conditions of the tailings pond, including the geographical location of the tailings pond, the surrounding human environment, the shape of the tailings pond, the watershed, the elevation of the base of the pond and the surrounding ridges, and the general engineering geology, etc.;
- A description and evaluation of tailings dam design and current status, including starter dam structure type and size, tailings dam raising method, embankment or accumulation height, storage capacity, slope of outer embankment of tailings dam, dam body deformation and seepage, and corresponding engineering countermeasures etc., as well as a quantitative analysis of tailings dam stability based on survey data or empirical data;
- A description and evaluation of the design and current status of the tailings pond flood control facilities, including the class of the tailings pond, flood control standards, total volume of stormwater, peak flood flow at the site, type of flood drainage system, structural size and condition of flood drainage facilities, etc., as well as a review as to whether the flood control capacity of the tailings pond and the reliability of the flood discharge facilities can meet the design requirements;
- An evaluation of the reliability of safety monitoring facilities, including monitored parameters, quantity and location of monitoring points, accuracy, monitoring frequency, and early warning functions of safety monitoring facilities;
- A safety analysis of dam stability and the flood drainage system of the tailings pond during the next evaluation period;
- An evaluation of the degree of perfection of safety management.

11.4.2 The safety status evaluation report should have clear evaluation conclusions, and the evaluation conclusions should include:

- A determination as to whether the stability of the tailings dam meets the design requirements;
- A determination as to whether the flood control capacity of the tailings pond meets the design requirements;
- A determination as to whether the safety monitoring facilities of the tailings pond meet the design requirements;
- Mutual safety impacts of the tailings pond and the surrounding environment;

- A determination as to whether the dam body stability and flood control capacity of the tailings pond meet the design requirements during the next evaluation period;
- Safety countermeasures;
- A clear conclusion as to whether the tailings pond has the safe production conditions to continue production and operation.

12. Tailings Pond Project Documents

12.1 The production and operation unit shall establish a tailings pond project file management system. The tailings pond project file shall include the relevant historical records formed during the construction and management of the tailings pond, and ensure its completeness, accuracy, safe keeping and effective use.

12.2 The tailings pond project files should be managed separately according to the stages of project construction, production and operation, remining, and closure.

12.3 The tailings pond construction and remining project files should include the following documents and information:

- Approval documents related to project construction, such as project approval, verification or filing;
- Surveying and mapping data such as the elevation of the permanent benchmark points, coordinate positions, control network, and topographic maps at different scales;
- Geotechnical engineering investigation data of the reservoir area, dam body and main structures at different stages;
- Design documents, drawings and design changes for different design stages;
- Safety evaluation materials such as safety pre-evaluation, safety approval evaluation, and safety status evaluation;
- Construction and supervision materials such as documents, reports, drawings, images, and records of construction and supervision units during the construction process of the project;
- Relevant records during the trial operation period, trial operation reports and other trial operation materials;
- Approval information, such as documents, reports, drawings, and records related to construction, supervision, design, evaluation, and the construction unit when the project is completed.

12.4 The production and operation files of the tailings pond should include the annual operation plan, production records, safety inspection records and handling, accidents and handling, etc.

12.5 The engineering documents for a closed tailings reservoir should include survey reports, safety status evaluation, closed reservoir design, construction and approval and other materials.

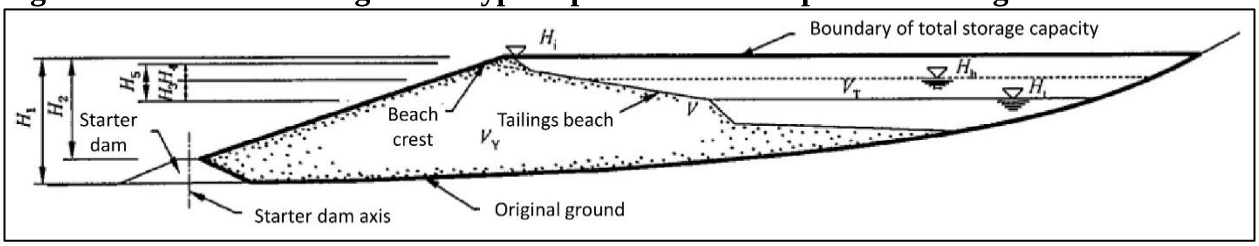
12.6 Other files should include the management documents of the tailings pond during the operation period, as well as internal reports and analysis materials.

12.7 Online monitoring data, images and other materials that are stored in electronic files shall be backed up.

Appendix A (Informative Appendix)
Schematic Diagrams of Typical Parameters of Tailings Ponds

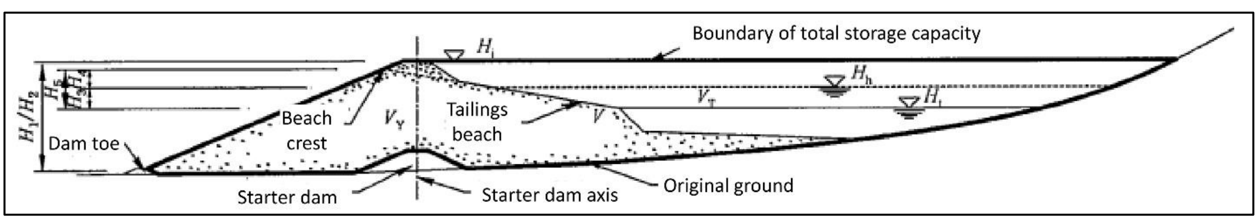
Figures A.1 to Figure A.7 show diagrams for the typical parameters of different dam raising methods for mixed tailings storage and dry tailings storage.

Figure A.1. Schematic diagram of typical parameters for upstream tailings dams



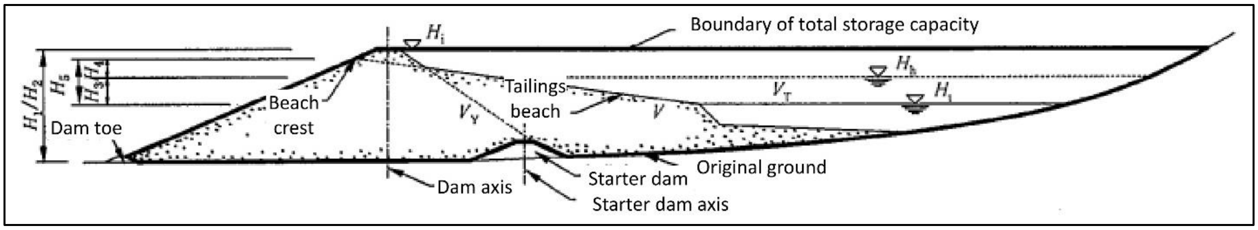
Legend:
V = Total storage capacity;
V_Y = Effective storage capacity;
V_T = Flood regulation storage capacity;
H_i = Elevation of the dam crest during the operation period;
H_h = Design flood elevation;
H_t = Initial water level elevation of flood regulation;
H_1 = Tailings dam height;
H_2 = Embankment height or accumulation height;
H_3 = Flood adjustment height;
H_4 = Safe freeboard under non-seismic operating conditions;
H_5 = Flood height.

Figure A.1. Schematic diagram of typical parameters for upstream tailings dams



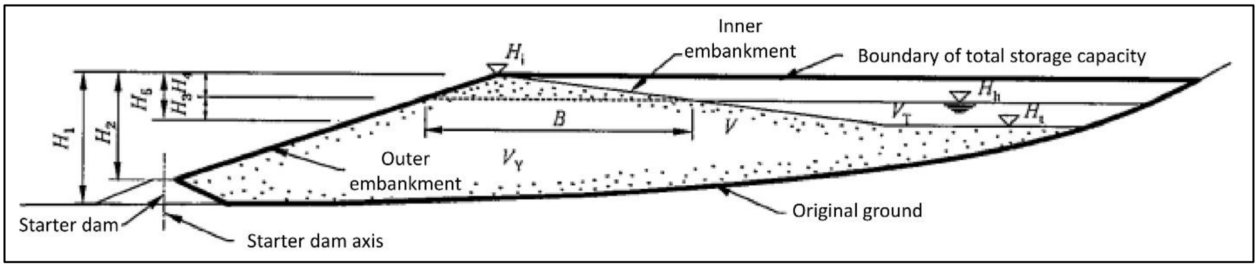
Legend: Same as Figure A.1

Figure A.2. Schematic diagram of typical parameters for centerline tailings dams



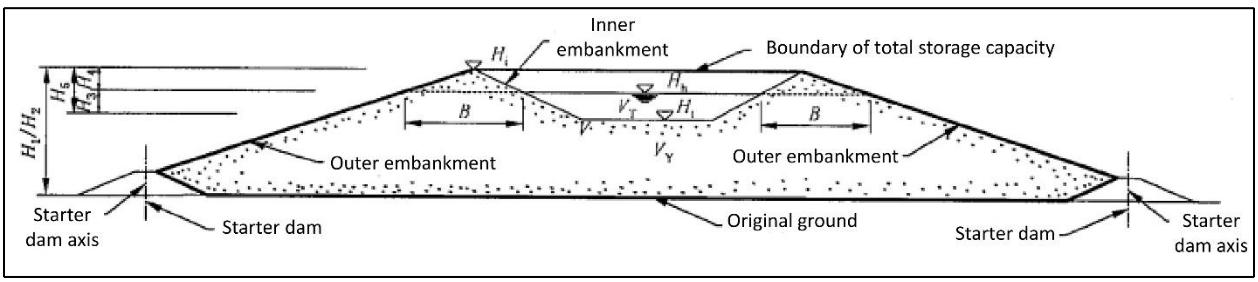
Legend: Same as Figure A.1

Figure A.3. Schematic diagram of typical parameters for downstream tailings dams



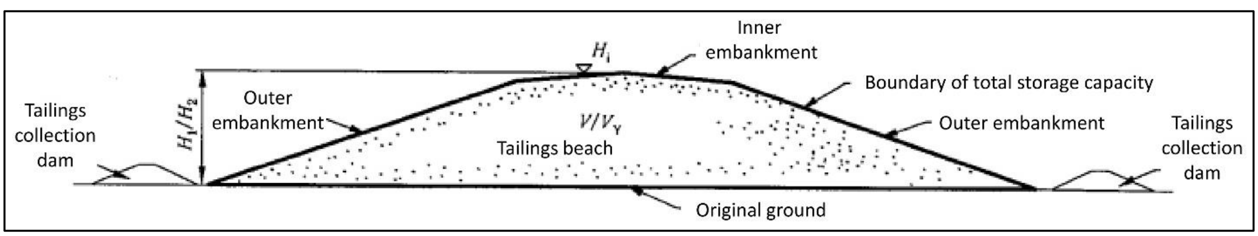
Legend: B = Flood control width; the rest are the same as Figure A.1

Figure A.4. Schematic diagram of typical parameters of a dry tailings pond constructed using the upstream discharge tailings stack method



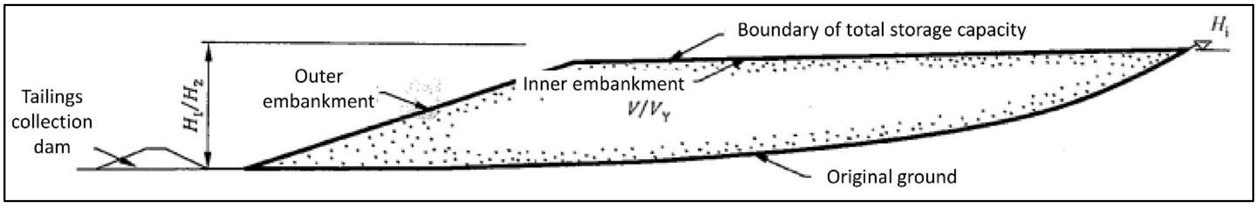
Legend: B = Flood control width; the rest are the same as Figure A.1

Figure A.5. Schematic diagram of typical parameters of a dry tailings pond constructed using the peripheral discharge tailings stack method



Legend: Same as Figure A.1

Figure A.6. Schematic diagram of typical parameters of a dry tailings pond constructed using the center discharge tailings stack method



Legend: Same as Figure A.1

Figure A.7. Schematic diagram of typical parameters of a dry tailings pond constructed using the downstream discharge tailings stack method

Appendix B (Normative Appendix)
Tailings Nomenclature Table

Table B.1 presents the nomenclature for tailings based on the particle size distribution and plasticity index.

Table B.1. Tailings Nomenclature

Tailings		
Category	**Name**	**Description**
Size	Gravel	Particles larger than 2 mm are 25-50% of the total mass
	Coarse sand	Particles larger than 0.5 mm exceed 50% of the total mass
	Sand	Particles larger than 0.25 mm exceed 50% of the total mass
	Fine sand	Particles larger than 0.074 mm exceed 85% of the total mass
	Silty sand	Particles larger than 0.074 mm exceed 50% of the total mass
Size and Plasticity	Silt	Particles larger than 0.074 mm do not exceed 50% of the total mass and the plasticity index is less than or equal to 10
Plasticity	Silty clay	Plasticity index greater than 10 and less than or equal to 17
	Clay	Plasticity index greater than 17
When naming, the first name should be chosen in the particle gradation from larger to smaller. The plasticity index shall be determined by calculation corresponding to the liquid limit measured when a 76 g disc is immersed in the soil to a depth of 10 mm.		

APPENDIX B:

TRANSLATION OF CHINESE WORK PLAN FOR THE PREVENTION AND RESOLUTION OF TAILINGS POND SAFETY RISKS

March 2, 2020
Source: Department of Basics for Production Safety

About the printing and distribution of "The Prevention and Resolution of Tailings Pond Safety Risks"
Notification of Work Program
Emergency [2020] No. 15

To the people's governments of all provinces, autonomous regions, and municipalities directly under the Central Government, the Xinjiang Production and Construction Corps, and relevant central enterprises:

With the approval of the State Council, the "Work Plan for the Prevention and Resolution of Tailings Pond Safety Risks" is hereby issued to you. Please implement it conscientiously.

Ministry of Emergency Management
National Development and Reform Commission
Ministry of Industry and Information Technology
Ministry of Finance
Ministry of Natural Resources
Ministry of Ecology and Environment
Ministry of Water Resources
China Meteorological Administration
February 21, 2020

Work Plan for the Prevention and Resolution of Tailings Pond Safety Risks

In order to deeply learn the lessons of tailings pond dam breach accidents at home and abroad, effectively prevent and resolve the safety risks of tailings ponds in our country, and ensure the safety of people's lives and property, this plan is formulated.

1. Guiding Ideology

Guided by Xi Jinping's Thoughts on Socialism with Chinese Characteristics for a New Era, there should be full implementation of the spirit of the 19th National Congress of the Party and the Second, Third, and Fourth Plenary Sessions of the 19th Central Committee and adherence to the relevant decisions and deployments of the Party Central Committee and the State Council to implement the responsibilities of all parties in production safety. The safety risk management and control capabilities of tailings ponds should be improved, safety risks in tailings ponds should be effectively prevented and resolved, and the safety of people's lives and property and social stability should be effectively protected.

2. Working Principles and Objectives

2.1 Working Principles

Development should be safe and people-oriented. There should be adherence to the idea of people-centered development, the concept of safe development should be firmly established, there should be a focus on protecting the lives and property of the people, the various tasks of preventing and resolving safety risks in tailings ponds should be implemented, and local economic and social development should be promoted while ensuring safe production, as well as the healthy development of the enterprise.

There should be implementation of responsibility and formation of synergy. There should be strengthening of the leadership responsibilities of local people's governments, the regulatory responsibilities of relevant departments, and the main responsibilities of tailings pond enterprises for safe production. There should be strengthening of overall coordination, strict supervision and evaluation, the establishment of government-industry coordination, departmental collaboration, and efficient and powerful working mechanisms, as well as the promotion of the orderly development of work.

Key points should be highlighted and implemented step by step. According to the degree of safety risk, priorities shall be set and work shall be reasonably arranged with the focus on "overhead ponds" (tailings ponds with residents or important facilities within 1 km from the toe of the embankment of the starter dam along the downstream tailings flow path). Tasks and progress plans should advance steadily.

Measures should be adapted to local conditions and with comprehensive implementation of policies. There should be strict adherence to seeking the truth from facts. Based on the local characteristics, a work path should be adopted that is suitable for the promotion of work within the local conditions. There should be adherence to "one policy for one reservoir." There should be study and determination of targeted safety risk management and control measures for each tailings pond safety risk situation.

2.2 Work Objectives

Starting in 2020, under the premise of ensuring the normal construction and development of mines for strategic minerals and minerals that are in short supply, the number of tailings ponds across the country will only decrease and not increase, and no new "overhead ponds" will be constructed. By the end of 2022, the safe production responsibility system for tailings ponds will be further improved, and the responsibility for safety risk management and control will be fully implemented. The preparation of the "one policy for one reservoir" safety risk management and control plan for all tailings ponds will be completed, and safety risk management and control measures will be fully implemented, tailings pond safety risk monitoring and early warning mechanisms will have been basically formed, and dam failure accidents caused by non-force majeure factors will be definitely curbed.

2.3 Key Tasks

2.3.1 The system of responsibility for preventing and resolving tailings pond safety risks should be strengthened and improved.

2.3.1.1 The leadership responsibilities of local people's governments should be clarified. There should be adherence to the identical responsibilities of the party and the government, dual responsibility for one post, joint management, and accountability for dereliction of duty. The local people's governments should lead the system of responsibility for the guarantee of the safe production of tailings ponds. The main person in charge of the local people's government at all levels is the first person responsible for the prevention and resolution of tailings pond safety risks in the region and is responsible for the leadership for work in tailings pond safety risks. For tailings ponds without a production and operation unit, the local county-level people's government shall assume the responsibility of the unit for safety risk management and control. (People's governments at the provincial level are responsible for implementation.)

2.3.1.2 Responsibilities for departmental supervision should be clarified. The local people's governments at all levels should further clarify the responsibilities of the relevant departments in accordance with the principles of management of industry, management of business, management of safety, management of production and operation, and the determination as to who is in charge. There should be comprehensive promotion of the prevention and resolution of tailings pond safety risks in aspects such as safety supervision, forest land and grassland requisition, river protection, and water and soil conservation. It is further necessary to establish and improve the mechanism of supervision of safety risk classification, and to clarify the responsibility for supervision of each tailings pond. (People's governments at the provincial level are responsible for implementation)

2.3.1.3 There should be strict implementation of the main responsibility of the enterprise. The legal representative and the actual owner of the tailings pond enterprise are jointly the first person responsible for preventing and resolving safety risks in the enterprise, and are fully responsible for preventing and resolving safety risks. It is necessary to equip professional and technical personnel to manage tailings ponds, implement a system of responsibility for safe production for all employees, strengthen the responsibilities of each functional department for safe production, implement dual responsibilities for one post, and assume corresponding responsibilities for preventing and resolving safety risks according to the division of responsibilities. (People's governments at the provincial level are responsible for implementation.)

2.3.2 The control of hazards should be strengthened and the number of tailings ponds should be strictly controlled.

2.3.2.1 There should be strict implementation of the control of the total amount of tailings ponds. All provinces (autonomous regions and municipalities directly under the Central Government) shall adopt policies and measures such as equivalent or reduced replacement in order to control the total amount of tailings ponds in the region in coordination with the requirements of national economic and social development planning, land use, safe production, water and soil conservation, and ecological environmental protection in the region. Control means that, starting from 2020, under the premise of ensuring the normal construction and development of mines for strategic minerals and minerals in short supply, in principle, the number of tailings ponds will only decrease but not increase. It is necessary to implement a notification system for the basic situation of tailings ponds. At the beginning of each year, information such as the number, name, address, ownership or management unit of the tailings ponds of the previous year will be announced on the websites of the local government and relevant departments and other local mainstream media, with active addition of public opinion and social public supervision. (People's governments at the provincial level are responsible for implementation.)

2.3.2.2 There should be strict review of the conditions for control of hazards. New mining projects should be encouraged to give priority to the use of existing tailings ponds and consider whether it is truly necessary to build new tailings ponds. There should be strict review of new tailings pond project approval, project site selection, river protection, safe production, ecological environment protection, etc. Approval will be granted only if a project meets the requirements of relevant national laws, regulations, standards and policies such as the overall layout of the mine, land and space planning, river protection, production safety, water and soil conservation, and ecological environmental protection. There should be strict control of the construction of tailings ponds for independent ore processing plants. It is strictly forbidden to build new "overhead ponds" and tailings ponds with a total dam height of more than 200 meters. It is strictly forbidden to build new (or modified or expanded) tailings ponds within 3 kilometers from the banks of the main streams of the Yangtze River and the Yellow River, and 1 kilometer from the banks of their important tributaries. Newly built fourth- and fifth-class tailings ponds must be built as single-stage dams. (The National Development and Reform Commission, the Ministry of Natural Resources, the Ministry of Ecology and Environment, the Ministry of Water Resources, and the Ministry of Emergency Management shall guide the process according to the division of responsibilities, and the provincial people's governments shall be responsible for implementation.)

2.3.2.3 There should be strict control of expansion and increasing the height of tailings ponds. All relevant departments should strictly enforce the administrative examination and approval of proposals for expanding and increasing the height of tailings ponds, and should strengthen the engineering investigation, safety evaluation, water and soil conservation, environmental impact evaluation, engineering design, construction supervision, etc., of proposals for expanding and increasing the height of tailings ponds. Those proposals in violation of laws, regulations, standards and policies shall not be approved. It is strictly forbidden to approve the expansion or increasing the height of "overhead ponds" and tailings ponds for which the operating conditions do not match the design. (The National Development and Reform Commission, the Ministry of Natural Resources, the Ministry of Ecology and Environment, the Ministry of Water Resources, and the Ministry of Emergency Management shall guide the process according to the division of responsibilities, and the provincial people's governments shall be responsible for implementation.)

2.3.3 The implementation of responsibilities and the effective management and control of the safety risks of tailings ponds should be strengthened.

2.3.3.1 There should be comprehensive evaluation and control of the safety risks of tailings ponds. For tailings ponds without production and operation units, local people's governments at all levels should conduct an annual safety risk evaluation in accordance with the principle of hierarchical supervision, should study and formulate targeted safety risk control measures, and should clarify the responsible departments and persons responsible for implementing various control measures. Tailings pond enterprises should build a safety risk management and control system with hazard identification, process control, continuous improvement, and full participation. The dynamic evaluation of safety risks of tailings ponds should be strengthened, targeted safety risk management and control measures should be formulated, safety risk management and control plans should be compiled, and there should be clear implementation of the responsible departments and persons responsible for various control measures to ensure the effective implementation of safety risk management and control measures and ensure that tailings ponds safety risks are always kept under control. The water level in the reservoir should be reduced as much as possible and it should be ensured that the main operating parameters such as the length of the dry beach of the tailings reservoir, the safe freeboard, the flood control storage capacity, the depth below the surface of the phreatic line, and the flood drainage system always meet the design requirements. (People's governments at the provincial level are responsible for implementation.)

2.3.3.2 There should be a focus on preventing and resolving the safety risks of "overhead ponds." The local people's governments at all levels should take the "overhead ponds" as the key object for preventing and resolving major risks, and should continue to organize and carry out comprehensive management on the basis of curbing the major accidents that occurred in "overhead ponds" from 2016 to 2018. For "overhead ponds" that meet the conditions for relocating downstream residents, the relocation must be implemented as soon as possible. For those that do not meet the conditions for relocation, it is necessary to organize an evaluation of the effects of comprehensive treatment in the early stages, and check for omissions and address shortcomings in time to ensure safety. For the "overhead ponds" that have been treated with hidden danger management methods in the early stages, but have not improved the intrinsic safety level, enterprises should be urged to further improve the management plan, and the management should be carried out by means of tailings pond closure or upgrading or by the comprehensive utilization of tailings. In principle, the governance tasks will be completed before the end of 2021. Enterprises with "overhead ponds" must conduct a safety risk evaluation on the "overhead pond" every year. Within 1 km downstream of the tailings pond, no new residential areas, industrial and mining enterprises, bazaars, leisure, fitness and entertainment centers and other densely populated places shall be established. If a tailings pond becomes an "overhead pond" due to the construction of roads, railways and other projects, the project construction unit will fund the treatment of the tailings pond. (The National Development and Reform Commission, the Ministry of Finance, and the Ministry of Emergency Management shall guide according to the division of responsibilities, and the provincial people's governments shall be responsible for implementation.)

2.3.3.3 Tailings pond safety risk monitoring and early warning mechanisms should be established and improved. Tailings pond enterprises should establish and improve online safety monitoring systems and ensure their effective operation. By the end of June 2022, wet tailings ponds should have in place online monitoring of dam body displacement, phreatic surface, reservoir water level, etc., as well as video surveillance of important components, and dry tailings ponds should have in place online monitoring of dam surface displacement. Local emergency management departments at all levels should establish and improve tailings pond safety risk monitoring and early warning information platforms for interconnection with the online safety monitoring systems of the tailings ponds enterprises. All provinces (autonomous regions, municipalities directly under the Central Government) should have tailings pond safety risk-related information connected to the national disaster risk comprehensive monitoring and early warning information platform. The emergency management department should take the lead in establishing a major safety risk consultation and judgment mechanism with relevant departments. For extreme weather such as typhoons, heavy rains, and continuous rainfall, a reliable early warning information release system should be established to issue early warning information to enterprises in a timely manner and supervise emergency preparedness. (The Ministry of Emergency Management should take the lead in guiding, and the provincial people's governments are responsible for implementation.)

2.3.3.4. There should be improvement of the emergency management mechanisms for tailings ponds. Tailings pond enterprises should effectively improve special emergency plans, environmental emergency plans, and on-site disposal plans for accidents such as dam breaks, flooding, and damage to flood drainage facilities, and announce them to professionals and downstream residents, and establish emergency alarm systems in downstream residential areas. There should be necessary emergency rescue equipment and supplies to ensure reliable and unimpeded access to the dam road, as well as communication, power supply and lighting. There should be strict implementation of a system of emergency duty shifts, as well as special inspection and accident information reporting to ensure that, in the event of a dangerous situation, the emergency plan is immediately activated and reported quickly. Local people's governments at all levels should further improve emergency plans and strengthen the reasonable connection with enterprise emergency plans, and should regularly coordinate with tailings pond enterprises to carry out joint emergency drills with relevant government departments, township (town) governments, and downstream residents to effectively enhance emergency response capabilities.

The national comprehensive fire rescue team and production safety emergency rescue team should include tailings pond accident rescue into their scope of key fortifications. They should strengthen targeted training and equipment allocation, and improve professional rescue capabilities. In the event of a tailings pond production safety accident such as a dam break or flooding, the emergency management department should promptly report the accident information to the relevant departments, and the departments and units involved in the accident rescue should obey the unified command, strengthen coordination and linkage, and take effective emergency rescue measures to prevent the expansion of accidents and the occurrence of secondary disasters in order to reduce casualties and property losses. Necessary measures shall be taken during the accident rescue process to avoid or reduce the harm to the environment. (The Ministry of Natural Resources, the Ministry of Ecology and Environment, and the Ministry of Emergency Management shall guide according to the division of responsibilities, and the provincial people's governments shall be responsible for implementation.)

2.3.4 Comprehensive measures should be strengthened in order to effectively reduce the tailings inventory.

2.3.4.1 The management of closed tailings ponds and their comprehensive land management should be strengthened. The people's governments at the provincial level shall organize and formulate management measures for the closure of tailings ponds. For tailings ponds that have been closed and treated, the local people's governments at or above the county level must announce the implementation of the cancellation number, and they shall not be used as tailings ponds and shall not be reused for tailings discharge. Tailings ponds that have been operated to the final design elevation or no longer carry out tailing operations, tailings ponds that have been out of service for more than 3 years, and tailings ponds that have no production and operation units must be closed within one year. If the closure of the tailings cannot be completed on time due to special circumstances, the extension shall be reported to the corresponding emergency management department for approval, but the extension period shall not exceed 6 months. (The Ministry of Emergency Management shall take the lead in guiding, and the provincial people's governments are responsible for implementation.)

Tailings pond enterprises must strictly implement the requirements of the prepared land reclamation plan, and apply in a timely manner for approval to the natural resources department where the project is located. If other projects are constructed using the land of the tailings dam after the closure of the pond, the project construction unit must report to the relevant department for approval in accordance with the relevant regulations, and go through the relevant land use procedures in accordance with the laws and regulations. (The National Development and Reform Commission, the Ministry of Natural Resources, the Ministry of Ecology and Environment, and the Ministry of Emergency Management shall guide according to the division of responsibilities, and the provincial people's governments shall be responsible for implementation.)

2.3.4.2 The comprehensive utilization of tailings resources should be steadily promoted. There should be an increase in policy guidance and support, the active promotion of advanced and applicable technologies for the comprehensive utilization of tailings, such as tailings remining to extract valuable commodities, the use of tailings to produce building materials and fill exhausted mine workings, and the encouragement of tailings pond enterprises to reduce waste through the comprehensive utilization of tailings. Tailings pond enterprises should be encouraged to reduce tailings stockpiles and even eliminate tailings ponds through the comprehensive utilization of tailings, so as to eliminate tailings pond safety risks at the source. A number of typical demonstration projects for the comprehensive utilization of tailings should be constructed, and a number of demonstration centers for the comprehensive utilization of tailings should be constructed in areas where tailings generation and stockpiling are concentrated. The tailings recovery and reuse project must meet the safety requirements and be implemented in strict accordance with the reviewed and approved mining design to ensure safety. For the reuse of mineral resources in tailings ponds, tailings ponds with production and operation units shall be implemented by mining right holders, and tailings ponds without production and operation units shall be organized and implemented by management departments designated by county-level people's governments. (The National Development and Reform Commission, the Ministry of Industry and Information Technology, the Ministry of Natural Resources, and the Ministry of Emergency Management shall guide according to the division of responsibilities, and the provincial people's governments are responsible for implementation.)

2.3.5 Law enforcement inspections should be strengthened with severe crack down on violations of laws and regulations.

2.3.5.1 Key points should be highlighted and the law should be strictly supervised and enforced. Tailings ponds should be incorporated into the annual supervision and inspection plan for safe production and law enforcement inspections should be implemented with a focus on "overhead ponds" and out-of-use ponds. There should be a focus on major hidden dangers and an increase in special law enforcement. There should be an increase in the frequency and intensity of law enforcement inspections of tailings ponds during flood seasons and other key periods to ensure that various flood control measures are in place. Provinces (autonomous regions and municipalities directly under the central government) in the Yangtze River and Yellow River basins must attach great importance to the supervision of the safety of tailings ponds in the Yangtze River and Yellow River basins, and must strengthen the supervision of law enforcement inspection of the implementation of safety risk management and control measures for tailings pond enterprises, effectively preventing production safety accidents. (The Ministry of Emergency Management shall take the lead in guiding and the provincial people's governments are responsible for implementation.)

2.3.5.2 There shall be a severe crack down on violations of laws and regulations in safe production, such as construction without approval, malicious evasion of approval, construction not in accordance with the approved design, unauthorized raising of the height of the dam body, unauthorized change of dam construction method, failure to follow approval procedures for major changes, and unauthorized start-up of tailings ponds for more than 6 months. Tailings pond enterprises that have violated laws and regulations in safe production shall be subject to law enforcement measures such as revocation of licenses, suspension of production until rectification, closure and banning, and the strict pursuit of accountability in accordance with laws and regulations, so as to strictly prevent tailings pond production safety accidents caused by violations of laws and regulations. (The Ministry of Emergency Management shall take the lead in guiding and the provincial people's governments are responsible for the implementation.)

2.3.5.3 There shall be a severe crack down on violations of laws and regulations in areas such as ecological and environmental protection. For tailings ponds that have not obtained legal procedures for project approval, environmental protection, safe production, water and soil conservation, and land use, as well as tailings ponds that illegally occupy river courses, the county-level people's government will organize and ban them according to law. Those who fail to submit environmental impact evaluation documents for approval in accordance with the law shall be ordered to stop construction and be punished according to law. In the process of project construction and operation, if there is a situation that does not comply with the original administrative licensing documents, the construction unit shall organize demonstrations, carry out improvement measures, and report to the original examination and approval department for approval or filing according to law. Those who fail to report or submit request for approval shall be punished according to law. There shall be a severe crack down on illegal discharge of tailings into reservoirs, rivers, lakes, etc. (The National Development and Reform Commission, the Ministry of Natural Resources, the Ministry of Ecology and Environment, the Ministry of Water Resources, and the Ministry of Emergency Management shall guide according to the division of responsibilities, and the provincial people's governments shall be responsible for implementation.)

2.4 Work Requirements

2.4.1 There should be a strengthening of organizational leadership. All provincial people's governments are accountable for the overall responsibility for the prevention and resolution of tailings pond safety risks in their regions. They must strictly implement responsibilities, strengthen overall planning and coordination, carefully organize arrangements, break down and refine work tasks to specific departments, and supervise relevant departments and cities and counties. People's governments at all levels should do an exemplary job in carrying out the preceding responsibilities. The Ministry of Emergency Management shall take the lead in promoting the prevention and resolution of tailings pond safety risks. The National Development and Reform Commission, the Ministry of Industry and Information Technology, the Ministry of Finance, the Ministry of Natural Resources, the Ministry of Ecology and Environment, the Ministry of Water Resources, and the Meteorological Administration shall cooperate closely according to the division of responsibilities to act as a joint force.

2.4.2 There should be extensive publicity and guidance. Full use should be made of public opinion publicity channels to increase the publicity of knowledge on preventing and resolving tailings pond safety risks. In particular, employees of "overhead pond" enterprises and surrounding residents should be organized to watch tailings pond production safety accident warning education films, and the awareness of employees and surrounding residents should be strengthened. Employees and surrounding residents should have risk awareness, should understand risk knowledge, and should reach consensus on preventing and resolving safety risks of tailings ponds. Timely exposure of illegal enterprises and typical cases will create a good environment for public opinion and guide the formation of a working situation where the whole society works together.

2.4.3 There should be an increase in capital investment. Tailings pond enterprises must increase investment in safety to ensure the effective implementation of safety risk management and control measures. Local people's governments at all levels should take tailings ponds as an important part of disaster risk investigation and key hidden danger investigation projects, arrange financial support and guide tailings pond enterprises to prevent and resolve safety risks, and especially to increase the relocation of downstream residents by "overhead pond" enterprises. There should be support for the comprehensive utilization of tailings. For places where the governance of "overhead ponds" has achieved remarkable results, the relevant departments of the State Council will study and provide necessary support.

2.4.4 There should be a strengthening of supervision and evaluation. The Safety Committee of the State Council will include the prevention and resolution of tailings pond safety risks into the content of the work safety and fire protection work evaluation of the provincial people's governments, and the local people's governments at all levels should also include this work in the safe production and fire protection work of the people's governments at lower levels. The content of the evaluation is to ensure that various work tasks are implemented and completed on schedule and those who fail to implement the work must be strictly held accountable in accordance with laws and regulations. It is necessary to strengthen public participation, improve the reporting and reward system, unblock reporting channels, and encourage the public to supervise the implementation of measures to prevent and resolve tailings pond safety risks.