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WATERCOURSES AND INTERNATIONAL LAKES**

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**SAFETY GUIDELINES AND GOOD PRACTICES FOR TAILINGS MANAGEMENT
FACILITIES**

Note by the Joint Expert Group on Water and Industrial Accidents

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I. MANDATE

1. The Conference of the Parties to the Convention on the Transboundary Effects of Industrial Accidents and the Meeting of the Parties to the Convention on the Protection and Use of Transboundary Watercourses and International Lakes mandated the Joint Expert Group on Water and Industrial Accidents to draw up safety guidelines and a summary of good practice for tailings management facilities¹. This mandate is reflected in the Conventions' workplan for the Joint Expert Group on Water and Industrial Accidents (ECE/CP.TEIA/2006/9 and ECE/MP.WAT/2006/7 section III, paragraph 15) that was adopted by the governing bodies of both Conventions at their respective meetings (Rome, 15–17 November 2006, and Bonn, Germany, 20–22 November 2006).

2. Authorities, TMF operators and the public are invited to apply these guideline and good practices, which are intended to contribute to limiting the number of accidents at tailings management facilities and the severity of their consequences for human health and the environment.

II. INTRODUCTION

3. There is a growing body of evidence and understanding that environmental degradation of transboundary watercourses and/or international lakes can be caused by unintended large-scale transboundary movement of hazardous materials as a result of tailings management facility (TMF) failures.

4. Such failures from TMFs have contributed to transboundary pollution via mass movement of wastes (generally tailings containing heavy metals and hazardous and/or toxic compounds) as suspended solids and dissolved materials.

5. Pollution of such waterways and related damage or risk to human health, infrastructure

¹ In this guidelines, a **tailings management facility** (TMF) is intended to encompass the whole set of structures required for the handling of tailings including the tailings storage facility (TSF), tailings dam(s), tailings impoundment, clarification ponds, delivery pipelines, etc., where:

Tailings are the fine-grained waste material remaining after the metals and minerals recoverable with the technical processes applied have been extracted. The material is rejected at the “tail end” of the process with a particle size normally ranging from 10 µm to 1.0 mm.

A **TSF** is a facility used to contain tailings. This can include a tailings dam (impoundment and pond), decant structures and spillways. A TSF can also be open pits, dry stacking, lakes or underground storages

A **tailings dam** is a tailings embankment or a tailings disposal dam. The term “tailings dam” encompasses embankments, dam walls or other impounding structures, designed to enable the tailings to settle and to retain tailings and process water, which are constructed in a controlled manner.

A **tailings impoundment** is the storage space/volume created by the tailings dam or dams where tailings are deposited and stored. The boundaries of the impoundment are given by the tailings dams and/or natural boundaries.

and environmental resources has the potential to negatively affect relations between neighbouring countries.

6. Such risks are posed by TMFs in all categories: active, idle/inactive, neglected, temporarily or permanently closed, abandoned or orphaned. There is particular concern regarding the large number of neglected, abandoned or orphaned TMFs where active monitoring or maintenance is not undertaken.

7. A TMF represents a large capital investment and an integral part of mining and mineral processing activities. Its proper operation is a key factor in the overall successful operation of a mining project and its industrial processes.

8. The overall importance of TMFs to both the economic viability and social and environmental acceptability of any mining enterprise are often underestimated. Due to the fact that there is no direct financial return from the cost of design, construction, operation and rehabilitation of the tailings storage facility, it may be tempting to assign insufficient managerial and financial resources to the design, operation, management and/or closure of tailings dams.

9. Assigning low priority to the safety of TMFs has been shown to be a seriously flawed approach, as neglect of tailings dams has often been shown to be a major or significant contributing factor in the poor international record of tailings dam failures and incidents.

10. As accidents such as the tailings spill accident at Baia Mare (Romania, January 2000) have shown, failures and incidents at TMFs can have far-reaching consequences for the environment and environmental services to human health and to the social acceptance of mining activities.

11. Such failures and incidents can lead to significant costs for a company for items such as emergency response, clean-up and repairs, disruption of operation, damages claims, law suits, unscheduled closure works and the loss of company's share value. As such, accident costs almost universally exceed the resulting costs for a company to have ensured proper and adequate levels of safety and control in order to prevent the incident.

12. The failure of a tailings dam in any part of the world now has the potential to rapidly impact the social acceptance and regulatory frameworks for all other operations of the company concerned and also for the mining industry in general. Industry reputation is an important prerequisite for the promotion of mining within national development strategies. Negative impacts of such industrial accidents can be severely exacerbated when transboundary effects are involved.

13. Such damage to industry reputation and national development strategies is a recurring theme in international circles and is exemplified by the increased awareness being raised throughout the world by the European Commission (through its Mine Waste Directive), the United Nations Environment Programme (UNEP), the International Council on Metals and Mining (ICMM), the Mining, Minerals, and Sustainable Development (MMSD) Project, the

World Mines Ministries Forum (WMMF), the World Wildlife Fund (WWF) and the World Summit on Sustainable Development (2002). Such organizations are urging the mining and industrial sectors towards safe, sustainable development, which places a high priority on increased safety of tailings dams.

14. Such organizations also recognize the economic importance of the extractive industries to both national and local economies, including economies at all stages of development. Moreover, it is recognized that mining may constitute a first significant channel of foreign direct investment in some host countries and that in such instances the industry can serve a central role as a foundation for economic and social development.

15. The operation phase for a TMF can last many decades. Both mining and minerals processing are under constant evolution. Practices vis-à-vis design, operation and maintenance – as well as to regulation – of TMFs may evolve significantly during the life of a TMF.

16. Experience regarding the long-term behaviour and stability of TMFs after closure is still limited. In the context of tailings dams, long term is defined as 1,000 years, or more. While knowledge is constantly increasing, the majority of tailings dams closed and remediated to date (2007) were closed less than one or two decades ago. As such, practice can be expected to continually evolve.

17. The potential for both chronic pollution and acute risk associated with mine tailings deposits can be very long term. A significant number of examples exist where the remains of tailings and waste from mining operations conducted several centuries or even millennia ago still produce pollution in amounts that are harmful to the environment. This emphasizes the importance of proper operation and closure of today's tailings dams and waste dumps if unacceptable risks or negative impacts are to be avoided in the future.

18. It is recognized that many jurisdictions lack relevant regulations regarding issues related to abandoned and orphaned sites.

19. In recognition of the above, a substantial body of work has been performed by the global mining industry, geotechnical and related geotechnical sciences, international dam safety organizations, intergovernmental agencies and others – to generate guidelines for the building and operation of safe TMFs and their subcomponents – in particular, tailings dams.

20. In recognition of all of the above, in the context of the risk of accidents contributing to transboundary pollution affecting watercourses and international lakes, and to assist the national authorities and the operators in ensuring an adequate safety level at TMFs and an acceptable level of risk posed by such facilities, the UNECE member countries decided to draw up safety guidelines and good practices for tailings dams. These take the form of a set of recommendations that will contribute to the achievement of a basic level of safety for tailings dams.

21. The Joint Expert Group on Water and Industrial Accidents, through the established steering group with recognized expertise on tailings dams and transboundary accidents, drew up

the guidelines. It took into account input from authorities, operators of TMFs, financing institutions and non-governmental organizations (NGOs) during the workshop on safety of tailings dams held from 12 to 14 November 2007 in Yerevan.

22. The established steering group has based the guidelines directly upon the body of work produced by the global community of dam safety scientists, professional bodies and inter-governmental agencies. Notable among these is work by the European Commission, the International Commission on Large Dams (ICOLD), UNEP, ICMM and others. Regulating bodies such as the European Commission have also produced directives and regulations that influence TMF design and operation, and major financing bodies have developed safety assurance and design guidelines for their investments. Finally, a number of international instruments and guidelines on industrial accidents, chemicals management, environment impact assessment and public information on environmental risk are pertinent to the design and operation of TMFs.

23. The following are the recommendations and the key elements of UNECE guidelines and good practices for TMFs designed to prevent incidents at TMFs, with a key focus on tailings dams, and to limit the potential for negative impacts on environment, human health and infrastructure. They are based extensively on accepted and published good practice procedures to ensure conformity with international standards. Security concerns (e.g. sabotage, antagonistic actions.) and workers' safety are not within the scope of these guidelines; nevertheless, these are the concerns that should also be taken into account at all stages of the life cycle of TMFs.

III. PRINCIPLES FOR TAILINGS MANAGEMENT FACILITIES' SAFETY

24. Governments should provide leadership and create minimum administrative frameworks to facilitate the development, safe operation and decommissioning of TMFs.

25. The operators of TMFs have the primary responsibility for ensuring safety of TMFs and for formulating and applying safety management procedures, as well as for utilizing technology and management systems to improve safety and reduce risks.

26. Within the general scope of the relevant guidelines and good practice principles TMFs should be planned, constructed, operated and closed applying a case-by-case or site-by-site approach, as a result of varying climate and hydrology, topography, geology, tailings properties and other conditions.

27. Only competent – properly certified (in accordance with the national legislative, regulatory and safety management norms) – personnel should be engaged in the planning, design, construction, operation/management and closure of TMFs and the relevant competences should be described in the operation and management plan (see para. 57).

28. A systematic approach to managing TMF safety should be acknowledged by all stakeholders, and the high-quality life-cycle “planning – construction – operation – closure –

rehabilitation” approach should be ensured in all cases.

29. Understanding of processes in the life cycle of a TMF should be developed at the planning and design stage of the TMF, and should be further refined through practice and simulations.

30. The safety of TMFs depends especially on the individuals responsible for TMF planning and design (and approval), construction companies, operators, government and commercial inspectors, rescue services and professionals in closure and rehabilitation. Therefore, such persons should be adequately trained and qualified as well as certified when required.

31. TMFs should be operated in accordance with the construction, safety and environmental norms of the country concerned, taking into account internationally established best practice, and on the basis of an operating and management plan (operation manual) evaluated and accepted by the relevant competent authority, as appropriate.

32. TMFs should be classified based on a risk assessment taking into account parameters as specified in the annex to these guidelines.

33. Land-use planning, hydrological and geological considerations should be taken into account when evaluating optimum TMF placing and intended post-operational use.

34. For TMFs which pose a potential risk to neighbouring communities and land-uses due to their size or presence of hazardous materials, information to and involvement of these communities and individuals, in accordance also with internationally recognized procedures, should be ensured for the purpose of drawing up an emergency plan that the community understands.

35. Projects for TMF construction which have the potential to cause adverse environmental impacts across borders should be notified and consulted between Governments of neighbouring countries and the UNECE Espoo Convention and its provision to perform an environmental impact assessment should be applied.

36. TMFs should be operated in accordance with the provisions of the UNECE Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters (Aarhus Convention). Where the subject of concern is of transboundary nature, the principles of the Almaty Guidelines on Promoting the Application of the Principles of the Aarhus Convention in International Forums (<http://www.unece.org/env/pp/ppif.htm>) should apply.

IV. RECOMMENDATIONS

37. These guidelines constitute a minimum set of requirements to ensure a basic level of safety for TMFs. They highlight aspects to be considered to achieve an acceptable level of safety through applying different policies, measures and methodologies. Nevertheless, owners and

operators are encouraged to apply additional procedures and safeguards in accordance with local assessments to achieve the highest practical level of performance of their TMF.

38. These guidelines should also be applied in the context of relevant national requirements and existing international guidelines, recommendations and standards concerning TMFs, and using internationally accessible information sources.

39. Below are recommendations to the UNECE member countries, competent authorities and TMF operators. The technical and organizational aspects, listed in the annex, are an integral part of these guidelines and good practices.

A. Recommendations to UNECE member countries

40. UNECE member countries should identify competent authorities at the national, subnational and local levels that are given access to the necessary human resources and professional competences for the tasks foreseen in these recommendations.

41. UNECE member countries should adopt and enforce adequate legislation for ensuring the safe construction, operation, maintenance and closure of TMFs, including legislation for handling abandoned and orphaned sites from past activities. They should also make appropriate institutional arrangements, through, inter alia, the establishment of a coordinating mechanism comprising key players concerned.

42. UNECE member countries should ensure that if not done so, national inventories of operational as well as closed, abandoned or orphaned TMFs that may constitute a risk to human health or the environment are elaborated and maintained. National inventories of closed, abandoned or orphaned TMFs should consider both current impacts and risks for future negative effects (accidents and spills).

43. UNECE member countries should share experience and information on good practice for TMF safety in all the phases of its life cycle on a regular basis.

B. Recommendations to competent authorities

44. Competent authorities should ensure that all relevant authorities involved in TMF safety should cooperate with each other, preferably within an integrated system in which one authority plays a coordinating role.

45. Competent authorities should notify their counterparts in neighbouring countries about the TMFs which in the event of an accident could cause transboundary effects.

46. Competent authorities should introduce authorization and/or a licensing procedure to permit the construction of a TMF.

47. Competent authorities should evaluate and approve the design, operations and

management plans (operation manual) drawn up by operators.

48. Competent authorities should verify and endorse the TMF monitoring performed by the operator (or his agent) so that it fulfils set quality standards.
49. Competent authorities should ensure that TMF operators develop internal emergency plans for TMFs with significant risks and that they provide necessary information to the public and to relevant authorities, and cooperate with relevant authorities on preparing external plans.
50. For TMFs with significant risks to outside communities, relevant authorities shall develop external emergency plans in association with operators, community groups, local authorities and rescue services, and apply these plans off-site in the event of accidents (see, for example the APELL process discussed in the annex).
51. Competent authorities should ensure that the internal and external emergency plans are reviewed and tested periodically and, where necessary, revised and updated.
52. Competent authorities should apply methodologies for risk identification and assessment of closed, abandoned or orphaned TMFs using a step-by-step approach, starting with a basic screening of sites, whereby resources are gradually directed towards sites with the highest risk.
53. Based on the risks identified, competent authorities should make plans for risk reduction measures and/or monitoring (early warning) for closed, abandoned or orphaned TMFs.
54. Competent authorities should ensure (i.e. organize or arrange) training of inspectors on an ongoing basis so that the inspections are performed effectively. In addition, non-mining professionals dealing with environmental impact assessment and land-use planning for mining projects should be trained on tailings issues.
55. Competent authorities should encourage and engage in a “train the trainers” programme at existing educational institutions, so that trainers attain the necessary capacity for training company and government staff. Where possible, use can be made of international training programmes offered by various national and United Nations institutions.
56. Competent authorities should ensure meaningful public participation and easy access to information in accordance with the relevant provisions of the Convention on the Transboundary Effects of Industrial Accidents, the Convention on the Protection and Use of Transboundary Watercourses and International Lakes and in particular the Aarhus Convention (see para. 36).

C. Recommendations to tailings management facility operators

57. All TMFs should have an operation and management plan (operating manual) that is available to all personnel, local inhabitants, government inspectors and other relevant stakeholders. All documents relating to planning, design and construction should be maintained

in an accessible way, with records kept permanently for future reference.

58. TMF operators should monitor the TMF in accordance with the operation and management plan as approved by the competent authorities.
59. TMF operators should draw up and implement internal emergency plans and apply them on-site whenever a tangible risk for major accidents to occur has been identified or an uncontrolled event occurs that could lead to a major accident or a major accident has occurred. TMF operators should review, test, revise and update the internal emergency plans periodically, and always when there has been a change in the mine operation and management.
60. The TMF operator should notify competent authorities in the event of emergencies that have occurred on the site.
61. TMF operators should cooperate with competent authorities and local communities in preparing external emergency plans.
62. TMF operators should train their personnel and reinforce and revise personnel's knowledge on safety, in particular on how to identify potentially harmful events and/or circumstances.
63. TMF operators should implement safety audits for their facilities and promote the use of environmental management systems based on international standards.

Annex

TECHNICAL AND ORGANIZATIONAL ASPECTS

I. PRE-CONSTRUCTION AND CONSTRUCTION

A. Licensing

1. There should be a system of licenses dependent on the risk assessment for the TMF. The assessment should be done by the operator and evaluated by competent authorities. The risk assessment will be done on the basis of the operation and management plan (operating manual) drawn up by the operator. (More information can be found below in section C on hazard identification and risk assessment.)
2. The licensing procedure should differentiate between:
 - (a) Basic authorization procedure;
 - (b) Authorizations involving public participation;
 - (c) Authorizations involving environmental impact assessment and public participation.
3. The complex procedure (c) should be applied for TMFs where:
 - (a) The waste facility contains waste considered hazardous (recommended classification and threshold quantities under EU Directive 91/689/EEC); or
 - (b) The waste facility contains substances and preparations classified as dangerous (recommended classification and threshold quantities EU Directive 67/548/EEC or 1999/45/EC); or
 - (c) A failure or incorrect operation can give rise to a major accident.

B. Environmental impact assessment and land-use planning

4. An environmental impact assessment (EIA) should be considered as a precondition for construction and operation of a TMF (see the recommendations above in the section on licensing). The EIA should address the potential physical impact of the TMF on the environment and should be open for general public and interested or affected persons to comment and provide input on the assessment and if there are prerequisites to object it.
5. The EIA should address:
 - (a) Location criteria: climate, general topography, regional geology, seismic hazard, environmental sensitivity, hydrology (ground and surface waters), local geomorphology;

- (b) Tailings criteria: geochemical character of the tailings, physical and geotechnical character of TMF;
- (c) Site criteria: downstream infrastructure, cadastral boundaries, potential underlying mineralization, site topography, hydrogeology;
- (d) Management: tailings deposition method, water balance, method for managing storm events, monitoring;
- (e) Closure: completion criteria, intended post-operational land use, long term physical, geotechnical and biological stability, as well as ecosystem rehabilitation, if appropriate;
- (f) Evaluation of “O” solution/non implementation of the project.

C. Hazard identification and risk assessment

6. Before licensing the construction of a TMF a risk assessment should be performed. There are different ways to conduct a risk assessment and standard procedures are described in literature. To a lesser or greater extent they all include the five steps outlined below. These steps need to be taken by the applicant and the results should be evaluated by competent authorities. The process involves here also a sixth step, which is an evaluation of acceptability of risks.

Step 1 – Hazard identification

7. The applicant needs to evaluate possible hazards such as:
- (a) Toxicity and eco-toxicity of tailings material;
 - (b) Hazards to the aquatic environment arising from other than toxic effects of tailings material (pH, COD, salinity, dispersed material);
 - (c) Flood hazards due to the free liquid in tailings dam;
 - (d) Physical/mechanical hazards due to the movement of solid material (slurry transport and/or liquefaction phenomena) in the event of an accident;
 - (e) Hazards resulting from soil contamination by tailings/sludge.
8. The hazards identified will decide the level of ambition needed in the further assessment.

Step 2 – Accident scenarios

9. The applicant should describe scenarios of possible failure modes and identify what could cause them. The scenarios need to consider: (a) possible extreme events at the TMF location (e.g. rain and snowfall, snowmelt, earthquakes, landslides, avalanches); (b) failures of already built structures (e.g. other dams) situated upstream, whose failure could cause domino effects; and (c) causes related to the TMF management and control including human error.

10. During scenario description, records of accidents and near-misses at similar TMFs should be considered. No plausible scenario should be excluded.

Step 3 – Identification of potential receptors

11. In this step the applicant needs to identify who and what can be affected assuming possible scenarios (failures). Aspects for consideration relate to environment (water, soil, and biota), humans (life, health and living conditions), economical losses of population (damage to infrastructure, property). Special attention should be directed to scenarios that can cause damage in a transboundary context.

Step 4 – Safety measures

12. The applicant needs to describe safety measures aimed primarily at the prevention of potential scenarios (causes of failures) as identified in step 2. Secondly, measures aimed at limiting the consequences/impact, should a failure still happen, should be described. The latter will include measures for preparedness (warning, alert and alarm systems) and emergency response plans. Cooperation between TMF operators, competent authorities and local authorities (the community) is recommended for emergency planning.

Step 5 – Impact assessment

13. The applicant needs to assess the impact/effects of possible scenarios on the potential receptors as identified in step 3. In doing so the safety measures proposed under step 4 should be considered and an evaluation should be made as to how they limit the potential impact/effects.

Step 6 – Risk assessment and evaluation

14. Finally, the applicant should also assess the probability of principal scenarios (potential failures) as described in step 2, taking into account the proposed safety measures and their reliability. In doing so, site specific or generic data should be considered and in the event of the lack of such data, expert judgement should be applied. In some cases it will be possible to quantify the probability, e.g. return periods for flood events; in other cases, it will only be possible to discuss low and high probabilities in general terms. The resulting risks are a combination of the probability that a certain scenario will take place and the potential impact if it does. The different scenarios (failure modes) studied can be presented in a matrix with probability on one axis and impact on the other.

15. In this step, the applicant should also make a judgement if the risks related to the different scenarios are to be considered acceptable. Such acceptability assessments will distinguish risks potentially ranging from low probability and low impact to high probability and high impact. It is useful to make a division into three classes of risk: green – acceptable; yellow – conditionally acceptable; and red – unacceptable.

16. If all the risks associated with the planned TMF are deemed acceptable (i.e. fall into the green class of risk) the applicant can go ahead with his application, including the safety measures proposed in step 4 or otherwise. In other cases, stricter design and operational criteria, more frequent monitoring and/or other risk reduction measures should be evaluated and proposed as relevant. If there are no economically feasible or technically available measures to reduce the risk to an acceptable level, the logical result should be an objection to the construction of the TMF. Under such circumstances, an alternative location for the TMF may be a feasible solution.

17. The final decision about the acceptability of risks will be part of the licensing procedure and should involve competent authorities and other stakeholders (e.g. involved community representatives, the public etc.)

D. Dam safety

18. While planning and designing a safe TMF, particular attention should be directed to:

- (a) The tailings pond – the following parameters need to be assessed accurately:
 - (i) The stability of tailings (or other deposited material such as water treatment sludge);
 - (ii) Geological situation;
 - (iii) Hydrogeological situation;
 - (iv) Hydrological situation;
 - (v) Geophysical situation.
- (b) The tailings dam – the following parameters need to be assessed accurately:
 - (i) The slope stability of the dam;
 - (ii) The strength and stability of the foundation for the dam;
 - (iii) The stability of the tailing material (induced liquefaction);
 - (iv) Erosion to the dam (suffusion and outside erosion);
 - (v) Water recovery systems;
 - (vi) Emergency spillways;
 - (vii) Slope sliding;
 - (viii) The tailings delivery system to and on/around the TMF
 - a. Safety;
 - b. Environmental protection.

19. The dam-raising method should be chosen with regard to the local conditions (e.g. seismicity, tailings composition, severe climate). Special attention has to be given to quality control and site supervision during the starter works construction phase of the TMF.

20. Additional impoundments should be designed to receive inflow from emergency outlets.

21. Hazardous substances and process water should be reused as far as technically possible

(recycling) and in case it is not possible to recycle hazardous substances, they should be neutralized before they are discharged into the TMF.

II. OPERATION AND MANAGEMENT

A. Management

22. The TMF should be operated and managed on the basis of an operation and management plan (operation manual) and waste management plan (if such is not part of the operation manual) evaluated and approved by the competent authorities, which is developed in the planning phase and progressively modified. Its aim is to effectively manage the risks and hazards at the TMF (or waste facility) in order to stay within the risk green class (see risk classification the previous chapter's section C, on hazard identification and risk assessment).

23. The operation manual should contain:

- (a) A description of the tailings delivery system to and on/around the TMF (safety, environmental protection);
- (b) A description of all monitoring procedures –mechanisms for investigations: sampling locations, sampling frequency, checklists and compliance parameters such as: minimum capacity/freeboard, pore pressure, groundwater level, functioning of the drainage system, surface water diversion, dam movement, slope stability;
- (c) Procedures for reporting on non-compliance and failures;
- (d) Corrective actions to be applied in the event of non-compliance;
- (e) Internal emergency plan;
- (f) Assessment parameters for effectiveness and suitability of the operation manual.

24. Any changes to the operation manual should be subject to its performance analysis, which should be documented.

25. The performance of the TMF should be assessed and described during significant seasonal events and the data gathered should be used for rehabilitation planning.

26. In the event of TMF acid rock drainage potential, the management plans should primarily be developed to prevent or reduce the production of acidic drainage, and secondarily to collect and treat the acidic water to meet permit conditions or relevant emission standards.

B. Education and training of personnel

27. The life-cycle approach to TMFs requires that personnel in a variety of different professions and institutions have a common understanding and knowledge of the technical and managerial aspects, and use complementary professional procedures in their work. This complementarity may require a certain level of training (and retraining) of various persons in

different institutions.

28. The personnel concerned should be identified along the “planning-design-construction-operation-decommissioning-rehabilitation” chain.

29. A variety of different professions is involved, including engineers and managers, planners, regulators, environmental and safety specialists, and monitoring and auditing staff. It is important to appreciate the importance of the two-way training – informing mining engineers of issues in environmental and safety management, and conversely, giving environmental personnel the insights needed to deal with TMF issues.

30. The following are among the subjects where adequate skills need to be built through training programmes and on-site experience:

- (a) Technology and future trends in TMF design;
- (b) On-site procedures for safe operation and risk management;
- (c) Standards and regulations on TMF and for safety and environmental performance;
- (d) Managements systems and tools, including corporate social responsibility (CSR);
- (e) Measurements for operational and environmental quality;
- (f) Environment (including basic hydrology) and health issues;
- (g) Safety and environment auditing of the site and its facilities;
- (h) Reporting, both internal and for public information;
- (i) Communication.

31. The inherent uncertainties surrounding all potentially hazardous TMFs require special skills in risk assessment and management, but also in risk communication and reporting.

32. Inspectors will naturally have knowledge of design principles and of the current regulations. However they also need to develop a good understanding of operational and risk management practices for TMFs, as such facilities do not generate a revenue stream for the operating company and may therefore be neglected. More details on training of inspectors can be found in the next section.

33. Where TMFs are located in populated areas, communication and negotiation skills need to be built up to ensure that the public stakeholders are properly informed about (and involved in) decisions relevant to their interests. These interests often centre around social, environmental and economic issues for the local community which must be understood by managers and designers in particular, but also by inspectors and consultants.

34. Numerous avenues are already available for building the necessary broad-based competencies, especially through existing national education institutions and mining schools, nevertheless it is often very useful to first launch a “train the trainers” programme to bring all relevant staff up to a common level of understanding. Looking beyond existing national institutions, a number of online or correspondence courses are becoming available, and various

United Nations agencies have published self-learning manuals and train-the-trainers packages in subjects relevant to TMF management. Increasingly, international institutions and professional conferences also play a valuable role in promoting information exchange and learning. Wherever possible, training should focus on active, hands-on methodologies as the most effective means of training adults.

C. Education and training for inspectors

35. The inspectors should be trained in:

- (a) New technologies;
- (b) Standards and procedures;
- (c) Corporate (environment and safety) management methods and tools, and corporate auditing;
- (d) Monitoring and auditing standards for operations;
- (e) Risk assessment and risk communication;
- (f) Communication with operator personnel and the local community.

36. The training resources should be evaluated and augmented as necessary to provide the complete range of subjects and skills required for life-cycle TMF inspection.

37. The training should include simulations, practice, drills, role play, field exercises and discussing case studies of lessons learned. It should be an ongoing process and not a one-shot affair. Extensive material is available from United Nations agencies to support such events and programmes. Study tours of practices in other countries are also extremely valuable.

38. The training should be spread over time and be subject to reinforcement, revision and follow-up, with refresher courses provided at regular intervals.

III. INSPECTIONS

A. Facility inspections

39. Facility inspections should be performed by competent authorities at all phases of the life cycle of the TMF and should ensure that TMF operators are taking all the necessary steps to manage the safety of a TMF without posing any risk to the environment or human health. The inspectors should verify in particular if the TMF is managed in accordance with the legal and regulatory standards, as well as with the approved operation manual and waste management plan:

- (a) *During the pre-construction and construction phase*: verification of the location for the waste facility; verification of assumed factors affecting design in the field; construction of the tailings dam;

(b) *During the operation phase:* verification that the physical stability of the waste facility is ensured and that pollution or contamination of soil, air, surface water or groundwater are prevented; verification of regular monitoring of immission and emission measurements; verification if failures were properly reported and proper corrective action were taken;

(c) *During closure and after closure:* verification that the physical stability of the waste facility is ensured; verification of the rehabilitation process, including its proper documentation;

40. If the management of the TMF does not follow the operation manual and/or waste management plan, the inspection authority should urge the operator to introduce corrective actions within a specified period, and if this is not done, to take back the operation permit.

IV. IDENTIFICATION, ASSESSMENT AND MANAGEMENT OF ABANDONED SITES

A. Assessment and priority tasks on abandoned sites

41. The abandoned or orphaned sites should be regularly inspected by competent authorities depending on the risk posed by the site as assessed in the initial screening.

42. The initial screening should include a walkover survey concentrating on TMF features such as the containment dam, the beach, the water management system and the hydrographic catchment area as well as vulnerability factors of nearby or downstream communities and land-use, and any important natural areas requiring special protection.

43. Public access to sites which present significant risks to persons and animals should be restricted.

44. The components, structures and parameters specifically considered for inspection and screening in the event of any signs of unusual behaviour should include the following:

- (a) Geomorphological situation and catchment area (inflowing streams, size and topography of TMF catchment area, expected frequency and magnitude of flood events);
- (b) Dam crest (materials used, irregularities, depressions, signs of erosion);
- (c) Slope geometry (height, angle, berms);
- (d) Containment dam slope condition (materials, vegetation, signs of erosion, seepages, slumping, active mass movements such as slumping, sliding or rotational failures);
- (e) Lagoon condition (size relative to TMF, depth, geometry, vegetation, alien deposits such as litter);
- (f) Water management system (existence and condition of drainages, bypasses, decantation plant, contingency/emergency spillways, pumps);
- (g) Monitoring equipment (inter alia trigonometric points, survey targets, piezometers/standpipes)

(h) Historic incidents and accidents.

45. Depending on the result of the screening, the sites should be labelled from green to red classes of risk (“low risk”, “intermediate risk”, “high risk”)

46. Sites should be prioritized for a further detailed assessment based on the initial risk assessment. This assessment should lead to the development of a risk management strategy, which in some cases may be limited to monitoring, while other sites may require immediate action due to a non negligible probability of failure in the short term. The detailed assessment should include:

(a) Research on existing documentation;
(b) Detailed site surveys;
(c) Potential spot investigations;
(d) Calculations “back of the envelope” on probabilities of identified specific failure modes.

47. Starting with the highest risk sites, all risk sites should undergo appropriate investigation and data generation measures (e.g. topographical surveys). For each of them specific risk management programmes should be designed, tendered and contracted within a reasonable time frame. These risk management programmes will in some cases include plans for a full site remediation, while in other cases monitoring will be sufficient. Programmes can be divided in phases where the more acute risks are dealt with in the short term, and site remediation may come at a later stage.

B. Management of abandoned sites

48. The competent authorities should make an attempt to locate responsible party (former operator, landowner) for abandoned or orphaned sites and force them through legal actions to properly manage the site. In the event of long legal processes, the competent authorities should take required actions to prevent any disasters.

49. The management system for abandoned or orphaned sites should include the organizational structure, responsibilities, procedures and resources for determining and implementing the accident prevention policy:

(a) *Organizational structure*: competent authorities should be nominated to carry out the assessment and monitoring of abandoned or orphaned sites. They should be allocated adequate staff, technical means and budget to accomplish its mandate;

(b) *Identification and evaluation of hazards*: closed, abandoned or orphaned sites should be known and catalogued in an inventory containing their location and key characteristic and they should be labelled accordingly;

(c) *Monitoring and maintenance*: the sites should be monitored and maintained and remediation should be undertaken in the first place at those sites, where failures are likely or very likely to happen.

50. Removing or reengineering of sites will in most cases be very costly and should only be undertaken where appropriate risk reduction measures fail.

Note: Further guidance in dealing with abandoned sites, including the administrative machinery needed to address the management of such sites, can be found in the United Nations publication, *Identification and Management of Contaminated Sites – a methodological guide* (UNEP/ADEME 2005).

V. EMERGENCY PLANNING

51. Emergency plans should be established for each TMF for phases of construction, operation and closure. The appropriate emergency plan needs to be established prior to the issuing of permits for construction, operation or closure. Hence, they shall be drawn up within the periods set by local or international rules.

52. Emergency plans should be established, tested and revised by the TMF operator (internal plans) and by authorities (external plans), in particular:

- (a) Prior to commencement of operations;
- (b) If an accident or emergency situation occurred at the site or other similar sites;
- (c) When the emergency service organization or its senior personnel was changed;
- (d) After new technical knowledge becomes available or when new risks are identified;
- (e) If design values are approached as a result of changes, or in the case of mismanagement, structural problems, equipment modification or natural events;
- (f) At regular intervals as determined in the emergency plans themselves.

53. Among other things, the plan should evaluate downstream inundation hazards resulting from floods or dam failure, and upstream conditions that might result from major land displacements or increased flood flows. If applicable, the emergency plans should include inundation maps for the flows resulting from design floods and from possible failure of the dam.

54. Where there is a series of dams on the stream, analyses should be made considering the potential for progressive “domino” failure of the dams. To evaluate the effects of dam failure, maps should be prepared delineating the area which would be inundated in the event of failure. Analyses should be made to determine conditions which could be expected to result in slow, rapid or practically instantaneous dam failure.

55. The emergency plans, both internal and external, should include:

- (a) The scope and objective of the emergency plan;
- (b) Evaluation of emergency scenarios, risks, potentially affected areas, etc.;
- (c) Responsibilities of each member of the organization (chain of responsibility and authority for actions to be taken);
- (d) Organization of communication and notification procedures;
- (e) Available equipment for interventions;
- (f) Procedures for emergency response for each of the determined emergency scenarios;
- (g) Procedures for remediation.

A. Internal emergency planning

56. Internal emergency plans should be developed for each specific site and situation. Emergency plans should be tested and evaluated through periodic drills as defined in each plan.

57. Prior to development of an internal emergency plan an analysis should be made to determine the most likely mode of dam failure under the most adverse conditions and the resulting peak water outflow following the failure. The analysis should also identify any chemical substances or other potentially polluting materials that might be released in event of a TMF failure.

58. Internal emergency plans should contain estimations of amounts and types of equipment needed to deal with polluting or dangerous releases as well as construction materials and equipment needed for emergency repairs of the TMF based on the structural, foundation and other characteristics of the dams. Provisions should also be made for clean-up of any material that might be released from a TMF.

59. Internal emergency plans should be compatible with external emergency plans of the competent public authorities, and should be activated in a coordinated fashion in the event of a major accident.

60. Plans for notification of key personnel, local authorities and emergency services and the public must be an integral part of the emergency plan and should be prepared for all types of dam failure conditions.

61. The internal emergency plans should be part of the company's operating and management plan (operating manual), and should be regularly reviewed by senior management. Corporate personnel responsible for emergency management must be clearly identified to all staff on the site, and on-site personnel must receive adequate training for emergency procedures and incident reporting.

B. External emergency planning

62. External emergency plans should be prepared and implemented by the relevant authorities, conform to local needs and vary in complexity in accordance with the type and degree of occupancy of the potentially affected area. Where a TMF is identified as a substantial risk in such plans, the internal and external emergency procedures must be compatible.

63. The local community should be given the opportunity to participate in the preparation and revision of the external emergency plans, and to partake in any exercises that might be carried out. The local community should be entitled to express comments within reasonable time frames and due account should be taken of these comments.

64. It should be ensured that in border areas the contingency plans of two regions of neighbouring countries are compatible with each other and include contact details to allow proper notification of any emergencies that might occur. Ideally, the local communities and competent authorities of such neighbouring countries are given the same rights to participate in preparation and revision of the compatible external emergency plans.

Note: It should be recalled that the United Nations- approved process of “Awareness and Preparedness for Emergencies at the Local Level” (APELL process) has been developed to guide the preparation of external emergency plans. A version of APELL specific to mining has been developed jointly by UNEP and the mining industry.

C. Emergency planning for abandoned sites

65. The competent authorities should develop emergency plans for abandoned and orphaned sites, considering the above regarding internal and external emergency planning. Before developing the plans, which capabilities and responsibilities already exist should be verified:

- (a) Existing regional emergency response frameworks, such as civil protection, fire brigades, flood response;
- (b) Emergency response plans in place for a coordinated regional/transboundary response;
- (c) Clear command structure and management of interfaces between concerned authorities;
- (d) Existing models of scenarios for mining accidents and their integration into the community emergency plans.

VI. REFERENCES TO DOCUMENTATION ON MINING AND TAILINGS

66. A large amount of literature is available on tailings and tailings management. Some of the more relevant have been selected here, with emphasis on sources that offer access to readily available online documents and references, as these are often more accessible to readers with limited financial resources to purchase books.

67. Where possible, relevant United Nations documents have been highlighted, as these have often been subject to extensive international review prior to publication.

68. Finally a number of reference works published by industry or professional associations have been included.

69. Some of the sources below provide links to the primary references, but do not stock the full documents.

Note: Even the sources below that are not fully up to date can still provide valuable insights, information and further links.

General sources of information:

Mining Association of Canada (MAC; www.mining.ca).

Mineral Resources Forum (MRF; <http://www.mineralresourcesforum.org/>): Contains overview of main issues. Extensive literature on TMF and cyanide.

Good Practice Mining (<http://www.goodpracticemining.org/>). Case studies and guidelines on good practice in mining, including TMF.

Catalogue of United Nations documents on minerals development (<http://www.natural-resources.org/minerals/CD/index.htm>).

A general review of issues affecting the mining sector was published in several editions of the discontinued journal *Mining and Environment*, the last edition also being available in electronic form (<http://www.mineralresourcesforum.org/library/bookreviews/ie2000.htm>).

The International Commission of Large Dams (www.icoldd-cigb.net/) is an international non-governmental organization that provides a forum for the exchange of knowledge and experience in dam engineering. ICOLD has published authoritative bulletins concerning tailings dams.

The European Union Reference Document, “Best Available Techniques for Management of Tailings and Waste-Rock in Mining Activities” (<http://eippcb.jrc.es/pages/FActivities.htm>).

Directive 2006/21/EC of the European Parliament and Council of 15 March 2006 on the management of waste from extractive industries
(<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:102:0015:0033:EN:PDF>)

Authorities in Australia, Canada and South Africa have published guideline documents on tailings management. Relevant regulations from these countries are available from the relevant national institutional websites.

An excellent set of very easy-to-read "Best Practice Guidelines" is available from the Australian Government at: <http://www.unep.fr/pc/mining/library/library.htm>.

The International Council on Metals and Mining (ICMM) has produced a range of good publications (see http://www.icmm.com/library_pubcats.php).

References on **cyanide** can be found in the MRF website (see above) or on the website of the International Cyanide Code (www.cyanidecode.org)

For safe handling of cyanide and other chemicals during minerals processing, the OECD Guiding Principles are especially useful (<http://www1.oecd.org/scripts/ehs/guidingprinciples/index.asp>).

The references on **emergency preparedness and response** can be found on the UNEP APELL website see http://www.unep.fr/pc/apell/publications/pdf_files/pub-catalog-APELL.pdf . This includes the useful handbook on APELL in the mining sector (http://www.uneptie.org/pc/apell/publications/publication_pages/apellmanual.html). (available in English and Russian)

Other useful sources are also listed at: <http://www.icmm.com/sitewide.php?kw=APELL> and <http://www.icmm.com/sitewide.php?kw=emergency>

The new report on case studies in emergency response can be found at: http://www.icmm.com/library_pub_detail.php?rcd=184

A handbook on **hazard identification** in a local community can be found on the APELL website above. See http://www.uneptie.org/pc/apell/publications/publication_pages/hazardid.html

Identification and Management of Contaminated Sites – a methodological guide, (UNEP/ADEME 2005).

The International Association for Impact Assessment (IAIA) brings together researchers, practitioners, and users of various types of impact assessments worldwide (www.iaia.org/).

The International Organization for Standardization ISO 9000/ISO 14000 · Specific applications (www.iso.org/).

The Global Reporting Initiative – (GRI) develops and disseminates globally applicable “Sustainability Reporting Guidelines” for voluntary use by organizations reporting on economic, environmental, and social performance (www.globalreporting.org/).

Corporate social responsibility (CSR) is a concept whereby organizations consider the Global Reporting Initiative’s Sustainability Reporting Guidelines (see: en.wikipedia.org/wiki/Corporate_social_responsibility).

For **training**, a number of publications have been produced by UNEP and other partners. Some of these can be found at: <http://www.unep.fr/pc/mining/library/library.htm> Training in other areas such as EIA and Environmental Management Systems (EMS) is sponsored by the appropriate sectoral associations. UNEP has also produced trainers’ manuals on EIA and EMS. The The International Cyanide Management Institute (ICMI) trains prospective auditors in various aspects of cyanide management including TMF (www.cyanidecode.org).
