European Commission

Development of a guidance document on best practices in the Extractive Waste Management Plans

Circular Economy Action

Eco Efficiency Consulting and Engineering Ltd.

in collaboration with WEFalck, Pöyry Finland Oy, Botond Kertész & CRS Ingenería

22 January 2019

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Executive Summary

The Communication "Closing the loop - An EU action plan for the Circular Economy" describes the 'Circular Economy' as an economy wherein the value of products, materials and resources is maintained for as long as possible, and the generation of waste minimised. The Communication announced that the European Commission will develop guidance and promote best practices in the extractive waste management plans (EWMPs) by 2018.

The Raw Materials Initiative was put forward in 2008 to address the need for sustainable access to raw materials that manufacturing industries in Europe have. It was renewed in 2011 with the addition of the list of Critical Raw Materials, materials that have a high economic importance for Europe and where there is a risk of sufficient supply. The list is updated continuously, and the 2017 list features 27 critical raw materials. There is potential for some of these materials to be mined from historical waste, and investments in research projects are being done on these processes.

Since the entry into force of the Directive 2006/21/EC (Extractive Waste Directive) on 1 May 2008, according to Article 5 of the EWD operators have to submit EWMP as part of their permit applications. As a result of the many years of experience with EWMPs, a substantial knowledge base has now been established across the whole of the EU territory, which should enable the identification of best practices that merit a more widespread implementation across the extractive sector.

Taking into consideration the above, the Commission authorized a study[1] to support the identification of such best practices that contribute to a Circular Economy in EWMPs. This document is the first deliverable of this study, the guidance document focusing on:

- The prevention or reduction of extractive waste production and its harmfulness;
- The recovery of extractive waste by means of recycling, reusing or reclaiming such waste.

This guidance is intended as legally non-binding, targeted at competent authorities and extractive industry operators, aiming to integrate the Circular Economy principles into EWMPs, as well as to promote best practices related to Circular Economy that have been collected from submitted EWMPs.

The project aims to cover all extractive industries (industries extracting mineral resources such as energy fuels, metal ores, industrial and construction minerals). The undertaking is independent of and complementary to the work on the Best Available

[1] "Study supporting the elaboration of guidance on best practices in the Extractive Waste Management Plans" by Directorate-General for Environment under Service contract № 070201/2017/768854/ETU/ENV.B.3.

Techniques reference document on the management of waste from extractive industries (MWEI BREF) (European Commission, 2018).

Data to support the present guidance were provided by European Commission, after a call for input asking Member States to provide one or more of the following items:

- Guidelines on how to develop extractive waste management plans
- Extractive waste management plans (EWMPs)
- Pre-selected EWMPs containing candidate best practices
- Candidate best practices related to Circular Economy
- Hosting a visit to jointly draft fact sheets on candidate best practices related to Circular Economy.

These EWMPs were evaluated according to the Circular Economy given criteria. An assessment to fill gaps was perceived by country visits and bibliographic research. The information collected supported the first milestone of the project, namely, to identify candidate best practices with respect to the provisions of the Circular Economy Plan.

In addition to best practices, it is equally important to develop a methodology that describes how such plans can be produced. It was assumed that a risk-based approach would be most appropriate to guide the development of EWMPs. Thereby it is understood that most of the risk assessment would have been already undertaken as part of the Environmental Impact Assessment that in turn would have been undertaken as part of the mine licensing procedure. The EWMP would mainly act as a vehicle to summarise the waste management activities and to communicate these to regulators and the interested public alike.

The assessed information was cast into a Background Document that was sent to a wide range of stakeholders, such as competent authorities, the extractive industry, the Expert Group on Waste, the Raw Materials Supply Group, the Technical Working Group on the Best Available Techniques Reference document on the management of waste from extractive industries, academia and NGOs, in order to be commented on and to solicit additional practices. These experts were also invited to a Workshop on 'Best Practices of Extractive Waste Management Plans', which was held on 12 September 2018 in Brussels. The aim of the workshop was to obtain feedback on the Background Document and in particular on the candidate best practices in order to identify best practices. The resulting guidance is structured as follows:

1. **General information**: The scope, the approach and the limits of the guidance are presented. In this chapter the reader may find details about the investigation procedure to support the guidance.
2. **Risk based considerations**: The purpose of this chapter is to introduce risk-based considerations for the selection of appropriate waste management options, taking account also the principles of Circular Economy.
3. **Methodology to develop EWMPs**: This chapter is structured around the key elements that are presented in the Articles 5(2)(a) and 5(2)(b) of the EWD.

4. **Best Practices from EWMPs related to Circular Economy:** This chapter presents best practices, highlighting that the extractive industry actively searches for circularity aspects in relation to extractive waste management plans. Every practice that is referred to in this guidance is already applied by some extractive industries; however, it is understood that the applicability of every practice is related to a number of parameters, such as the local environmental conditions, behaviour and characteristics of the extractive waste, the geological background of deposit and the occupational health and safety restrictions.

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Abbreviation	Explanation
AMD / ARD	Acid Mine or Rock Drainage
CAPEX	Capital Expenditures
EIA	Environmental Impact Assessment
EWD	Extractive Waste Directive
EWF	Extractive Waste Facility
EWMP	Extractive Waste Management Plan
MWEI BREF	Reference Document on Best Available Techniques Reference Document for the Management of Waste from Extractive Industries (in preparation)
MTWR BREF	Reference Document on Best Available Techniques for Management of Tailings and Waste-Rock in Mining Activities
OPEX	Operating expenses

1. General information

1.1 Introduction

The Communication "Closing the loop - An EU action plan for the Circular Economy" describes the 'Circular Economy' as an economy wherein the value of products, materials and resources is maintained for as long as possible, and the generation of waste minimised. The Communication announced that the Commission will develop guidance and promote best practices in the extractive waste management plans (EWMPs) by 2018. The Commission requested information from public authorities, industry, environmental NGOs, knowledgeable experts and civil society. This report presents the results of the assessed received information and additional gathered data that identifies best practice in extractive waste management plans, placing a focus on those aspects related to Circular Economy.

1.2 Background

The present guidance is part of a study[2] pertaining in particular to (a) the integration of Circular Economy aspects into an Extractive Waste Management Plans and (b) the identification of Best Practices in Extractive Waste Management Plans (EWMPs) for aspects related to the Circular Economy. The scope of the present guidance is to explore approaches beyond minimum requirements of the Directive 2006/21/EC (Extractive – EWD) in order to promote Circular Economy concepts in the mining sector. According to Article 5 ("Waste management plans") of the Extractive Waste Directive 2006/21/EC (EWD), the Member States have to ensure that operators draw up an extractive waste management plan (EWMP). Specifically, Articles 5(2)(a) and 5(2)(b) of the EWD specify objectives of the EWMP related to the prevention or reduction of waste production and its harmfulness as well as the recovery of extractive waste by means of recycling, reusing or reclaiming such waste where this is environmentally sound. Thus, the EWD and in particular its Article 5 reflected already in 2006 what is in essence a Circular Economy perspective.

> "Optimisation of the ore extraction can be achieved by strengthening the role of the exploration and design phase, aiming the prevention of waste generation within the possible extent"

The mining sector is especially complex due to geological, geochemical, climatological, and social conditions of the location of each deposit, but also because of the breadth and range of the mining life-cycle, which is presented in Figure 1-1. According to the Swedish Guidance for the handling of the extractive waste, extractive waste generation can be prevented by optimising mineral extraction and processing taking into account the ore that is mined (developing new knowledge and technologies that address how to increase recycling of waste) (Swedish Environmental Protection Agency, 2016). An optimisation of the mineral extraction and processing can be achieved by strengthening the role of the two first steps of the mining life-cycle (exploration and design). The present guidance describes practices in the

[2] Service contract № 070201/2017/768854/ETU/ENV.B.3

field of recycling and recovery of extractive waste (potential use) that may be applied to the first five basic phases in a mining life-cycle (exploration, design, construction, extraction, and processing), and which have direct consequences on the generation and management of the extractive wastes.

Figure 1-1: The mine life cycle

From the beginning of the implementation of the EWD, some experience with EWMPs has been accumulated. Mine operators have to plan their operations in such a way as to ensure efficient use of resources by minimising extractive waste generation and are encouraged to promote the use of secondary raw materials and their accessibility as future resources. The extractive industry actively searches for circularity aspects that can be included in the mining operations, which may be summarised in EWMPs or EIAs. Therefore, for the development of the present guidance, an investigation on best practices from submitted EWMPs and EIA studies of the extractive industries was conducted, focusing mainly on those that reflect the essence of the Circular Economy perspective. In any case, it should be emphasised that the decision on the selection of best practices should take into consideration always the local geotechnical, geological and economic conditions.

1.3 Methodology

In July 2017, the Commission called on relevant stakeholders in the Member States' (MS) extractive industry, public authorities, industry, environmental NGOs and the civil society, to contribute their expertise and experience by providing one or more of the following:

- Guidelines on how to develop EWMPs
- Sample Extractive waste management plans (EWMPs)
- Pre-selected EWMPs containing candidate best practices
- Candidate best practices
- Hosting a visit to investigate the Circular Economy aspects within the EWMPs

In total 64 data items were gathered by the European Commission initiative in various forms, such as common industrial practices, national projects for extractive waste management, MS guidance documents, etc.

Following the European Commission's initiative, a further data collection process was conducted by a team of consultants in order to obtain more details on the practices in EWMPs that cannot be obtained through desk research alone. This project has also included country visits in order to collect relevant technical information. This further research via country visits was conducted in France, Germany, Hungary, Greece, Spain and Sweden.

The information collected supported the first milestone of the project, namely, to identify candidate best practices with respect to their provisions towards the Circular Economy Action Plan. This project has a strong reliance on the information provided to the Commission and the further data collection process by the consultant relying on publicly accessible information. Therefore, the best practices presented in this guidance are not necessarily comprehensive.

The EWMPs have been assessed, taking into account the following aspects:

- processes to prevent or reduce extractive waste generation and its harmfulness
- extractive waste management in the design phase and in the choice of the method used for mineral extraction and treatment
- the changes that the extractive waste may undergo in relation to an increase in surface area and exposure to conditions above ground
- placing extractive waste back into the excavation void
- putting topsoil back in place after the closure of the waste facility or re-using topsoil elsewhere
- using less dangerous substances for the treatment of extracted minerals
- recovery of extractive waste by means of recycling, re-use or reclaiming of such waste
- approaches for monitoring the implementation of EWMPs and their review

Furthermore, best practice identified should be considered in EIA and EWMPs, but local circumstances might not allow applying it in a given geological context. Similarly, the examples of best practice from a subsector might not be applicable for all installation of this subsector due to a given geological context.

In addition to highlighting best practices for extractive waste management, it is equally important to develop a methodology that describes how EWMPs can be produced. The role risk-based considerations play in choosing appropriate solutions is a useful guide to understanding the development of EWMPs. Most of the Risk based considerations would have been already undertaken as part of the Environmental Impact Assessment. The EWMP acts as a vehicle to describe the chosen extractive waste management activities and to communicate these to regulators and the interested public alike.

1.4 Initial assessment of the information gathered

Overall, a total of 75 Fact-Sheets were prepared, based on the EWMPs collected and through the country visits. As is shown in Figure 1-2, the majority of the collected practices are related to the metal ores and construction minerals. The collection process revealed a number of relevant practices, which prove that the extractive industry actively searches for strategies to maximise resource use that can be included in the mining and processing operations. The practices are mostly related to:

- Considerations of extractive waste production and its management in the design phase
- following strategies and techniques to fill excavation voids with extractive material (Note: in some MS these excavated materials are considered as waste and in some others as secondary raw material; the scope of the present guidance is only to present techniques that strengthen the role of the Circular Economy and not to discuss what is waste and what not)
- utilising waste rock in different kinds of earthworks on site during active mining operations, as landscaping material, or it may be sold outside for use as aggregate
- utilising extracted material that would otherwise be waste in various ways outside the mine environment, in earthworks, and even in the chemical industry
- Recycling or re-using of historical extractive waste
- Recycling of waste water
- Segregation and re-use of topsoil

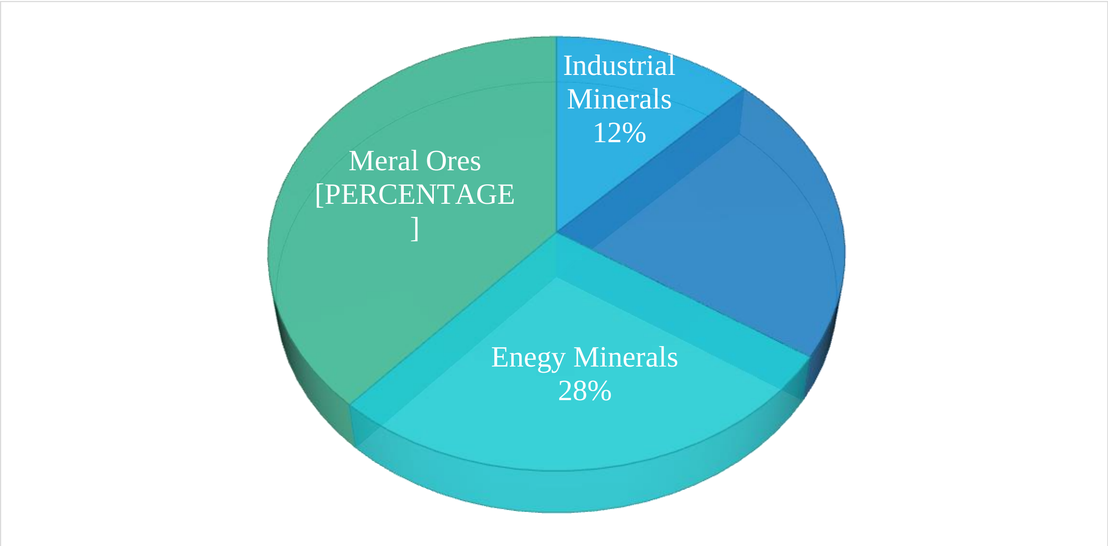

Figure 1-1: Percentage distribution of the sectors from which data could be collected.

1.5 Stakeholder consultation and workshop

The assessed information was cast into a Background Document (BD) that was sent to a wide range of stakeholders, such as competent authorities, the extractive industry, Expert Group on Waste, the Raw Materials Supply Group, the Technical Working Group on the Best Available Techniques Reference document on the management of waste from extractive industries, academia and NGOs, in order to be commented on and to solicit additional practices. These experts were also invited to a Workshop on ‘Best Practices of Extractive Waste Management Plans’, which was held on 12 September 2018 in Brussels.

Although the investigation of the practices was mainly focused on the EWMPs, the pre-licensing design phase for extraction is in most cases based on the Environmental Impact Assessments (EIAs), which covers the whole life-cycle of operations. In most cases the final EIA is the outcome of an iterative procedure that begins with the original proposal for extraction, processing of the extracted material, and the eventual (re-)use and disposal of materials for which no economically beneficial use can be found. Different extraction methods, processing techniques, and disposal options will result in different impacts on different environmental compartments. This iterative procedure ideally yields a process design and disposal solution for EW that provide the maximum economic benefits, while entailing environmental impacts deemed acceptable. In contrast to the EIA, the EWD requires a review of the EWMP every five years in order to take into account any substantial changes to the operation of the waste facility or to the waste deposited. The objective of the EWMP is to summarise these findings with respect to the actual extractive waste management options to be implemented. Article 5 of the EWD already contains provisions with respect to what later became known as the Circular Economy Action Plan. It has to be understood, however, that the (environmental, geotechnical, health) safety of the disposal option is a very important parameter and must always be considered in relation to environmental and Circular Economy aspects. To this end the EWMP will demonstrate that the necessary steps had been taken to prevent waste generation where it is possible and to encourage the recovery of extractive waste by means of recycling, re-using or reclaiming such waste, where this is environmentally sound and economically feasible.

This Guidance does not aim to interpret EU waste legislation including Article 5 of the EWD but aims to link the relevant provisions of Article 5 with the objectives of the Circular Economy Action Plan, covering all the extractive sectors' minerals. It is thus independent of and complementary to the work on the Best Available Techniques reference document on the management of waste from extractive industries (MWEI BREF). It is intended as legally non-binding guidance, targeted at competent authorities and extractive industry operators for the purpose of promoting the Circular Economy principles.

2 Risk based considerations

2.1 Scope and purpose of risk based considerations

Risk Assessment is a technical-scientific methodology to estimate quantitatively and qualitatively environmental and social risks arising from the technical options of extractive waste management. As noted before, in most cases such assessment would have been carried out as part of the EIA that is usually the basis of an operating license. However, scope and detail of the EIAs may vary from MS to MS and the following serves as a tool to cross-check, whether the Risk Assessment undertaken under the EIA is sufficient to support the development of the EWMP.

One of the aims of the risk-based considerations and choices in extractive waste management is to predict from the very beginning (design phase) potential impacts resulting from the generation and the management of the extractive waste and investigate possible solutions to avoid them. Any significant change that may arise at some point during the mining life-cycle may lead to proportional evaluation of the risk assessment. Risk management indeed is a procedure that iterates with operational planning and needs to be adapted progressively to changing operational conditions.

2.2 Risk based considerations used in the development and evaluation of the EWMPs

Risk based considerations contribute to setting priorities for environmental and social protection in an objective and scientific way. EWMPs reflect the risk-based selection of appropriate extractive waste management options, taking into account the waste hierarchy:

1. to prevent or reduce waste generation and its harmfulness;
2. to encourage the recovery of extractive waste; and
3. to ensure short and long-term safe disposal of the extractive waste. Risk management for this activity is elaborated in BAT 5 of the MWEI BREF (European Commission, 2018c)

The combination of information on risks and impacts is helpful to develop workable solutions for the specific context of a country and a company. Each of these possible solutions is reviewed with respect to the risk reduction strategy applied (based on relevant engineering principles) considering risks, impacts, as well as economic and social aspects. Typically, this stepwise process of risk management planning includes: establishing the design context, impact identification and failure risk identification, designs for risk elimination or reduction, and monitoring for efficacy (see Figure 2-1). Impact is a predicted (potentially prolonged) effect of the operation. On the other hand, risk is the probability that an unplanned event might occur multiplied by its impact.

Extractive waste risk evaluation is a complex procedure and may be associated with a wide range of failure scenarios. Site specific conditions (including for example geology and surrounding land-use) should always be considered. Sources, pathways and receptors should be adequately identified.

EWMPs are reviewed both internally and externally. Internal review is typically carried out on a regular basis to identify updating requirements. External review is typically carried out by competent authorities – for both, new and updated EWMPs. When reviewing an already submitted EWMP, one may follow the principles of risk assessment in order to identify potential risks to environment and human health. The review should also assess whether sufficient information is provided to enable the competent authority to evaluate the operator's ability to meet the three objectives listed above (prevent/reduce, recover, safely dispose). Moreover, it should ensure that the updated plan explains, in particular, how the extractive waste management considerations from the design phase, and the choice of method used for mineral extraction and treatment, will still fulfil its objectives.

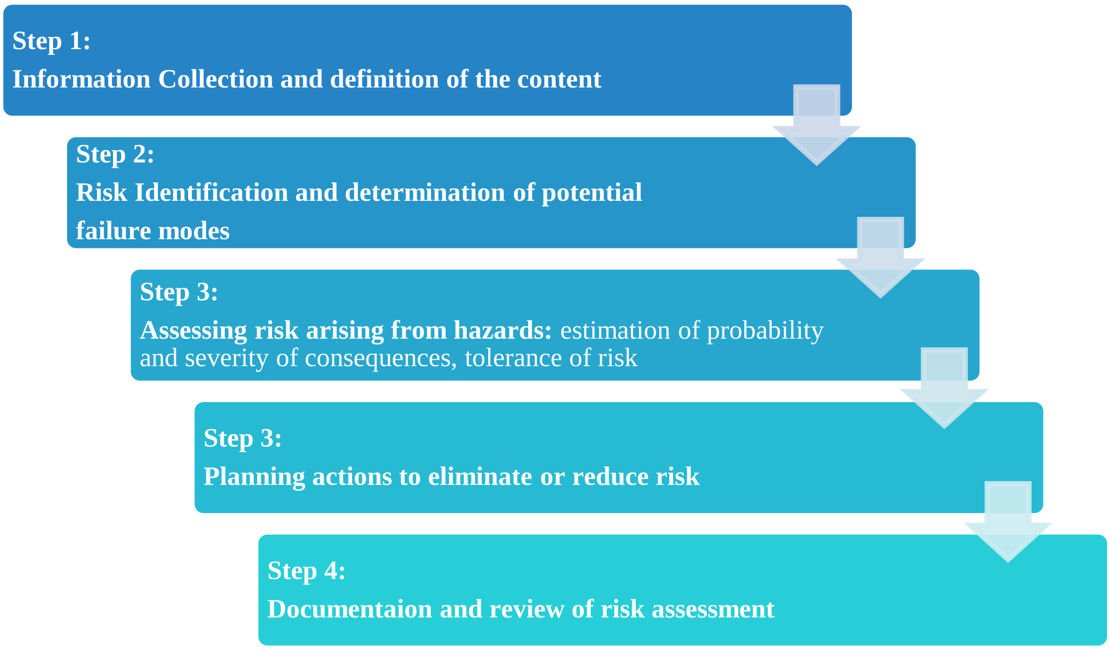

Figure 2-1: General Risk Assessment methodology scheme.

2.3 Risk identification along the life-cycle of an extractive operation

The characterisation of extracted material that may become waste should be the starting point of the Risk Assessment, which also takes into the consideration the chosen waste management option. It should be noted that the scope of the present guidance is only to present the key considerations of the Risk Assessment and not to discuss whether specific elements of the whole methodology will be covered by the EIA of the operation or by the preparations of the EWMP.

The purpose of this characterisation is to determine the nature of the extractive waste and steer possible management options, based on its geological and mineralogical characteristics, its geotechnical behaviour and geochemical characteristics. Commission Decision 2009/360/EC completing the technical requirements for waste characterisation laid down by Directive 2006/21/EC specifies technical requirements for extractive waste characterisation. Since the first EWMP is submitted at a project phase, where operation has not yet started, information obtained from the characterisation of extractive waste is relevant for the (periodic) reviews of these management plans.

Extractive industries provide mineral raw materials that are essential to downstream industries and economic sectors. Extractive industries provide, first of all, primary raw materials. However, the processing often targets only one or a few constituents. Hence, what would become extractive waste can actually be a potential source of further raw materials. Therefore, extracted material characterisation should include all parameters necessary to inform about potentially valuable constituents or properties that can be utilised in order to avoid the material becoming waste.

The design phase in many extractive industries is complex and may identify a wide variety of potential hazards, as they are given in detail in the MWEI BREF. The overall evaluation of risks may require some kind of aggregation to make different practices and scenarios comparable when selecting the final design.

The design phase of any particular extractive installation necessarily relies on several key input parameters related to the main purpose of the project, namely sustainable development of the mineral deposit. However, opportunities to consider extractive waste management and/or recovery may be found in the following areas:

1. Exploration phase
2. Selection of the most appropriate extraction methods
3. Extraction process planning
4. Design of the site layout
5. Selection of mining equipment
6. Optimisation of the process plant
7. Development of a commercial plan

Figure 2-2 illustrates the complexity of waste management in the extractive sector since parameters such as site-specific conditions, including the technical characteristics of the Extractive Waste Facility (EWF), its geographical location and the local environmental conditions, behaviour and characteristics of the extractive waste and geological background of deposit are only some issues that are described in Commission Decisions, such as:

- Commission Decision 2009/360/EC completing the technical requirements for waste characterisation laid down by Directive 2006/21/EC
- Commission Decision 2009/359/EC completing the definition of inert waste in implementation of Article 22(1)(f) of Directive 2006/21/EC
- Commission Decision 2014/955/EC amending Decision 2000/532/EC on the list of waste pursuant to Directive 2008/98/EC
- Commission Decision 2009/337/EC on the definition of the criteria for the classification of waste facilities in accordance with Annex III of Directive 2006/21/EC

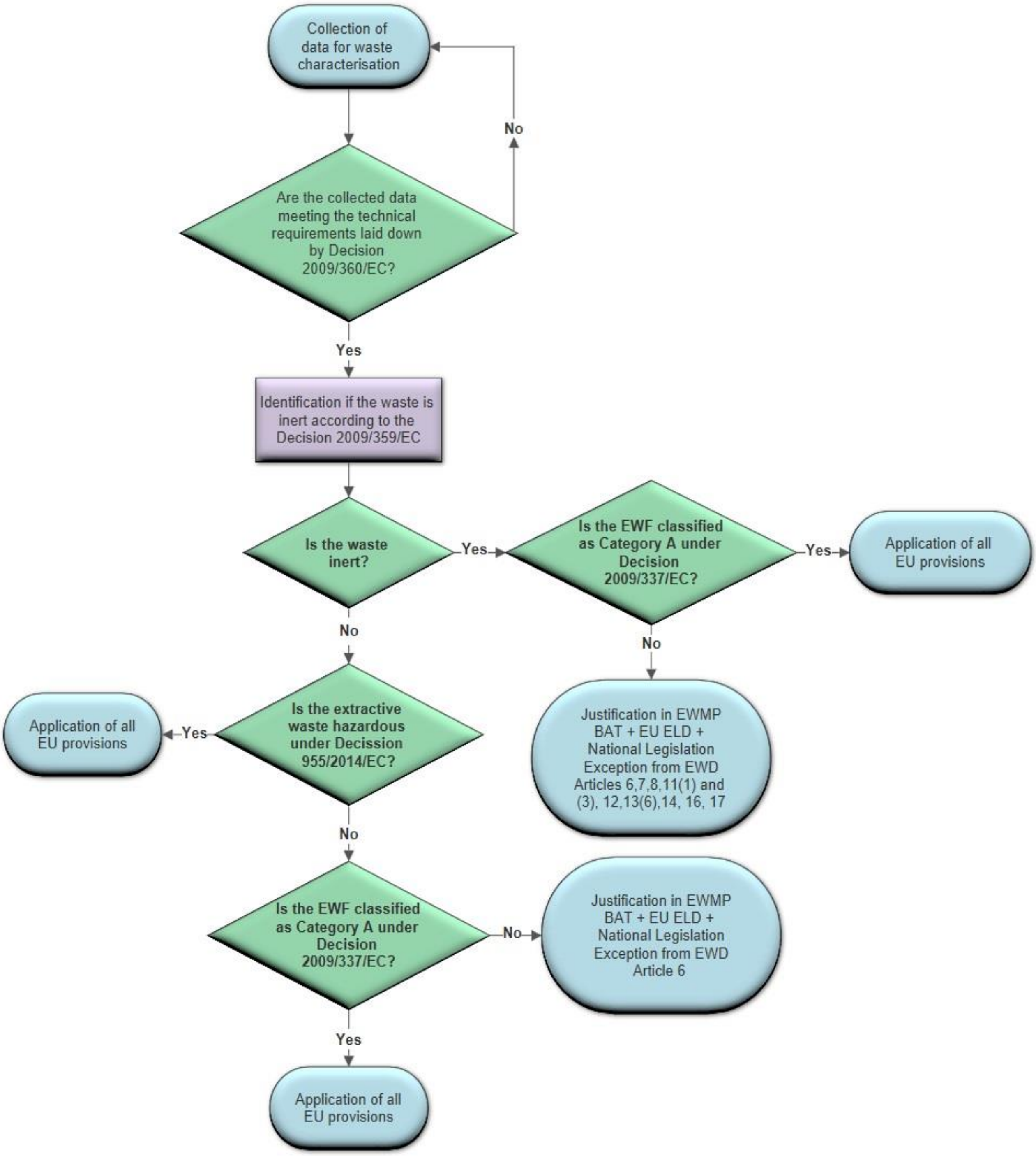

Figure 2-2: Decision tree for waste characterisation under the provisions of COM Decisions

In order to establish the necessary scope of the Risk Assessment, one needs to identify where, when and why these risks arise. Risks can then be quantified and management measures proposed. It is important to appreciate that risks can be managed as and when they arise ('end-of-the-pipe' treatment paradigm) or the root-cause can be identified and eliminated, thus also eliminating the risk. This may require a wider scope than what would normally be covered by the EWMP. Normally, the EWMP may be considered as a reporting platform of work that has already been done for either feasibility studies or licensing purposes.

The following non-exhaustive list shows examples of aspects that would need to be considered in order to establish the content of the Risk Assessment along the life-cycle phases of an extractive operation. It is known that in some cases, changing the processes in mining and subsequent treatment of the excavated material may result in wastes that are easier to manage and in EW management solutions with fewer inherent risks.

1. Exploration phase: the more thoroughly the resource has been explored, the more targeted and efficient the extraction can be, meeting the objectives of Art. 5§2 (a) and (b) of the EWD. A good knowledge of the mineral deposit allows for optimisation of the extraction, resulting in less extractive waste.
2. Selection of the most appropriate mining methods: the selection of the mining method, e.g. underground vs. open-cast, and mining technology is governed by a multitude of factors. While it is understood that CAPEX and OPEX in a given market environment are critical variables, today aspects of resource efficiency and minimisation of extractive waste generation also need to be taken into account. Modern at-the-face rock characterisation methods, selective extraction, utilisation of waste rock (in pit or for filling excavation voids) reduces the generation of extractive waste. For example, in room-and-pillar methods the utilisation of waste rock my not only reduce the amount of EW to be managed at the surface, but also increases the recovery of the target mineral.
3. Site design and scheduling: Good mining planning and scheduling based on good exploration and data handling is the basis for a targeted and efficient extraction, avoiding unnecessary extraction and thus excessive extractive waste generation. (This phase is continuously being developed.)
4. Choice of mining equipment: the choice of mining equipment may not only be determined by the needs, but also by the availability of and limitation to CAPEX. Operators will need to be aware that inadequate mining equipment may result in unnecessary generation of waste rock that may need to be managed as EW.
5. Process planning and optimisation. While one can assume that operators have a vested interest in effective processing of marketable products for a given market situation, the manageability of the resulting extractive wastes may not always be a design criterion. Within the limits of CAPEX available, operators may consider reducing risks and associated risk management costs (including insurance premiums) by selecting processing methods that result in less waste that needs to be managed in Category A facilities.
6. Periodic review of material streams: The valorisation of each element of the material streams generated in a mine and subsequent processing changes as a function of market conditions. Hence, it is in the interest of the operator to periodically review these streams and how they arise with a view to maximising this valorisation. This review will to include materials that previously were considered EW in the sense of the EWD. It makes economic sense to explore possible markets for materials that otherwise would have to be deposited as EW and for which EWMPs would have to be developed.

7. Planning for the long-term safety of EWFs. All EWFs not only have to fulfil criteria for operational safety and minimisation of impacts, but their closure and long-term management need to be provided for as well.

It should be kept in mind that these are multi-dimensional optimisation problems and one always needs to be aware of risk and impact displacement effects. A risk and impact analysis will help to underline the economic, social, and environmental effects of the extracted material. In this sense, the risk assessment and resulting management solutions as presented in an EWMP can serve to demonstrate to regulators and other (public) stakeholders that risks have been minimised and benefits, including those in the sense of a Circular Economy, have been maximised.

3 Methodology to develop EWMPs

3.1 Introduction

Extractive waste management planning can be a complex process, requiring environmental, social, engineering and economic inputs. It is an integrated part of good operational management and EWMPs can be seen not only as a permitting tool, but also as a communication tool. Developing EWMPs is a systematic way to assess availability and adequacy of all essential components of extractive waste management.

EWMPs present measures for prevention or reduction of extractive waste generation and its harmfulness, as well as the recovery of extractive waste by means of recycling, re-using such waste where this is environmentally sound and economically feasible, and without disregarding the needs for short and long-term safety and stability of extractive waste management solutions. Such actions imply that EWMPs are based on the understanding that waste management imply proactive measures to avoid or reduce waste generation per se.

Some key elements that need to be determined before the drafting of an EWMP are questions such as: which material should be evaluated? who should draft the EWMP and when? This information is discussed in the following boxes.

Question 1: What is extractive waste?

'Extractive waste' means "the waste resulting from the prospecting, extraction, treatment and storage of mineral resources and the working of quarries" but excluding:

- waste that is generated by the prospecting, extraction and treatment of mineral resources and the working of quarries, but that does not directly result from those operations;
- waste resulting from the off-shore prospecting, extraction and treatment of mineral resources;
- injection of water and re-injection of pumped groundwater as defined in the first and second indents of Article 11(3)(j) of Directive 2000/60/EC, to the extent authorised by that Article.

Question 2: What materials are evaluated in an EWMP?

Taking into consideration the EWMPs that were selected through the gathering of relevant data, the following approaches related to the term "management of extractive waste" have been identified:

- Some EWMPs address the management of excavated material after it has been classified as extractive waste
- Other EWMPs develop a wider perspective and address all streams of excavated material explaining the material streams considered as (by)product and those classified as (extractive) waste.

It has to be understood that material that is defined as "extractive waste" is subject to the EWD, while other types of waste that are beyond the term "extractive waste" are subject to the Waste Framework Directive, or Directive 2008/98/EC of the European Parliament, and consequently these wastes are out of the scope of the present guidance.

Question 3: Who is responsible for drafting an EWMP?

The "operator" is the natural or legal person responsible for the management of extractive waste, in accordance with the national law of the Member State (MS). It is known that some jurisdictions require an EWMP from all extractive operations, while other jurisdictions are satisfied if the EIA and the license application demonstrate that no EWs arise, thus obviating the submission of an EWMP.

Question 4: When should an EWMP be drafted and how often shall an operator review it?

According to the national laws of MSs, an EWMP can be submitted as part of an application for planning permission, forming a component of the application documentation or being contained within an environmental impact assessment (EPA Ireland, 2012).

According to the EWD, the waste management plan shall be reviewed every five years and/or amended, if substantial changes have taken place in the EWF or in the extractive waste itself. It should be noted that the EWMP is not necessarily a document that is only submitted once in the first permit application. Competent authorities may need to be notified of amendments.

3.2 The role of the mine life-cycle in drafting EWMP

Every mine is unique and, therefore, the type, the amounts and the characteristics of the extractive waste differ, depending on the deposit, the geology and the process technology applied at the site. The extractive waste originates mainly from two production stages: mining (extraction) and mineral processing (Lèbre, 2016).

Although the generation of extractive waste starts mainly at the construction stage, extractive waste management should be taken into consideration along all the stages of the mining project life-cycle, including the exploration and design phase. Figure 3-1 illustrates the phases, where extractive waste can be generated during the life-cycle of a mine. Better advance planning of the operation improves the efficiency of extraction, reducing the amount of unwanted extraction that may become extractive waste, minimising the environmental footprint.

A well-developed EWMP should be based on the best available technical knowledge and the substantial experience established across the mining sector in order to achieve (a) optimisation of extraction, (b) reduction of environmental impacts until deemed acceptable, and (c) strengthening of recycling.

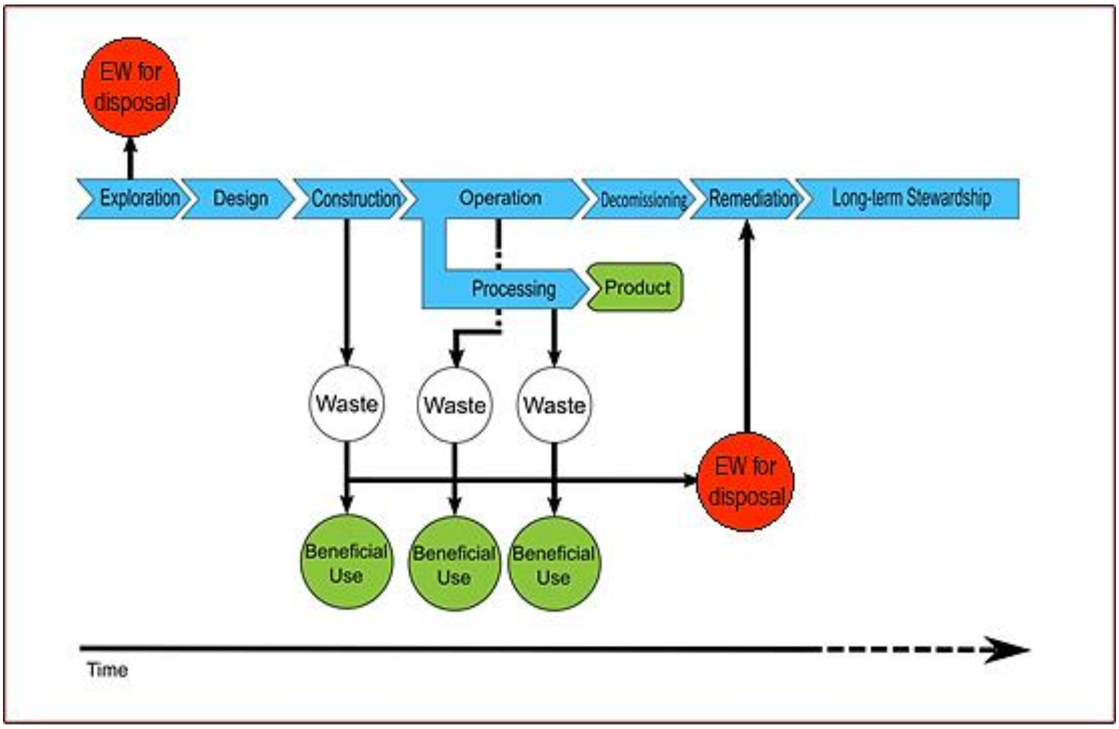

Figure 3-1: Extractive waste as part of the mine life cycle.

3.3 Guidelines for the development of an EWMP

To assist the reader, Table 3-1 provides a selection of details from already submitted EWMPs from different parts of Europe. This list is neither exhaustive nor tailor-made for every extractive industry or for any location, but it includes a useful selection of issues that should be considered during the drafting of a EWMP.

The actual scope depends on the local circumstances and also on individual MSs requirements, if MSs have formulated such. The EWMP presents (a) a description of the operation generating extractive waste, (b) extractive waste characteristics, (c) quantity of extractive waste generated, and (d) the proposed classification for the extractive waste facility.

A considerable amount of the information is usually generated and/or collated during the different stage feasibility studies and drafting of the initial EIA for the extractive operation. The EWMP provides information on possible adverse effects on the environment and human health, resulting from the disposal of the EW and the mitigation measures, in particular from contaminated run-offs and leachates, water and wind erosion. The time frame to be considered covers construction, operation and post-closure phases, taking into account the geological, hydrological and hydrogeological, seismic and geotechnical characteristics of the site or of the EWF.

Table 3-1 Example contents of an EWMP

Issues covered in the EWMPs	Examples of parameters
Administrative information	Name of the company
	Site location (coordinates)
	Site manager
	Officer responsible for extractive waste area
	Contact details
	Emergency contact details
	Date
Geological description of the mineral deposit	Rock type and mineralogy description of the mineral resource to be used
	Size and geometry of the mineral deposit
Description of materials streams (supported by flow-diagrams)	List of each type of material, including quantities and destination
Waste produced from individual processes	Excavation
	Crushing and grinding
	Flotation, magnetic separation or other separation processes
	Exploration works
	Other processes
Mineralogical and geochemical characterisation per material/waste	Rock type
	Mineral assembly
	Bulk chemical composition including (at least) components of potential concern, such as As, Cd, Co, Cr, Cu, Hg, Mo, Ni, Pb, V and Zn
	Acid generation potential and neutralization potential
	Presence of (fibrous) minerals of concern (e.g. asbestos)
	Potential chemical processing residues
	Waste(s) code according to Decision 2014/955 (Waste Catalogue) • Assessment whether the EW is inert is based on the technical requirements that are presented in the Decision 2009/359/EC • Assessment whether the EW is inert, based on method EN 15875: Sulfide sulfur content % (<0,1% or <1% and NTP (normal, temperature, pressure) > 3
	Hazardous Properties according to Regulation 1357/2014/EC - properties of waste that render it hazardous
	Solubility of metals, oxyanions and salts
Geotechnical characterisation and material geotechnical behaviour per material/EW	Grain size distribution
	Density
	Porosity
	Permeability
	Fraction composition (dominant mineralogical composition)
	Water content
	Plasticity indices
	Degree of compaction

Issues covered in the EWMPs	Examples of parameters
	Shear strength
	Friction angle
	Compactability
	Compressive strength
Waste class according to COM Decisions 2009/359/EC, 2009/360/EC and 2014/955/EU	Hazardous waste / Non-hazardous non-inert waste / Inert waste
Category of EWF	Category A / Non-Category A (Decision 2009/337/EC)
Facility structures (all EWFs on the site)	Design and constructional details of the EWF
Management of excavated material *Note: though not explicitly covered by the EWD, depending on the operational and market conditions, some of these wastes can become EW at any given moment*	Excavated materials *(quantities as function of time)*
	Quantities and types of excavated materials used for construction purposes in the mine/quarry *(as function of time)*
	Quantities and types of excavated materials used for filling mine voids for engineering or resource recovery reasons (*as function of time)*
	Top-soils removed and stored *(as function of time)*
	Quantities of non-EW and their management routes *(as function of time)*
Management of EW (per waste, supported by detailed maps of the deposition areas)	Quantity of EW deposited *(as function of time)*
	Planned quantity to be deposited EW *(as function of time)*
	Total quantity of extractive waste to be deposited during the life-cycle
	Quantities of EW recovered and re-utilised *(as function of time)*
Risk assessment	Summary of risk assessment carried out under the initial EIA, any updates, or specifically for the EWMP
	Specific conditions contributing to risks: • Climatic conditions (e.g. rainfall intensities and frequencies) as drivers for the migration of contaminants • Description of possible natural events (e.g. earthquakes, vulcanism, etc.) that may compromise the EWF
	Risk elimination or risk reduction measure
Emergency plans *(detailing actions and responsible persons)*	Emergency plans for Category A EWFs
	Emergency plans for other EWFs
Operational monitoring	Geotechnical stability (dams, slopes)
	Groundwater: levels, quality
	Surface waters: quantity, quality
	Air quality
	Erosion control (turbidity in surface waters)
	Radiological monitoring (where required)
Closure plans	Provisional plans *(to be updated periodically together with the EWMP)*
	Financial provisions to ensure orderly closure
Long-term management plans	Preliminary plans for the after use of the extraction site and the EWFs *(to be updated periodically together with the EWMP)*

Issues covered in the EWMPs	Examples of parameters
Supporting documentation 1. Geology: nature shape, size and typology of the resource 2. Mineral deposit area: type, final shape, structure of filling and transport type 3. Study of the state of soil and water at deposit area (baseline study) 4. Information of environmental impacts caused by extracted waste and deposit area 5. Information of preventive actions taken to minimize environmental impacts 6. Report of current and post-action control and follow-up 7. Acid rock drainage and metal leaching assessment report 8. Closure plan **Note:** *the majority of the above documentation would have been already produced as part of the baseline survey and the EIA licensing procedure*.	

The scope of the EWMP is steered by the nature of the mining operation and extractive waste generated on the site. EWMP describes how both impacts and risks arising from the EW or the EWFs are managed.

Certain extractive operations are likely to produce only inert wastes owing to the types of geological materials excavated. Such operations may include aggregates, ornamental stones or certain industrial minerals, and operations extracting peat. These operations may be required to produce only simplified EWMPs, not covering the whole suite of variables as outlined in Table 3-1.

4 Best Practices from EWMPs related to Circular Economy

The following practices focus on resource management applied in the extractive sector that can play a central role in the Circular Economy.

4.1 Best Practice 1: Effective exploration and site lay out

Extractive materials management (including waste) practices start at the design phase for the mine operation. Optimisation of ore extraction and minimisation of waste generation can be accomplished by strengthening the first steps of the extractive industries life-cycle, such as exploration, characterisation and operation design, taking also into consideration the commercial environment.

Figure 4-1: Parameters related to the Circular Economy as applied in the extractive sector

The exploration efforts are the basis for a mining project. Non-invasive exploration methods, namely various types of geoelectrics and seismics, can be used to enable more targeted extraction. Geophysical techniques, such as Electrical Resistivity Tomography (ERT), Ground Penetrating Radar (GPR) or different forms of seismics are used with a view to:

- optimising subsequent use of invasive investigation (drilling)
- improving the quality and marketability of the product, learning in advance its characteristics
- optimising the mineral extraction through localisation of areas to be avoided or targeted

Modelling of the deposit and careful characterisation of the resource can result in minimising the extraction of unwanted and non-marketable materials - thus minimising the generation of extractive waste.

Furthermore, advance planning of the operation improves the efficiency of extraction, avoiding sterilisation of resources and reducing the amount of unnecessary extraction (efficient use of resources). The EWMPs collated for this guidance provide a considerable amount of information with regard to practices involving a detailed modelling of the deposit and choice of mining strategy by selecting underground or open-pit mining techniques. However, any choice of mining strategy depends on a wide range of factors, including the depth of the target mineral below ground, the extent of its occurrence, the characteristics and tectonics of the host rocks, the groundwater hydrology, permissible footprint, available mining technology, and human resources available. In general, near-surface occurrences may be exploited in open-pit mines, while deeper deposits are exploited in underground mines.

Another parameter that it is evaluated during the design phase (pre-licensing process) of an extractive operation are the likely characteristics of the extractive waste. At EU level, the most relevant standards applicable to investigating the expected behaviour and characteristics of future extractive wastes are:

- CEN/TR 16365:2012 Characterisation of waste. Sampling of waste from extractive industries
- CEN/TR 16376:2012 Characterisation of waste. Overall guidance document for characterisation of waste from the extractive industries
- CEN/TR 16363:2012 Characterization of waste. Kinetic testing for assessing acid generation potential of sulphidic waste from extractive industries
- CEN/TS 16229:2011 Characterization of waste. Sampling and analysis of weak acid dissociable cyanide discharged into tailings ponds
- EN 15875:2011 Characterization of waste. Static test for determination of acid potential and neutralisation potential of sulphidic waste

Relevance for Circular Economy:

Integrated planning based on the following waste management objectives: prevention, re-use and recycling, highlighting the design phase as a basic step to achieve the Circular Economy principles contribute to the social acceptance of an extractive operation.

Effective characterisation of the resource and extractive waste and advance planning of the operation improves the efficiency of extraction, avoids sterilisation of resources (i.e. helps future generations to have access to virgin raw materials), ensuring a continued, steady and adequate supply of the raw materials needed by society and minimises the amount of unnecessary extraction and thus reduces waste.

The decision between underground mining and open-pit is a key decision during the planning phase and is taken with consideration of the implications for the Circular Economy in relation to environmental, economic and social benefits. Careful planning to reduce the need for materials handling and to allow progressive rehabilitation can help to prevent or reduce waste production and its harmfulness, in particular by considering the technical, economic and environmental possibilities for placing materials back into the excavation void after extraction.

Case studies:

According to EWMPs from bauxite mines in Greece (ELMIN (now Imerys) and Delphi-Distomon SA (now MYTILINEOS), bauxite extraction is based on detailed modelling of the deposit, which in turn is based on integrated geotechnical research from the planning phase onwards. The deposit is selectively extracted with the aim of minimising as efficiently as possible the generation of extractive waste.

Data for the integrated planning were also mentioned in the EWMP from Colas Északkő Kft. (Construction Sector) in Hungary. Specifically, Colas Északkő Kft has been planning a complex life-cycle assessment, considering the available raw material reserve and the generation and management of extractive waste. An extensive exploration programme (around 1,250 meters of drilling and large surface geophysical study) helped to estimate the total quantities of product and extractive waste.

The “Lujar” underground mine (Minera de Órgiva, Spain) is located in an impressive valley between the Sierra Nevada and the Sierra Lujar, whose beauty entices tourists to come to the Alpujarra region. To make it easier for mining and tourism to coexist, the Minera de Orgiva´s objective was to be completely unnoticeable in the surrounding villages, reducing to almost zero the environmental impacts. Firstly, Minera de Orgiva installed the mineral processing plant underground, so the ore does not have to be brought to the surface before it has become the final product. Doing so affects a total reduction of noise, dust, land occupation, etc. The company also decided to eliminate the visual impact of the extractive activities by using the extractive waste as material for filling the excavation voids inside its own mine, but also for reclamation purposes outside the boundaries of the mine site (details in chapter 4.5).

In Greece the bauxite mining near Mount Parnassos ten years ago was undertaken partially from an open pit mine and partially underground. According to the EWMP by Delphi-Distomon SA (now MYTILINEOS), the company decided to turn exclusively to underground mining in order to minimise the extractive waste that would have to be deposited on the surface by filling the excavation voids. This decision is also part of the corporate social responsibility policy.

Another example from Greece is the marble quarry of DIONYSSOMARBLE. According to the company, the demand for decorative/ornamental stones has been steadily rising due to their use in modern architecture. Increased demand has led to intensive extraction in existing marble quarries. The immediate consequence of this extraction is the gradual depletion of surface deposits. In addition, strict environmental restrictions already impose the underground extraction of decorative stone deposits.

4.2 Best Practice 2: Effective rock breaking

Rock loosening is traditionally effected either by mechanical excavators or by drilling and blasting. An optimal selection of mechanised wall-casings and mining machines depends on the expected geological and geotechnical conditions, leading to more targeted extraction and, as a consequence, to efficient production and waste reduction. The same principle applies to the blasting strategy and technique. The variation of the rock properties and their different mechanical behaviour affects the excavation by drill-and-blasting. The optimisation of the process of drill-and-blast in the design and the operation phase of the mine leads to the reduction of extractive waste and wastage of drill-time and explosives. For both approaches, either with the selection of the appropriate equipment or a blasting design, the key is (a) to investigate the deposit via an in-pit exploration, and (b) to try to minimise the mineral/sterile ratio with computer simulations in order to conduct a more targeted extraction. It should be noted that these strategies may be constrained by technical limitations, such as the minimum tunnel cross-section required for equipment or ventilation. There may also be minimum requirements in a MS's respective mining code.

Relevance for Circular Economy:

The optimisation of the process of drilling and blasting and the selection of the appropriate extraction equipment leads to the reduction of drill time (energy efficiency), consumption of explosives and of waste generation. Furthermore, this practice enables efficient ore excavation and helps to prevent sterilisation of unextracted mineral material on site.

Case studies:

Examples of selective ore extraction by choosing the appropriate extraction equipment were chosen from four operations: Readymix-Lesence Kft. (construction minerals) in Hungary, Delphi-Distomon SA (bauxite) in Greece, JSW S.A. (energy mineral) and Bogdanka Coal Mine, both operating in Poland.

The construction mineral company noted that extraction planning is based on the selection of proper machinery and equipment (for the most part earth-moving machines), primarily with a view to prevent waste generation.

The bauxite mining company mentions that choosing the proper size underground machines necessary for mining and tunnelling works is made according to the shape and the type of the ore leads to the optimum ore recovery.

JSW S.A. Poland limits the extraction of material that would become waste by selecting less contaminated coal (without interlayers) through precise adjustment of the extraction machinery and by considering:

- an optimal selection of mechanised wall casings and mining machines, depending on the expected mining-geological conditions,
- proper longwall projection accounting for the presence of larger geological disorders (faults, horseback etc.).

Lubelski Węgiel “Bogdanka” S.A. (“Bogdanka” Lublin Coal) in Poland noted that rational extractive waste management begins at the design of the extractive operation, while being flexible during the extraction phase. Limiting the amount of mining and processing waste is achieved by use of:

- adequate machinery and equipment for extraction of the ore
- sorting machinery to separate coal from gangue,
- gangue for underground construction works

Baumit Kft (construction minerals) in Hungary noted that the planning of the drilling and blasting phase is one of the most important steps since the optimisation of this phase leads to the prevention of waste generation and efficient use of resources.

Additionally, some operators reported that maximisation of the ore extraction reduces the likelihood of the remaining ore being sterilised, weathered or oxidised, so that no unextracted material can come into contact with mine waters, this contact producing AMD and contributing to the discharges of dissolved metals.

4.3 Best Practice 3: Efficient haulage

The mine access and transport network and choosing an adequate hauling equipment and technique is a multi-dimensional optimisation problem that has to be considered at the design phase and may be regulated under national or sub-national mining laws in the Member States. In some cases, extractive materials are transported or pumped many kilometres to an appropriate site for treatment or deposition. Optimising the way (underground or surface transportation, using trucks or conveyor belts, or transported as slurry) usually leads to efficient use of energy, less disturbance of the surroundings and in some cases reduces the amount of rock to be excavated. The costs of using extractive materials that in principle qualify as by-products/products are influenced by the transportation distances and the haulage systems.

A well designed and maintained haulage network is the key to minimising haulage hazards and costs, and increasing productivity. However, the design of the network should also take into consideration local conditions and safety. Efficient haulage is an essential part of the whole mineral extractive project since no amount of maintenance will fix a poorly designed network.

A life-cycle emission and energy balance of the hauling equipment may lead to the proper decision being made whether maintaining and repairing existing equipment at the bottom line leads to higher emissions and/or energy requirements than using new, more energy-efficient equipment.

A poorly designed and constructed road infrastructure may need repeated maintenance (consumption of raw materials) and may lead to accidents. Each component of the road infrastructure should therefore be adequately addressed at the design stage (Thompson, 2010).

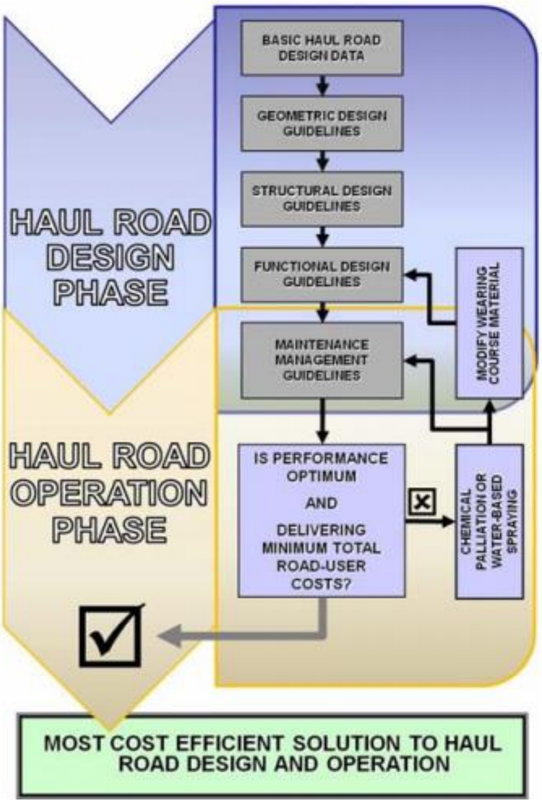

Figure 4-2: Typical integrated approach to road design (Thompson, 2010)

Relevance for Circular Economy:

Optimising the access to the operational site and transport network and choosing an adequate hauling equipment and technique usually leads to efficient use of energy, less disturbance to surroundings and in some cases reduces the amount of rock to be excavated.

Case study:

Two examples highlighting the importance of effective haulage have been chosen, one from Greece, from the metal ore sector, and one from Hungary (construction minerals). Both argue that the benefit of optimising the transportation network and the selection of modern equipment achieve a reduction in CO2 emissions and improved energy efficiency.

One should be aware, however, that replacing existing mining equipment with more modern equipment may lead to operational energy savings, but a life-cycle energy balance has to show that this replacement leads to overall energy savings and thus reduced environmental impacts. Maintaining and repairing older equipment may consume less virgin materials and energy and thus be more in the spirit of the Circular Economy.

4.4 Best Practice 4: Effective ore sorting and selective ore processing

Separation of processing fractions maximises beneficiation efficiency and may, in some cases, reduce the harmfulness of the extractive waste produced.

Better *in situ* separation of ore from extractive waste occasionally means prevention of waste generation and better extractive waste management. For example, better distinction between ore and waste rock may reduce wear and tear of machines by avoiding excavating unnecessary quantities of harder rock.

In certain instances, separation practices may create opportunities to identify and commercialise by-products. Furthermore, this practice prevents leaving unextracted mineralised material on site (resource sterilisation).

Relevance for Circular Economy:

Waste management objectives regarding prevention, re-use, and recycling highlight that the distinction between ore and waste rock may strengthen the application of Circular Economy principles by producing secondary raw material and by reducing the environmental footprint of extractive waste.

Case studies:

Selective ore processing at Aitik mine in Sweden consists of desulphurization and reducing the amount of hazardous waste. Desulphurisation offers an interesting integrated approach to tailings management and control of acid mine drainage (AMD) (e.g. Benzaazoua et al. 2000, Benzaazoua & Kongolo 2003, Bois et al. 2004, Hesketh et al. 2010). In desulphurisation, acid forming sulphide mineral fraction is either partly or fully separated from the tailings by froth flotation before the final deposition into the mine waste area (Kongolo et al. 2004, Kauppila et al. 2011). The application of selective ore processing in the mine closure phase at Aitik mine offers an integrated approach to both tailings management and control of seepage water quality.

This practice is applied during the pre-processing of Greek diasporic bauxite, which contains approximately 2-3 % of $CaCO_3$. In order to reduce the consumption of caustic soda and to reduce the amount of bauxite residues (=dewatered red mud) the Company removes the $CaCO_3$ using heavy media separation. The separated $CaCO_3$ is sold as a secondary material for construction purposes and as a raw material in the cement industry.

(Source http://wiki.gtk.fi/)

4.5 Practice 5: Effective usage of excavated materials

4.5.1 Filling excavation voids with excavated material

Certain mining, remediation and construction methods require the placing back of extracted materials into excavation voids. Application of these strategies - as far as they are technically and economically feasible and environmentally sound - requires due consideration of the requirements of equipment access, costs, productivity, stability and/or ventilation, which are investigated in the design phase and regulated under national or sub-national mining laws in the Member States.

In many EWMPs submitted to the European Commission, the application of placing back extracted materials into excavation voids is presented as best practice since it contributes to the prevention and/or reduction of extractive waste generation, simultaneously contributes to site remediation, and avoids occupying new land for the collection, storage and disposal of extractive waste. At the same time, instead of using virgin construction materials for rehabilitation purposes, the extractive industry utilises its own waste. Furthermore, in some cases, this practice allows for the exploiting of secondary stopes once the backfill of the primary stopes has structurally consolidated, resulting in resource efficiency.

In EWMPs related to tailings, reference is made to Cemented Tailing Backfill (CTB) technology. Its components (cement, tailings and water) are combined and mixed in a plant usually located on the ground of the mine. CTB, according to the mining sector, helps to alleviate the environmental impact of potentially hazardous mill tailings and extends the life-time of the tailings management facility since less volume is required. Instead of cement, material with hydraulic properties, such as fly-ash, are commonly used as binder. Potential and actual environmental impacts from CTB need to be balanced against safety gains by less surface disposal of tailings.

Whilst this often means that the material placed back into excavation voids becomes inaccessible itself for future use or re-processing, it usually also avoids leaving more valuable mineralised material on site (sterilisation of resources).

Relevance for Circular Economy:

Placing of excavated materials back into excavation voids contributes to the prevention/reduction of space needed for the disposal of extractive wastes and their harmfulness. The extractive material is not deposited or stored at the surface and at the same time contributes to the remediation purposes.

Cases studies:

The practice of filling excavation voids with extractive material was mentioned by all the mineral sectors and almost one third of the practice examples received were related to strategies and techniques for (back-)filling EWs into mined-out voids. Some examples are:

a) ***Lafarge, 35771 Vern-sur-Seiche from France***: Backfilling of EW in order to raise the pit floor above the groundwater level in order to reduce the volume of water to be pumped out of the pit.

b) ***JSW S.A. (energy mineral sector) from Poland*** argues that the usage of EW as material for filling excavation voids achieves the goal "zero waste generation and using waste as resources" (usage of EW instead of virgin aggregates).

c) ***Mina Lujar (Minera de Órgiva), Spain (industrial minerals)*** uses extractive waste not only to fill excavation voids in the underground mine "Lujar", but also uses the extractive materials for reclamation purposes outside the boundaries of the mine site.

d) ***Minas de Aguas Teñidas S.A.U. from Spain (metallic mineral sector)***: Use of thickened and cemented tailings for the filling of underground stopes. Backfilling the primary stopes with paste tailings could be considered as a best practice, taking into account the practical reasons below:

   - Filling excavated stopes with CTB that achieve sufficient structural strength allows mining of the space in between them, thus increasing resource efficiency by more extraction from the same mine.
   - The tailings are cemented in paste processing plants such that the resulting material has the required quality to backfill the exploited stopes.
   - Approximately 50% of the total amount of tailings are finally disposed into the mine. This practice prevents ARD generation through buffering. The cement used in the paste preparation results in an ARD inert backfill. From a geochemical point of view, the paste is stable, which minimises the generation of ARD.

e) ***Agnico Eagle, Finland, Kittilä Mine***: Their EWMP also refers to the paste backfill with tailings in underground mining.

f) ***Chaux et Dolomie Francaises, Neau (53) Chaux de Provence SACAM, Châteauneuf -Les-Martigues (13) in France***: The dolomite quarry produces various Ca-Mg-oxides, lime and dolomites for a wide range of applications. The dolomite is subject to thermal treatment to obtain the oxide and residues are returned to the quarry. The various residues are mixed and backfilled into the mined-out part of the quarry. The mixing of the various types of extractive and processing wastes leads to an inertisation of the quicklime and the mixtures can be used for backfilling and remediation purposes. The benefit is an inertisation of reactive processing residues by mixing them with EWs (saving virgin raw materials).

g) ***Boliden Mineral AB***, mine Garpenberg, Sweden: The mining strategy is to backfill waste rock and, according to the conditions in the permit, the tailings as well. The tailings that are not used for backfilling are transported wet in a pipe-line (a backup line is installed to make the maintenance easier) to the tailing pond that is water-saturated.

h) The Swedish EWMPs from ***LKAB***, ***Malmberget Mine*** (EWMP 2012) and ***Zinkgruvan,Nya Enemossen*** (EWMP 2015) also apply the practice of filling excavation voids with excavated material.

4.5.2 Construction minerals as marketable materials from extractive wastes

Overburden and waste rock may be recovered for the production of aggregates and lead to a reduction of volumes of extractive wastes that need to be managed in EWFs. The viability of producing construction minerals depends strongly on the local market demand for material of defined properties (e.g. meeting respective norms and acceptable transport costs). Aggregates are used in building, road construction, civil engineering, coastal protection, and for construction purposes in the mines themselves. While inert residues by definition do not pose a problem with respect to environmental acceptance, under national or sub-national laws in the Member States, non-inert non-hazardous excavated material may be acceptable for certain applications, e.g. road foundations. This depends on their specific properties, and the technical, economic and environmental requirements. Some EWMPs, mainly from the construction minerals sector, declare that (certain) waste materials can become materials marketable to the chemical industry, where it can be justified in environmental terms in accordance with binding environmental standards at Community level.

Relevance for Circular Economy:

Using extracted by-product or waste as construction minerals – as far as it is technically feasible and environmentally sound – leads to less extractive waste being generated and offsets primary production of construction minerals elsewhere.

Cases studies:

The extractive sector places importance on the use of construction minerals as marketable materials from extractive wastes since one third of the collected practices (27%) are methods related to recycling or re-use strategies.

Most of the companies that belong to the construction sector make a reference to the practice “use (recovery) extractive waste for the production of mineral aggregates” in their EWMPs. Specifically, the majority of EWMP collected in France (EWMPs from 43 quarries) show a common practice of:

- setting aside top-soils for building (temporary) vegetated dams around the extraction operation; the top-soil will be later used in remediation;
- separating storage of overburden to back-filled at closure and for landscaping the excavated area;
- using suitable and non-marketable materials for construction purposes in the extractive operation;
- quarries and pits tending to market as much as possible of the extracted material but depending on (local) demand and market conditions.

Swedish EWMPs mention the utilisation of extractive waste for construction purposes inside and outside the site or facility (e.g. LKAB Kirunavaara Mine, LKAB, Malmberget Mine, LKAB Mertainen Mine). Specifically, LKAB’s Mertainen mine re-uses waste rock for the construction of roads and impoundments outside the mine site (a notification to the authorities is needed and the material needs to be characterised so it is safe to use for the construction purpose). Waste rocks that are suitable for construction work are utilised by many quarries in Finland (e.g. Nordkalk Oy Ab’s Mustio limestone quarry, Mondo minerals B.V. Uutela’s talc mine, SMA Mineral, Kalkkimaa factory, and the Rantamaa and Ristimaa limestone quarries).

For the industrial mineral sector, companies such as Interbeton Construction Materials S.A (kaolin quarry in Greece) propose that part of the extractive waste (sterile material) is used inside the site for earthworks and maintenance of the road network. This practice helps to reduce the amount of waste that needs management as well as replaces virgin construction raw materials.

Many companies in Poland (JSW S.A., Bogdanka S.A. (Lublin Coal Mine), Polska Grupa Górnicza S.A., TAURON Wydobycie S.A. (ZG Sobieski and ZG Janina) show that aggregates production technology is simple and possible for use in construction works, among others, as filling, land levelling as well as aggregate in concrete. Specifically, JSW S.A. follows recovery approaches for waste management, such as the following:

1. "The use (recovery) of extractive waste for the production of mineral aggregates"***:*** Use of extractive waste from mechanical coal sorting (waste code 01 04 12) for the production of aggregates, according to technical approval and systematic quality control by
   - the *Roads and Bridges Research Institute* in Warsaw for a construction material named "Mineral and mine aggregate of JSW" and
   - the *Technological-Natural Institute* in Falenty for a product named "Hydrotechnical aggregate of coal mine slate of JSW"
2. "Sales and use of extractive waste in not-processed form": Waste under the waste codes 01 01 02 and 01 04 12 produced by the mining industry of hard coal mining may be used as construction material (earthworks, hydrotechnical embankments) or some generated waste from the flotation procedure may be used as raw material for the ceramic industry

In Hungary, Colas Északkő Kft. (construction minerals) managed a large-scale landscaping project at the Tállya Andesite Quarry, which is inside a Natura2000 area and UNESCO Tokaj Wine Region Historic Cultural Landscape World Heritage protection zone, until 2014. A total of 170,000 m^3 mining waste was used for the landscaping project.

From the ore mining sector, the EWMPs by Rosia Montana Gold Corporation S.A. and Hellas Gold S.A. (mixed sulfides) note that overburden and waste rock, due to the suitability of their geotechnical and geochemical characteristics, will be used particularly for the construction of the waste facility, but also for other uses (e.g. road construction). The Swedish EWMP from Zinkgruvan, Nya Enemossen mentions utilisation of tailings in dam constructions.

4.6 Best Practice 6: Effective management of topsoil

Topsoils are mineral-organic materials that provide the growing substrate for the plant cover. Topsoils are ecosystems of their own, depending on a set of environmental conditions, such as rainfall distribution and temperature ranges. This means that the functionality of topsoils can be easily impaired or destroyed. Rebuilding this functionality takes years, if not decades.

Putting topsoil back in place after the closure of the waste facility or, if this is not practically feasible, reusing topsoil elsewhere (for example, landscaping and re-vegetation purposes) may strengthen the application of Circular Economy principles. Therefore, all topsoil removed during construction and preparation for mining should be stored at separate locations and under conditions that impair their functionality as little as possible. For the same reason, their reuse is encouraged as expeditiously as possible. During the operational phase, the soil heaps will vegetate by free succession, which provides a protection against their erosion and dust generation and also helps to maintain their fertility.

Relevance for Circular Economy:

The use of local topsoil works best for fast re-vegetation with local plant species and avoids extraction and transport of topsoil from elsewhere.

Case Studies:

Rosia Montana Gold Corporation S.A. in Romania: The topsoil stockpiles and the overburden stockpiles are expected to cover some 40 ha of land altogether. The total area of these stockpiles is relatively small, as about 30% of the soil stripped during the operational phase can be re-used during the same phase and only 70% need to be stored for later re-use during the closure phase. Temporary land-use at the stockpile sites is primarily agricultural with cattle and sheep grazing, fields for forage and some woodland. Sterilisation of the soil resource under the topsoil piles will be temporary for the life of the Project. Following removal of the topsoil stockpiles the soils are expected to return to their original use, supporting pastures for grazing and forage.

Readymix-Lesence Kft. in Hungary: The management of stripped topsoil is based on a careful analysis and planning of the material flows of the extractable mineral raw materials. Topsoils are stored for later use in re-cultivation and reconstitution of arable lands. It is important to return and spread the topsoil over the original area as soon as possible, possibly within three years, in order to retain fertility. If this is impossible within the three-year time frame, the topsoils are treated as inert waste, and are taken into account in our waste management plan.

The use of local topsoil for landscaping and covering purposes is also mentioned in Finish EWMPs (***Agnico Eagle Finland Oy,*** Kittilä Mine (gold), ***Mondo Minerals B.V,*** Uutela Mine (talc), ***Yara Suomi Oy,*** the Sokli project (phosphate)). An important aspect is to keep organic and inorganic material separate when stripping the ground, in order to keep the material characteristics for the landscaping purposes.

4.7 Best Practice 7: Disposal planning and management for later recovery

Re-processing of historical extractive waste is a long-standing practice that is adopted for all kinds of minerals: energy, metal ores, industrial and construction. Residues of low value originally, which are readily available in tailings or heaps, undergo processes of recovery in order to obtain fully qualified products, such as metals, aggregates, coal (energy products) etc. Technological advances make it economically feasible to use historical extractive waste as a resource – especially in combination with newly discovered ore-bodies and/or site clean-up and river restoration projects.

The EWMPs may consider such reworking of extractive waste from the outset, at the planning stage, by segregated emplacement where this is operationally and spatially feasible.

Relevance for Circular Economy: Re-processing of historical extractive waste:
The utilisation of historical waste as raw material increases the long-term value obtained from the original extraction, offsets primary production elsewhere and simultaneously contributes to site rehabilitation. Whilst this usually improves environmental conditions locally by

removing non-inert components, it seldom reduces the total amount of extractive waste to be subsequently managed.

Case studies:

EWMP from Penouta mine in Spain: The Penouta Mine was closed in 1985 without any rehabilitation of the site. Strategic Minerals Spain has carried out several studies to find ways to exploit the tailings ponds containing tantalum and niobium. The processing of tailings from the old Penouta mine produces around 1% of tin, tantalum and niobium metals, and 99% remain tailings. The latter are mainly composed of silicate minerals that can be reprocessed, obtaining around 70% of industrial minerals, namely quartz, mica, feldspar and kaolin. The overall process aims to achieve a reduction of mining wastes by around 80%. The final residue will be used as material for environmental rehabilitation.

Hellas Gold S.A. in Greece: Re-processing of historical waste (tailings from the enrichment of pyrites) to produce concentrates of galena, sphalerite and arsenopyrite. The historical waste is the residue of the ore treatment (since 2000) after recovery of these minerals. The re-working uses more efficient extraction and thus reduces the amount of ARD generating minerals in the tailings.

Canteras de Santullan S.A. in Spain (aggregates and production of calcium carbonate): Under the pressure of a very difficult situation due to the economic crisis at the end of the 2000s, the company decided to reconsider fundamentally and from a mining-technical point of view all existing processes and, with relevant investments, to increase drastically the recovery of reserves and recycle large stocks of old wastes.

The decision reduced mining costs, improved the quality of and added value to the final mineral products, transforming the company from a small local supplier of low-value construction aggregates to one of the biggest European exporters of high-quality industrial and chemical limestone products by sea transport from Bilbao port.

Interbeton S.A. (Titan Group) in Greece: Company owns a heap of low-grade kaolin (as old historical residue), which is mixed with high-grade kaolin (according to the trade specifications), targeting use of the total of the historical exploited material. This historical residue was not mixed with other waste (like overburden) during the production phase, thus it can be used now as raw material due to new lower grade marketing needs. This illustrates the benefit of segregated disposal in view of later re-working.

4.8 Best Practice 8: Effective monitoring of the implementation of the EWMPs and their review

Each Extractive Waste Management Plan is reviewed by the operator every five years and/or amended, as appropriate, in the event of substantial changes to the operation of the waste facility or to the waste deposited. Monitoring is an important tool to verify that an EWMP meets its objectives. The monitoring of an EWMP should be dynamic and provide records that can be utilised as a basis for the continuous optimisation of resources use and minimisation of the residual material that will end up in an extractive waste facility.

Typically, the operator develops a monitoring plan that also includes parameters relevant to the EWMP. The details of the proposed monitoring actions may include water and soil sampling and on-site or in situ measurements, geotechnical tests, topographical surveys, and surveys using remote sensing techniques.

A EWMP's monitoring records not only demonstrate compliance with the initial permit, but also may provide useful information for:

- decisions related to waste minimisation
- research for minimisation of hazardous properties of extractive wastes
- prevention or at least minimisation of any long-term negative effects, for example attributable to migration of airborne or aquatic contaminants from the waste facility
- Assurance long-term geotechnical stability of any EWF exists in the ground surface

EWMP is reviewed by the operator every five years and/or amended, as appropriate, in the event of substantial changes to the operation of the waste facility or to the waste deposited, supported by monitoring techniques, in order to prevent or reduce as far as possible any negative effects - actual or potential - on the environment or on human health, and lead to fast corrective actions, if needed.

Relevance for Circular Economy:

Starting from the design phase of a mining site, the EWD emphasises the concept that effective design will reduce the generation of extractive waste, encourage its recovery and minimise short- and long-term liabilities. Indeed, the ultimate goal would be to ensure that, where possible, a closed site can be left without the need for on-going monitoring. Therefore, keeping regular records of the all the quantities and composition of extractive wastes generated at a site will aid decision-making on its fate and ensure its optimal management.

Case study:

According to the ***EWMP from Rosia Montana Gold Corporation S.A.*** (Romania) the EWMP is subject to periodic review and update over the life of the mining operation, in response to internal and external reviewer comments, regulatory changes, changes in mining operations, stakeholder communications, internal audit and management review results, and other factors. The implementation of the Extractive Waste Management Plan is also supported by a number of detailed, lower-tier Standard Operating Procedures. The Structural Relationship of lower-tier Management Plans in the Environmental and Social Management System is presented in the following figure.

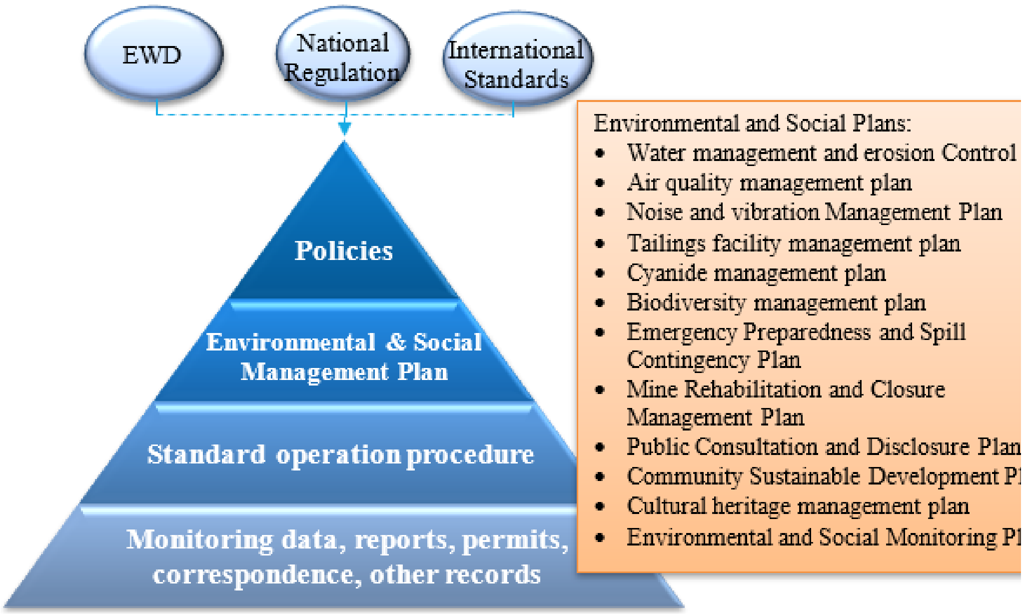

Figure 4-3: Environmental and social management system (Source: EWMP from S.C. Rosia Montana Gold Corporation S.A.

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