5. Alternative Analyses

Table of Contents

Table of Figures

Table of Tables

List of Exhibits

The location of the Project is essentially dictated by the geology of the target ore reserve and it is beyond the remit of the EIA process to consider alternative targets for mineral exploitation. The following Chapter therefore identifies and assesses the following principal types of alternative options:

- locations for the processing and mining waste management activities that comprise the Roşia Montană Project
- timing and projected duration of the mining operation
- selection of principal methods for mitigating impacts involving assessment of mining and processing technologies
- options for project water management and
- development of project infrastructure.

This information supports the summary of preferred and rejected alternatives presented in Section 1.7, Table 1.7.1, and is provided pursuant to the requirements of Section 5/Annex 2 of Ministerial Order (M.O.) 863.[i]

As is also required under Romanian EIA regulations and guidance, this Chapter also assesses the "no-project" option, i.e., that the Project does not proceed.

The potentially negative impacts associated with the selected alternatives as well as the mitigation measures subsequently planned for all phases of the Project are identified in the impact tables presented in the individual subsections of Chapter 4.0. A suite of detailed management plans will support these measures. These management plans are important elements of the Project's Environmental and Social Management System (see Section 1.9), and are subject to systematic improvement processes as noted in Section 3.3 of the Roşia Montană Project Environmental and Social Management Plan (ESMS Plans, Plan A).

1 No-Project Alternatives

1.1 Null or No-Action Alternative

A “null” or “no action” alternative is presented in order to provide a baseline against which to compare other alternatives for the various elements of the Roşia Montană Project. Under this alternative, the project would not be undertaken in any form. The current (Roşiamin) mining operation near the community of Roşia Montană would cease its operations by 2008 with the forecast removal of its subsidy.

The main potential negative impacts associated with the adoption of a null alternative include the following:

- continued pollution of streams and soil within the proposed Project boundary, primarily from uncontrolled run-off and seepage from the Rosiamin operation, historic mine workings, and uncontrolled waste disposal practices;
- loss of a major local and regional employment opportunity (estimated at 200 – 500 direct jobs during pre-construction, 1,200 during construction, and 540 during operation; additional indirect employment figures are estimated at approximately 400 – 500 jobs during pre-construction; 3,600 during construction; and 1,620 – 2,700 during operations);
- loss of current developmental investments associated with exploration, permitting, EIA preparation, and other preliminary activities, with a resulting loss of interest on the part of private investors, commercial banks, or international lending institutions regarding future mining developments in the region or Romania as a whole;
- loss of support for the eventual development of a modern, compliant regional solid waste management facility in Câmpeni, as discussed in Chapter 3 and the Project *Waste Management Plan* (See **ESMS Plans, Plan B**);
- loss of the opportunity to conserve, improve, or enhance existing ecological conditions through implementation of specific restorative and rehabilitative activities, including enhancement of riparian habitats, replanting of native species, establishing a network of migration corridors, and the relocation of any affected rare plants to suitable habitats, as outlined in the Project *Biodiversity Management Plan* (**ESMS Plans, Plan H**);
- continued dereliction of historic buildings and sites and loss of the cultural heritage preservation opportunity represented by the Archaeology and Historical Monuments Preservation Programme, described in the Project *Cultural and Heritage Management Plans* (see **ESMS Plans, Plans M1 and M2**);
- loss of a centuries-long tradition of mining as a local and regional cultural asset; and
- outward migration of the local and regional population, especially young families seeking viable employment and career opportunities.

In the best of circumstances, the Roşia Montană region would have:

- strong economic and job opportunities,
- minimal environmental and social impacts from mining or any other major economic developments, and
- the technical capabilities and resources necessary for the remediation of historical environmental impacts.

In order to achieve this goal (and to prevent the negative socio-economic and environmental impacts associated with the shutdown of all mining operations at Roşia Montană), a viable economic resource is required that is capable of generating substantial employment opportunities, as well as sufficient revenues to permit resolution of historical environmental issues. If the “null” or “no action” alternative is carried out, existing negative socio-economic and environmental impacts will persist and/or accrue in the region, unless other economic resources can be identified that can support the mitigation of these issues. As discussed in Section 1.2, the development of viable alternative industries is highly unlikely. For these reasons, the “null” or “no action” alternative is rejected as a viable solution, because it ignores or is incapable of addressing the environmental and socio-economic needs of the Roşia Montană region.

A summary of the assessment of environmental impact of the no-action alternative compared to the selected option (that the Project proceeds) is provided in Table 5-1 below. Details of no-action alternative are presented in the Appendix of this Chapter.

Table 5-1. Impacts of No-action Option compared to Selected Option

Environmental Issues	Options		Comments
	No Action	Project proceeds	
Water flows and quality	Long term negative impacts continuing as a result of uncontrolled ARD and run-off from existing un-rehabilitated mine workings and waste	Forecast significant beneficial long term impact arising as a result of the imposition of comprehensive water management and mine closure plans	The proposed Project delivers highly significant, long-term benefits compared to the no-action alternative
Air quality	Existing baseline conditions would prevail long term, i.e., essentially good quality with occasional domestic heating influences and dust from unvegetated and unrestored surfaces	Forecast short-term impacts on air quality from site activity (dust), and air emissions (gases and fumes), latter maintained within permitted limits to ensure safety of workforce and adjacent community	The Project introduces significant new sources of air pollution in the short term, but these will be controlled
Noise and vibration	Existing baseline conditions would remain long term, i.e., typical of semi-rural area	Forecast short-term impacts arising from operation of vehicles and equipment, blasting and mining activities generally; mitigation to be applied to keep noise and vibration within permitted limits	The Project introduces significant new sources of noise and vibration in the short term, but these will be controlled
Soil	Rosia Valley: long term condition of land dereliction would remain with unrestored dumps and pits; Corna Valley: existing long-term conditions would remain, ie relatively undisturbed agricultural use of soils; some influence from emissions from unrestored mine waste dumps will continue	Rosia Valley: rehabilitation of operational areas would restore soils and growth media to support vegetation; Corna Valley: long-term impact on soils from land take for TMF and waste rock stockpile; mitigation by rehabilitation of sites using stored soils with revegetation and establishment of a productive end-use	Land take for the Project will impact soil resources, particularly in the Corna valley; however, rehabilitation will mitigate this and the mining dereliction in Rosia Valley will be remedied

Environmental Issues	Options		Comments
	No Action	Project proceeds	
Biodiversity	Baseline conditions will prevail long-term; loss of opportunity for improvement in biodiversity through a comprehensive habitat creation and enhancement programme	Short term impacts arising from land take; long term, opportunity to conserve, improve, or enhance existing ecological conditions through implementation of the Project *Biodiversity Management Plan*	Again, land take will impact significantly on existing habitats, however the planned rehabilitation measures create opportunity for enhancement of biodiversity values
Landscape	Baseline conditions will prevail long-term with continued impact of derelict mined land in Rosia Valley	Long and short-term impacts arising from land take and earth-moving; mitigation to minimise long term impact by rehabilitation and establishment of interesting features	The Project will have a significant impact on landscape and will give rise to short-term visual impact
Socio-economic issues	Significant impact of closure of mining in area on jobs and investment leading to acceleration of generally worsening socio-economic conditions	Significant inward investment from Project leading to general improvement in socio-economic conditions; long-term positive impacts dependent on success of proposed Community Sustainability Development Programme (CSDP)	The Project brings significant socio-economic benefits and the CSDP is designed to make this a long-term effect
Cultural heritage	Impacts arising from lack of investment; long-term continued deterioration of historic monuments and buildings and lack of access to ancient mining remains	Impact on historic sites from land take, offset by investment in long term preservation of historic remains, houses and other important structures as well as assuring access to sites and features of interest	Again, land take creates impacts, but inward investment enables this to be offset and create long term benefits, by appropriate planning and resourcing
Transportation issues	Existing baseline conditions prevail long-term with poor transportation links and infrastructure	Short-term impact on highways from increase in heavy traffic; positive impact from significant inward investment available to upgrade infrastructure to provide long-term benefits	The Project will have a short-term negative impact in regard to road traffic volumes and amenity; inward investment provides the opportunity to improve the transportation infrastructure
Transboundary impacts	The existing derelict mining site will remain a long-term source of heavy metal pollution that will continue to add to the pollution load carried by Mures river out of the country	The Project will deliver a long-term positive impact on water quality that will contribute to the improvement in quality of Mures river flowing out of the country; mitigation against impacts arising in a Transboundary context as a result of abnormal conditions has been included within the Project design, fully in line with Romanian, EU and international requirements and guidance	The no-action option allows the continuation of chronic pollution that ultimately affects the quality of rivers flowing out of Romania

1.2 Other Industries Alternatives

1.2.1 Baseline significant issues

In order to bring viable and sustainable economic benefits to the Roşia Montană region from the development of industries other than mining, several significant baseline issues must be considered Difficulties faced by local economic development include:

- Demographics. Notably the declining total number and average age of the population; health is poorer than the Romanian average; the majority of men of working age are engaged in mining-related activities either directly (at the mine) or indirectly (servicing the mine and its staff)
- Financial. A significant proportion of the population is at poverty level. Many people depend on subsistence agriculture to supplement their livelihoods.
- Skills. The area is dominated by mining-specific skills. There is likely a capacity gap to develop and manage businesses effectively, especially to take advantage of Accession to the EU or other market opportunities.
- Isolation. The area is relatively remote from anticipated markets. Additionally, Roşia Montană has no through traffic that would give rise to incidental visitations.
- Transport infrastructure. The condition of the roads is generally poor, exacerbating the isolated nature of the area. The nearest railheads are about 80 minutes drive, to Alba Iulia, and 90 minutes to Deva. Roads to these railheads are in poor condition. The nearest airport is at Cluj Napoca, some two hours drive from Roşia Montană.
- Other infrastructure. Water supply, waste water treatment, waste management including municipal and hazardous, and electricity supply are all below optimal standards in comparison with other regions in Romania and in particular to EU levels.
- Environment. There are significant environmental problems including pollution of water. Roşia Stream has a pH of 2.5 and significant heavy metal pollution as a consequence of past and current mining operations; lakes in the area, all man-made for (earlier) mining purposes have heavy metal pollution including mercury; water wells and bores also have heavy metal pollution including cadmium and selenium. There are numerous old tailings dumps, waste heaps and other mine-related equipment and waste that need clearing, remediating and rehabilitating in order to return the area to a condition fit for a productive use.
- Clean up and mitigation costs. The cost of stand-alone remediation of the current environmental problems has not been fully assessed. However, it is likely that minimal rehabilitation to provide an acceptable site closure would be in excess of 20million EUROS. Development of an appropriate quality water supply, waste water treatment, waste management, energy and transport infrastructure has also not been formally defined. Costs for this are likely to be high.
- Other centres. Other centres such as Campeni and further afield at Timisoara, Arad Oradea, Satu Mare, Deva, Cluj Napoca, Baia Mare and many others are closer to markets and more developed in terms of infrastructure, diversity of labour and professional skills, and are likely to be perceived as having lower investment risk. These will, and do, attract investment at the expense of areas such as Roşia Montană, and are experiencing positive growth.
- Liability. Considering the anticipated Accession to the EU and thus the applicability of EU standards concerning environmental liability, potential investors may be intimidated by the potential liability for considerable clean up costs should they purchase polluted lands.

- Perception. Mono-industrial areas such as Roşia Montană are not in general well regarded in terms of investment targets. The specific skills set, the condition of the towns and surroundings including social and environmental, and generally poor economic circumstances create a negative impression. There is a trend of people leaving such areas.

1.2.2 Alternative industries

Nonetheless, it has been suggested that under the null or "no-action" alternative, a number of other industries besides mining could be developed in the region that would provide a comparable level of economic benefit. A recent study titled "Social & Human Problems in the Mining Zone Roşia Montană identifies a number of potential alternate industries, including:

- agriculture (e.g. food crops, animal husbandry);
- tourism;
- forestry and wood processing;
- light and home-based industry (e.g. knitting);
- gathering of native flora and fauna for pharmaceutical purposes; and
- meat processing.

While some potential exists for each of these alternatives, it must be emphasised that considerable development would have to occur for each alternative to be so stimulated that it could support the regional economy at a level comparable to that associated with a large-scale, viable, modern mining operation. Moreover, each alternative has an associated set of environmental impacts which must be considered, potentially at a level of detail similar to that represented by this EIA document.

1.2.2.1 Investment in remediation and infrastructure required

Table 5.2 describes the minimum level of investment in remediation and infrastructure required under each alternate industry identified in the referenced report. As is noted above and confirmed by this table, economic development within the Roşia Montană region is currently limited by the extent of existing pollution of regional waterways and other wastes from the many abandoned historical workings, at levels that renders much of the region unattractive to alternative industries – profoundly so in the case of tourism. Significant investments would therefore have to be made to remediate these environmental problems and properly close the existing Rosiamin mine and its associated facilities prior to the development of alternate industries. Without external investment, the cost of resolving these historical environmental liabilities to a condition capable of supporting alternate industries is currently beyond the means of existing local and regional entities. There is also no centralised entity representing any of the alternate industries identified above that is capable of financing the environmental remediation.

In addition, any sustained economic alternative must also provide the source for funding the appropriate infrastructure necessary to support the future development of economic activity. Necessary infrastructure includes, but is not limited to, providing clean drinking water, wastewater treatment systems, hazardous and municipal waste collection and disposal systems, and other types of infrastructure that may be necessary for the development of a particular industry. Taking tourism as an example, significant investment would be required to develop museums or historical sites of interest to a level at which they would stimulate tourist interest without the additional interest afforded by a working mine. Additional investment would also be required to develop the hotels, roads, restaurants, water supply and wastewater treatment systems, hazardous and municipal waste disposal facilities, and other infrastructure that would be required to support a significant level of tourism.

Without substantial investment, it is unlikely that any of the alternate industries noted in Table 5.2 can provide the direct or indirect employment and level of wages that can be supported by a modern, large-scale mining operation. However, it should also be noted that none of the alternatives are necessarily precluded by the presence of a mining operation, especially if a significant portion of the basic remediation and infrastructure development needs of those alternate industries are borne by the proposed mining project. For instance, the current project design incorporates the partial remediation of the pollution of waterways from historical mining operations. The proposed project also supports the development of viable water supply and wastewater treatment systems, a regional solid waste disposal facility conforming to newly issued Romanian standards, the construction of a new village to support displaced residents, and other infrastructure elements that, although required to support the mining operation, will also be of lasting benefit to the local community.

Therefore, under an “alternate industries” alternative it will be extremely difficult for the probable economic value of any alternate industry to separately attract the level of investment necessary to resolve existing historical environmental and social issues. Any significant developments under the alternate industry scenario would be subject to the same EIA regulations as the Roşia Montană Project, and would potentially require an investment in site investigation and planning that in many respects will be similar with that identified in this EIA.

Table 5-2. Areas Requiring Investments in Remediation and Infrastructure for Alternate Economic Drivers Suggested Under Null Alternative

Alternative Economic Drivers	Regional Waterways Remediation	Soil Remediation	Roşiamin Mine Closure	Drinking Water Supply	Solid Waste Disposal Infrastructure	Wastewater Treatment Infrastructure	Additional Infrastructure
Agriculture, Grazing, Meat Processing	Remediation of historical mining operations is required to prevent further degradation of water resources and contaminated water impacts to crops and grazing animals, as well as to provide an opportunity for resource recovery.	Soil remediation may be required in historically impacted areas to ensure crops and grazing animals are not contaminated by uptake of metals.	The scope of the Roşiamin mine closure must ensure that crops and grazing animals are not contaminated by uptake of metals in impacted areas.	Remediation of drinking water supplies may be required to minimise contaminated water impacts to grazing animals as well as to provide adequate clean drinking water supplies to the local population.	Development of a compliant regional municipal solid waste landfill will be required. Interim accumulation and storage measures for hazardous wastes associated with the processing of meat and foodstuffs will have to be developed, pending identification of a permanent Romanian hazardous waste disposal option.	Wastewater impacts associated with raising cattle, fertilising crops, and operation of abattoirs and/or food processing plants must be evaluated with regard to impacts on community water supplies. Treatment systems and/or buffer zones for agricultural runoff or industrial effluents may be required.	Regional abattoirs and processing plants for meat and other foodstuffs will need to be financed and built. Transportation impacts to move products to market will also need to be considered, and road improvements may have to be financed.
Tourism	Remediation of historical mining operations will be required to prevent further degradation of water resources and to resolve visual impacts of contaminated waterways. The visual impacts caused by uncontrolled disposal of solid wastes to waterways must also be resolved.	The visual appearance of land surfaces impacted by historical mining operations must be improved via revegetation programmes, in order to better ensure tourist demand.	The scope of the Roşiamin mine closure must ensure that minimal visual impacts to the landscape remain; if mining areas or artefacts are reserved as tourist attractions, closure plans must arrange for the necessary infrastructure and safety precautions to support tourist access.	Remediation of drinking water supplies will be required in order to provide adequate clean drinking water supplies, both to tourists and to the local population.	Development of a compliant regional municipal solid waste disposal facility will be required. Interim accumulation and storage measures for any hazardous wastes will have to be developed, pending identification of a permanent Romanian hazardous waste disposal option.	Wastewater impacts associated with potential tourist and tourist support industry impacts must be evaluated and treatment systems developed and installed to accommodate the anticipated usage. Treatment system locations must not detract from the overall visual attractiveness of the region from the perspective of a tourist.	Hotels, museums, restaurants, public restrooms, sites of interests, and associated shops or tourist facilities must be developed to support the anticipated tourist load, as well as the needs of local tourist-industry workers.
Forestry, Wood Processing, Wood Products Manufacturing	Remediation of historical mining operations is required to prevent further degradation of water resources and to provide an opportunity for resource recovery.	For forestry, soil stabilisation and erosion control measures must be established to protect existing forest resources, and to support sustainable forestry operations.	The scope of the Roşiamin mine closure must ensure that soil stabilisation and erosion control measures are established to protect existing forest resources and the potential development of sustainable forestry operations.	Remediation of drinking water supplies will be required in order to provide adequate clean drinking water supplies to the local population.	Development of a compliant regional municipal solid waste disposal facility will be required. Interim accumulation and storage measures for hazardous wastes associated with the processing of wood products will have to be developed, pending identification of a permanent Romanian hazardous waste disposal option	Wastewater impacts associated with nursery, logging, and wood processing operations must be evaluated with regard to impacts on community water supplies. Treatment systems for industrial effluents may be required.	Regional lumber mills, nurseries, and wood product processing plants will need to be financed and built. Transportation impacts to move products to market will also need to be considered, and road improvements may have to be financed.
Cottage Industries	Remediation of historical mining operations is required to prevent further degradation of water resources and to provide an opportunity for resource recovery.	Not applicable.	The scope of the Roşiamin closure must ensure that water resources are not further degraded.	Remediation of drinking water supplies will be required in order to provide adequate clean drinking water supplies to the local population.	Development of a compliant regional municipal solid waste disposal facility will be required. Interim accumulation and storage measures for hazardous wastes will have to be developed, pending identification of a	Wastewater impacts associated with combined cottage industry and residential use must be evaluated with regard to potential impacts on the quantity and quality of community water supplies. A municipal water	Development of warehouses or logistics systems to collect goods for distribution to market will be required. Transportation impacts to move products to market will

Alternative Economic Drivers	Regional Waterways Remediation	Soil Remediation	Roşiamin Mine Closure	Drinking Water Supply	Solid Waste Disposal Infrastructure	Wastewater Treatment Infrastructure	Additional Infrastructure
					permanent Romanian hazardous waste disposal option.	treatment system capable of handling additional cottage industry wastewater loads will be required	also need to be considered, and road improvements may have to be financed.
Flora/Fauna Gathering for Pharmaceutical Purposes	Remediation of historical mining operations is required to prevent further degradation of water resources and to provide an opportunity for resource recovery.	Soil remediation may be required in historically impacted areas to ensure pharmaceutical flora/fauna are not contaminated by uptake of metals.	The scope of the Roşiamin mine closure must ensure that pharmaceutical flora/fauna are not contaminated by uptake of metals in impacted areas.	Remediation of drinking water supplies will be required in order to provide adequate clean drinking water supplies to the local population.	Development of a compliant regional municipal solid waste disposal facility will be required. Interim accumulation and storage measures for hazardous wastes associated with pharmaceutical product processing operations will have to be developed, pending identification of a permanent Romanian hazardous waste disposal option	Wastewater impacts associated with pharmaceutical product processing operations must be evaluated with regard to impacts on community water supplies. Treatment systems for industrial effluents may be required.	Regional processing plants or warehouses to collect products for distribution will need to be built. Transportation impacts to move products to market must also be considered, and road improvements may have to be financed.

1.2.3 Impacts of Alternative Industry Option compared to Selected Option

A summary of the comparative environmental assessment of development of alternative industries and the proposed mining project is presented in Table 5-3.

Table 5-3. Impacts of Alternative Industry Option compared to Selected Option

Environmental Issues	Options		Comments
	Alternative Industry	Project proceeds	
Water flows and quality	Likely alternative industries unable to fund remediation of chronic pollution which would remain	Forecast significant beneficial long term impact arising as a result of the imposition of comprehensive water management and mine closure plans	The proposed Project delivers highly significant, long-term benefits compared to the no-action alternative
Air quality	Some impact on air quality would arise, however emissions would have to meet statutory limits	Forecast short-term impacts on air quality from site activity (dust), and air emissions (gases and fumes), latter maintained within permitted limits to ensure safety of workforce and adjacent community	Any new industry would introduce new sources of air emissions that would have to be appropriately controlled; the impacts of mining are also short-term in nature
Noise and vibration	As for air quality	Forecast short-term impacts arising from operation of vehicles and equipment, blasting and mining activities generally; mitigation to be applied to keep noise and vibration within permitted limits	The Project introduces significant new sources of noise and vibration in the short term, but these will be controlled; the impacts of mining are also short-term in nature
Soil	Industries would be unable to fund remediation of derelict lands which would remain; any "Greenfield" development would impact soils as a result of land take	Rosia Valley: rehabilitation of operational areas would restore soils and growth media to support vegetation; Corna Valley: long-term impact on soils from land take for TMF and waste rock stockpile; mitigation by rehabilitation of sites using stored soils with revegetation and establishment of a productive end-use	Land take for the Project will impact soil resources, particularly in the Corna valley; however, rehabilitation will mitigate this and the mining dereliction in Rosia Valley will be remedied
Biodiversity	Existing areas of land dereliction would remain and it is unlikely that other industries would be able to fund any significant programme of biodiversity enhancement	Short term impacts arising from land take; long term, opportunity to conserve, improve, or enhance existing ecological conditions through implementation of the Project *Biodiversity Management Plan*	Again, land take for the Project will impact significantly on existing habitats, however the planned rehabilitation measures create opportunity for enhancement of biodiversity values
Landscape	Existing visual impacts of past mining would remain; impacts on landscape from new industries would be dependent upon scale and nature of the projects	Long and short-term impacts arising from land take and earth-moving; mitigation to minimise long term impact by rehabilitation and establishment of interesting features	The Project will have a significant impact on landscape and will give rise to short-term visual impact

Environmental Issues	Options		Comments
	Alternative Industry	Project proceeds	
Socio-economic issues	Introduction of new industries would have a positive impact on the community, but significance and duration would be dependent upon the nature of the proposals	Significant inward investment from Project leading to general improvement in socio-economic conditions; long-term positive impacts dependent on success of proposed Community Sustainability Development Programme (CSDP)	The Project brings significant socio-economic benefits and the CSDP is designed to make this a long-term effect
Cultural heritage	Likely alternative industries unable to fund any significant programme to safeguard the cultural heritage of the area and also make it accessible to visitors; deterioration of historic remains and building would continue	Impact on historic sites from land take, offset by investment in long term preservation of historic remains, houses and other important structures as well as assuring access to sites and features of interest	Again, land take creates impacts, but large-scale inward investment enables this to be offset and create long term benefits, by appropriate planning and resourcing
Transportation issues	New industries would impact negatively on existing transport infrastructure and likely scale of new investment would allow for only limited improvements	Short-term impact on highways from increase in heavy traffic; positive impact from significant inward investment available to upgrade infrastructure to provide long-term benefits	The Project will have a short-term negative impact in regard to road traffic volumes and amenity; the greater significant inward investment attached to a large scale mining project provides the opportunity to improve the transportation infrastructure
Transboundary impacts	Introduction of new industries is unlikely to have a direct transboundary impact. However, the scale of investment would not be sufficient to fund remediation of an existing water quality problem that is adding to pollution loads that are in turn significant in the transboundary context	The Project will deliver a long-term positive impact on water quality that will contribute to the improvement in quality of major rivers flowing into adjacent States; mitigation against impacts arising in a Transboundary context as a result of abnormal conditions has been included within the Project design, fully in line with Romanian, EU and international requirements and guidance	The alternative industries option provides no assurance that chronic pollution of local streams that ultimately affects the quality of rivers flowing out of Romania will be halted

1.2.4 Conclusion

While it is correct that a diverse multi-sector economic base is important for the sustained economic growth of the region, the economic basis and infrastructure necessary to attract these new and diverse industries to the region must first be established. By providing economic stimuli and by addressing many of the region's most pressing environmental and infrastructure issues, the proposed mining operation would serve the region's ultimate goal of economic diversity in a number of important ways. For the aforementioned reasons, the development of alternate industries has been rejected as an alternative option but it is highlighted that the Project does not preclude development of such industries in parallel, and to the contrary, it solves several key problems that discourage inward investment.

2 Project Timing and Production Rate Alternatives

2.1 Delayed Project Start-up

2.1.1 Discussion of alternatives

Delays in start-up of a project can have environmental benefits, as illustrated in the following examples:

- Development of transport and infrastructure could be underway and its completion would allow minimisation of traffic impacts from new projects; also, new housing could be under construction and its completion will enable satisfactory housing of project workers and other people attracted to the area by the increased economic activity.
- Development of new technology that may have significant environmental benefits for a proposed project could be underway.

Baseline studies indicate that there are no programmed infrastructure or other proposed developments for the Roşia Montană area that could be of benefit to the Project in environmental terms by appropriate timing of start-up. As noted above, such development is forecast as only likely to arise in the short to medium term as a result of Project implementation.

An additional alternative closely related to the null alternative has been suggested that involves delaying mining operations until such a time that the technology associated with ore processing is sufficiently developed to significantly further reduce environmental risk and potential for impacts. This alternative has essentially the same potential impacts as the null alternative over the full period of time for which mining would be delayed. Alternate ore processing technologies are separately evaluated in Section 4. It may be concluded from this examination that no alternate ore processing technology exists that is both suitable for the geochemistry of the Roşia Montană ore and so well understood that it could be developed and proven to be effective and safe without first undergoing a very lengthy process of development and testing.

2.1.2 Conclusion

It is therefore impossible to provide any meaningful forecast for alternative project timing on this basis and for this reason, the **delayed mining operations alternative is rejected as not being viable**. The environmental impact of this alternative option is therefore not analysed. Nevertheless, the following conclusions may be drawn in regard to the ***principle*** of delaying start up of the Project:

- A delay in the Project would result in a delay in the remediation of the existing severe water pollution problem;
- Realisation of other significant benefits would also be delayed, including employment opportunity and inward investment at a time when closure of Rosiamin operations is about to further impact local socio-economic conditions;
- technology to be employed in the Project is designed to BAT requirements and will meet or exceed Romanian and EU standards for environmental control.

2.2 Production Rate Alternatives

A range of economically viable Project production rates were evaluated by RMGC to determine the optimal plant throughput. These studies considered mine life, facility capacity, equipment needs, labour force, site plan efficiency, water requirements, and other factors. In addition, mining, process and infrastructure costs were developed to assess the economics of the proposed project at the different throughput rates. The results of this study indicate that the project begins to meet key financial profitability criteria at throughputs above 6Mt/a and that the economics improve up to the maximum throughput of approximately 20Mt/a. However, capital costs increase with higher production rates. Considering all factors, a nominal ore feed rate of 13Mt/a was therefore determined to be optimal for the Roşia Montană Project.

A lower production rate of 8Mt/a would likely result in the following:

- an increase in the life of the mine operation;
- reduction in initial mine and processing equipment costs;
- decrease in equipment needs;
- reduction in personnel requirements;
- decrease in average daily water requirements; and
- increased overall costs.

The higher production rate of 20 Mt/a would likely result in the following:

- decrease in the life of the mine operation;
- increase in initial mine and processing equipment costs;
- increase in equipment needs;
- increase in personnel requirements;
- increase in average daily water requirements; and
- increased overall costs.

The production rate of 13Mt/a is being used for design of the pit and process facilities. The design of the open-pits has optimised ore tonnage and grade for scheduling purposes, over the life of the mine. The current mine life is projected at 17 years following a pre-production phase of less than one year. Actual mining occurs only during the first 14 years. During the remaining 3 years, stockpiled, low-grade ore will be processed. The increase or decrease of the production rate will proportionally extend or shorten the mine life.

The environmental impacts of the production scenarios set out above are compared in the following Table 5-4.

Table 5-4. Impacts of Production Rate Options compared to Selected Option

<table>
<tr><th rowspan="2">Environmental Issues</th><th colspan="3">Production Options</th></tr>
<tr><th>8 Mt/a</th><th>20 Mt/a</th><th>13 Mt/a (selected)</th></tr>
<tr><td>Water flows and quality</td><td colspan="3">All options allow remediation of existing pollution problem; final remediation would be achieved earliest by 20 mtpa option</td></tr>
<tr><td rowspan="2">Air quality</td><td>Lowest emission levels generally, but longer duration</td><td>Highest emission levels, but shorter duration</td><td>Optimal in terms of emission levels and duration</td></tr>
<tr><td colspan="3">Emission levels for ALL options would be in accordance with regulatory controls and guidance</td></tr>
<tr><td>Noise and vibration</td><td colspan="3">Emission of noise and vibration as for air emissions</td></tr>
<tr><td>Soil</td><td colspan="3" rowspan="3">All production options would result in the same land take and modification of habitats and landforms and therefore impacts would be similar</td></tr>
<tr><td>Biodiversity</td></tr>
<tr><td>Landscape</td></tr>
<tr><td>Socio-economic issues</td><td>Smallest demand for labour which would lead to lower job opportunities, but over a longer term</td><td>Largest demand for labour, but over a shorter period of time which would increase potential for an economic “bust”</td><td>Optimal labour demand in terms of job numbers and duration</td></tr>
<tr><td>Cultural heritage</td><td colspan="3">Similar land take and therefore similar environmental impacts</td></tr>
<tr><td>Transportation issues</td><td colspan="3">The impact on roads and transportation systems would be broadly proportional to production rate. High production rate would generate high levels of site traffic, but for shorter duration and vice-versa.</td></tr>
<tr><td>Transboundary impacts</td><td colspan="3">All options include remediation of existing pollution leading to reduction in pollution loads that ultimately might affect water qualityin adjacent states; all options are designed to be safe and secure under normal and abnormal operating conditions</td></tr>
</table>

3 Project Location Alternatives

3.1 Mine Location Alternative

The economic benefits of the mine are a function of both the value of ore extracted, and the amount of ore extracted. As in most production situations, there is an economy of scale, and larger-scale operations tend to reduce unit costs. A reduction in the scale of the mineable resource therefore has a direct impact on the economics of the project.

In all mining operations, the locations of excavations must be optimised in order to make a project economically viable. A mining operation must recover the mineral of interest from its natural location in the deposit at a reasonably predictable cost, which must be less than the probable value of the metals once they are sold. Rock that can be mined for economic benefit is defined as “ore.” Key factors in the definition of ore include:

- value of the recoverable metal (credit);
- facility installation cost (debit);
- mining cost (debit);
- processing cost (debit); and
- overburden management and rehabilitation/closure cost (debit).

The most important factor in defining the value of an ore deposit is the concentration (grade) of metals in the rock being mined. It is this grade that ultimately dictates where mining can occur economically. Metal grades are quantified by laboratory testing of rock from the subsurface, which is typically obtained by drilling and sampling. More than 161,000 metres of drilling and sampling have been completed for Roşia Montană Project to define the extent of mineralised rock that can be characterised as ore, and from which gold and silver can be recovered.

A specific resource model was issued to define the value of the Roşia Montană deposit; this model includes key attributes on:

- topography;
- interpreted lithology;
- rock code (i.e., air, existing waste stockpile, or in situ rock);
- alteration;
- region (e.g., Orlea, Cetate, Jig)
- void proportion (which accounts for existing underground mine workings);
- bulk density;
- mined density (which also accounts for existing underground mine workings);
- mean gold grade;
- mean silver grade; and
- sulphur content.

Other parameters, such as hardness, were also considered. The consideration of hardness is used for estimation of mining and milling rates. Similarly, sulphur content is used in the calculation of gold recovery in the mill. Extensive quality control and statistical evaluations were also used help ensure the validity of the model.

The block model was subsequently applied to evaluate possible mining configurations, including location, geometry and depth of excavations (i.e. the open pits). The block model enables mine planners to maximise recovery of ore and minimise mining of overburden or waste rock. Using this method, an optimal mine geometry and mining sequence was developed. External economic factors, such as the price of gold and silver, the cost of fuel for the mine equipment, and the cost of mill processing reagents, can affect the configuration of the pits by changing the value of "ore".

The **pit configurations** that have been **proposed** for development in the Roşia Montană Project are shown in **Exhibit 5.1**, and were optimised through a detailed evaluation of the ore deposit geology, geometry and metallurgy, in addition to economic factors such as commodity prices and operating costs for various processing options. Any deviation from the optimised design either in number of pits, size of pits, or processing options will have a direct effect on the economic viability of the project.

Alternative pit locations at this site, **are not feasible**, because the pit locations are dictated by the location of ore grade mineralisation. Therefore, alternate locations for mining are not available. Exclusion of selected areas of the ore body from mining increases unit mining costs and reduces the economic viability of the Project. For example, a sizeable component of the Roşia Montană mineral resource is located in a historic mining area, and, as depicted in **Exhibit 5.1**, is underlain by a complex network of abandoned underground workings that are in some cases many centuries old. Exclusion of the "Roman Galleries" historic mining areas in particular would directly impact the Cârnic and Orlea mining areas, and would make recovery of the gold and silver uneconomic in these areas. In the Cârnic pit location, this would mean excluding up to 50% of the resource, or approximately 7 million ounces of gold. For the Orlea pit area, up to approximately 14% of the resource would be excluded or approximately 1.3 million ounces of gold. Because of the amount of the mineable resource that would be involved, any such exclusion would result in a mining project that is not economically viable. While RMGC recognises that the archaeological and cultural features of historic mining areas must be protected to the extent possible, the proposed Roşia Montană Project location is the only economically viable option. This is reflected in the boundaries of the license area, final industrial zone, and protected areas that have been negotiated with local regulatory authorities.

Viable alternative options cannot be identified in this case and no environmental analysis is possible.

3.2 Process Plant Mill Location Alternative

The general location of the process plant (mill) was selected to provide a substantial buffer zone of Project concession land between milling activities and the adjacent community. A location in the central portion of the concession was also desirable in order to minimise haulage distances from the open pits (that are fixed in location, as explained in the previous section) and associated haulage-related impacts (i.e. dust, noise, and exhaust emissions), as well as to make the best possible use of existing areas that had already been impacted by previous mining operations. It was also desirable to place the mill at an altitude that (to the maximum extent possible) permits gravity transport of detoxified mill tailings to the Tailings Management Facility. The selected mill site presented in **Exhibit 5.2** meets these criteria. **No other viable alternatives exist that would not have involved the creation of new land impacts, longer haulage routes, or locations unacceptably close to the adjacent community**. Therefore, the location of the process plant in the central portion of the concession is the preferred alternative; all other locations within the concession have been rejected for the above reasons as set out in Table 5-5 below.

Table 5-5. Impacts of Alternative Plant Location Options compared to Selected Option

Environmental Issues	Options		Comments
	Non-centrally located plant	Centrally located plant (selected)	
Water flows and quality	Larger project footprint creates *potential* for increased disturbance and pollution	Project footprint minimised, reducing *potential* for impacts on water to a minimum	Ability to minimise Project footprint is a major factor in mitigating against environmental impacts
Air quality	Extended footprint increased potential for increased dust emissions; *potential* for greater exposure of adjacent communities to programmed emissions, depending on location	Project footprint minimised, reducing *potential* for dust generation to a minimum; buffer mitigates against exposure of adjacent communities to emission of gases and fumes	
Noise and vibration	As for air quality	As for air quality	
Soil	Larger footprint increases land take and direct impact on soils	Optimised footprint minimises land take and direct impact on soils	
Biodiversity	Larger footprint increases land take and direct impact on habitats and wildlife	Optimised footprint minimises land take and direct impact on habitats and wildlife	
Landscape	Larger footprint increases land take and visual impact	Optimised footprint minimises land take and visual impact	
Socio-economic issues	No significant discrimination in regard to socio-economic factors		
Cultural heritage	Larger footprint increases land take and *potential* for direct impact on historic sites and remains	Optimised footprint minimises land take and *potential* for direct impact on historic sites and remains	Ability to minimise Project footprint is a major factor in mitigating against environmental impacts
Transportation issues	No significant discrimination in regard to transportation issues, unless a processing site was selected remote from the mine and/or waste management facilities, in which case, there would be potential for major impacts related to transportation		
Transboundary impacts	No significant discrimination in regard to transboundary issues		

3.3 Tailings Management Location Alternatives

3.3.1 Background

The need for a Tailings Management Facility (TMF) is related to the strong preference for tailings-generating metal extraction processes over heap leaching alternatives. This preference was originally established in the pre-feasibility study phase of the project and is a basic assumption of the economic model for the project.

Since 1999, several studies were conducted to identify and evaluate alternative TMF sites, considering a broad range of technical, social, economic and environmental factors.

Economic, topographic, geographic, and environmental impact constraints have established a fundamental need for a valley fill structure located close to the proposed process plant.

The initial TMF options study was undertaken as part of the initial Definitive Feasibility Study (DFS) in 2001 and this identified nine sites within 4 valleys in the vicinity of the Roşia Montana project site.

During 2002, RMGC conducted a separate value engineering study, which considered the sites evaluated previously, as well as some new alternatives for the location of the proposed TMF. This study included some eight possible alternatives for a TMF location and technology, some of which represent further consideration of particular options identified during the 2001 DFS study.

This section therefore summarises the assessment of all these available options for the project in respect of the location for the proposed TMF and ranks them in order of preference, based on Environmental, Social, Technical and economical criteria.

3.3.2 Design Criteria

For the purpose of the TMF site alternatives considered in this study, the following key design criteria provide a point of reference:

- Storage capacity for 240 M tonnes of tailings which includes the design capacity of 218 M tonnes plus a 22 M tonne contingency;
- No programmed discharge of TMF effluent to the environment;
- Collection and pump-back of seepage collected below the toe of the TMF embankment;
- Centre-line construction above the starter dam;
- A low permeability core and cut-off wall for the starter dam.

The above design criteria meet the design objectives for safety in the most cost-effective manner and were applied for all potential locations.

3.3.3 TMF Potential Sites and 2 alternatives to TMF

3.3.3.1 First stage of option identification

As indicated above, nine sites were initially identified for the location of the proposed TMF (see Exhibit 5.3.)

These potential sites were located in four valleys, as follows:

3.3.3.2 Tolacesti Valley (location of existing Roşia Poieni TMF) SITE A1

Site A1 is located north of the mine site and is the more distant of the sites identified within the Tolacesti Valley downstream of the Roşia Poieni TMF. The site identified does not provide sufficient tailings storage capacity for the full planned requirements of the life of mine plan.

Development of a TMF on Site A1 will have direct impact on two villages located in the area of influence. The Tolacesti Valley although considered relatively environmentally undisturbed at this location, hosts the Roşia Poieni TMF for the storage of copper tailings from the Roşia Poieni Mine.

3.3.3.3 Tolacesti Valley SITE A2

Site A2 is located immediately upstream of the Site A1 and therefore is the second most distant site to the proposed location for the Roşia Montana plant. The location is currently partially occupied by the Roşia Poieni TMF and therefore some interference might occur and a design that accommodates this effect would need to be implemented. Preliminary calculations based on a conceptual design for the proposed facility indicate that the full life of mine volume of tailings could be stored on this site.

3.3.3.4 Tolacesti Valley SITE A3

Site A3 is located at the head of the Tolacesti Valley and is the nearest to the Roşia Montana site amongst those in the Tolacesti Valley. Site A3 would only allow the development of a small TMF facility that will not have sufficient capacity to store the required volumes for the Roşia Montana Project.

This section of the valley is relatively undisturbed because the existing Roşia Poieni TMF is located further downstream from this location. The development of a TMF on this site will have a direct impact on two small settlements.

3.3.3.5 Abruzel Valley SITE B1

Site B1 is located to the east of the Roşia Montana project site at the foot of the Abruzel Valley. The location is currently occupied by a number of small villages and settlements and the development of a TMF on this site will directly impact on a significant number of people who will have to be relocated. The site has seen some mining activity in the past and it is possible that problem ground conditions could be found in the foundations of a potential TMF associated with the old mine workings. The site has sustained significant environmental impact in the past as a result of this previous mining activity.

The proximity of the site to the project and the characteristics of the topography make it an efficient option with relatively low development costs although a development on this site will not have sufficient storage capacity for the planned life of mine tailings production.

3.3.3.6 Abruzel Valley SITE B2

Site B2 is located upstream of the site B1 to the east of the Roşia Montana project. The characteristics of this site are similar to those of site B1 with similar distance from the project site and similar tailings disposal capacity. The location has a lower potential impact on people with only four communities directly affected although this is still considered to be high. There may also be similar foundation concerns to those for B1.

3.3.3.7 Corna Valley SITE C1

Site C1 is located at the foot of the Corna Valley to the immediate south of the mine site. This valley has already been significantly impacted by previous mining activity and its proximity to the project site makes it particularly attractive due to relatively low development costs.

The site selected would allow the development of a TMF which would be sufficiently large to accommodate life of mine tailings production. Due to the characteristics of the area, the site has the greater potential storage TMF capacity of the nine sites identified.

3.3.3.8 Corna Valley SITE C2

Site C2 is located immediately upstream of and can be characterised similarly to Site C1. Development of a TMF on the site would provide sufficient tailings storage capacity for the life of mine plan and due to its proximity to the project site and local conditions has the lowest development cost.

As indicated earlier the valley has been impacted by previous mining activity. However there are settlements that will need to be relocated.

3.3.3.9 Corna Valley SITE C3

Site C3 is located at the head of the Corna Valley closest to the Roşia Montana project site. The topographical characteristics of the area will only allow a TMF which would not provide sufficient tailings storage capacity for the life of mine plan tailings production.

The TMF will have direct impact on one village currently located in the Valley.

3.3.3.10 Salistei Valley SITE D1

Site D1 is located to the west of the mine site and is in the vicinity of the existing Rosiamin mine tailings facility. The site characteristics will only allow the development of a TMF which will not have sufficient capacity to store life of mine tailings production.

Due to the presence of the Salistei TMF, the valley is significantly impacted and the proposed development would not directly impact any new villages.

3.3.3.11 Second stage of option identification

Subsequent to the completion of the 2001 tailings site definition work, RMGC commissioned a further tailings alternatives evaluation study, incorporating the knowledge obtained in previous studies as well as further information on the project and conditions in the potential sites identified. Based on the initial options work described above, six potential alternatives for storage that would satisfy the tailings disposal requirements for the project were defined as follows:

3.3.3.12 Corna Valley

This alternative considers the construction of a cross valley type dam in the Corna Valley. The proposed site is located south of the project area, approximately aligned with the position of Site C2 as described above.

The facility will be constructed with a prepared low-permeability tailings basin and tailings drainage system and the retaining dam will include a zoned rockfill starter dam approximately 78 metres high with a low permeability core and subsequent raises constructed using the centreline method to form a centreline zoned rockfill dam with an ultimate crest height of approximately 185 meters.

The design approach for the facility indicated that a low permeability core was required on the starter dam to minimise seepage through the embankment, however, it also indicated that subsequent centreline raises to the dam embankment will not require a low permeability core. Downstream slopes will be constructed at approximately 2H : 1V in order to provide suitable factors of safety against failure for the starter dam configuration as well as for the final dam configuration.

The design maintains a positive groundwater gradient in the tailings impoundment that prevents tailings solution migration outside the facility. Seepage through the pervious embankment will be collected and recirculated into the facility. In addition to the above, this site has the advantage that it forms a pollution control structure in relation to potentially contaminated water run-off from operational areas adjacent to the facility.

The proposed site and TMF layout allows for the storage of life of mine tailings production although, as indicated earlier, the relocation of some residents will be required.

3.3.3.13 Salistei Valley

This option is equivalent to that identified as Site D1 above. The Salistea Valley option entails enlarging the existing tailings facility, currently being used for tailings deposition from Rosiamin operations, to create a TMF capable of storing the life of mine tailings production for the project.

The existing TMF at Salistea consists of a small starter embankment and upstream raises constructed using the coarse fraction of the tailings materials to a height of approximately 60 m.

For the Roşia Montana project, the existing embankment would be enlarged by constructing a downstream buttress and a centreline rockfill raise to accommodate process water storage and approximately two years of tailings production. Considerable foundation preparation would be required to raise this dam where it extends over the existing tailings to ensure that it meets slope stability design criteria. Foundation preparation would include the installation of wick drains in the tailings to improve its drainage characteristics and, therefore, increasing the strength of the materials (see schematic cross section below).

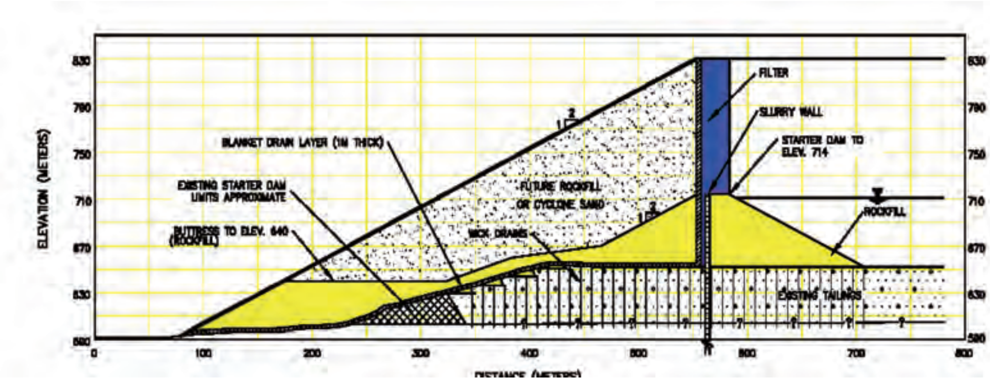
In addition, a slurry wall would be constructed to minimize process water seepage through the starter dam. Extensive instrumentation would be installed to confirm the degree of strengthening of the foundation materials prior to constructing new raises.

The ultimate dam would be constructed with multiple centreline rockfill raises on the starter embankment to an elevation of 830 m. This dam design also incorporates the pervious dam concept; therefore, a low permeability core will not be installed in any of the raises. This would maintain a positive groundwater gradient towards the impoundment that will provide containment of tailings solution. Seepage through the embankment would be collected by a downstream secondary containment system and pumped back to the tailings impoundment.

Geotechnical analysis of the proposed dam layout has confirmed that the remediation measures proposed for the existing Salistei Dam together with the proposed design for the centreline raises to the dam and the provision of a slurry wall to prevent seepage would result in a dam embankment with adequate factors of safety against failure.

The site has advantages and disadvantages of which the most important are the construction on a location deeply disturbed by past and current mining activity thus minimizing the disturbance of new sites for the construction of the TMF and the difficult construction conditions to be encountered specifically in areas of the existing TMF, respectively.

In addition, the development of a TMF at this location would result in a facility that can only accommodate 225 million tonnes of tailings which is less than the design criteria of 240 million tonnes.



Salistei Schematic Design

3.3.3.14 Roşia Poieni TMF

This option is similar to that described during the 2001 DFS as Site A2 and consists of the utilization of the existing tailings facility for the Roşia Poieni mine operation.

The Roşia Poieni Tailings Facility is located approximately nine (9) kilometres north-east of the Roşia Montana plant site. The current tailings facility is a rockfill dam with an unlined impoundment formed by a starter rockfill dam to 630 m elevation, a further downstream raise to 680 m elevation and two consecutive upstream raises to 683 and 686 m elevation respectively.

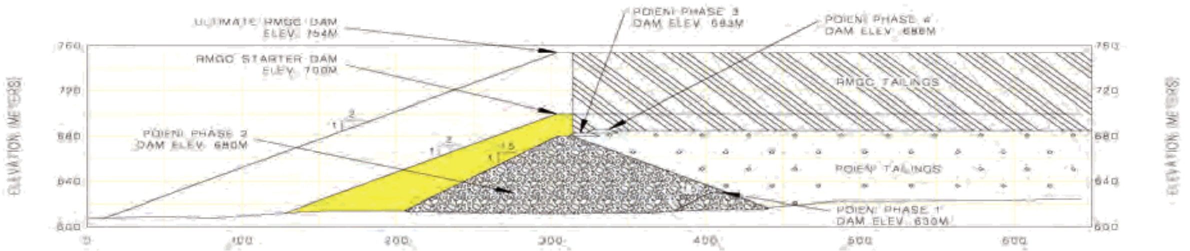
The conceptual design for the Roşia Montana TMF on this site includes the initial construction of a centreline dam raise to 700 m elevation and the subsequent construction of centreline raises to a final dam crest of approximately 754 metres.

Preliminary stability analysis conducted for the proposed layout indicates acceptable factors of safety against failure for the dam embankment at each stage of the construction and operation of the structure.

Tailings from the Roşia Montana project would be pumped over the dividing ridge to the Roşia Poieni TMF site.

Some of the advantages of the Roşia Poieni site include the fact that the site currently contains an active tailings facility; therefore, reducing the extent of new impacted areas for the project. The land around the perimeter of the existing facility has been acquired by the Roşia Poieni operations so expansion of the facility will not require land acquisition. The main disadvantage of this alternative relates to the distance of the site to the Roşia Montana project site, requiring the pumping and piping of the tailings produced over a long distance before final deposition.

The following schematic figure shows the conceptual design proposed for the raises to the existing Roşia Poieni TMF



Roşia Poieni Schematic Design

3.3.3.15 Combination of Săliştei and Roşia Poieni Sites

The development of this alternative was initially considered due to the expected problems envisaged for the mingling of copper and gold tailings should the Roşia Poieni TMF be used for the deposition of tailings from the Roşia Montana mine concurrently with the deposition of tailings from the Roşia Poieni operation.

The Săliştei Valley dam would be used initially for the deposition of gold tailings from Roşia Montana until operations at Roşia Poieni ceased at which time construction of the centreline raises to the Roşia Poieni dam and deposition of gold tailings at this facility would commence.

The conceptual design for the extension of these facilities is similar to that described above although the extent of the raises is adjusted to the particular requirements of the deposition plan.

A similar site combination concept was proposed during the initial stages of the 2001 DFS whereby the Roşia Montana Tailings could be disposed of at the Roşia Poieni facility and the remainder of tailings production from Roşia Poieni would be disposed in a separate purpose built small facility in the Ştefanca Valley.

All these site combination options are currently considered redundant due to imminent closure of the Roşia Poieni mine site and the cessation of tailings deposition at the TMF rendering the site potentially available for sole use by the Roşia Montana operation.

3.3.3.16 Filter Press Tailings with Disposal in Corna Valley

This option was initially considered by the post-2001 TMF options re-evaluation and discarded in the pre screening of options process for the following reasons:

High operational costs of between US$ 2 and US$ 3 per tonne; and

The lack of operational experience and resultant risk with this type of operation.

These reasons are still considered valid and applicable and this alternative will not be considered in any further detail.

3.3.3.17 Backfilling of Open Pits

Similarly to the option of Filter press tailings, this alternative was eliminated from any further consideration at the pre screening of options in the MWH study. The pits created by the extraction of ore at Roşia Montană will be backfilled using waste rock as ore extraction in each pit is completed. The presence of old workings in the pit walls would also create complications for tailings containment. There are no other available open pits for the deposition of tailings within a reasonable distance of the project site.

Similarly to the alternative of Filter press tailings, this option will not be considered any further in the analysis.

The following Table 5-6 presents a summary of the characteristics for the alternative sites considered and a brief description of the social and environmental impacts assessed at the preliminary stage.

Table 5-6. Summary of Alternative TMF Sites

Alternative	Technical Summary	Environmental Impacts	Social Impacts
Corna Valley	Dam Height: 190 m Impoundment Storage Volume: Adequate Foundation Conditions: Adequate Geotechnical Limitations: None	Impacts to Existing Valley: Yes Area of Disturbance: 3.5 km2 Potential groundwater/surface water (GW/SW) Impacts: No	Displaced Residences: Yes Aesthetic Impacts: Yes Land Within PUG/PUZ: Yes
Roşia Poieni Tailings Facility	Dam Height: 140 m Impoundment Storage Volume: Adequate Foundation Conditions: Adequate Geotechnical Limitations: Landslide along pipe alignment	Impacts to Existing Valley: No Area of Disturbance: 4.4 km2 Potential GW/SW Impacts: Existing operations – yes. Future operations will address GW/SW impacts	Displaced Residences: No Aesthetic Impacts: Yes Land Within PUG/PUZ: No
Salistei Tailings Facility	Dam Height: 230 m Impoundment Storage Volume: Adequate Foundation Conditions: Poor Geotechnical Limitations: Yes	Impacts to Existing Valley: No Area of Disturbance: 3.0 km2 Potential GW/SW Impacts: Existing operations – yes. Future operations will address GW/SW impacts	Displaced Residences: Yes Aesthetic Impacts: Yes Land Within PUG/PUZ: No
Combined Alternatives	Dam Height: Varies Impoundment Storage Volume: Adequate Foundation Conditions: Adequate Geotechnical Limitations: None	Combined alternatives almost double the potential environmental impacts, since two separate facilities would need to be developed.	Combined alternatives almost double the potential environmental impacts, since there are two facilities developed.

Based on the descriptions above and an initial assessment of the potential capacity of the different alternative tailings facilities, some options were not considered for further analysis due to environmental and technical reasons that would prevent the achievement of the main purpose of the facility.

Based on the above, the sites at Ştefanca and Abruzel were not considered in any further detail because they are remote from the mine site, would significantly increase the overall Project footprint and also present a significant potential environmental impact should a TMF be constructed, requiring the displacement of people. All of the above combined with the fact that the resulting TMF would not satisfy the requirements for the life of mine tailings production plan make these alternatives unviable.

In addition, as indicated above, the alternatives of implementing a filter press system for the disposal of dry tailings on the Corna Valley and the disposal of tailings in open pits are also eliminated from the comparative analysis at this stage.

However, the following options did justify further analysis and final selection of a preferred option for the disposal of tailings arising from the Roşia Montana Gold Project:

- Valley Type TMF at Corna Valley (C2 above)
- Expansion of the Sălştei TMF
- Expansion of the Roşia Poieni TMF
- Combination of Sălştei and Roşia Poieni Sites.

Table 5-7 below summarises the main characteristics of the proposed tailings facilities at the sites selected for final analysis.

Table 5-7. Summary of Short-listed TMF Options

Alternative	Starter Dam Downstream Slope (H:V)	Final Dam Downstream Slope (H:V)	Starter Dam capacity rockfill ratio	Final Dam capacity to rockfill ratio	Ultimate Dam Height (m)	Ultimate Storage Capacity (Mt)
Corna	2 : 1	2 : 1	6.01	11.83	185	240
Salistei	2 : 1	2 : 1	3.10	5.63	230	225
Roşia Poieni	2 : 1	2 : 1	34.99	38.23	148	241
Salistei / Roşia Poieni	2 : 1	2 : 1	6.40	7.91	180/124	242

3.3.4 Comparison Criteria for short-listed TMF options

Basis of analysis

In order to conduct a comparative analysis and rank the site options, six basic categories were considered in order that the ranking process was not biased to any particular item. In addition, the ranking process assumed that each of the six categories is of equal weighting or importance. The six categories are as follows:

- Environmental Risk
- Impact on Community
- Constructability
- Capital costs
- Operating costs
- Complexity / ease of operation.

It was assumed that the closure and rehabilitation costs, and the long term monitoring costs for each option (on a cost per tonne of ore processed basis) will be similar for each site under consideration. It should be noted that closure, rehabilitation and post closure monitoring costs are largely dependent on the type of TMF (i.e., valley, paddock, side of hill, central thickened discharge etc) for a given size of facility, and therefore these costs have been considered similar at this stage as all the options considered are of the same type (valley dam) and relatively similar in size. The exception to this is the alternative option that comprises a combination of the Roşia Poieni and the Sălіştei Valleys for which a penalty factor will be included in the operating cost category to account for the increased rehabilitation and post closure costs resulting from dealing with two separate sites.

Analysis

3.3.4.1 Environmental Risk:

The main environmental risks / impacts for each of the options have been assessed as follows:

i. Seepage from the TMF impacting on the downstream groundwater / surface waters, and ultimately any groundwater source downstream of the facility.
ii. Rupture of the tailings delivery pipeline.
iii. Failure of the TMF embankment (due to an extreme seismic event) leading to the flow of tailings downstream.
iv. Failure of the TMF embankment (breach following extreme precipitation and accumulation of water on the facility) leading to the flow of tailings downstream.
v. Impact on areas not previously impacted by mining and mineral processing operations.

Item (i) has been assessed as having a low to very low probability of occurrence, provided appropriate seepage control measures are incorporated into the final design of the tailings facility. These measures are simple to construct and relatively inexpensive and are considered essential to any modern tailings management facility.

Item (ii) has been assessed as having a moderate to high probability of occurrence, however as this event is envisaged to have less consequence than a failure embankment, the risk is assessed as similar to the other hazards. It should be noted that the risk from a failed pipeline increases with the length of line and the hazard posed increases where the pipeline crosses a river or a new valley on its way to the tailings facility. Based on this, the Corna alternative is considered to have the lowest risk as the proposed TMF site is located near the proposed plant site for the project and the pipeline will be fully contained by the same valley to which the TMF will form a containment dam thus minimising the potential impact beyond the project site. The Săliştei alternative is also considered of low risk as the pipeline route would follow the route of the existing tailings pipes thus minimising any additional impact. The Roşia Poieni alternative is considered to have the greater risk given the distance to the plant site.

Item (iii) has been assessed as having a very low probability of occurrence provided the embankments are designed and constructed using good construction practices and the operation of the facility follows best practice. The potential environmental impact for each option was assessed as being similar, although the options including the use of the Săliştei Dam are considered to be more at risk due to the condition of the underlying materials in the site of the proposed embankment and the extensive foundation preparation works required to remediate the site prior to construction of the dam raise. The Roşia Poieni alternative is considered to have a lower risk due to the lower height of the ultimate dam wall.

Item (iv) has been assessed as having a low to very low probability of occurrence provided drainage diversion works are constructed to minimise the potential for the accumulation of water on the facility. Although similar, the Roşia Poieni alternative is considered to have a lower risk as the shape of the impoundment, resulting in a greater capacity to rockfill ratio, also reflects the potentially smaller catchment for this alternative. In addition, some diversion works would already be in place for the Roşia Poieni dam resulting in lesser additional impact.

Item (v) has been assessed to have similar risk for the Roşia Poieni and the Săliştei alternatives because they are all located in areas currently hosting tailings storage facilities and therefore already impacted. The Roşia Poieni alternative is considered slightly more favourable as land ownership and use issues have already been resolved by the acquisition of the land surrounding the existing TMF by the Roşia Poieni mine. The alternative at Corna is considered less favourable because it involves the occupation of a new valley with a tailings facility. In this case, although the Corna Valley has some significant impact from previous mining activities, the impact of a new tailings facility on the site will be incremental and less favourable when compared with the other options. The alternative of the combinations of sites is also considered less favourable as it will involve the further complicating impact on two valleys rather than one.

The following Table 5-8 summarises the ranking of the sites with respect to items (i) to (v).

Table 5-8. Site Ranking - Environmental Risk (1 lowest – 5 highest)

Alternative / Risk-/ Impact	Corna	Salistei	Roşia Poieni	Roşia Poieni / Salistei
Seepage risk	1	3	2	4
Tailings line rupture	1	2	3	4
Stability risk	2	3	1	4
Runoff diversion	2	3	1	4
Impacted area	3	2	1	4
Rank Score	9	13	8	20

The table 5-8 indicates that the Roşia Poieni and Corna alternatives have a similar ranking with respect to "Environmental Risk". The Săliştei alternative is third ranked and the combination of sites at Roşia Poieni and Săliştei is a distant last-ranked option. This is mainly due to the fact that this alternative has to include the potential impact of two tailings disposal sites and the associated infrastructure.

3.3.4.2 Impact on Community:

An assessment of the "Impact on the Community" of each of the TMF alternatives being considered was made based on the distance of the proposed facility or its associated infrastructure to the nearest village and the requirement for the relocation of population should a particular alternative be selected.

The Roşia Poieni and Săliştei alternatives will be developed entirely within the confines of an existing TMF and therefore will have no significant direct impact on any surrounding community. Furthermore, the proposed tailings pipeline route will utilise the existing routes to Săliştei and partly to Roşia Poieni with a new section required from the Roşia Montana plant to the Roşia Poieni.

The Corna alternative will have direct impact on existing communities in the Corna Valley. As indicated earlier, this valley has been significantly impacted by previous mining activity. However, there are still a significant number of settlements in the valley and the relocation of people currently living in the footprint on the proposed TMF will be necessary.

3.3.4.3 Constructability:

An assessment of the constructability of embankments for each of the TMF alternatives was made based on an assessment of availability of borrow materials at each site (i.e. within the TMF basin) and the potential difficulties envisaged for foundation preparation activities for some of the sites.

The constructability of the proposed TMF embankment for the Corna and Roşia Poieni alternatives is considered to be similar, although the efficiency of the embankment at Roşia Poieni will result in a higher ranking. This will be compensated at the Corna site by the abundance of rockfill available for the construction of the embankment. This material will be sourced from the waste rock from the mine given its proximity to the proposed Corna dam embankment.

The alternatives involving the Săliştei TMF have been given a lower ranking as the stabilisation of the existing dam and the foundation preparation works could present a serious risk to the development. The alternative considering the combination of the Roşia Poieni and Săliştei Dams will require lesser works at Săliştei due to the lower final embankment height of the Săliştei Dam for this alternative.

3.3.4.4 Capital Costs:

Various capital cost analyses, to different degrees of accuracy, have been undertaken for the comparison of alternative TMF options for the Roşia Montana Project. Conceptual level cost estimates are included in Table 5-9 and the level of costs has been considered in the determination of the ranking for each individual alternative.

Table 5-9. Alternatives Conceptual Level Cost Estimates

Alternative	Cost (US$)
Corna Valley	148 433 153
Total Initial Direct Cost	56 467 576
Total Initial indirect Cost	8 420 993
Total Sustaining and capital Cost	83 544 584
Salistei Valley	269 976 875
Total Initial Direct Cost	89 745 926
Total Initial indirect Cost	8 420 993
Total Sustaining and capital Cost	171 809 956
Roşia Poieni Valley	75 507 522
Total Initial Direct Cost	37 958 729
Total Initial indirect Cost	8 420 993
Total Sustaining and capital Cost	29 127 800
Combination of Roşia Poieni and Salistei Valleys	237 739 856
Total Initial Direct Cost	37 958 729
Total Initial indirect Cost	8 420 993
Total Sustaining and capital Cost	191 360 134

3.3.4.5 Operating costs:

An assessment of the operating cost for the operation of a TMF for each of the alternatives was made based on the length of pipe from the plant site to the dam site location and consideration of the likely pump static head (i.e., the greater length and static head, the greater the 'pipe losses' and hence greater the power requirements).

It has been assessed that power costs represent the main operating cost for the TMF. Other costs would include general maintenance, labour (to switch on pumps, changes spigots etc). It should be noted that general maintenance and labour costs will also increase the further the TMF is away from the plant.

In addition to the above, maintenance costs of non-pipeline items, such as tunnels and bridges for the pipeline installations, as well as booster pump stations also need to be considered.

The assessment indicates that the alternatives for Corna and Săliştei are the most favourable given their relative proximity to the plant site and the simplicity of the proposed pipeline route which lacks any complicated structures, has no tunnels or bridges to maintain and does not require the maintenance of pollution control dams or infrastructure along the pipeline route. The Săliştei alternative is marginally more favourable than the Corna alternative given the potential use of an existing pipeline corridor from the plant site to Săliştei.

The Roşia Poieni alternative presents the most unfavourable conditions, with greater distances to the plant site resulting in increased power costs for the pumping of the tailings and the return water and increased maintenance costs for the pipeline and associated infrastructure, including tunnels, bridges and pollution control measures.

3.3.4.6 Complexity of Operation:

It is envisaged that a TMF developed at each of the sites under consideration would comprise a similar operational design concept, as follows:

i. Surface water management: Surface water would be recovered from the facility by a floating pontoon pump or similar and pumped back to the plant.
ii. Tailings deposition: Spigotting will be undertaken from the main embankment and from several spigot locations off a slurry ring main surrounding the facility.

It has been assessed that complexity of the operation is directly related to the length of the embankment required and to a lesser extent the length of the delivery pipeline. A long embankment requires additional control over the spigotting to ensure appropriate management of the surface pond and the return water system. A lengthy pipeline will require the operation of booster pump stations and/or break pressure systems which could create some operational problems, in particular during start up.

Similarly, seepage control is of primary importance for environmental protection and a long embankment will require additional drainage collection features and a proportionately greater risk of failure of such features.

An important part of the complexity of operations analysis is the consideration of the effect on the overall project water balance of having two operating tailings facilities at any time during the project. This could have a significant impact on water treatment costs and therefore the exposure to risk of this alternative is considered high.

Based on the above, it has been assessed that the Corna Alternative is the most favourable location, as it requires a relatively short length of dam embankment but will require a significantly simpler tailings delivery system. The Roşia Poieni alternative is marginally less favourable than Corna with the Săliştei alternative being considered the least favourable of the single site alternatives given the expected additional complexity of deposition control due to the seepage and other risk associated with the foundation preparation works and the management of the risk from the existing embankment.

The operation of the Combination alternative is considered the least favourable given the requirements to operate two tailings facilities at some stage of the project.

3.3.5 Results

The results of the comparative analysis are based on the assessment of the different alternatives in relation to the criteria as described above. The ranking system used is similar to that presented above for environmental risk.

The summary ranking system incorporates the results of the environmental risk assessment as one element in order to avoid excessive bias of the options in favour of environmental considerations. Table 5-10 presents the results of the comparative ranking.

Table 5-10. Site Ranking – Assessment of Site Options

Site / Category	Corna	Salistei	Roşia Poieni	Roşia Poieni / Salistei
Environmental Risk	3	4	2	6
Impact on Community	5	1	4	5
Constructability	2	6	2	5
Capital Cost	3	5	2	5
Operating Cost	2	3	6	4
Complexity of Operation	2	5	3	5
Rank Score	17	24	19	30

Notes:

Rating based on a scale of 1 “best” to 6 “worst”

Minimum possible score for an individual site is 6.

Total score for an individual category, 15

Total of all scores, 90

Where sites were considered as having a similar ranking with respect to a category, the respective sites were given the ‘same’ score (the total score of the individual category should always be 15)

The above assessment and ranking provides a scoring for environmental impact that focuses on the most significant issues relating to siting of the TMF (e.g., land take and impact on local communities). The following Table 5-11 provides a more comprehensive summary of the environmental impact for each of the valid options identified above.

Table 5-11. Impacts of Alternative TMF Site Options compared to Selected Option

Environmental Issues	TMF Siting Options			
	Corna (selected)	Salistei	Roşia Poieni	Roşia Poieni / Salistei
Water flows and quality	Direct impacts on Corna stream and valley drainage; positive impact on water quality due to management of existing ARD problem	Site is centred on a valley that is already impacted by a TMF; opportunity to improve the safety and security of existing TMF, but construction and operating risks are higher due to existing structures	Land take less significant than for Corna because of existing TMF; opportunity to improve the environmental performance, safety and security of existing TMF; increased potential for spills due to extended tailings pipelines	Land take favourable, however two sets of infrastructure increases complexity and risk of operational problems; extended pipeline hazard created
Air quality	Introduces additional potential dust nuisance source to Corna valley	Site already impacted, but potential for impact would be increased due to greater area	Site already impacted, but potential for impact would be increased due to greater area	Increased potential for impacts in two valleys
Noise and vibration	Introduces new noise emission sources to Corna valley	As above	As above	As above
Soil	Land take creates direct impact on soils over tailings basin	Land take less significant than for Corna because of existing TMF	Favourable option regards minimising land take and impacting soils	Favourable option regards land take and impacting soils; less favourable than single site, due to increased infrastructure
Biodiversity	Land take creates direct impact on habitats over tailings basin	Land take and habitat loss is less significant than for Corna because of existing TMF	As above, regards habitats	As above, regards habitats
Landscape	Creates new landform in floor of valley	Impact on landscape is less than Corna due to existing TMF	As for Salistei	As for Salistei and Roşia Poieni
Socio-economic issues	Results in relocation of people living within the TMF footprint	Favourable location to minimise impacts on local community	Less favourable than Salistei option due to pipeline and supply corridor construction	Less favourable than Salistei/Roşia Poieni single site options due to additional infrastructure and impact on two valleys
Cultural heritage	Potential for impacts on cultural heritage over TMF basin	As above	As above	As above
Transportation issues	Requires relocation of Roşia Poieni access road	No significant transportation issues	Possible pressure on existing village transport corridor above existing TMF due to pipeline construction	As above
Transboundary impacts	High safety factors due to ease of construction, minimises risk of dam failure or overtopping	Complexity of construction due to existing structures; less favourable than Corna sites regards risks of failure or overtopping	Requirements for extended pipelines increases potential for rupture and spillage	Less favourable than Salistei/Roşia Poieni single site options due to additional infrastructure, complexity and resulting risks

3.3.6 Conclusions

The results of the assessment of potential alternatives for the location of the proposed TMF at Roşia Montana indicate that although numerous sites are available for the construction of the facility, only a few are suitable given their size or location.

Based on the comparative analysis carried out for the alternatives identified, the preferred site for the development as a TMF site for the project is the Corna Valley. This alternative ranks second in terms of environmental impact alone, however, due to its relatively moderate capital costs, low operating costs and a relatively low complexity of operation, the overall ranking results in a more favourable score than that of the Roşia Poieni option.

The Roşia Poieni option ranks second most favourable site. Despite being the preferred option both in regard to environmental impact and impact on community criteria, expected high operating cost and the additional complexity of the operation of the tailings delivery pipeline have a detrimental effect on its overall ranking.

The Corna Valley site provides the required design storage capacity for the life of the mine plus a substantial contingency. It has the advantage of being close to the process plant and open-pit sites, thus minimising the project footprint. It will be designed to accept tailings that have been detoxified in the process plant's SO_2/air treatment circuit.

3.4 Inert Waste Landfill Location Alternative

As noted in Chapter 3, non-hazardous inert wastes generated during construction or mining operations will be deposited in a specially constructed Inert Waste Landfill adjacent to the waste rock stockpile at the upper end of the Corna Valley. Location of this landfill (see Exhibit 5.2 for initial location) is based on a desire to use only previously impacted land, upgradient from a facility able to contain any runoff, and to eliminate the impacts that would be associated with the rejected alternative, (i.e., offsite transportation and disposal at an appropriately permitted municipal landfill).

It is anticipated that during the mine life the facility will eventually be covered by the extension of the Cârnic waste rock stockpile. Therefore, new landfill cells may be created periodically, based on need, in either the Cârnic or Cetate waste rock stockpiles. During the later years of the mine life, after active mining is completed and the low-grade ore stockpile is being processed, a final inert waste disposal cell will be established in the Cetate waste rock pile near the plant site. This will be sized to accommodate the inert waste generated as part of the last years of mining and closure.

The following Table 5-12 sets out a comparative assessment of environmental impacts associated with the selected option and disposal off-site.

Table 5-12. Impacts of Alternative Inert Waste Landfill Location Options compared to Selected Option

Environmental Issues	Options		Comments
	Disposal off-site	Disposal on-site (selected	
Water flows and quality	No differentiation between the options		This conclusion assumes that the off-site facility is appropriately regulated and managed
Air quality			
Noise and vibration	Additional noise and vibration generated as a result of transport off-site	Deposition within the site boundary and a buffer protecting adjacent communities	
Soil	No differentiation between the options		This conclusion assumes that the off-site facility is appropriately regulated and managed
Biodiversity			
Landscape			
Socio-economic issues	Results in consumption of landfill space that could be used for other wastes	Efficient use of on-site facilities for disposal	
Cultural heritage	No differentiation between the options		This conclusion assumes that the off-site facility is appropriately regulated and managed
Transportation issues	Transportation off-site adds to highway traffic with noise, safety and traffic congestion issues	No off-site transportation	
Transboundary impacts	Issue of no significance in transboundary context		

4 Technology and Principal Environmental Impact Mitigation Alternatives

4.1 Mining Technology

With regard to the potential reduction of environmental impacts from other mining technologies, it must be noted that most of the “high” grade ore in the district has been previously extracted during historic underground mining, and the potential for continued extraction of high-grade ore from the underground mines in the district is very limited. Therefore, the success of the Roşia Montană Project will depend on the successful implementation of a bulk-tonnage, low-grade operation.

Conventional underground mining (e.g., room and pillar, open stope) results in very little surface impact. However, application of a conventional underground mining requires a high-grade ore deposit to offset the high cost of mining. Underground mining methods are commonly more than ten times more expensive than surface mining methods for shallow ore deposits. Underground mines require a larger labour force, and the scale of equipment is small. This results in a high unit cost of mining because production rates are low while labour costs are high.

The other two most widely applied bulk tonnage mining methods are:

- block caving (underground) and
- open pit (surface).

Block caving is the only feasible underground mining alternative for a low-grade ore consideration.

Advantages:

- Its main advantage is the reduced storage requirement for waste rock.

Disadvantages:

- A successful block cave operation has the potential to approach open pit mining production rates, but costs are higher, commonly as much as five times higher.
- Controlling the extent of the subsidence area and the impacts to the surface can be extremely problematic. In a block cave, ore is initially extracted from a deep development level. After removal of the rock at the development level, the de-stabilised roof material caves under its own weight and is removed from a sub-level extraction gallery. As the cave operation matures, the cave propagates upward and eventually is expressed in a surface subsidence area. The subsidence area is commonly more than twice the area of the extraction footprint, and can represent a significant physical hazard, particularly so if abandoned workings are located in the subsidence area. .
- The difficulty of controlling the production grade of ore is also a drawback of block caving. Caving operations are controlled predominantly by gravity and the fragmentation characteristics of the rock mass. Unless these characteristics are well understood, cave ore can become highly diluted by wall rock. Dilution results in premature termination of ore production from selected cells within the cave (reduced tonnage) and/or reduced grade.

Either of these conditions could have a potentially critical effect on project economics. For this reason, this option is concluded to be non-viable and is not assessed further

In summary, the inherent opportunity represented in the proposed Roşia Montană Project hinges on the re-development of past underground workings and small open-pit mines as a large-scale open-pit operation. The economic basis for the Roşia Montană Project depends on the ability to mine and process the remaining low grade ores interspersed among historic workings, using modern large-scale open-pit mining techniques and large-scale equipment. Underground mining of the remaining Roşia Montană gold and silver ore is not a viable alternative, regardless of whether open-stope or block fault caving methods are used.

A viable alternative to open pit mining is therefore not identified and analysis of environmental impact is not relevant.

4.2 Metal Extraction Technology

4.2.1 Overview

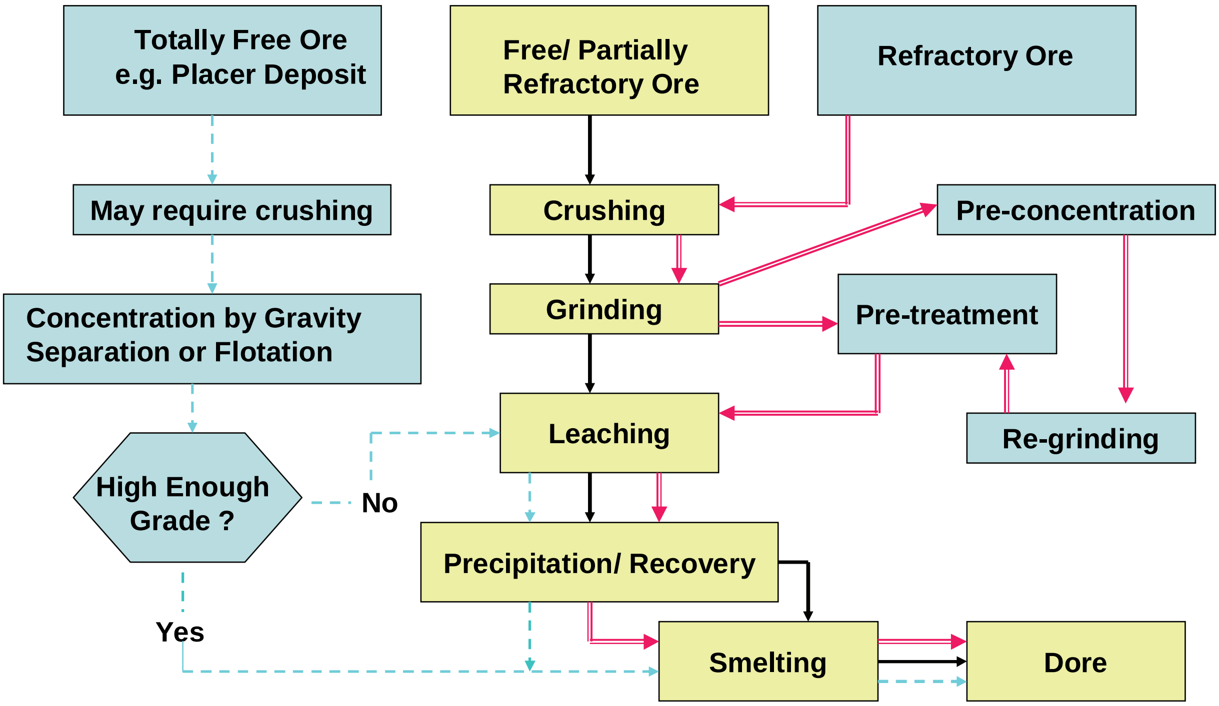
The selection of the best processing route for the treatment of any gold ore involves a series of unit operations that is the best trade off between minimization of input requirements (reagents, energy, labour, etc) and maximizing the recovery of the values (percentage of the gold initially in the ore that is recovered). In addition to this there are a series of constraints that the process route has to meet, namely:

- the geochemistry of the ore and its variability; in general, gold ores are classified as free gold or refractory based on the percentage recovery obtained when subjected to conventional cyanidation;
- the size of the deposit as this will determine the range of potential technologies that are available for a particular ore type, in some cases the best option can be the production of a concentrate and final treatment off-site;
- the legal framework regulating emissions and impacts and prescribing Best Available Techniques (BAT) for processes;
- the state of the art, by which is meant the available proven BAT that can be considered for obtaining a set processing objective ; and,
- economics, in order for the project to proceed and meet all the social responsibilities it has to be profitable and three factors are particular important: -
  - the price of the product, namely gold and silver, over which RMGC has no control;
  - the cost of the capital to be used by the project over which RMGC has no control; and
  - the capital and operating expenses (capex/opex) which is constrained by the factors noted above.

The engineering challenge is to be able to overcome these constraints over the length of the project when many of them can vary considerable over the life of the project. All these constraints have interactions that are different with each ore.

In order to be concise in the discussion of the metal extraction alternatives, a general overview of the technical options for the processing of gold ore is provided in Figure 4.1. This figure shows the main options available for the different types of ores. No two mineral processing plants are the same, the reason being that every ore is different and the engineering solution found to beneficiate the ore is different due to the constraints mentioned above.

Figure 5.1 Alternative Gold Treatment Options



Totally free gold ore

Totally free gold ore can be defined as ore where gold particles are liberated (free) so that they can be recovered by physical means. Suitable technologies for these types of ores are gravity separation that exploits the difference in specific gravity between gold (specific gravity (s.g.) 19.6) and surrounding minerals (usually s.g. between 2.5 and 3.0) or flotation that uses physico-chemical means to float the gold or the gold containing particles while depressing the other minerals. The particle size of the gold plays a significant role in whether gravity or flotation techniques are able to provide the desired recoveries. If the gold concentrate contains enough gold (high grade) then it can be subjected to smelting as a final step. Otherwise, if the concentrate is a lower grade, then it is subjected in more recent times to cyanidation and in the past to amalgamation (using mercury). The advantage of free gold ores is that process water (effluent) tends to be benign and tailings solids are coarse and fairly inert. When cyanidation is used, the impacted water will contain cyanide ions and therefore the effluents have a higher potential to impact receiving waters if these waters are not treated prior to discharge.

Refractory gold ore

At the other extreme, gold ores are classified as refractory if the recovery of gold by conventional cyanidation is less than 90%. Several reasons exist why an ore is refractory and to what extent, namely:

- the gold particles are in a “strong” physical association with gangue minerals;
- the gold particles are totally encapsulated by gangue minerals;
- the gold is a component of a mineral such as gold tellurides, and
- the gold can is in “solid solution” within gangue minerals, usually sulphides.

In addition and specific to use of cyanide in gold extraction, the following characteristics may be important:

- there are other minerals that are able to react preferentially (over gold) with cyanide such as pyrrhotite and secondary copper sulphides; these minerals are called cyanicides; and
- other minerals tend to adsorb any dissolved gold in solution and therefore it becomes impossible to recover the gold from solution e.g. carbonaceous and clayey materials.

In order to recover the gold from refractory ores, it is necessary to create the conditions for the gold to be dissolved into solution (leaching) and then to recover the gold ions from the solution. Several alternatives are available to achieve this and usually this consists of a pre-treatment step (bacterial leaching, roasting, pressure oxidation or a combination of the previous ones including possible pre-concentration with gravity or flotation). The recovery of the gold ions can be done by either zinc precipitation or a variant of carbon adsorption, e.g., carbon in pulp (CIP) and carbon in leach (CIL). Finally the gold is smelted to produce dore. The more severe the pre-treatment, the more likely that associated gangue minerals will be dissolved and therefore more heavy metals will end up in solution. In order to meet discharge limits, it may then be necessary to treat the impacted waters to precipitate heavy metals and to destroy excess cyanide employed. In addition, the solids generated from the process tend to be in the fine particle ranges.

Free/ Partially Refractory Ores:

Ore that has features of both previous categories may fall within this category. The main reasons why ore might behave in this way are as follows:

- the gold particles are very fine, and despite being free, leaching with cyanide is required;
- it is not possible to liberate the gold particles, but it is possible to expose some part of the particle such that leaching can be employed, and/or
- some of the gold particles in the ore are refractory and some are free.

The impacted water and solids generated from processing free/ partially refractory ore is somewhere between the two extremes explained previously.

Process

From Figure 5.1, in general, the processing of gold ore can be divided into 5 different unit processes, namely:

- comminution (size reduction of the minerals, that is crushing and grinding);
- pre-treatment or pre-concentration (if required);
- leaching (carried out using cyanide for the last 100 years);
- precipitation of the gold ions, and
- smelting.

In theory there are advantages to dividing the process into these five units to allow the comparison of equivalent unit operation that potentially can be optimised separately to build an ideal process route. In practice, there is a strong correlation between them and the process route chosen limits to an extent the comparison of the different alternatives. For instance, the level of grinding required depends on whether whole ore CIL treatment or flotation pre-concentration plus CIL will be used. In the next sub-sections, each of the unit process will be discussed; but the comparison from a BAT perspective will be carried out at the process option level.

Rosia Montana ore

Finally the Roşia Montană ores are classified, under the scheme presented in this section, as partially refractory due to the association of some of the gold with sulphides. The leaching section, as part of the process option selection, will be extensively discussed to address the selection of cyanide as the preferred leaching reagent. In addition to the technologies used for the extraction of the gold, the basis for the technologies chosen to comply with emission limits will also be discussed.

4.2.2 Consideration to determine the Best Available Techniques (BAT) for the Roşia Montană Gold Project

The production of metal by leaching of gold ore is within the scope of the Integrated Pollution Prevention and Control (IPPC) Directive (96/61/EC) which aims to achieve a high level of environmental protection. The emissions limits set to achieve this are based on Best Available Techniques (BAT), which balances the cost to the operator against the benefit to the environment. IPPC aims to prevent emissions and waste production and where this is not practicable, reduce them to acceptable levels.

The EU Commission has been producing a series of Best Reference Document on Best Available Techniques (BREF) for the different industrial sectors to set out what is considered BAT. A BREF document has not been produced to cover the production of metal by leaching of gold ore. The Reference Document on Best Available Techniques in the Non-Ferrous Metals Industries addresses precious metal production but not from ores. The Reference Document on Best Available Techniques for Management of Tailings and Waste-Rock in Mining Activities addresses mining and mineral processing solid waste.

The reference document on the Best Available Techniques for the management of waste resulted from mining activities, adopted in 2004, refers to the tailings and waste rocks, without having specific stipulation on gold mining. However, it is mentioned that the processes using CIL treatment for gold extraction, BAT means the following:

- Reduce the used CN quantity by:
  - Operational strategies to minimise the cyanide consumption;
  - Automatic dosing of the cyanide;
  - Peroxide pre-treatment, if applicable;
- Treatment of the residual cyanide before discharge into the tailings dam;
- Apply the following safety measures:
  - Size the cyanide treatment circuit to a double capacity than the necessary size;
  - Install a back-up system for adding lime;
  - Install certain spare electrical generators

Since there is no specific BREF applicable for the production of metal by leaching of gold ore there is a need to determine BAT. The general considerations on how to determine BAT are described in the following paragraphs.

Annex IV of the IPPC Directive lists considerations to be taken into account generally or in specific cases when determining BAT, bearing in mind the likely costs and benefits of a measure and the principles of precaution and prevention:

- the use of low-waste technology;
- the use of less hazardous substances;
- the furthering of recovery and recycling of substances generated and used in the process and of waste, where appropriate;
- comparable processes, facilities or methods of operation which have been tried with success on an industrial scale;
- the nature, effects and volume of emissions concerned;
- the consumption and nature of raw materials (including water) used in the process and their energy efficiency;
- the need to prevent or reduce to a minimum the overall impact of emissions on the environment and the risks to it; and,
- the need to prevent accidents and to minimise the consequences for the environment.

A key point is that BAT needs to include (as well as a treatment technology a management strategy to achieve optimal waste prevention and control. It makes economic sense to plan production processes and their waste release to minimise emissions and material consumption.

4.2.3 Comminution

Size reduction of the mineral may be the single main consumer of energy in the processing of mineral ores depending in the process selected. As such, comminution is important not only in terms of capital and operating costs but also in terms of environmental impact related to energy consumption. The comparison in terms of energy consumption is difficult because the energy efficiency of the different classes of machines used is dependent on the particle size distribution aimed at for the ore. For instance crushers are more efficient than conventional grinding mills in the +10 mm range of particles and conventional ball mills are more efficient than stirred mills in the 1 to 0.1 mm range. In general the efficiency of comminution depends on the following variables, amongst others;

- characteristic of the ore;
- the classification system attached to the grinding system;
- the degree of fineness aimed at;
- the environment of grinding (wet or dry);
- with some classes of size reduction equipment, the size of the machines;
- the reduction ratio employed, and
- the grinding mechanism.

The degree of fineness is determined by the technological process chosen and this in turn limits the class of machinery or group of machines that can be chosen. It is for this reason that comparison of alternatives for comminution circuits can only be discussed meaningfully as part of the process selection and this will be discussed below. As part of the process selection the following comminution options were studied:

- fine grinding as part of either intensive cyanidation of the sulphide "gravity" or flotation concentrates;
- crushing as a component of heap leaching options; and,
- semi-autogenous (SAG) milling plus ball milling as part of a conventional flowsheet.

4.2.4 Pre-treatment, pre-concentration and leaching

At the present time, three major technological options exist for recovering precious metals from gold-bearing ores: gravity, flotation, and leaching processes. Each technology is further described in the following paragraphs:

- **The gravity process** recovers free gold from the ore. The gravity concentrate can be cleaned in a series of gravity-related steps to produce a higher-grade concentrate, which can ultimately be smelted. This method works efficiently when coarse gold is present in the ore. Gravity processes are typically capable of recovering gold of a grind size down to 200 mesh.
- **The flotation process** is normally used to recover free gold if it occurs below a 200 mesh particle size and/or is associated with sulphide minerals. The initial flotation concentrate can usually be upgraded in additional flotation steps for direct smelting.
- **The leaching process** is commonly used when the precious metals are not recoverable by either gravity or flotation processes, or cannot be upgraded to produce a concentrate suitable for direct smelting.
- A fourth alternative involves **an appropriate combination of these three technologies** in order to produce a concentrate that is suitable for smelting purposes.

The Project feasibility testwork programme studied a number of flowsheet options presented in the next box.. All tests were conducted with cyanide as the lixiviant, as this was the most likely practical option for Roşia Montană .

1. "Bottle Roll Leach" – equivalent to a whole of ore CIP operation.
2. "Gravity leach" - equivalent to recovering free gold and heavy minerals with a gravity circuit.
3. "Gravity and oxygen" – as for 2 above but using oxygen to enhance leach rate and potentially reduce cyanide consumption as well as increasing overall extraction of the gravity tails.
4. "Gravity pre-oxidation" – as for 2 above, however the gravity tailings are agitated and aerated in an attempt to reduce cyanide consumption and to enhance leaching of gold in the gravity tails.
5. "CIL" – Carbon in Leach, whole ore leaching in the presence of carbon. This process reduces the effect of "le Chatliers" principle and losses of gold to active surfaces present in the ore.
6. "Float con leach" – use flotation to generate a concentrate and only use cyanide leach on this concentrate. Flotation tailings are not leached for gold.
7. "Float con leach at 10 µm" – as for 6 above however the concentrate is ground to nominally 10 µm to liberate contained gold and then leached in cyanide. Again, flotation tailings are not leached.

8. “Float con leach tail leach” – as for 6 above however the flotation tailings are also leached with cyanide to recover contained gold.
9. “Float con leach 10 µm tail leach” – as for 7 above however the flotation tailings are also leached with cyanide to recover contained gold.
10. “Float POX leach” – similar to 6 above in that a flotation concentrate is generated, however in this case it is oxidised using pressure oxidation (POX) to destroy the sulphide matrix and liberate gold for cyanidation.
11. “Float POX leach, tail leach” – as per 10 above however in this instance the flotation tailing is also cyanide leached.
12. “Gravity con and tail leach” – Produce a gravity concentrate and cyanide leach this separately to the gravity tail. All components are effectively leached.
13. “Gravity con leach 50µm tail leach” – As for 12 except the gravity concentrate is ground to nominally 50 µm to liberate gold contained in sulphides in the gravity concentrate.
14. “Gravity con leach 10µm tail leach” – As for 12 except the gravity concentrate is ground to nominally 10 µm to liberate gold contained in sulphides in the gravity concentrate.
15. “Heap leach” – the whole of ore is crushed (not milled as per all the previous options) and stacked in heaps and then leached with a cyanide solution.

The various flowsheets were simulated by testwork to establish the metallurgical performance and the extractions were estimated. The gross revenue generated by each option was calculated and each of the flowsheets ranked – operating costs were not taken into consideration. As a consequence, the ranking is directly related to the extraction of gold achieved. The results as extracted from the Minproc report are provided in the following Table 5-13.

Table 5-13. Summary of Recovery and Revenue Ranking

Flowsheet Option	Au Rec %	Ag Rec %	Total Metal Revenue $/t	Revenue Ranking
Leach (bottle roll only)1	72.3	47.6	11.83	12
Gravity leach	72.4	47.6	11.85	11
Gravity + oxygen	72.4	52.5	11.93	10
Gravity pre-oxidation	73.8	54.4	12.16	8
CIL	76.3	46.6	12.42	5
Float con leach	62.8	54.9	10.49	14
Float con leach at 10 µm	66.3	62.7	11.15	13
Float con leach tail leach	76.5	66.0	12.77	4
Float con leach at 10 µm tail leach	80.0	73.7	13.43	2
Float POX leach2	79.0	65.3	13.14	3

[1] All whole ore/gravity leach testwork was conducted at P_{80} = 150 µm, 0.1% CN and 24 hours leach retention time.

Float POX leach tail leach	92.7	76.3	15.42	1
Gravity con and tail leach	73.9	51.1	12.13	9
Gravity con leach 50 µm tail leach	74.5	51.9	12.24	7
Gravity con leach 10 µm tail leach	75.0	53.3	12.34	6
Heap Leach	49.2	34.2	8.08	15

The assessment shows that in the flotation of a concentrate, oxidising the concentrate and leaching with cyanide both the concentrate and the flotation tails provides the highest recovery and gross revenue. Whilst this may be the case, this does not necessarily provide the best project economics as there are significant differences in capital and operating costs between all the options.

The following Table 5-14 ranks the options in terms of capital and operating costs using different level of sensitivity for the different factors of revenue, capital and operating costs.

Table 5-14. Summary of Flowsheet Options Ranked According to Revenue, Capital and Operating Costs.

Flowsheet Option	Revenue		CAPEX		OPEX	
	+15%	-15%	+30%	-30%	+30%	-30%
Leach (bottle roll only)	6	4	4	6	4	7
Gravity leach	7	5	5	7	5	9
Gravity + oxygen	5	3	3	5	3	5
Gravity pre-oxidation	2	2	2	2	2	2
CIL	1	1	1	1	1	1
Float con leach	14	13	13	14	13	14
Float con leach at 10 µm	13	14	14	13	14	13
Float con leach tail leach	11	10	9	10	10	11
Float con leach at 10 µm tail leach	10	11	10	11	11	6
Float POX leach	12	15	15	12	15	12
Float POX leach tail leach	3	12	12	3	12	3
Gravity con and tail leach	9	8	8	9	8	10

[2] POX recoveries have been assumed to be 97 gold recovery and 92% silver recovery. These are estimates based on PFS testwork results.

Gravity con leach 50 µm tail leach	8	7	7	8	7	8
Gravity con leach 10 µm tail leach	4	6	6	4	6	4
Heap Leach	15	9	11	15	9	15

The tests indicate that the whole ore CIL option is considered the best option evaluated. The variables chosen to produce Table 5.15 are indirectly indicative of the variables to determine BAT. **The whole ore CIL option is BAT because**:

- it uses a less hazardous substance (this being cyanide as cyanide is less hazardous than alternatives as will be discussed in the following sections),
- whole ore CIL has been used in many other similar ores to Roşia Montană ’s with success and on a larger scale than the one envisaged at Rosia;
- the volume and emissions are more benign than with other processes that achieved similar recoveries, and there is established and proven technology that will ensure that the emissions are compliant with Romanian and international discharge standard;
- recycling and re-use of water has been designed in the process so that fresh water consumption has been minimized;
- the comminution circuit chosen is typical of large tonnage processing facilities treating ore such as Roşia Montană as it is the comminution circuit that better balances the needs of minimizing energy consumption, robustness and reliability of operation and minimization of grinding media consumption;
- the whole ore CIL option represents the smallest plant size of all the options available for this type of ore;
- the CIL option does not require additional reagents as would the flotation and pressure oxidation options;
- the CIL option will have the lowest power consumption as no additional plant is required (flotation cells, fine grinding plant, etc.);
- in the design of the CIL plant at Rosia, lessons were learned from hundreds of CIL plants that have been built around the world;
- a Seveso II exercise was undertaken in order to minimize the hazards and risks associated with the operation of the project in general and the CIL and TMF facilities in particular; and,
- RMGC has developed a comprehensive Environmental and Social Management System that will ensure compliance with discharge standards, inbuilt continuous improvement and minimizes risks to the environment and communities around the operation.

In conclusion the whole ore CIL plant is not only the best viable treatment technology available but due to the large number of plants of this type around the world, this is the technology that can be combined with a management strategy that will ensure optimal efficiency in terms of energy consumption and ore values recovery. The process selected is therefore confirmed to be BAT and is also considered to be the only viable option having regard to the ore type and fundamental Project economics. It is not appropriate to undertake comparative environmental impact assessment of options that are non-viable.

4.3 Alternative Lixiviants

A number of processes and reagents other than sodium cyanide have been used historically for the recovery of gold. Gravity concentration and amalgamation with mercury have long been in use, but bioaccumulation and other highly significant environmental and health and safety issues associated with mercury use at any scale make this process untenable in a modern mining operation. Sodium hypochlorite, sodium thiosulphate, bromine, and chlorine were all used commercially prior to 1880 for some limited types of gold ores. However, the development of the cyanidation process in the late 1880’s and early 1890’s provided a simple, low-cost alternative that was effective on a much wider range of ore types. Cyanide has been used to recover approximately 80% of the gold produced internationally since that time, and approximately 92% of the gold produced in the last 20 years. Most of the remaining gold production in this time period has been as a by-product from flotation concentration and smelting of base metals such as copper, with very small amounts still produced by amalgamation and gravity concentration methods.

Although the workplace health and safety procedures and general environmental management practices for handling cyanide are well established and governed by international codes of practiceii (which are reflected in the Project’s Cyanide Management Plan; see ESMS Plans, Plan G), such measures do have an attendant economic and risk management cost which must be borne by the mining operation. In an effort to improve the economics of the extraction process, major mining companies have been working for many decades to develop acceptable alternatives to the sodium cyanide for gold extraction. Numerous other reagents have been identified as possible alternatives to cyanide in addition to those in use prior to the development of cyanidation. Some have been subject to extensive study, including ammonium thiosulphate, hypochlorite/chloride and thiourea. Only limited research has been done on many of the other possible reagents due to factors such as their high cost, harsh operating requirements, or a poor understanding of their basic chemistry.

All identified alternatives that could currently be viewed as potentially viable are either less effective, more costly, require more extreme operating conditions (e.g. high temperatures, very acidic/low pH processing environments), necessitate high concentrations and large volumes of various reagents, and/or present risks to health or the environment equal to or greater than use of cyanide, especially when the need to transport large volumes of less effective reagents is considered.

A systematic evaluation of alternative reagents to cyanidation has been developed by Gos and Rubo (“The Relevance of Alternatives Lixiviants with Regards to Technical Aspects, Work Safety and Environmental Safety” (http://technology.infomine.com/enviromine/publicat/cyanide.pdf)). This approach to evaluate the alternatives lixiviants to cyanide is within the spirit of the BAT approach which is a balanced trade off between economics and environmental performance and therefore the framework of this evaluation has been adopted and discussed below. Gos and Rubo compared cyanide with thiourea, thiosulphate, thicyanate, bisulphide, ammonia and halogens based on 11 criteria groups in three categories:

- Economics
  - Capital investment,
  - Extraction economics,
  - Availability,
  - Cost considerations of detox/recycling.

- Process applicability
  - Limitations (e.g. ore type, selectivity, control, separation),
  - Recyclability
  - Detoxifiability
  - Large Scale Applications (proven technology).

- Toxicity
  - Emissions,
  - Handling (e.g TLV and LD50)
  - Environmental Toxicology (e.g LC 50).

From the above list of criteria it is worth explaining how the toxicity related ones are applied in the evaluation. The rest of criteria are self explanatory. The lethal dosage (e.g LD50) as well as the occupational health standard (e.g. TLV) can be considered to yield indications as to how difficult the lixiviant is to handle safely. The criteria for ecotoxicity can be indicated by the lethal concentrations for aquatic life (e.g. LC50) and the categorisation of the lixiviant into classes of water contaminants. This classification is well-defined in Germany and is called the WGK (Wassergefährdungsklasse). The German Federal Water Management Act requires that substances be evaluated for negative influence on the physical, chemical or biological characteristics of water. The water hazard potential is based on the properties of the substances (in particular acute oral toxicity for mammals), toxicity for aquatic organisms (mostly fish and bacteria) as well as biodegradability and bioaccumulation. It categorises contaminants into into numeric water hazard classes (WKG or WHC depending whether the German or English acronym is used). The following table describes the classification:

Class	Hazard Potential
NWG	Not hazardous (formerly WGK=0)
1	Slightly hazardous to water
2	Hazardous to water
3	Extremely hazardous to water

Evaluation of alternative lixiviants under the above criteria yields the following:

- **Thiosulphate** is considered by some to be an attractive alternative to cyanide. However, the process chemistry is complex and the reagent consumption rate is high. The gold-thiosulphate complex is approximately 10 orders of magnitude weaker than the gold-cyanide complex. The process also requires ammonia, which is toxic to aquatic life and has significant handling and storage issues. Moreover, there are currently no satisfactory commercial-scale techniques for recovery of metallic gold from thiosulphate leach solution. Detoxification by oxidation would be very expensive due to the high chemical oxygen demand. Recycleability is at best limited due to the decomposition of thiosulphate to sulphate and sulphide. The LD50 and LC50 values are high; thiosulpahte is a reducing agent with the potential to reduce the oxygen concentration in any natural waterway. In addition, highly toxic sulphide and bisulphide are spontaneous decomposition products of thiosulphate.

- **Thiourea** has been investigated as a possible alternative to cyanide, but has several significant drawbacks. The gold-thiourea complex is approximately 15 orders of magnitude weaker than the gold-cyanide complex. Leaching with thiourea must be done at a pH of 1 to 2, necessitating special handling equipment and materials, and substantially increasing operating costs and workplace health and safety risks. More important, however, is the fact that thiourea is a suspected carcinogen and therefore is not an option without the institution of complex and extensive engineering and health and safety program controls. Thiourea is intrinsically unstable and decomposes rapidly to substances that are unable to leach gold and has a toxicity profile that is no more favourable than cyanide. If the oxidation potential is not high enough, the ammonium ion and thiocyanante is formed in significant quantities. This decomposition would also limit its recyclability, although a complete detoxification would seem to be possible but extremely expensive. Thiourea has ,been used in large scale applications. Thiourea has been classified as a water contaminat (WKG=2). Release of H2S and NH3 in higher quantities is also possible.
- **Thiocyanate** can leach gold in the pH range of 1-3 at higher temperatures (up to 85oC). The low pH and high temperatures would indicate high capex and opex. The availability of thiocyanate may also be a restriction and if thiocyanate had to be detoxified, a considerable oxygen demand would be necessary, which would increase further the opex. Advantages of thiocyanate are that the LD50 is high, classified as a slight water contaminant (WGK=1) and the ecotoxicity data is favourable. No large scale application is known for thiocyanate.
- **Bisulphide** has been proposed as a lixiviant. The process is more suitable for bio-oxidised ores, because a sulphate ion source is required for bisulphide generation. Long retention time and a closed system would be required because of the use of H2S, which would result in a high capex. The detoxification cost would be very high because of the high chemical oxygen demand. In reference to safe handling, H2S has a similar TLV as cyanide and H2S is classified as a water contaminant (WGK= 2). No large scale application is known for bisulphide. In conclusion, bisulphide does not offer technical advantages over cyanide nor does it have such favourable lethal toxicity and ecotoxicity data to warrant a more favourable classification with regard to safe handling or environmental damage in case of a spillage.
- Leaching gold with **ammonia** must be conducted at a temperature in excess of 100° C and 1.7 to 7.9 bar, which presents very difficult operational and process engineering issues. The gold-ammonia complex is at least 11 orders of magnitude weaker than the gold-cyanide complex. As previously noted, ammonia is toxic to aquatic life and has significant handling and storage issues. High temperature and pressure means high capex and opex. Kinetics are substantially better than cyanide. The system would have to be closed to prevent the emission of ammonia. Ammonia has a similar TLV to cyanide and is classified as a water contaminant (WGK=2). The ammonium ion is classified as a slight water contaminant (WGK=1). Ammonia and lixiviant containing ammonia or the ammonium ion cannot be considered to be a lixiviant that has a more favourable profile regarding toxicity or exposure considerations than cyanide.
- Various **halide systems [iodine/iodide, chlorine/chloride (including the "Haber" process), bromine/bromide]** have been evaluated as potential alternatives to cyanide leaching. Several of these systems are useful for recovering gold from gold-rich materials such as copper refinery slimes, but have significant shortcomings when applied to the leaching of gold ore. The gold-halide complexes are not stable, and require a level of chemical and process control not economically achievable in a gold ore leaching

facility. Additionally, halides are typically toxic to aquatic life and have a wide range of storage and handling issues associated with them. The handling of chlorine and bromine has very low TLV, lower than cyanide. Chlorine is classified as a water contaminant (WGK= 2), bromine is a strong water contaminant (WGK = 3). And Br-, I2 and I- as slight water contaminant (WGK= 1).

- Some scientists hope that **bacterial leaching ("bioleaching")** of gold ores (as opposed to the use of bioleaching as a pre-treatment before cyanidation) will one day prove to be a viable alternative to the use of cyanide for a limited range of ore types. However, while this technique has generated interest at laboratory and pilot scales, little progress has been made in its full-scale industrial application.

The following Table 5-15 summarises the issues discussed in the previous paragraphs. The ranking has been given as follows: a favourable criterion has been given a value of 5 and the colour used is yellow, an acceptable criterion has been given a value of 3 and the colour used is grey and finally an unfavourable criteriion has been given a value of 1 and the colour is red.

Table 5-15 was generated to give equal weight to each of the groups of criteria as there were only three environmental criteria as opposed to four for the economics and process applicability.

The ranking presented indicates that despite the fact that cyanide is not an ideal reagent for gold extraction it is substantially better than any alternatives when viewed under BAT criteria. Until a new reagent is proven more effective in all respects for gold extraction, it must be concluded that cyanide is BAT for gold extraction. A comparative environmental assessment of the lixiviant options has therefore not been undertaken on the basis that alternatives cannot be classed as BAT and are therefore not viable.

Table 5-15. Summary and Ranking of Alternative Lixiviants for Gold

Reagent	Economics				Process Applicability				Environment		
	Capital Investment	Extraction Economics	Availability	Cost (Detox/ Recycling)	Limitations	Recyclability	Detoxifiability	Large Scale Applications	Emissions	Handling	Environmental Toxicology
Thiourea	3	1	3	1	1	1	5	3	3	1	1
Thiosulphate	3	1	5	1	1	1	5	3	3	5	3
Thiocyanate	1	1	3	1	3	3	5	1	5	5	3
Bisulphide	1	3	5	1	1	3	5	1	3	1	1
Ammonia	1	1	5	3	3	3	1	1	3	1	1
Halogens	3	3	5	1	3	3	1	3	3	1	3
Melonitrile	3	3	1	1	5	1	3	1	3	3	1
Cyanide	3	5	5	3	5	5	5	5	3	1	1
Summary											

Reagent	Economics				Process Applicability				Environment		
	Capital Investment	Extraction Economics	Availability	Cost (Detox/ Recycling)	Limitations	Recyclability	Detoxifiability	Large Scale Applications	Emissions	Handling	Environmental Toxicology
Reagent	Economics	Process	Environ	Corrected Env.		Total	Total/Maximum Possible Total (%)				
		Applicability									
Thiourea	8	10	5	6.7		24.7	41.2				
Thiosulphate	10	10	11	14.7		34.7	57.8				
Thiocyanate	6	12	13	17.3		35.3	58.8				
Bisulphide	10	10	5	6.7		26.7	44.5				
Ammonia	10	8	5	6.7		24.7	41.2				
Halogens	12	10	7	9.3		31.3	52.9				
Melonitrile	8	10	7	9.3		27.3	46.4				
Cyanide	16	20	5	6.7		42.7	71.9				
						Maximum Possible Total = 60					

4.4 Alternative Methodologies for Cyanide Detoxification

4.4.1 Overview

The analysis and selection of an optimal gold processing alternative from the feasible ones has been previously presented and it was concluded that gold leaching using cyanide (whole ore CIL) is the BAT alternative for the Roşia Montană Project. Because of the presence of cyanide (WAD and stable metal complexes) in the tailings, these are considered dangerous waste and, notwithstanding other characteristics, the TMF may be classed as a “Category A” facility under the new EU mining wastes Directive. Detailed data referring to the composition and characteristics of this waste stream have been presented in Chapter 2, based on the geochemical investigations on the tailings from pilot tests for gold extraction.

The project has proposed the following approach to cyanide use and management based on BAT considerations, the International Cyanide Management Code and other European, international and national technical and environmental regulations:

- minimization of cyanide usage and wastage by its recovery in the process circuit and reuse, by thickening the tailings slurry prior to cyanide destruction and recirculation of waters with cyanide content;
- detoxification of remaining cyanide in slurry by using the INCO process which is recommended for such wastes and has the largest industrial application in Europe and is able to consistently achieve cyanides concentrations < 10 mg CN-WAD/l, as required by the EU Directive on management of waste from extractive industries for water discharged to the TMF;
- recirculation of waters from the TMF to the technological process during the entire operating period and ensuring that there is sufficient storage capacity in the TMF during normal operating conditions, in case of extreme rainfalls events or other extreme meteorological events;
- control of processes for natural attenuation of cyanide and heavy metal concentration in ponds and providing treatment possibilities as need be, by adequately processing the pond waters, in the closure period, in order to re-use or discharge it in the surface water system. For this reason, during the closure/post closure period, the secondary cyanide treatment system will be retained, as long as necessary;
- having regard to any possible (non-programmed) requirement for release of treated effluent to the environment,
- in order to attain the 0.1 mg CN-t/l concentration required under Romanian regulations, the INCO process will be coupled with a secondary cyanide treatment system that will be developed during the construction phase of the project using large scale testwork to confirm performance; at this stage use of a peroxide process is favoured because this technology has been tested in industrial conditions and does not produce a secondary waste product requiring special treatment; the activated carbon adsorption and reverse osmosis methods will be tested also;
- the seepage with potential cyanide, heavy metals and nitrogen compounds content from various retaining facilities are collected, monitored, and recycled, during the operating period, in the TMF and process plant;
- treatment lagoons (based on biological processes) will be built and tested downstream from the TMF during the operational period of the project with the purpose of treating seepage in the closure and post closure phases to be able to discharge drainage into the Corna Valley.

In the following sub-sections the preferred BAT detoxification system (INCO) will be compared with alternatives processes to document the overall advantage provided by the INCO process. The ideal characteristics of the cyanide detoxification technology are as follows:

- proven technology for the scale of operation required;
- able to meet EU mine waste Directive disposal limits for TMF (<10 ppm CNWAD) in a consistent and routine manner;
- able to assist meet discharge requirements to receiving waters if necessary;
- able to meet health and safety standards;
- technology is robust and low risk;
- balanced capex/opex and overall cost;
- able to treat slurries and solutions efficiently;
- does not generate toxic by-products which are difficult to dispose of; and,
- there are proven management strategies to ensure achievement of discharge regulation.

The cyanide removal processes can be classified into destructive or recovery types:

- The destructive methods transform the cyanides into non-toxic products by chemical, biochemical or photolytic processes.
- The recovery processes separate the cyanide from the effluent and recycle it for reuse in the process.

The best known cyanide treatment technologies of the industrial effluents, applied on large scale or only to industrial pilot scale are the following:

Destructive processes based on oxidation/bio-oxidation:

- alkaline chlorination;
- oxidation in the system of SO2 - air (INCO, Noranda);
- oxidation with peroxides (Dupont-Kastone, Eflox, CombinOx);
- ozone oxidation;
- biological processes;
- natural degradation/attenuation;

Recycling / Recovery processes:

- HCN stripping at low pH (AVR process);
- recycling of cyanide effluents;

Other processes:

- precipitation processes (Prussian Blue);
- DTOX;
- ROLB;

- ion exchange processes (Vitrokele, Augment)
- electrochemical oxidation;
- reverse osmosis;
- other recovering processes.

The following lists the currently applied cyanide treatment alternatives in Europe according to the BAT Reference Document on Best Available Techniques for Management of Tailings and Waste-Rock in Mining Activities [3]:

Treatment processes	Stage	Applications	Comments
Natural degradation neutralization by atmospheric CO_2 absorption HCN volatilization cyanide complexes dissociation cyanide complexes precipitation	Commercial	Discharge into surface waters or tailings ponds	Application is limited to site specific factors (climate) and regulations.
Oxidation processes			
Alkaline chlorination	Commercial	Discharge into surface waters or tailings ponds	Displaced by SO_2-air and H_2O_2 due to cost and inability to remove iron complex cyanides.
SO_2/air process	Commercial	Discharge into surface waters or tailings ponds	Universal application, slurry treatment can result in elevated reagent consumption
Oxidation with hydrogen peroxide	Commercial	Discharge into surface waters	Not applicable to slurries due to reagent consumption
Adsorption on activated carbon	Development	Discharge into surface waters	Limited to low CN concentrations. Depends on site conditions
Biological treatment	Commercial	Discharge into surface waters	Limited to low CN concentrations. Depends on site conditions. May require supplemental heat in the system
Cyanide recycle - AVR	Commercial	Discharge into tailings ponds	Not very practical on slurry High capital cost Need sufficient recoverable cyanide to break even on operating costs versus cyanide recovered. Precipitation of CuCN lowering cyanide recovery. Ussualy becomes too expensive when trying to recover below 30 mg CN/l. Therefore, still need for removing/destroy cyanide after AVR

4.4.2 Destructive Methods

SULPHUR DIOXIDE/AIR PROCESS (INCO)

The process is carried out in the presence of air (or oxygen), sulphur dioxide (gaseous or in the form of sodium sulphite or metabisulphite, ammonia bisulphite, gases from pyrite or elemental sulphur incineration), pH=8-10 adjusted with lime. The reaction times for slurry treatment are in the range of 20-120 minutes, depending on slurry composition. The oxidation rate initially decreases with the rise of pH value but this trend is changing to the end of reaction leading to a range of operating pH = 8.5-10. The technique allows the removal of cyanide bound to iron by precipitation of an insoluble ferrocyanide salt. Heavy metal complexed cyanides are removed in the order Zn>Fe>Ni>Cu, following oxidation of the free cyanide.

For a certain amount of catalyst, the rate-limiting step of the process is the oxygen transfer rate in the solution. The stirring and air/SO2 injection systems are critical for process performance and for solid attrition. The ratio of air to reactor volume is important and represents an INCO patent claim. The availability of dissolved oxygen depends on aqueous-system viscosity and on stirring conditions. The concentration of dissolved oxygen is low when the viscosity is high and the rate of the process is lower.

In order to choose the optimal solution for supply and use of sulphur raw material, the transport costs (higher in case of liquid SO2 if rail transport is not an option) and handling risks (higher in case of liquid SO2), acquisitions and investment costs have to be taken into consideration. The less expensive option regarding cost of the raw material is the use of elemental sulphur but the investment costs for the oven makes this option less feasible in case of small production capacities and/or with a short operational period.

It is noted that if the selected option is SO2 generation by elemental sulphur combustion (economic for high capacities), the capital costs can rise by 80%, but the operating cost decrease by approx. 60%. Thus, there are theoretical possibilities for diminishing the operation costs in time if the metabisulphite become expensive or the SO2 consumption rises from different reasons (higher cyanide consumption in the base process, less favourable reaction conditions, more restrictive discharging conditions).

As mentioned above, copper catalyzes the oxidation of cyanide to cyanate, the effect being proportional with copper concentration. This is an advantage in case of Roşia Montană slurry which contains suitable copper concentration (≤ 50 mg Cu/l slurry content).

The INCO process is already applied on an international level being licensed for approx. 80 sites. This process is the most applied technology for the treatment of tailings slurry with cyanide content in Europe and is recommended as BAT.

Few examples of INCO industrial applications are presented below.

- <u>Scottie Gold Mines (Stewart, British Columbia, Canada)</u> processes aprox. 200 t ore/day having aprox. 15 g Au/t. Solution treatment is performed using two serials reactors, the slurry entering to the second stage. Na2SO3 and Na2S2O5 are the process reagents.
- <u>Mc Bean Mine (Kirkland Lake, Ontario, Canada)</u> processes 500 t ore/day having aprox. 5 g Au/t.
- Technological configuration is very flexible. The slurry and solution can be treated together or separately using <u>one or more serial reactors</u> according to slurry characteristics.
- <u>Caroline Mines Ltd. Canada</u> (1300 t ore/day) applied successfully INCO technology as a replacement for alkaline chlorination; it was proven that it is less expensive regarding to installation and operating costs, more robust and efficient referring to effluent quality. On the other hand, SO2/Air process havs to be operated by more qualified operators and comes with additional license costs [6].
- <u>Ovacik mine</u> use for slurry treatment two serial reactors and <u>the cyanide detoxification being mainly completed in the first reactor</u>. Sodium bisulphide and NaOH are the reagents. Cu2+ as CuSO4 is the catalyst. Reactor II continues the cyanide degradation

and precipitates the compounds of Fe-cyan, heavy metals, As, Sb, in the presence of Fe III.

On European level, the SO2 process is applied for slurry treatment before the discharging into settling ponds [3]. Generally, this treatment process leads to residuals concentrations of total and WAD cyanide below 1 mg/l.

The next table shows the cyanide concentrations for more mines according to *BREF Best Available Techniques for Management of Tailings and Waste-Rock in Mining Activities* [3].

Point of sampling, water system	Boliden	Ovacik	Rio Narcea
	mg/l		
Leach/ Slurry			
Free CN-	120	200	400-450
Free CN-, min/max	50/70	180/220	-
Measurement frequency	1/day	1/2h	continuous, on line
PH	-	10.5	10.5
The discharging point from Detox			
Free CN-	-	-	0
CN- WAD	-	0.33	10-30
CNT-	0.87	0.40	10-30
min/max	0.31/1.34 CNT-	0.06/0.88 CN- WAD	1/40 CN- WAD
Measurement frequency	1/day	1/2h	1/3h
PH	-	7-8	8.5
Settling pond			
Free CN-	-	-	0
CN- WAD	-	0.23	20-30
CNT-	0.3	0.39	-
min/max	0.05/0.74 CNT-	0.04/0.71 CN- WAD	10/30 CN- WAD
Measurement frequency	occasionally	1/day	1/day
PH	-	7-8	8.5
Discharging from the settling pond			
Free CN-	0.06	no discharging	0
CNT-			0.5-1
min/max	0/0.33		0.2/2 (WAD)
Measurement frequency	1/day		1/day
PH	-	-	8-8.5

Likewise, in the following table are emphasized, in addition, the treatment performances of INCO process in case of tailings slurries with ≤ 60% solids content for different mining sites from North America, Asia and Australia.

INCO process (SO2/air) - Summary table with industrial applications for the treatment of tailings slurry with ~ 50% solids content (Stuart Smith Aurifex Pty Ltd - 2006)

Site	Solids content, %	Cyanides, mg/l	
		Initial slurry	Treated tailings
Musselwhite, Canada	50	CN-u.e = 50	CN-WAD = 1-2
Chatree Gold - Pitchit, Thailand	35-45 (designed estimation) predicted optimization by thickening - recirculation (50% solids slurry content)	No determination	CN-t < 20
Gympie Eldorado Gold Mines - Queensland, Australia	55-50	CN-free = 50-100	CN-WAD ≤ 2 CN-WAD ≤ 1 (in TMF)
Bronzewing Gold Wester Australia, Australia	50	CNt- = 160 CN-WAD = 100	CN-WAD ≤ 5 (CN-WAD average ≤ 1,5)
Henty Gold*, Tasmania, Australia	60	CN-WAD = 150	CN-WAD ≅ 2

* INCO (SO2/aer) process replaced the initial treatment process - alkaline chlorination

The INCO process has the following disadvantages:

- consumption/costs of the reagents depend on aqueous system composition and on the required quality for discharging;
- the process generates calcium sulphate in the aqueous flow from the treatment process;
- additional treatment processes might be required to achieve very low total cyanides, metals and ammonia (cyanide degradation product) concentrations, for example to allow direct discharging of the decant water from TMF into natural receivers;
- the application of the INCO process requires know-how on hydrodynamics and kinetics of the cyanide treatment process;
- because the process is patented, users must pay royalties.

In general, the INCO process has the following advantages:

- high efficiency for the treatment of all the aqueous systems with cyanide content (slurries, and solution) with efficient removal of all cyanide forms by oxidation-precipitation reactions and of heavy metals;
- this is the preferred process on a European and international level for slurry treatment. The technology is proven on an industrial scale at a European and international level and

accepted by Reference Document on Best Available Techniques for Management of Tailings and Waste-Rock in Mining Activities;

- it is generally accepted as efficient and flexible; the process can handle influent quality variations better than alternative technologies by adjustment of the rate of reagent and catalyst addition;.
- reagents are readily sourced and there is the option of replacing them with less expensive ones as economic circumstances might dictate, without detriment to performance;
- the operating costs are comparable to or less than other chemical treatments of cyanide removal processes (alkaline chlorination, hydrogen peroxide, Caro's acid) which are applied or ready to be applied at an industrial level;
- although the application of the INCO process at an industrial level requires a good technical understanding of the hydrodynamics and kinetic problems in the treatment process of the slurry, technical assistance/ know-how is readily available from suppliers that have good industrial experience. Once the process is fine tuned for the particular project, the technology is robust and versatile;
- the process/installations are easy to restart after temporary shutdown and quickly reach a steady state operating condition;

The sulphur dioxide/ air process (INCO) is the preferred technology for the Roşia Montană project based on comparative testing results that confirm INCO is BAT for this Project.

Based on the results of the lab/pilot tests performed on Rosia Montana ore the following can be concluded:

- the CIL slurry treatment performed on Roşia Montană ore using SO2/Air system is able to obtain residual WAD cyanides below 10 mg/l maintaining good capex/opex costs; at the lab/pilot scale less than 1 mg CNWAD/l and less than 5 mg CNT/L were obtained ;
- should it be required (depending on the prices of reagents and the demands of technological process) it is the possible to use SO2 generated by elemental sulphur combustion with a short recovery period for capital invested.

NORANDA PROCESS

The Noranda version of the SO2 /air process is similar to the INCO process in that SO2 and copper are used to detoxify cyanide from effluent streams. In the Noranda process however, SO2 gas or liquid SO2 is injected into slurry at such a rate as to reduce the pH to between 7 and 9. Addition of air is not required under these conditions. The technology has not been as widely employed as the INCO process, being predominantly used in Noranda's own operations. Although potentially applicable to the processing needs of the Roşia Montană Project, it has not been used nearly as widely as the INCO version of the process, and offers no technological advantages over the INCO process. [2, 9]

HYDROGEN PEROXIDE OXYDATION PROCESS (DuPont-Kastone, Degussa)

A series of cyanide treatment processes based on hydrogen peroxide application were developed and patented. Hydrogen peroxide oxidizes the free cyanide to cyanate in the presence of copper.

Complex cyanides of Cd, Cu, Ni and Zn are also oxidized to cyanate [2]. The metals released from the complex during the oxidation process are precipitated as insoluble compounds (hydroxides, cyanides, iron complex), the residual concentration depending on the pH value of the reaction media. The reaction rate decreases at lower temperatures.

The process of cyanide degradation by oxidation with hydrogen peroxide is applied to slurry treatment at industrial level but involves higher costs than in case of the treatment of settled wastewater [3, 9] and the constraints on the hydrogen peroxide oxidation process are due to the difficulties of handling the reagent and high reagent cost.

There are two methods developed on an industrial scale based on H2O2 usage. These are the DuPont-Kastone process (oxidation with hydrogen peroxide and catalyst of Cu II and CH2O) developed for the treatment of cyanide effluents from galvanic applications and the Degussa process (H2O2/Cu2+).

For a specific H2O2 concentration, the reaction rate increases together with the increase of Cu2+/CN ratio but the efficiency of the process is reversed with the ratio of Cu2+/CN because the copper and other transitional metals act as catalysts for hydrogen peroxide decomposition and the consequence is the rise of oxidant reagent consumption.

The Degussa process was used at the Ok Tedi gold mine in western Papua New Guinea to treat tailings slurry prior to discharge into a natural watercourse. The consumption of hydrogen peroxide was in the range of 0.4 to 1.0 litre of 70% reagent per cubic metre of tailings slurry, which resulted in significantly higher operating costs in comparison with SO2/air processes. Due to the costs associated with the reagent, only free cyanide and weak complexes were targetted. The higher stability complexes were not detoxified, as the low soluble iron levels and high turbidity of the river was determined to offer adequate protection from photodecomposition of these complexes.

The testwork undertaken for the Roşia Montană Gold Project shows that the hydrogen peroxide treatment of the slurry from CIL tests performed on Roşia Montană ore samples involves a high H2O2/CNWAD ratio which makes this method less economically advantageous than SO2/Air and Caro acid processes [7, 8]. It is noted that there are limited examples of industrial scale application of this method for slurry treatment.

CARO's ACID OXIDATION PROCESS (EFFLOX)

Detoxification with Caro's acid (peroxymonosulphuric acid - H2SO5) is another version of the hydrogen peroxide process and is the most effective variation for treatment of slurries. The potential offered by the use of Caro's acid has been known for many years; however, production, storage and dosing are technologically difficult. The "Efflox" process developed by Solvay Interox allowed Caro's acid to be mixed at an effluent dosing point, thereby simplifying the process and resulting in a practical treatment option. The Efflox process relies on reaction of sulphuric acid and hydrogen peroxide to produce H2SO5, which reacts rapidly with cyanide to produce cyanate. Use of a catalyst is normally not required. Benefits include insensitivity of the reagent to the presence of transition metals, which means it can be used to treat slurries. The rate and efficiency of heavy metal precipitation is also enhanced, and a low capital cost makes the process attractive where seasonal detoxification is required (e.g., sporadic flows due to spring thaw or high rain periods).

Efflox plants have been successfully operated in Europe, North America and Australia. The major disadvantage of the process is that reagent costs are generally much higher than those associated with SO2/air processes applied to detoxification of slurries, with no significant benefit in the effluent quality. Although the low capital cost is beneficial, operating cost penalties often outweigh the benefit. The Efflox process generally finds application in the treatment of solution effluents on a short-term basis for discharging to natural receivers.

The cyanide removal process from the slurry based on Caro's acid was tested for a slurry study case as part of the CIL tests performed on Rosia Montana ore [7, 8]. This process was identified as a reliable option for Roşia Montană project but less advantageous (higher operating costs) than SO2/Air process.

COMBINOX TECHNOLOGY

This method is a combination of the oxidative processes based on SO2/Air and peroxides (hydrogen peroxide or Caro's acid) and is able to reach low residual concentrations of metals and cyanide. The process is flexible, adaptable to feeding conditions and, when applicable, is superior to these two distinct processes mentioned above.

The reaction system is INCO and the reagents are a combination of peroxide, sulphur dioxide and air and Cu2+ catalyst. INCO installations can be adapted to CombinOx technology.

CyPlus recommends this process for slurry treatment because of low operating and capital costs and because of operating flexibility. The reaction rate is higher than SO2/Air process [https://mycyplus.com/cyplus/anonym/products/combinox.htm].

The Reference Document On Best Available Techniques for Management of Tailings and Waste-Rock in Mining Activities (July 2004) notes the combination of SO2/Air and H2O2 processes as an emerging technique in developing stage without commercial application [3].

Roşia Montană testwork shows that the slurry treatment from the CIL tests performed on Roşia Montană tailings using CombinOx technology will not produce acceptable WAD cyanide concetrations, under acceptable economic conditions which might make this process an alternative to INCO for this large industrial application [5].

ALKALINE CHLORINATION

This process was applied on a large scale up to 1982 but currently it is less used because of the risks of handling chlorine and of cyanogen chloride generation, a very toxic gas. Also, it has a high reagents consumption.

This method was the first large-scale chemical process adopted for the treatment of cyanide waste in the mining industry. The process was generally replaced by SO2/air process [2,3 6,9]. At one time, up to eight North American operations used this process to treat mill solutions; however only two applications remain due to the increased use of the SO2 process.

The process is based on oxidation, with chlorine or hypochlorite, of the cyanides and sulphocyanides in alkaline conditions.

Alkaline chlorination is a two step process, with chlorine supplied either as liquid chlorine or as hypochlorite. The first stage of reaction provides rapid oxidation of cyanide to cyanogen chloride, which is itself a toxic product. Under alkaline conditions (pH 10 – 11), however, the cyanogen chloride (ClCN gas; very toxic) is then converted to cyanate by the hydroxide ion. A high pH must be maintained to ensure rapid conversion to cyanate and to avoid the release of highly poisonous cyanogen chloride. The stoichiometric chlorine requirement to convert cyanides to cyanate is typically significantly exceeded as the chlorine reacts with thiocyanate and cyanate itself. For a slurry, there will be a considerable reaction between the chlorine and the ore particles themselves, again increasing chlorine consumption. Therefore, there is an additional pollution with active chlorine and chlorides of the treated effluents.

The alkaline chlorination process also involves retention times that vary a great deal in reactor volumes, from lows of some 0.5 hours up to 14 hours, with 6 to 8 hours residence time being usual. This is a very large volumetric requirement for a large-scale operation such as Roşia Montană Project. The process also is not very effective in removing iron cyanides from effluent streams. Review of the literature suggests iron removal efficiencies of less than 15% [2, 3, 6, 9].

Given the disadvantages of high operating and capital costs, presence of elevated chloride levels in effluents, use of very corrosive reagents, and no benefit in effluent quality beyond that which can be obtained using SO2/air techniques, alkaline chlorination is not preferred for treatment of the Roşia Montană Project tailings.

OZONE OXIDATION

Ozone is a strong oxidant (stronger than chlorine or hydrogen peroxide) and also reacts with cyanide to form cyanate. Further reactions to produce nitrogen and carbonate can occur. Ozone cannot oxidise iron cyanides without the presence of ultraviolet light. The high oxidative capacity of ozone is such that it reacts with many of the ore components in slurry resulting in high consumption rates of the oxidant. The cost of generating ozone is prohibitive using current technologies; however, a new type of ozone generator is being developed which may significantly reduce the cost in future operations. Nevertheless, at this point in time, ozonation is most suitable for treatment of small volumes of solutions, not slurries.

The technology has not been widely applied within the mining industry at comparable scales of operation, and as such is not a preferable or BAT option for treatment of the Roşia Montană slurry.

BIOLOGICAL TREATMENT –Bio-oxidation

- Biological treatment of cyanide effluents is extensively used in the mining industry for dilute solutions as a polishing step before discharging into natural receivers, typically for effluents from settling ponds or for seepage.
- Biological processes use continuous flow systems, with attached biomass (biofilters) or suspended biomass (active sludge), and they are able to remove cyanides, thiocyanates, cyanates, ammonia and metals (by a biosorption process) from these dilute solutions [1].
- There are industrial applications which treat seepage in the operational phase or during closure. In the case of the Ellsburg mine, the application of cyanide removal by biological processes led to the reduction of cyanide concentrations in wastewater below the limit level of 0.5 mg/l stipulated for South Africa .
- Rio Narcea mine in Spain has two parallel lines of biological treatment with the recirculation of the water into the technological process.

However, biological processes do not represent an alternative for the primary slurry treatment process. This option is a reliable solution for the advanced treatment in a lagoon system of some dilute effluents (seepage) in the closure and post closure phases as is proposed for the Project.

NATURAL DEGRADATION/ ATTENUATION

The natural degradation (attenuation) of the cyanides involves high retention time in the settling ponds. The cyanide degradation is a consequence of a series of physico-chemical and biological processes: volatilization, photochemical degradation, chemical oxidation, biological oxidation, hydrolysis and other processes such as precipitation and adsorption on solids. However, volatilization is the most important process.

Natural cyanide attenuation occurs with all cyanide solutions exposed to the atmosphere, whether intended or not [1]. Natural degradation is influenced by existing species and their concentrations in solution, pH, temperature, light intensity, oxygen concentration, and the type of bacteria and characteristics of the pond (surface, depth, turbidity, turbulence, the presence of ice).

Although settling ponds are generally designed to allow the separation and retention of solids, the cyanide degradation occurs naturally and is able sometimes to decrease concentrations to within the range of discharge limits. The natural attenuation processes can be intensified by increasing the biological degradation component in a specially designed lagoon.

On a worldwide scale, natural degradation is still the most common treatment method of treating cyanide in dilute gold leaching effluents, although it is often supplemented by other treatment processes. In the case of the Roşia Montană project, based on the modelling of natural cyanide attenuation process in TMF, the cyanide concentrations in the decant pond can be expected to vary seasonally, with the lowest attenuation in the winter, but overall, the WAD and total cyanide concentrations in the decant pond can be expected to be approximately 50 percent of the concentration in the tailings discharge.

For all of the cyanide attenuation and water balance cases considered for the Roşia Montană Project, rapid decline in the supernatant pond total and WAD cyanide levels are expected following shutdown of the mill. It is estimated that within 6-36 months following shutdown of the mill both the total and WAD cyanide levels will decline to less than about 0.1 mg/l through a combination of dilution and natural attenuation. However, it is recognised that natural degradation is not an applicable process for cyanide destruction under the terms of the new mining wastes management Directive, i.e., to be able to reduce CN WAD concentrations in the untreated slurry discharged to the TMF below 10 mg/l.

4.4.3 Recovery processes

ACIDIFICATION-VOLATILIZATION-RENEUTRALIZATION (AVR)

The process is applicable to slurries and solutions and consists of decreasing the pH between 2-3 using sulphuric acid or sulphur dioxide, stripping of HCN, followed by HCN absorption into an alkaline solution of NaOH or $Ca(OH)2$. The recovered cyanide is recycled back to the gold extraction process. The effluent of the desorption phase is neutralized with lime to a slightly alkaline pH.

The efficiency of cyanide recovery is strongly influenced by pH in the stage of acidification - stripping and by the ratio of WAD CN / total cyanide content (concentrations higher than 150 mg/l WAD CN are favourable).

The process is perceived as potentially hazardous because HCN is deliberately generated. In additions, the complexity of process scale-up and the investment costs are probably the highest compared to other alternatives for cyanide removal from the slurry. Sealed stirring tanks and desorption/sorption columns are needed. The equipment is expensive because of the required precautions against exposure to HCN gas. The operating costs are high because of high consumption level of reagents for acidification and final re-neutralization and because of high energy consumption corresponding to high levels of air flow which must be maintained in the processes of desorption/absorption (aprox. 500-700 Nm3 air/m3 slurry). Moreover, there are additional expenses for authorizations and assurance because of high risks related to high pumped flows of the HCN/air mixture. The technology is more appropriate for sparsely populated areas.

There are problems with desorbers clogging when this technology is applied to the treatment of slurries and therefore this technology is more applicable to solutions.

The process is applied in the field of gold and silver extraction for specific reasons, which are more related to economics than environmental protection. The economics may be favourable especially in very remote locations where the costs of cyanide transportation threaten the viability of the mining project and risks of HCN generation are acceptable.

A study into AVR application for Roşia Montană indicated the following [13]:

- Roşia Montană project would need a desorption/sorption AVR installation about 8 to 10 times bigger than any similarly existing system for slurry. Using design parameters for existing installations the results show exceptional dimensions for key equipments. The implementation of the AVR at such a scale might generate unpredictable problems in operation. The process does not have the same ecological efficiency of SO2/Air: the slurry post AVR will still contain some 10 ppm CNWAD and so the system is not as effective in attaining discharge limits;
- both processes (INCO and AVR) consume similar amounts of power;
- the process does not consume metabisulphite but involves high sulphuric acid and lime consumptions for acidification - volatilization and reneutralization;
- AVR economic efficiency seems to be better than SO2/Air process but this depends strongly on the sulphuric acid cost;

Because of the impossibility of maintaining net economic advantages for a long period of AVR system running and because of the necessity to have two steps of slurry treatment in order to reach low levels of WAD cyanides, this process of cyanide recovery was not considered to be a viable option for Rosia Montana project.

CYANIDE RECOVERY BY PROCESS EFFLUENT RECYCLING

Cyanide can be recovered and re-used by recycling cyanide-containing solutions within the metallurgical circuit [1]. This is commonly conducted using thickeners or filters to separate solution from tailings, with the solution being recycled to the grinding and/or leaching circuits.

It has been recommended that this approach is evaluated by all mining operations using cyanide because of its simplicity and effectiveness; however this method cannot be the complete solution to cyanide removal requirements; cyanide destruct technology is required to achieve the imposed low concentrations in slurry discharged to the TMF (or clarified effluent to natural receivers).

Recovery of cyanide from tailings by means of internal recycling is a process that is economical and environmentally desirable, because it reduces the cyanide input for the processing plant and also the chemical reagent and energy consumption in the destructive treatment process for cyanide. Recycling of cyanide in a metallurgical circuit rather than discharging it to the tailings pond it is therefore BAT according to Reference Document on Best Available Techniques for Management of Tailings and Waste-Rock in Mining Activities.

This method of detoxification of tailings by means of cyanide recycling in the metallurgical circuit was chosen as a feasible technology for the Roşia Montană Project and it represents an essential step in the cyanide management system as it is integrated to the ore milling and leaching and overall tailings detoxification process (together with SO_2/air treatment) [9].

4.4.4 Other Processes

PRECIPITATION AS INSOLUBLE CYANIDE COMPLEXES

All cyanide types react with ferrous iron Fe^{2+} to form complexes with low solubility such as $Fe_4[Fe(CN)_6]_3$ (Prussian blue) or other compounds as ($M_XFe_Y(CN)_6$) [. The iron complex cyanide precipitation is limited to situations where the precipitation reactions can be carefully controlled and the solids can be separated and properly disposed. In the past, this process was widely used to convert free and WAD cyanides to less toxic iron-cyanide compounds, but its present utility is as polishing step in order to reduce total cyanide concentrations to less than about 1 to 5 mg/l.

The process is optimally carried out at a pH of about 5.0 to 6.0 and iron is added as ferrous sulphate ($FeSO_4$-$7H_2O$). Ferrous sulfate dosage varies according to the cyanide concentration and the required degree of treatment.

In case of the Roşia Montană project, the cyanide precipitation as cyanide complexes is not a reliable alternative because of the operational scale and the type of treatment flow but heavy metals precipitation (Cu, Cd, Zn) as ferrocyanic salts occurs anyway during INCO process because of the presence of iron in the tailings.

"DTOX"

"DTOX" is a process developed at commercial scale by the Mineral Process Control Co. – Australia for cyanide and heavy metals treatment from water and soil. The process uses polysulphides for the precipitation of metals and conversion of cyanide to thiocyanate which is less toxic. The possible applications (recommended by supplier) include: settling ponds, remediation of underground water and soil. It is understood that some mining companies keep a stockpile of DTOX (NaS_x, 39 % solution) as a safety measure, in case of cyanide spills.

Because the process is not proven on an industrial scale (especially for tailings streams), DTOX was not considered as a viable option for the Roşia Montană Project.

ELECTROCHEMICAL OXIDATION

This method destroys by electrolytic process the cyanide at the anode while heavy metals are collected at the cathode. Current density and voltage cell, type of the electrodes, pH and the nature and composition of the treated wastewater are variables that need to be determined.

It is noted that the method has been reported to have relatively high economic efficiency and a small environmental impact. All the heavy metals are collected to the cathode (can be recovered and used) and the reaction products are not toxic - CO_2 and N_2. At present efforts are being made in order to improve the process for industrial applications, and sufficiently reliable to be used for the treatment of residual cyanide flows. There are no data about slurry applications.

The process is therefore as yet unproven having regard to application at Roşia Montană.

IONIC EXCANGE (VITROKELE, AUGMENT) AND ACTIVATED CARBON ADSORPTION PROCESSES

These technologies are based on strong basic ion exchange resins (Vitrokele and Augment) that are able to retain and recover WAD and free cyanide below 1 mg CNWAD/l from solutions (settled water) with lower operating costs than the value of recovered cyanide. The adsorption on activated carbon and the ion exchange process are used especially in case of recovery and reuse technologies or for advanced treatment of the effluents.

Vitrokele and Augment technologies were not considered advantageous options for Roşia Montană project because of complexity and investment costs. These technologies could be solutions for advanced treatment of some diluted effluents under specific conditions.

REVERSE OSMOSIS (RO)

The free and complex cyanides are retained in a wide range of concentrations (up to 3500 mg/l) and the level of cyanide concentration in the RO effluent is 0.5 mg/l. The main limitation is the applicability to a slurry application. The solutions must first be settled because of membrane clogging. Membranes filled with gas or connected to a pre-coagulation system of the suspended solids could be used.

Compared to chemical processes, the membranes retain the cyanide in its original form which creates disposal problems or a need for further treatments.

Large scale applications are still limited despite their nominalization as BAT by US-EPA (but not for the extractive industry) and reverse osmosis was not considered a viable option for slurry treatment in Roşia Montană project.

ROLB PROCESS

Riddarhyttan Resources AB of Sweden has developed a process for the detoxification of cyanide and thiocyanate. This process is known by the acronym of “ROLB” and is reported to be effective for slurries and liquors including waste streams from CIL circuits, heap leach liquors, and electroplating effluents. The process was developed to treat effluents from

Riddarhyttan's proposed Suurikuusikko facility in northern Finland. This plant will use bio-oxidation of a refractory sulphide concentrate to release locked gold. This process produces thiocyanate levels in leach liquors that are orders of magnitude greater than would be found in typical CIL applications.

The ROLB process is suited to specific effluent streams that are high in thiocyanate, which is a condition unlikely to be encountered by the Roşia Montană Project. Moreover, this technology has yet to be proven at full operational scale, and capital and operating costs remain undefined. A patent application for the process was submitted in April 2004; since the details of the process are not in the public domain at this time, it cannot be considered a Best Available Technology (BAT). For all of these reasons, the process is not considered to be suitable for detoxification of the Roşia Montană tailings.

NEW PROCESSES

Several other options for cyanide recovery are under development but need piloting and full plant implementation: these include the 'Sart process' and the 'Hannah process' [3]. Such new processes are also not sufficiently established to be regarded as BAT and suitable for application at Roşia Montană .

4.4.5 Process option evaluation

The following Table 5-16 presents a general comparison between INCO and the alternatives considered.

Table 5-16. Comparative analysis of the slurry/solutions treatment processes

	Treatment processes							
Criteria of analysis	SO2/air/Cu2+ (INCO)	H2O2/ Cu2+	Caro's acid	CombinOx	Alkaline chlorination	Ozone	Biological treatment	Natural degradation/ attenuation
Active/Passive	Active	Active	Active	Active	Active	Active	Active	Passive
Treatment of free and WAD cyanides	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Catalyst required	Yes (Cu II)	Yes (Cu II)	In general no (Cu II)	Yes (Cu II)	No	Preferable Yes (Cu II)	No	No
Heavy metals removal	Yes precipitation-complexation	Yes precipitation-complexation	Yes precipitation-complexation	Yes precipitation-complexation	Yes precipitation-complexation	Yes precipitation-complexation	Yes biosorbtion	Yes precipitation-adsorption on solids
Precipitation of iron cyanides	Yes	Yes	Yes, partial	Yes	Yes, partial oxidation of FeII to FeII	Yes, partial oxidation of FeII to FeIII	No	No
Reaction rate	Moderate	Moderate	High	High	Moderate	High	Low	Low
Large industrial applications for slurry	Yes (recommended) The most used option and the only applied in Europe	Less applications than INCO	Developing phase	Research-development (emerging technique)	Yes Has generally been replaced	No	No (excluded)	No (excluded)
Large industrial applications for settled water (mining activities)	Yes	Yes	Developing phase	Research-development (emerging technique)	Yes	No	Yes	Yes
Effluent alkalinity after treatment	Moderate pH=8,5-9	Moderate pH=8,5-9	Normal pH=7,5-8,5	Moderate pH=8,5-9	High pH=10,5-11	High pH=10,5-11	Normal pH= 6,5-8,5	Normal
Reagent excess comparing to stoichiometric (for slurry treatment)	Moderate	High	Moderate	Moderate	High	High	No reagents added	No reagents added

	Treatment processes							
Criteria of analysis	SO2/air/Cu2+	H2O2/ Cu2+	Caro's acid	CombinOx	Alkaline chlorination	Ozone	Biological treatment	Natural degradation/ attenuation
Reagent corrosiveness	Yes Corrosive	Yes Moderate	Yes Strong corrosive	Yes Corrosive	Yes Corrosive	Yes Moderate	It is not the case	It is not the case
Risks related to reagents handling	Yes Moderate, depends on SO2 source	Yes Moderate-high Oxidant	Yes Very high (must be prepared with special techniques at the dosage point)	Yes Moderate-high	Yes Moderate, depends on the reagent type oxidant	Yes Moderate-high Preparing on-site Strong oxidant	It is not the case	It is not the case
Operating cost	Moderate Alternative reagents	High	High	High	High	Prohibitive	Low	It is not the case
Investment cost	High	High	Moderate	High	High-Moderate	Moderate	Low	-
Royalty fee	Yes	Yes	Yes	Yes	No	No	No	No
Possibility to adapt the installations for other processes, respectively for cyanide flows	Yes	Yes	No	Yes	Yes	Yes	No	No
Environmental risk	Emissions of cyanate and gypsum in water	Emissions of cyanate in water	Emissions of cyanate and gypsum in water	Emissions of cyanate and gypsum in water	Emissions of cyanogenchloride and possibly chlorine in air. Emissions of cyanogenchloride, chlorides and chlorine in water	Emissions of cyanate in water	-	HCN emissions to air
Need for additional slurry treatment before pumping to the pond	No	No	No	No	No	No	-	-
Need for additional water treatment in order to discharge into natural receiver	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes

The following Table 5-17 shows the ranking of the different technologies based on the comparative analysis discussed in the previous sub-sections. Each criterion received a relevance index (from 1 to 5) and each alternative received a rating point from 1 to 5 according to relatively performance in the frame of the criteria. The score for each alternative is obtained by multiplying the rating point by the relevance index and summing all these for all criteria.

Table 5-17. Cyanide destruct process ranking

	Criteria							SCORE
	Robustness of the technology	Versatility	Low risk	Industrial experience	Environmental performances	Investments	Operating and maintenance costs	
Criteria relevance	***4***	***3***	***1***	***5***	***5***	***2***	***3***	
Alternative								
SO2/air/Cu2+	5	5	4	5	5	4	4	***109***
H2O2/Cu2+	5	4	4	4	4	5	3	***95***
Caro's acid	3	4	2	3	4	3	3	***76***
Combinox	5	4	4	2	5	4	3	***88***
Alkaline chlorination	4	3	1	5	3	3	2	***78***
Ozone	3	3	3	3	4	2	2	***69***
Biological treatment	3	1	5	3	2	3	5	***66***

The scores cover a large value domain; as expected, BAT recommends industrial scale applied processes obtained similar high scores.

For the most relevant criteria (environmental performance and industrial experience), the INCO process obtained the highest score. Because it has the highest total score, the best environmental performance, and is BAT recommended, the INCO process is considered the optimal option for the Roşia Montană Project.

4.4.6 Conclusions

The possible alternatives for the treatment of aqueous systems generated from the process were analysed for application to slurry and dilute solutions (tailings pond water).

Slurry

Based on economic and environmental criteria, European and international experience and tests for the treatment of slurry from the cyanide leaching process applied to Roşia Montană ore, two cyanide treatment processes were selected in order to treat the slurry from the gold ore processing flow as follows:

- partial treatment of the slurry by thickening in order to recover the cyanide from the re-circulated supernatant, which results in:
  - a decrease of the fresh cyanide consumption in the ore processing system;
  - a decrease of the cyanide concentration for the slurry to be treat by the INCO system;
  - ability to recover and recycle cyanide as a component of the process water.
- destructive treatment of the cyanide from the slurry using SO_2/Air oxidation system which has the following advantages:
  - high treatment efficiencies for all aqueous systems with cyanide content (slurries and solution), able to remove most types of cyanide by oxidation - precipitation reactions and the metals;
  - at present, INCO is the preferred process on a European and international scale for slurry treatment. The technology was already tested on industrial scale in Europe and on an international level and is accepted by Reference Document on Best Available Techniques for Management of Tailings and Waste-Rock in Mining Activities;
  - it is generally accepted, efficient, flexible. The process can handle influent quality variations better than alternative technologies by adjustment of the rate of reagent and catalyst addition;
  - reagents are readily sourced and there is the option of replacing them with less expensive ones as economic circumstances might dictate, without detriment to performance;
  - the operating costs are comparable or less than other chemical treatments of cyanide detoxification processes (alkaline chlorination, hydrogen peroxide, Caro's acid) which are applied or emerging on an industrial level;
  - although the application of the INCO process on an industrial level requires good technical knowledge in order to overcome the hydrodynamics and kinetic problems in the treatment process of the slurry, there is considerable experience in this. Once these issues are solved for a specific project, the technology is proven to be robust and versatile;
  - the process/installations are easy to restart after temporary shutdown and very quickly reach the working parameters;
  - the installation can be easily adapted to other cyanide destruction tasks, if it is required, in the closure period.

The proposed cyanide usage and management at Roşia Montană complies with BAT recommendations as follows [3]:

- recycle cyanide in the circuit rather than discharging it to the tailings pond by thickening or solid washing.
- WAD cyanide destruction before tailings discharge into tailings pond.

Cyanide diluted solutions

The main cyanide diluted water source with cyanide content is the decant pond TMF (decant water and seepage). In operation, the decrease of cyanide concentrations in the pond continues by natural attenuation (without water discharge in the environment). Based on experience and process modelling, the decreasing of cyanide concentration from the pond during operation is expected to be about 50%.

The TMF pond will become a wastewater source at the closure stage. Before it is used for flooding the Cetate pit or discharging into natural receivers, and if the total cyanide concentration is above the stipulated limit under NTPA 001 (0.1 mg/l), the water from the pond will be treated using the secondary cyanide treatment system which will remain operational in this period. In this case an optimal technology will be selected, based on the results of pilot tests of the following treatment processes:

- peroxide based oxidation
- adsorption (activated carbon or bone char)
- reverse osmosis.

There are some options available to further improve technological aspects of the selected INCO process, if needed, as follows:

- decreasing of the reagent costs using sulphur dioxide generated by elemental sulphur combustion, if the price of metabisulphite rises or consumption of cyanide increases due to change of ore composition;
- increasing of the efficiency of the cyanide treatment process, according with ore composition (occurrence of metals such as As, Sb or the increase of copper concentration) by using cascade reactors. The reaction time ensured by the project makes this modification possible.

The processes, which were proposed in the project for the treatment of slurry and settled water with cyanide content, are the optimal options, taking into account industrial application experience and environmental performance and are recommended as BAT options.

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4.5 Alternative Methods for Tailings Disposal

A conventional tailings slurry method of disposal of gold ore processing effluent was specified as a result of feasibility-level testing and was factored into the development of the final Project economic model. The current Project model and preferred TMF location both presume the availability of a stable, low-maintenance, gravity-assisted, fluidised tailings transport system. The preferred (tailings slurry) methodology facilitates gravity transport. Other tailings forms and deposition methodologies have been suggested, but were rejected for the reasons noted in the following paragraphs:

Thickened tailings with paste additives: Adding cement pastes to thickened tailings is a deposition method that is normally employed in very arid climates in which water cost and availability are significant design constraints. However, the water supply costs associated with the preferred option described previously in this Chapter are reasonable, and the site cannot be considered arid as it experiences substantial precipitation events in all seasons. In addition, this option does not provide any socio-economic advantage, as it would not eliminate the need for use of the Corna Valley as a deposition area, and associated resettlement needs. This methodology also does not eliminate the need for some type of retention, nor does it eliminate the need to manage surface water and control seepage from deposited materials and old mine wastes.

It should be noted that the Project economic model and preferred TMF location depend, in part, on the efficiency and simplicity of gravity assisted tailings transport methods. Thickening would also require the addition of capital associated with a paste plant and pumping systems. In addition, any assessment would have to include all associated expenses and operational and maintenance concerns. These additional costs would be partially offset by the reduced capital costs of a smaller containment dam, but the sizing of the tailings pipeline would also have to be adjusted, and new deposition arrangements developed to permit discharge in the centre or upper end of the Tailings Management Facility.

Dry (“stacked”) tailings: This deposition method is normally employed in very arid or very cold climates where water availability, cost, and management issues are very critical constraints on the design of a mine. The method is also used in seismic regions where the long-term stability of a tailings dam is a major issue. The Project site experiences substantial precipitation, is not located in a high-seismicity area, and does not experience sustained, unusually cold climatic conditions. Process water needs would be reduced, but may be offset by the need for spray systems or other methods to control airborne dust. In addition, a dewatering plant and tailings filtration systems would have to be developed. Tailings conveyor systems would also have to be built, powered, and maintained, and, over the life of the mine would create significant additional solid waste management issues in the generation of used belting and worn-out conveyor system elements. Moreover, this option does not eliminate the need for the use of the Corna Valley as a deposition area for tailings and filter press water, and would create a significant potential for windborne dispersion of tailings from the tailing pile pending completion of restoration and revegetation operations. Additional diversion channels and upstream cut-off trenches or grout curtains would also potentially have to be developed, as well as seep collection ditches at the downstream end of the facility. These additional costs would be partially offset be the reduced capital costs of a smaller containment dam.

Both of these tailing disposal alternatives have the potential to result in acceptable conditions for closure, since the tailings materials would be relatively solid and therefore suitable for placement of a soil cover material. However, both alternatives are very costly, and have never before been tested at the production rates planned for this project. These alternatives are therefore rejected as being non-viable.

Given the need to employ conservative technologies with minimal associated risks and sustainable economics, the tailings disposal scheme represented by the deposition of detoxified, thickened tailings in the TMF is preferred. With the proper management of the tailings reclaim pond location and size, the surface of the tailings can be stabilised to allow placement of an engineered soil cover designed to reduce infiltration to an acceptable level, or to eliminate it altogether.

It is concluded that there are no technically acceptable alternatives to the selected method of tailings deposition and a comparative assessment of environmental impact is not relevant in this case.

4.6 Waste Rock Disposal Location Alternatives

Waste rock produced during the development of the mine will be comprised of ore body host rock lithologies (i.e. volcanic dacites and breccia). Waste rock disposal alternatives considered include:

- use for construction;
- placement in dedicated waste rock stockpiles located in the vicinity of the pits, and
- pit backfill.

A combination of these options is proposed that includes use of waste rock for construction, with excess material placed in dedicated waste rock stockpiles located in the vicinity of the pits. Under this combined alternative, waste rock will be used for construction of the Corna Valley TMF embankments, the inert waste disposal facility, and other impoundments. If not required for construction, waste rock will be hauled to the Cetate and/or Cârnic stockpiles. The mine plan schedules the Cârnic pit to be mined out prior to the Cetate pit, allowing it to be backfilled in the later years of mine life. This approach has the advantage of limiting the project footprint by minimising the requirement for dedicated waste rock stockpiles and borrows areas. This combined solution is the preferred alternative.

The option of storing or using waste rock off-site is not considered to be viable for the following reasons and was rejected:

- Storage or use off-site would increase the overall project footprint and extend the potential impact area;

- Storage off-site is not BAT due to the potential for acute operational impacts arising, such as traffic impacts, noise, dust and visual impact;
- This option is economically not viable, considering the costs of transport and the lack of any ready need or market for such material, for example for bulk fill.

Other possible alternatives were considered but were rejected as follows:

- **Stockpiling with no pit backfilling or use of waste rock as construction materials:** Construction materials would have to be quarried from other sources. Areas requiring revegetation would be greater, and pit lake volume could not be minimised.
- **Backfilling pits with no use of waste rock as construction materials:** The equipment costs associated with this alternative are prohibitive, do not preclude the need to develop stockpiles in the initial years of the project, and would significantly increase air quality noise, and resource impacts of the project during the later years of operation and closure. Construction materials would also have to be quarried from other sources.

A comparative assessment of impacts associated with viable options for waste rock disposal is summarised in the following Table 5-18.

Table 5-18. Impacts of Alternative Waste Rock Disposal Options compared to Selected Option

Environmental Issues	Waste rock disposal options		
	Stockpile only	Pit backfill only	Combined solution (selected)
Water flows and quality	Surface stockpiling creates most potential for creation of contaminated run-off and increased land take and therefore disturbance of existing drainage patterns	This method is regarded as BAT and minimises overall project footprint and therefore potential for impact; economic limitations apply, however	This method optimises the balance between use of waste rock for construction, for backfill and for stockpiling to minimise overall footprint and potential for impact on water flow and quality
Air quality	Surface stockpiling creates the greatest potential for dust generation arising from wind blow, but the piles may be rehabilitated progressively	This method is efficient in regard to containment of waste rock, but final pit filling would extend the period of working and involve re-handling of waste rock and this would increase emissions of dust	The combined method optimises the balance of disposal options, no re-handling of waste rock is required and no delay to closure will result
Noise and vibration	Noise and vibration is associated mainly with the truck haulage	Dumping in-pit would reduce noise levels when the truck is within the pit, however, the operations are extended and noise impacts would therefore be extended in duration	The selected option again provides an optimisation between the disposal methods and does not require extended operations for final backfill
Soil **Biodiversity** **Landscape**	This option would increase Project footprint and this would increase direct impact on soils, habitat and landscape	This option would minimises project footprint and direct impact on soils, habitat and landscape	This option is designed to achieve a practical balance, minimising footprint to the extent possible
Socio-economic issues	No significant difference between the options		
Cultural heritage	This option would increase Project footprint and this would increase potential for impact on cultural heritage	This option would minimises project footprint and potential for direct impact on cultural heritage	This option is designed to achieve a practical balance, minimising footprint to the extent possible
Transportation issues **Transboundary impacts**	No significant difference between the options		

4.7 Alternative ARD Wastewater Treatment Options

Acid Rock Drainage (ARD) is being generated due to the old mining activities at Roşia Montană and will be generated by any future mining operation. Due to the typical characteristics of ARD (namely, low pH and presence of heavy metals, metalloids and neutral salts in solution), water treatment will be required if any water is to be discharged to the environment in line with Romania discharge regulations (NTPA 001/2005).

Traditionally the mining industry has treated these waters using a conventional process which involves:

- the addition of an alkali to increase the pH, to precipitate metals,
- a solid/liquid separation step to remove metal hydroxides and gypsum precipitates, and,
- the disposal of the metal containing sludge.

The proposed method in the Project, for ARD wastewaters which remain to be treated (aprox. 400-600 m3/h) in various development phases of the Project activity consists of the following:

- treatment in two steps with $Ca(OH)_2$ in the presence of air up to pH = 11 for metal precipitation (including manganese) and flocculation - settling. The settled water is recirculated in the technological process and for other uses;
- pH correction with carbon dioxide in order to assure the imposed discharge consent conditions (7.5-8) and aluminium precipitation, followed by flocculation - settling.

After the second pH adjustment step, water is discharged in order to maintain satisfactory flows in the Corna and Roşia streams.

The process above involves the removal of sulphuric acidity by precipitation of calcium sulphate and metals as hydroxides. However, under these conditions, the statutory limits imposed for total content of dissolved salts, calcium and sulphates would be exceeded; the concentrations of these in water are determined by the $CaSO_4$ solubility (~ 2000 mg/l).

The environmental performance of the process was therefore analyzed starting from:

- the need for fulfilment of the Romanian effluent discharge standard;
- correlation of the imposed limits with similar regulations from other countries;
- toxicity upon the aquatic organisms of the discharged chemical compounds;
- involved costs, which influence the process application.

In this context, the following can be taken in consideration:

- according to **NTPA 001**, the maximum admissible concentrations for Ca^{2+} and SO_4^{2-} are 300 mg/l, respectively 600 mg/l; the total admissible concentration of dissolved salts is 2000mg/l.
- **Law 458/2002** referring to quality of potable water in Romania indicates the limit of 250 mg/l for SO_4^{2-} and does not regulate calcium concentration (the hardness is requested - minimum five German degrees).
- In the **Guide to potable water quality, Geneva 2004** (WHO), it is noted that sulphate can induce a taste to water, depending on the nature of the associated ion and limits of 250 mg/l of sodium sulphate and 1000 mg/l of calcium sulphate are recommended.
- In other countries, the limits for this type of compounds are differently regulated: on rivers section (Hungary), on areas or industrial activities (Germany) and can vary in large domains.
- Published data on calcium sulphate indicate the following limits:
    - fishes LC 50 (96 hours) - 2980 mg/l [1,2];
    - Daphnia LC 50 (24 hours) > 1970 mg/l [1];

- alga LC 50 (96 hours) - 3200 mg/l [1];
- alga NR 30 days - 1872 mg/l [3].

These data indicate that the toxicity of calcium sulphate upon the aquatic flora and fauna appears at concentration levels higher than its solubility in water.

It is BAT to use lime precipitation to treat ARD, adding ferric salts if required to remove arsenic. However, lime precipitation alone does not achieve the Romanian NTPA 001/2005 standards for Sulphate and Calcium (and TDS which, as a sum parameter, is closely related to both). Therefore, additional treatment technologies which can serve as an add-on to simple lime treatment is required or alternatively technologies that can replace the BAT conventional lime neutralization process. It is worth noting that other alkali agents such as sodium hydroxide, sodium carbonate, magnesium hydroxide, limestone, dolomite can be used instead of lime, however based on effectiveness, cost and environmental consideration in general, lime is always the first choice for this application. The following Table 5-19 summarizes these alternative technologies to the conventional lime dosing treatment.

Table 5-19. Alternative wastewater treatment technologies

Technology	Technological Effectiveness	Cost (CAPEX +OPEX)	Advantages	Disadvantages
Lime/CO2	High	Medium – low	Wide application spectra; robust technology, including ARD Sludge easily managed; removes sulphates up to the limit of Ca sulphate solubility	Larger sludge volume to be processed (when compared to CaO/CO2 technology)
Ammonia	Good, especially for Fe2+, Mn	Medium	Easy operation	High operational risk. Impacts upon ecosystems NH3 is toxic. Process difficult to control There are zones where NH3 use is prohibited Limited applicability to mine waters treatment
Sulphides	Medium (sensitive to water composition)	Medium	Specific especially for Zn, Pb	The reactive sludge management is difficult. Regenerates potentially ARD sludge.
Reverse osmosis	Very good	Medium	Large application spectrum	Membrane fouling; reduced life time for membrane It has been applied to mine waters treatment
Electrodialysis	Very good	Medium	Wide application spectrum	The management of membrane refuse is difficult. May need an extra treatment stage. Limited applicability to mine waters treatment
Ion exchange	Very good	High	High Selectivity	Regeneration needs reagent consumption and raise disposal / use problems for the solution used for regeneration
Adsorption on active C	Good	Medium-high	Technology commercially available.	Limited efficiency. Needs regeneration of used carbon. Limited applicability to mine waters treatment
Evaporation. Distillation, crystallization	Very good	Very high	Good operation control, wide application spectrum	High costs, high energy consumption. Not used at industrial level Sludge difficult to dispose of. Limited applicability to mine waters treatment.
Electrolyses	Medium	Very high	Produces metals ready to use in the industrial circuit	High costs, high energy consumptions Limited applicability to mine waters treatment
Ettringite precipitation (Walhalla process)	High	Medium	Proven technology which also reduces Ca in the water to the NTPA 001/2005 limits	Produces considerable volumes of wastes
ThioPaques process (reactor-based biological SO4 reduction	High	High	Small volume of residues, residues can possibly be sold	Process possibly difficult to control, generation of sludge with potential for ARD
GypCix (precipitation plus ion exchange processes)	High	High	Drinking water quality	Unresolved question of brine disposal
Barium salts precipitation (e.g., BaSO4, BaS)	High	High	Low SO4 in effluent	Does not meet Ca standard, will lead to non-compliance of Chloride in effluent

The table indicates that only the Ettringite and Reverse Osmosis techniques can be considered to combine the capability of meeting the NTPA-001/2005 and be cost effective. These are therefore further evaluated below. It is also worth noting that many of the technologies compared in the previous table depend on conventional lime treatment to deal with the brines generated.

THE ETTRINGITE PROCESS

The Ettringite process, also known as the Cost Effective Sulphate Removal (CESR) or WalHalla™ process is an additional precipitation step for the removal of soluble gypsum that directly follows the lime addition and sedimentation process typically used for treatment of acid rock drainage (ARD). Although, the conventional ARD treatment process is effective in removing metals in the form of hydroxides, it cannot lower the concentration of sulphate in the form of gypsum below gypsum's solubility, which is required to meet the NTPA-001/2005 standard. With the addition of the Ettringite process, the Roşia Montană Project will be able to meet the NTPA-001/2005 standard for sulphate and consequently meet the TDS limit as well.

The Ettringite process is nearly identical to the ARD process in that a chemical is used to precipitate out the contaminants of interest through the use of a mixing tank followed by a sedimentation basin to settle out the precipitated solids. The Ettringite process takes advantage of the already high pH discharge from the conventional lime dosing ARD process and can use the existing lime slaker system from the ARD process to further elevate the pH to 11.5. Once at this higher pH, a mixing tank with a retention time of 30 to 60 minutes is utilized with the addition of the proprietary chemical SX-44 (calcium aluminate cement). SX-44 will precipitate the remaining sulphate by combining with the soluble gypsum in the wastewater and the additional calcium added through the lime to form a solid ettringite (Ca6Al2(SO4)3(OH)12· 26H2O). The solid ettringite is then settled out in a solids contact clarifier with the resulting effluent discharged to a pH neutralization step that uses carbon dioxide gas. The carbon dioxide neutralization step is the same system employed by the conventional lime dosing ARD process for post neutralization so there is no additional capital cost. The use of carbon dioxide is preferable to acid due to handling concerns and safety, and it also reduces scaling by precipitating calcium carbonate, aluminium hydroxide and small amounts of ettringite. The effluent from the neutralization step is then passed through a lamella clarifier, included with the ARD system, to remove these final precipitated solids before being discharged.

The Ettringite process has many advantages in addition to the relatively low levels of sulphate that can be achieved in the effluent. The Ettringite process allows the engineer to design the retention time and SX-44 dosing rates to specifically meet a desired effluent sulphate concentration thereby minimizing capital and chemical costs. Solids from the clarifier are easily dewatered and typically form a non-leachable cake that can be disposed of in a non-hazardous landfill since it normally passes the leaching test. In the Roşia Montană case, the sludge would be disposed with the ARD treatment plant sludge with the tailings in the Tailings Management Facility. In comparison to membrane technologies, the Ettringite process has a lower capital cost and does not require the disposal of a liquid waste stream. The Ettringite process has many installations in Europe and is preferred to the use of other available technologies because of its simple design and ease of operation.

Table 5-20 presents an evaluation of the conventional lime dosing, Ettringite and reverse osmosis technologies at budget level.

Table 5-20. Comparison of viable wastewater treatment technology costs

Method	Costs		Wastes	Primary Reagents and Comsumables	Environmental Protection
	Capital Costs	O&M Costs (to yr 1-17)			
Conventional Lime and carbon dioxide	Baseline $5.1M for ARD Plant	Baseline $0.51M/yr for first 7 yrs, $0.64M/yr for next 10 yrs = $10M for ARD Plant	Lime Treatment Sludge	Lime and CO2	Good - Exceedance of standards result in no environmental or human health impacts
Conventional Lime and carbon dioxide plus RO Polishing	High $5.1M + $8.2M = $13.3M	High $10M +$12.6M = $22.6M	Lime Treatment Sludge, Sulfate from Brine, Brine (less sulfate and blend into effluent)	Lime and CO2, RO Membranes, Anti-scalant	High - additional gypsum sludge disposal
RO or Similar Technology as Primary Treatment	High $8.2M	High $13.5M (does not include cost for brine disposal)	RO Brine (membrane life may be severely limited, very challenging to operate) Feasible brine disposal option has not been identified and costed.	RO Membranes, Anti-scalant, Pretreatment chemicals	Good - but with brine disposal issue
Conventional Lime and carbon dioxide plus Ettringite Precipitation	High $5.1M + $4.3M = $9.4M	High $10M + $25M $35M	Lime Treatment Sludge and Ettringite Precipitant Sludge	Lime and CO2, SX-44 reagent (available in Europe)	High - additional sludge disposal issue, but can go to TMF with lime treatment sludge.

The previous table presents alternatives technologies that are able to meet NTPA-001/2005 standards. Considering the cost associated with the additional technologies, it is worth noting the low toxicity related to aquatic organisms exposed to the expected discharged from the conventional lime dosing ARD plant.

In conclusion, a multi-criteria analysis to evaluate the options for wastewater treatment was carried out, taking into account criteria for environmental performance, economics, operating risks and also versatility of the process, which allows modifications according to actual results and also the robustness. This is summarised in Table 5-21.

Table 5-21. Selection of the optimal alternative for ARD treatment

Method	Criteria							SCORE
	Technology robustness	Versatility	Reduced risk	Industrial experience	Environmental performance	Investment capital	Operation and maintenance capital	
Criterion relevance	4	3	1	5	5	2	3	
Alternative								
Conventional Lime and carbon dioxide	5	4	4	5	3	4	4	96
Conventional + Ettringite	4	4	4	4	5	3	1	86
Reverse Osomosis	4	3	4	4	5	4	3	91
Conventional + RO	4	4	4	4	5	2	2	87
Conventional Lime Dosing has been included as a reference since the conventional technology cannot meet the discharge standard NTPA 001/2005. The cost of disposal of the brine is not included.								

The cost of the disposal of the brine from the reverse osmosis (RO) option as a complete replacement to conventional lime treatment would probably reduce the score of RO, i.e., similar to the other alternatives.

It is emphasised that all of the options discussed are potentially viable and it is concluded that treatment to meet the required discharge standard can be successfully achieved.

All of the treatment options may be used in an environmentally acceptable manner to achieve the same objective and in terms of a broad comparative environmental impact assessment; there is little difference between them. As for other detailed technological option analyses discussed in this Chapter, an impact assessment matrix is therefore not relevant.

While not meeting in full the requirements of the Romanian effluent discharge standard for certain parameters with low potential for impact on the environment, it is clear that the selected conventional process for ARD water treatment (lime and CO2) is the optimum, being BAT, the most commonly applied industrial treatment and with good environmental performance, and low risk. Application of an additional ettringite treatment step will assure attainment of the NTPA 001/2005 standard in full.

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5 Transportation Issues

5.1 SHLO Transportation Routes

Construction of the Project will require the transportation of very large items of pre-fabricated machinery and special assemblies to Roşia Montană. All of these items (for example, mill components and haul trucks) require fabrication at the point of origin. RMGC commissioned a study in 2003 to assess alternatives for shipping super heavy lift and over dimensional (SHLO) mining equipment to the Roşia Montană Project site from various entry ports in Romania, while also evaluating documentation and customs clearance procedures. Barging and rail options were also evaluated, but are considered unsuitable due to the inadequacy of infrastructure to handle the given dimensions and weight.

Three Romanian entry points were identified: Constanța, Borş and Nădlac. Since SHLO equipment is usually hauled to the nearest port for loading onto heavy lift ships, Constanța, a seaport, is the preferred alternative over the inland points of entry through Hungary (Borş and Nădlac). Although obtaining permits for hauling SHLO equipment from European sources through Borş and Nădlac is a very difficult process, these points of entry will be held in reserve as potential secondary alternative routes for this project, and may be used for some specific SHLO shipments if road conditions or load characteristics are such that the Constanța route is not safe or viable.

A comparative environmental assessment of SHLO routing options is not warranted or practicable for the EIA. Decision-making on this will be carried out, in liaison with the Romanian authorities during the detailed design stage when more information on source of plant and materials is available and timing of shipments is known. However, the main environmental issues involved will be limited to traffic safety and delays presented by the movement of large items of mobile and processing plant during the construction phase and at closure.

5.2 Site Access Alternatives

5.2.1 Project site access

During the development of the Project, the existing access road to the Roşia Poieni plant along the Corna Valley will be displaced by the construction and operation of the Tailings Management Facility. A suitable bypass road will therefore be required that is acceptable to Roşia Poieni mine management. Six alternative access road alignments were therefore compared based on the following criteria:

- road length;
- terrain difficulty;
- number of affected properties;
- likelihood of interference with mining activities;
- level of deforestation required along the road routes;
- requirements for relocation of the road during later phases of mine life;
- proximity to other mining facilities / opening of new areas that would otherwise not be affected by the Roşia Montană Project;
- winter access and maintenance requirements; and

- acceptability to external stakeholders, particularly the management of the Roşia Poieni mine.

The basic characteristics and general advantages and disadvantages of each alternative are summarised in Table 5-22; locations are depicted in Exhibit 5.6.

The alternatives were evaluated and ranked using a weighted matrix technique, as shown in Table 5-23, and are discussed further in the following paragraphs.

- **RP1: Alternative 1, Access from Bucium Valley (Southern Bypass)**: The 2002 SNC Lavalin Basic Design report proposed a new southern bypass road, starting in the Bucium Valley and following the ridgeline between the Bucium and Corna Valleys. This option would require construction of 6.7 km of new road. Average and maximum road gradients would be 6% and 8%, respectively. This southern route does not interfere with mine operation, allows for easier construction along the ridgeline, and requires a limited number of additional land purchases. This route is also preferable to the management of the Roşia Poieni mine, and as noted in Table 5-21, is considered overall to be the most preferable alternative.
- **RP2: Alternative 2, Access from the Corna Valley (A)**: This road would have average and maximum gradients of 5% and 10%, respectively, and would be 8.7 km in length. This alternative was rejected because it would interfere with mining operations and requires four haul road crossings, as well as being longer than most options; some deforestation would also be required.
- **RP3: Alternative 3, Access from the Corna Valley (B)**: This road would have average and maximum road gradients of 5% and 10%, respectively, and would be 9 km long. This alternative was rejected because it interferes with mining operations, and requires deforestation and four haul road crossings. This was also the longest alternative.
- **RP4: Access from the Roşia Valley, downstream of the Cetate Water Catchment Dam (Northern bypass)**: This road would be 6.6 km long and would have average and maximum road gradients of 8% and 10%, respectively. From primarily a technical and economic standpoint, this alternative presents some distinct advantages compared to the other options. Although similar in length to Alternative 1, Alternative 4 would require significantly fewer retaining structures, and could be constructed at lower cost. However, during consultations in early 2004, Roşia Poieni mine management expressed concerns that this alternative would increase travelling distance and time to their plant, and expressed their opposition to this route. This alternative was also rejected because it would require additional property purchases.
- **RP5: Alternative 5, Access from the Roşia Valley, downstream of the Cetate Water Catchment Dam**: The road would have average and maximum road gradients of 8% and 10%, respectively, and would be 6.4 km long. This alternative was rejected because it would create interference with the mining operation and would have to be relocated in later phases of mine life.
- **RP6: Alternative 6, Existing road in Bucium/Abruzel Valleys**: This option would require upgrading of an existing 6.8 km section of road and construction of 3.2 km of new road. This alternative was rejected because a large number of existing properties in the narrow Abruzel Valley would be affected, and the road is almost entirely outside the concession boundary. It would also introduce heavier traffic into the otherwise unaffected Abruzel Valley, and would be difficult to maintain in the winter.

Table 5-22. Evaluation of Onsite Access Alternatives

Description	Technical characteristics	Advantage	Disadvantage
Alternative 1, Access from Bucium Valley (Southern Bypass)	Length 6.6 km, 6% average grade 8 % max. grade	Does not interfere with the mine operation Easier construction along ridgeline Limited additional property purchase required Favoured by Roşia Poieni mine management	Opens Bucium Valley to heavier traffic. Some deforestation required Lies partially outside the concession boundary
Alternative 2, Access from Corna Valley (A)	Length 8.7 km, 5% average grade	About 70% of the road could be constructed as part of the mining haul road. Could be used as a main access to the mine	Interference with mining operation Requires four haul road crossings Longer than most alternatives Some deforestation required
Alternative 3, Access from Corna Valley (B)	Length 9.0 km, 5% average grade	About 30% of the road could be constructed as mining haul road. Could be used as a main access to the mine	Interference with mining operation Requires four haul road crossings Longest of all alternatives Some deforestation required
Alternative 4, Access from the Roşia Valley, downstream of the Cetate Water Catchment Dam (Northern bypass)	Length 5.4 km, 8% average grade	Shortest route Does not interfere with mine operation Could be used as access for relocation of 110 kV line No deforestation required Sunny southern exposure	Requires additional property purchase Not favoured by Roşia Poieni mine management
Alternative 5, Access from the Roşia Valley, downstream of the Cetate Water Catchment Dam	Length 6.4 km, 8% average grade 10 % max. grade	Sunny southern exposure	Interference with mining operation Would have to be relocated in later phases of mine life
Alternative 6, Existing road in Bucium/Abruzel Valleys	Rehabilitation/ widening of 6.8 km, New length 3.2 km, New avg. grade 9% New max. grade 10%	Maximises the use of the existing municipal road Does not interfere with mine operations	A large number of existing properties in the narrow Abruzel Valley would be affected Almost entirely outside the concession boundary Introduces heavier traffic in the Abruzel Valley Difficult maintenance in winter

Table 5-23. Comparison of Site Access Alternatives

Description	Evaluated parameters *									Score (out of 100)	Rank **
	Length	Terrain difficulty / Cost	Number of affected properties	Interference with future mine operations	Additional deforestation required	Requires relocation during the mine life	Proximity to the proposed mine/ Compactness/ Opens new areas	Future maintenance / winter access	Acceptability to the Roşia Poieni mine		
Alternative 1, Access from Bucium Valley (Southern Bypass)	9	6	7	9	5	10	4	5	9	74.5	1
Alternative 2, Access from Corna Valley (A)	6	5	9	2	5	10	9	7	9	70.5	3
Alternative 3, Access from Corna Valley (B)	5	4	5	2	5	10	9	3	9	59.5	5
Alternative 4, Access from the Roşia Valley (Northern bypass)	9	8	4	9	10	10	8	8	4	73.5	2
Alternative 5, Access from the Roşia Valley, downstream of Cetate Water Catchment Dam	10	7	10	3	8	2	9	7	4	68	4
Alternative 6, Existing road in Bucium/ Abruzel Valleys	8	5	2	10	7	10	1	2	5	55.5	6
Assigned Weight	15	15	15	10	5	10	10	5	15		

* Scoring: 10 = best, and 0 = worst

** Ranking: 1 = best, and 6 = worst

The previous detailed techno-economic analysis is also supported by the broader comparative assessment of environmental impact for the access options, as summarised in the following Table 5-24.

Table 5-24. Impacts of Alternative Site Access Options compared to Selected Option

Environmental Issues	Roşia Poieni Site Access Options					
	Option RP1 (selected)	Option RP2	Option RP3	Option RP4	Option RP5	Option RP6
Water flows and quality	Involves mainly new construction but this is adjacent to southern margin of project footprint, on a ridge top with minimal additional impact on existing drainage and low potential for stream pollution	This option aims to combine access to the Roşia Poieni site with access to the Roşia Montana site and therefore minimises project footprint and potential for additional impact	Environmental impacts very similar to Option RP2, with similar route	Technically favourable regards ease of construction; water management straightforward, minimising potential for impacts	As for Option RP4	Involves re-construction of Abruzel valley road and would increase the overall Project footprint and therefore the potential impacted area
Air quality	Remote from communities; no significant impact	No significant additional impacts likely		Emissions from Roşia Poieni traffic would add additional pollution sources for Roşia valley	As for Option RP4	Introduces additional emission sources into the Abruzel valley
Noise and vibration	As above	As above		As above	As above	As above
Soil	Mostly new construction and slightly increases land take and impact on soil resources	Minimal additional land take, therefore favourable option		Some new construction, adding to land take and impact on soils	Minimal additional land take, therefore favourable option	Involves re-construction of Abruzel valley road and would increase the overall Project footprint and therefore the potential impacted area
Biodiversity	Constructed adjacent to operational areas; small additional impact on biodiversity	Small additional impact on habitat via land take		Some new construction, adding to land take and impact on habitats	Small additional impact on habitat via land take	As above
Landscape	Long-term additional impact with construction of new road along ridge line	Minimal additional land take, therefore favourable option		Long-term additional impact with construction of new road along northern valley side	Minimal additional land take, therefore favourable option	As above
Socio-economic issues	Consultation indicates that this option is preferred by the Roşia Poieni mine management; no other significant issues	Would create significant operational complications for the Roşia Montana mine due to haul road crossings and safety issues; additional property purchase required in Corna valley		Additional property purchases would be required in Roşia valley; consultation indicates that this option is preferred by the Roşia Poieni mine management	Would create problems for the Roşia Montana mine due to haul road crossings and safety issues; this option is preferred by the Roşia Poieni management	Would increase impact area to include people in the Abruzel valley
Cultural heritage	Mostly new construction and slightly increases land take and potential for impact on cultural heritage	Minimal additional land take, therefore favourable option		Some new construction, adding to land take and increasing potential for impact on cultural heritage	Minimal additional land take, therefore favourable option	Would increase impact area to include cultural heritage values in the Abruzel values
Transportation issues	Increases traffic levels in Bucium valley; however, most of route is new construction	Raises significant safety issues due to activities on the Roşia Montană site		Increases traffic levels in Roşia valley; however, half of route is new construction	Raises significant safety issues due to activities on the Roşia Montană site	Traffic impacts introduced to Abruzel valley
Transboundary impacts	No significance for Roşia Poieni site access					

5.2.2 Roşia Montana plant access

Three alternatives were considered for the location of the access road to the Roşia Montană Project process plant. Alternative locations are depicted in Exhibit 5.6; further details are provided in the following paragraphs.

- **PA1: Alternative 1, Plant Access from Southern Bank, Roşia Stream**: Under this alternative, a dedicated access road would be constructed along the same general alignment as the current Roşiamin mine railway. This alternative is preferred because it is as short as Alternative 2, is much shorter than Alternative 3, is built primarily on previously impacted land (i.e., the existing railway right of way), would require minimal deforestation, would require no stream crossings, and (with respect to Alternative 2) would substantially minimise the heavy vehicle traffic and associated noise impacts to the existing habitations and other village structures along the Gura Rosiei to Roşia Montană road.
- **PA2: Alternative 2, Plant Access from Existing Roşia Montană Road**: This alternative would require a major upgrade of the existing Gura Rosiei to Roşia Montană road, including widening and straightening of the road and three new bridges. This alternative is rejected because of the potential impacts of road widening on existing village structures (many of which already have minimal setbacks from the existing roadway), and the general proximity of (and potentially excessive noise and traffic impacts to) dwellings and other village structures.
- **PA3: Alternative 3; Plant Access from the Corna Valley**: This road would be newly constructed from Gura Corniei up the northern flank of the Corna Valley. Although this alternative would minimise traffic noise impacts to dwellings in the Roşia Valley, this alternative is rejected because it would be built on land that is largely unimpacted by previous mining or construction activities, would be the longest of the three alternatives, would require substantial deforestation, would be difficult to maintain in winter, would be constructed largely outside of the current boundaries of the mining concession, and would require multiple stream crossings.

The above analysis is also supported by the broader comparative assessment of environmental impact for the access options, as summarised in the following Table 5-25.

Table 5-25. Impacts of Alternative Options for Plant Access compared to Selected Option

Environmental Issues	Roşia Montana plant access options		
	Option PA1 (Selected)	Option PA2	Option PA3
Water flows and quality	Uses existing route and is shortest, minimising potential for sort-term pollution and disturbance of water courses	Similar to option PA1 regards water impacts	A new route that would have most potential for short-term water pollution and disturbance of existing drainage patterns
Air quality	Route protects local community from impact	Route uses existing road and increases exposure of local community to short-term impact	Route protects local community from impact
Noise and vibration	As above	As above	As above
Soil	Uses existing route with minimum land take and soil disturbance	Similar to option PA1 regards soil impacts	New route that involves maximum land take and most potential for long-term impact on soils
Biodiversity	Uses existing route with minimum land take and habitat disturbance	Similar to option PA1 regards biodiversity impacts	New route that involves maximum land take and therefore most potential for long-term impact on biodiversity
Landscape	Exploits and existing route and is short, minimising visual impact	Similar to option PA1 regards landscape impacts	New route that involves creates most potential for long-term impact on landscape
Socio-economic issues	Route minimises impacts on community and public roads	Route would create a significant impact on local community with impact on public roads	Least direct impact on socio-economic issues
Cultural heritage	Minimum land take and minimal potential for impact on cultural heritage	Similar to option PA1 regards cultural heritage impacts	Maximum land take with most potential for land disturbance that may impact on cultural heritage
Transportation issues	Uses existing redundant route with minimum impacts on existing transport infrastructure	Uses public highway and creates a significant short-term impact on existing transport infrastructure; post-closure, possible beneficial impact as a result of road upgrading	No significant impact regards transportation issues
Transboundary impacts	No transboundary issues raised		

5.3 Cyanide Transportation Route Alternatives

Based on an estimated cyanide consumption of 11,000 to 12,000 tonnes per operational year, a supply system is planned that involves transportation of solid sodium cyanide briquettes and conversion to liquid at the destination (the Roşia Montană Project process plant). This is a recognised BAT, and is the safest, efficient and economic way to ship the required quantities of sodium cyanide to the Roşia Montană Project site. Shipment will be made in custom-made, returnable, containers, and two container deliveries by truck are anticipated each day of the operational phase of the project.

Delivery of sodium cyanide from production sources in Romania is rejected because of concern over the ability of suppliers to produce and deliver sodium cyanide in full accordance with the International Cyanide Management Codeiii, in the required briquette form, at the required purity and quality, and in the required volumes. Should the capabilities and performance of Romanian sources improve in this regard over the course of the Project, this alternative may be re-examined.

Two preferred alternatives exist for the delivery of sodium cyanide briquettes from international sources.

- One alternative assumes marine delivery from qualified international sources to the Romanian port of Constanța, followed by truck transportation to the Project site over the preferred delivery route identified in the SHLO equipment transport study discussed above (i.e. routing from Constanța to the Project site via Slobozia, Bucharest, Chitila, Piteşti, Râmnicu Vâlcea, Sibiu, Sebeş, Turda and Abrud).
- The other preferred alternative assumes shipment from qualified European production facilities through Hungary by rail and truck to the Project site. In order to maintain a reliable supply of sodium cyanide and to maintain the flexibility to respond to changing road conditions or weather-related issues, both of these sources and routing alternatives will potentially be employed.

With regard to the overland delivery alternative, a detailed transport and logistics survey providing an evaluation of potential transport routes from Western Europe was conducted in October 2002. The results of the survey suggest several alternative combined rail/road transport routes that merit detailed consideration because of the international nature of this particular transportation scenario. Based on discussions with licensed transport companies operating in the region, it was recommended that rail transportation be used to the extent possible, in order to minimise travel time on the Romanian road system, in some cases accepting longer transport times in order to avoid potentially dangerous road conditions. Four alternative transportation routes were evaluated, as listed below.

- from Germany by rail to Budapest, Hungary, then by truck transport to Roşia Montană;
- from Germany by rail to Szeged, Hungary, then by truck transport to Roşia Montană;
- from Germany by rail to Deva, Romania, then by truck transport to Roşia Montană; and
- from Germany by rail to Cluj Napoca, Romania, then by truck transport to Roşia Montană.

Receiving container terminals and the truck routes from the train terminal to the next city were analysed (i.e. from the Budapest terminal to Szeged via road; from the Szeged terminal to Deva via road; from the Deva terminal to Roşia Montană via road; and from the Cluj Napoca terminal to Roşia Montană via road). The results of the survey are summarised in the following:

5.3.1 Container Terminal Comparisons

Point of Transfer: Budapest, Hungary: Sodium cyanide briquettes would be transported from the manufacturer to Budapest, Hungary via rail and transferred at the Budapest Container Terminal to truck for transport to Roşia Montană. The Budapest Container Terminal is located in the city centre of Budapest; however, a new terminal is currently being built outside the city centre in the area of the junction between motorway M0 and National Road

51. Using the current container terminal the trucks will have to pass through urban areas to reach the motorway M0/M5.

The current container terminal has eight tracks in total, of which three can be used for loading and unloading of containers from/to railcars and trucks by crane while the others are capable of the same loading and unloading operations via a mobile container crane. Approximately 4000 containers are handled per month at the terminal with various loads. Customs clearance can be carried out on site. The terminal also has a certified ISO 9001 Quality Management System in place.

There is a separate designated area for dangerous goods, however within this designated area, materials segregation practices could be improved. All container terminal personnel (approximately 30 personnel at the time of the survey) are trained according to the current edition of the European Agreement concerning the International Carriage of Dangerous Goods by Road (the so-called "ADR" regulations)iv, and are experienced in handling dangerous goods. A fire truck specially designed for responding to emergencies related to chemicals and dangerous goods, along with fire fighters who are specially trained and equipped to handle chemical accidents and incidents, are located at the terminal. There is also a doctor based in the railway station near the container terminal and a hospital with a flying ambulance located approximately one kilometre away.

Point of Transfer: Szeged, Hungary: The Szeged Container Terminal is located in the southern suburbs of the city, near the Tisza River. There is a dam that protects the container terminal from flooding by the river. The terminal is not fenced or guarded and therefore can be accessed by the public. The terminal is closed on Saturdays and Sundays. Trucks from the terminal would have to pass through the city centre and over the Tisza River to reach the main road first class 43 (E 68) towards Romania.

The terminal has two tracks, each 200 metres long. These tracks can carry out loading and unloading from/to railcars and trucks by crane and a sideloader truck. Approximately 600-800 various loads are handled at this terminal per year. Customs clearance can be carried out on site. The terminal also has a certified ISO 9001 Quality Management System in place.

All personnel (approximately five permanent employees) are trained according to the current edition of the "ADR" regulations. There is medical service based in the central station, near the container terminal, and the hospital is approximately one kilometre away. There is no fire-fighting department on site, however there is a civic protection station equipped with special equipment to handle chemicals and dangerous goods, which can be on site within one hour. In case of emergency, the city fire brigade, located approximately five kilometres away, can be called.

Point of Transfer: Deva, Romania: This container terminal was unavailable during the time the survey was conducted. If this route is desired as an alternative, the capabilities of the facility to properly handle the anticipated transport of cyanide and the emergency response capabilities present will need to be further analysed.

Point of Transfer: Cluj Napoca, Romania: This container terminal was unavailable during the time the survey was conducted. If this route is used as an alternative, the capabilities of the facility to properly handle the anticipated transport of cyanide and the emergency response capabilities present will need to be evaluated. This terminal also had no fencing, which may represent a certain risk.

5.3.2 Road Transport Route Conditions

Budapest, Hungary to Szeged, Hungary: The truck route between Budapest, Hungary and Szeged, Hungary is 180 kilometres. Mobile phone coverage is provided by PANNON GSM throughout the entire route. The roads between Budapest and Szeged are in generally good condition and no extremely high risks were identified at the time of the survey. The main risks on this route are urban traffic in Budapest, Kistelek, Balastya, and Szeged.

Szeged, Hungary to Deva, Romania: The truck route between Szeged, Hungary and Deva, Romania is approximately 260 kilometres. Mobile phone service is provided by PANNON GSM in Hungary and by Connex in Romania and coverage is available throughout the route. This route is generally in acceptable condition. The main risks associated with this route include travel through the urban areas of Szeged, Deszk, Kiszombor, Mako, Naklac, Ara, and Deva. In addition, a railway level crossing at Mako poses a risk. The greatest concern associated with this route is the proximity of the Mures River which runs parallel to the road on the way into Deva for 1.5 kilometres and creates potential for significant impact related to the risk of accident and cyanide reaching the river.

Deva, Romania to Roşia Montană, Romania: The truck route between Deva and Roşia Montană is approximately 80 kilometres. Mobile phone service is provided along the entire length of the route by Dialog, Orange, and Connex mobile phone service providers. This route is considered dangerous due to poor road conditions and mountainous terrain. There are considerable traffic accident risks in Deva and Abrud. In addition, there are four locations where waterways come very close to the route. In addition, a dam is currently being constructed near the village of Bruces, which could represent either a minor or major risk of pollution, depending on the distribution and proximity of water in relation to the road when the dam is completed.

Cluj Napoca, Romania to Roşia Montană, Romania: The truck route between Cluj Napoca and Roşia Montană is approximately 167 kilometres. Mobile phone service is provided along the entire length of the route by Dialog, Orange, and Connex mobile phone service providers. This route requires transport through the urban areas of Cluj Napoca and Alba Iulia. In addition, parts of the road south of Cluj Napoca and east of Roşia Montană are considered dangerous. The greatest concern associated with this route is the proximity of the Somesul Mic River and ponds before and after the town of Turda.

5.3.3 Conclusions

It was acknowledged that overall, the safest approach would be to maximise use of rail transport and minimise the road travel to Roşia Montană, despite longer transport times, to avoid potentially dangerous road conditions. Two of the transfer-point alternatives (Deva and Cluj) minimise overall road travel time and should be considered to be generally preferable, but both road routes present hazards that require mitigative measures as noted in Section 4.10. **Preference will be given to the Deva and Cluj routes in normal conditions.**

Regardless of which of the two major preferred transportation route alternatives RMGC selects, the Company is committed to using the safest route possible for transporting sodium cyanide briquettes to the project site, considering all areas of concern including rail and road safety, unloading and loading safety, emergency response capabilities, urban area considerations, traffic impacts and road conditions, as well as the range of mitigative measures for sodium cyanide transport discussed in Section 4.10. The determination of the preferred route must also be balanced with the feasibility of reliably receiving the procured cyanide as scheduled, the capabilities of the container terminals to receive and process the cyanide containers, customs clearance issues, weather, and general road conditions.

It is therefore concluded that for the purposes of environmental impact assessment, identification of a range of options for cyanide shipment remains to be carried out, fully in line with Romanian and EU requirements, the Cyanide Management Plan and following detailed consultation with the relevant authorities in light of firm information on timing, rail and road conditions, and other factors applying at the time. **A comparative environmental assessment of possible options is therefore not appropriate here.**

6 Other Project Design Component Alternatives

6.1 Workforce Housing Alternatives

The Project workforce will number approximately 1200 during the construction phase, which will drop to 500 during the operations. RMGC has recognised the potential impacts that such an influx of workers presents for the local communities, and a number of housing options have been considered as follows:

- **Reliance on existing local and regional housing infrastructure**: Although local and regional workers will be hired on a preferential basis, reliance on existing local and regional housing infrastructure is rejected as a sole alternative, as available rental housing of serviceable quality that is a reasonable commuting distance from the Project site is in very short supply. Although local workers will be hired that already have suitable residences, it may be assumed that of the order of 700 individuals will have to be accommodated on a temporary basis for the two years of the construction phase. Moreover, as the distance of housing from the Project site increases, the transportation impacts associated with the travel of workers to and from the site and other infrastructure impacts (e.g. potable water use, sewage treatment, waste collection and disposal) may be exacerbated.
- **Temporary construction camp**: A temporary construction camp could be located within the industrial protection zone near the process plant site. While such a camp could potentially be sized to house the entire construction workforce, and offers positive benefits (e.g. minimisation of travel impacts, more efficient management of wastewater and solid wastes) it is rejected as an alternative because it is a temporary construction and cannot, of itself, resolve housing needs for the 17 years of operation and subsequent closure activities. Moreover, it does not represent a long-term benefit in that it does not improve the housing infrastructure in nearby communities.
- **Purchase and conversion of Roşia Valley apartment blocks to dormitory use**: Existing apartment complexes in the Roşia Valley could offer housing to roughly 500 individuals, if properly renovated and provided with reliable power, potable water systems, wastewater treatment, community kitchen facilities, municipal waste collection services, and other necessary infrastructure improvements. Because construction would be of a more permanent nature, this alternative would improve the long-term availability (post- Project closure) of affordable housing within the local community along with a number of construction employment opportunities, minimisation of transportation and infrastructure impacts, and other benefits. It is recognised that individual property purchases would have to be negotiated with existing owners and renovation requirements may potentially be extensive.
- **Combined alternatives: Roşia Valley dormitory conversions plus use of other regional/local housing infrastructure**: A combined alternative is preferred that would provide most of the necessary housing for the construction and operations-phase workforce developed via 1) negotiations with local and regional authorities and landlords for the development or conversion of existing housing, and 2) to the extent possible, the purchasing and renovation of existing apartment facilities in the Roşia Valley. Because it would result in a substantial improvement in local housing infrastructure, it is believed that this alternative would result in the greatest long-term benefits for nearby communities and this option has been selected.

A comparative environmental assessment of these options is presented in Table 5-26.

Table 5-26. Impacts of Alternative Worker Housing Options compared to Selected Option

Environmental Issues	Worker Housing Options			
	Existing housing only	Workers camp only	Rosia apartments only	Existing plus Rosia apartments (selected)
Water flows and quality	Potential for widening areal impacts from housing workers regards sanitation	Efficient solution allows full control of worker-generated sewage effluents, etc	Efficient solution, as for camp	Less efficient than camp or apartments regards environmental control but acceptable compromise regards other issues
Air quality	Least favourable regards vehicle related emissions	Most favourable regards vehicle related emissions	As for camp	Less favourable, but acceptable compromise
Noise and vibration	As for “air quality” – impacts related to worker transport			
Soil	Favourable, minimising land take	Potentially least favourable, requiring additional land take	Favourable, minimising land take	Favourable, minimising land take
Biodiversity	Favourable, minimising land take and disturbance	Potentially least favourable, causing disturbance and requiring additional land take	Favourable, minimising land take and disturbance	Favourable, minimising land take and disturbance
Landscape	Favourable, minimising land take and visual impact	Potentially least favourable, causing disturbance and increasing visual impact during operation	Favourable, minimising land take and visual impact	Favourable, minimising land take and visual impact
Socio-economic issues	Increased pressure on housing and other social infrastructure during construction and closure	No operational pressure on local housing but minimises long term beneficial impact regards housing infrastructure	Minimises operational pressure on housing infrastructure and provides limited long-term housing benefits	Minimises operational pressure on housing infrastructure and provides widespread long-term housing benefits
Cultural heritage	No impact	Requires land take, with resulting potential impact on historic remains	No impact	Potential for beneficial impact if wider inward property investment includes housing stock of conservation value
Transportation issues	Least favourable option with greater worker travel required	Most favourable option	Favourable option	Less favourable, but acceptable compromise
Transboundary impacts	No significant transboundary issues			

6.2 Hazardous Waste Disposal Alternatives

As noted in Chapter 3, permitted hazardous waste disposal options are still presently under development in Romania, which will necessitate the development of a controlled, temporary hazardous waste storage facility (see Exhibits 5.2). The Temporary Hazardous Waste Storage Facility will accept containerised hazardous waste (e.g. paint residues, chemical/oil spill cleanup residues), which can be accumulated and safely stored pending identification of an appropriately licensed offsite disposal facility. The Temporary Hazardous Waste Storage Facility will be located behind security fencing, and will consist of a bermed and covered concrete pad over an impermeable barrier, with a sump to contain any potential spillage. The facility location was selected to use previously impacted land, upgradient from a facility capable of containing any potential runoff, and which shares road access with other major facilities.

Until an offsite hazardous waste disposal facility is constructed and permitted, no other viable options exist and environmental assessment of options is not relevant.

6.3 Municipal Waste Disposal Alternatives

No permitted municipal waste disposal facility currently exists in close proximity to the Project site. As noted in Section 3.4, in the near term, municipal waste from RMGC operations will be consolidated and transported by truck to the TRACON Sanitary Landfill in Sibiu. As a longer-term solution, RMGC is working with the local communities in a co-operative effort to site, design, and develop a regional municipal landfill at Câmpeni, in accordance with the requirements of Decision No. 162, Landfill of Waste and relevant European Union regulations. If successful, the landfill operation resulting from this effort will be a significant, long-lasting benefit to the local communities. RMGC has hosted initial discussions with the mayors of Roşia Montană and Abrud to discuss municipal waste management issues, and it has been agreed that municipal waste management is the responsibility of the Local Councils. The mayors have also agreed that a new, fully compliant waste facility is a priority and must be developed by an association of communities that together has a population of at least 20,000 people. The mayors have also committed to engage the mayors from neighbouring communities in a joint waste management consortium. To reach a population figure of 20,000, all villages in the Abrud river basin and the downstream portion of the Bistra will need to be included. Once established, the consortium will apply for appropriate legal status.

RMGC, in its role as the largest business in the area, will provide maps and technical support, as required, and will work with the mayors in the selection and development of a suitable waste site. However, the mayors will negotiate among themselves to select the most suitable site. Once the association has been finalised and the site selected, the consortium will apply to the European Union for Phare program funding in order to properly support the project.

In parallel with this planning it is noted that a Waste Transfer Station has been approved for location in Abrud. This is favourable for the project because the waste transport distances involved would be less than 10 km. Construction of the Abrud Waste Transfer Station is planned to begin in 2006 with completion expected in 2008.

There are no appropriate alternative options for disposal of this category of waste, and environmental assessment of options is not relevant.

6.4 Water supply and management alternatives

6.4.1 Fresh Water Supply

6.4.1.1 Preliminary screening

The selection procedure and evolution of the preferred option for process water has involved many water supply studies and consideration of options, including those addressed during earlier feasibility and other scoping studies.

Fundamental options for water supply in the initial screening included:

- Groundwater
- Existing surface storage facilities
- New water supply impoundment
- Surface water abstraction
- Use of municipal water supply.

The first three fundamental options were eliminated at this stage for the reasons stated below, with the last two forming the focus for more detailed consideration.

Groundwater - investigations indicated no significant aquifers in the vicinity of the Project site. In addition, many local communities and isolated dwellings rely on shallow wells for water, and any pressure on the minor groundwater resources that do exist would have the potential to impact current users.

Existing surface storage - the region contains several reservoirs constructed for supply of water to local communities. It is possible that these sources could be used for the Project, but new pipelines and easements would have to be negotiated and the mine would likely be competing with the communities for limited water resources during times of drought.

New surface water impoundment - While construction of a new process water reservoir is certainly possible, this alternative would result in additional land requirements, relocation needs, and many other associated impacts.

6.4.1.2 Municipal water supply

The fresh water supply in this option relies on water extraction from the existing 400 mm water main from Câmpeni to Abrud, located alongside the Abrud River. The water originates from the Mihoeşti reservoir some 2 km west of Câmpeni, where it is filtered and chlorinated. The local utility has reportedly indicated the need to upgrade and extend the existing water treatment plant (and possibly other existing structures and facilities), if additional withdrawals for the Roşia Montană Project are required. Use for the Project would involve a branch from the existing 400 mm pipeline at the village of Gura Roşia, where a pump station and surge tank would be constructed. A new 4.5 km pipeline would take the water to the plant.

Site investigations revealed several concerns regarding the feasibility of this alternative. The existing 400 mm pipeline has reportedly been out of use for a number of years, which at least partially explains severe water shortages reported in Gura Roşia and Abrud. Furthermore, visual observation of the Mihoeşti reservoir and other available information indicates relatively modest water storage capabilities at the Mihoeşti dam, the primary purposes of which seems to be flood control and the existing regional water supply. The capacity of the existing reservoir relative to meeting the long-term water supply needs of the area, including the proposed water supply for the Roşia Montană Project, is questionable. The design capacity of the existing treatment plant is of the order of 486 m3/hr (135 l/s) and the projected Roşia Montană Project peak water demand of 251 m3/hr (see Section 4.1.2) would need a capacity increase of around 52%.

In addition, ROMPROED (a private engineering consultant under contract to Alba Iulia County) performed a feasibility study of the Câmpeni -Abrud water supply network with the objective of identifying emergency upgrade requirements. The ROMPROED study indicates that the capacity of the existing system is probably sufficient to meet the demands of the project. However, the study also recommended a number of emergency upgrades, which includes the pumping station at Gura Roşia and repair or replacement of a 150 m long section of the 400 mm pipeline, which was reportedly exposed to water erosion in the Abrud River.

As part of this evaluation, discussions were held with the local water authority regarding costs for supply of treated water via the existing pipeline. Rates of approximately ∈30/m3 were indicated, which make this option very expensive in terms of operational costs over the life of the mine. The pipeline has not been used for many years, and would have to be replaced. In addition, it was noted that significant modifications on the water intake for the plant were required, as well as an estimated ∈20M in other major refurbishments.

6.4.1.3 Surface water abstractions

A separate assessment was conducted to evaluate surface water abstraction alternatives. The assessment included site inspections and review of historical alternatives previously considered for supply of fresh water to the site. These three options are:

- Abstraction from the Abrud River in Gura Roşia, upstream of the Roşia River confluence; this option would provide a relatively short pipeline from the existing water intake and an independent water supply for the Roşia Montană Project, but would suffer from the limited flow and poor water quality in the Abrud River. The option would require upgrade of the existing pumping station at the plant or construction of a new one, and about 5 km long new pipeline
- Abstraction from the Aries River at the existing water intake of the Roşia Poieni mine at Girde and an independent pipeline to the Roşia Montană plant. Due to the terrain configuration, this option would require a number of pumping stations and about 13 km of new pipeline
- Abstraction from the Aries River at a new intake located just upstream of the Aries–Abrud confluence, a new pipeline to Gura Roşia along the abandoned railway on the left bank of the Abrud River, and a new pipeline along the route proposed in the SNC Lavalin Basic Design report, approximately 11.8 km in length.

Based on all the aforementioned studies and preliminary option assessment, six options were developed:

<u>Option 1</u>: Tapping into the existing 400 mm municipal water supply pipeline at Gura Roşia and pumping to the Roşia Montană plant. Potable water quality is not necessary for the primarily industrial water use needs of the Project, and selection of this option would negatively impact the capacity of the Water Treatment Plant to supply potable water in response to regional growth. The existing water intake arrangements would have to be rebuilt to accommodate increased usage, and the Water Treatment Plant itself is estimated to need ∈2M in renovations. In addition, the existing pipeline has been disused for many years, and is so corroded as to require replacement.

Option 2: Pumping directly from the Abrud River along a 5 km long pipeline, similar to Option 1. Water in the Abrud River is of poor quality (Class 5), and minimum annual flows are of the order of 60 to 80 l/s. Based on the Abrud River flow duration curve and an assumed minimum environmental flow of 100 l/s, the present water abstraction level from the Abrud River does not even appear to be sustainable for the existing operation.

Option 3: Water abstraction from the Aries River at the Girde intake and pumping via a new independent pipeline parallel to the existing Roşia Poieni conduit to the existing Roşia Poieni reservoir, and then following the northern bypass road and the relocation route of the 110 kV transmission line. Two sub-options would be feasible: (i) new pumps at the existing Girde intake on the Aries River, or (ii) a new independent intake and pumping station at the Aries River, likely upstream of the existing Girde intake. The option would require a number of agreements with Roşia Poieni, i.e. permission to use part of their intake, as well as to use a part of their only partially used water abstraction licence; and, construction of a new pipeline along the existing Roşia Poieni conduits and within the Roşia Poieni concession boundary.

Option 4: Water abstraction from the Roşia Poieni water tanks (located above the Roşia Poieni processing plant, to which they pump water from the existing Girde intake), into a new pipeline to the Roşia Montană Project. This option would entirely rely on the ability and willingness of the Roşia Poieni operation to continuously supply the required water to the Roşia Montană Project.

Option 5: Negotiation of an agreement with Roşia Poieni to extend their existing pipelines to the Roşia Montană plant. In this option, Roşia Poieni would be the de facto water supplier for the Roşia Montană project. As in options 3 and 4, this alternative suffers from a heavy reliance on a third party.

Option 6: Water abstraction from the Aries River upstream of the Aries-Abrud confluence, construction a new pipeline to Gura Roşia (along the abandoned railway on the Abrud River left bank), followed by a new pipeline along Roşia Montană river. Based on the minimum daily recorded flow in the Arieş River and the maximum actual abstraction rates by other users, the Project would have 100% reliable water supply, while at the same time allowing three times higher minimum environmental flow than required by Apele Române. If the existing users were to abstract up to their maximum licensed amount, the Arieş River would still meet all demands 96% of the time. The remaining 4% of the time represents periods of extreme low flow. Given that actual abstraction is only 16% of the licensed abstraction, it appears highly likely that sufficient flow would be available.

The pipeline routes of these options are shown in Exhibit 5.4. They have also been evaluated (see Table 5.27) and ranked using a weighted matrix technique, the results of which are shown in Table 5.28.

Based on this assessment, **Option 6 has been adopted as the only truly viable and preferred option and is so described in Section 4.1.2**. A high dependence on the continued viability of the Roşia Poieni operation is not considered to be sustainable, which eliminates Options 3, 4, and 5. Option 2 demonstrates inadequate water quantity and quality, and unacceptably high operating costs (i.e. payment for treated water) eliminate further consideration of Option 1.

6.4.1.4 Conclusions

The preferred option is therefore assessed as the sole acceptable option for water supply and a comparative environmental assessment with the non-viable options is not appropriate.

Table 5-27. Water Supply Option Evaluation

Option	Description	Technical characteristics	Advantage	Disadvantage
1	Tap into existing 400mm pipe	1 pumping station, ~ 285 m head (*), ~ 4.5 km pipeline	Low environmental impact and likely straightforward permitting Drinking water quality Could relatively quickly be converted into Option 6, if required by changed conditions in the future, taking advantage of the already installed system	Dependence on municipal water availability and future municipal demand Very high operating costs associated with payment to local water authority for supply of treated water; replacement of pipeline, revision of water intakes, and major renovations of the water treatment plant would be required.
2	Abstraction from the Abrud River	1 pumping station, ~ 300 m head (*), ~ 4.8 km pipeline	Cost effectiveness (relatively low capital and O&M cost). Independence, self-operated supply system, i.e. higher supply reliability.	Insufficient water during low flows More complex permitting process Low water quality
3	Abstraction from the Aries River at Girde and an independent pipeline	Several pumping stations, ~13 km long pipeline	Good water quality and availability.	Difficult terrain, high capital, operation and O&M cost. A part of the route through the Roşia Poieni property. Likely more complex permitting process.
4	Water abstraction at existing Roşia Poieni holding tanks	Likely 1 new pumping station, ~ 7 km new pipeline	Good water quality and availability. Moderate construction, operation, O&M cost	Dependent on the Roşia Poieni equipment and goodwill – low supply reliability.
5	Roşia Poieni to supply water	Likely 1 new pumping station, ~ 7 km new pipeline (to be built and operated by Roşia Poieni)	Good water quality and availability. Low initial and O&M cost.	Dependent on the Roşia Poieni equipment and goodwill – low supply reliability. Likely high operating cost.
6	Abstraction from the Aries River at Campeni (confluence) and an independent pipeline to the plant	New intake and likely 1 new pumping station, ~ 12 km new pipeline.	High reliability of the self operated water supply system Can relatively easily be designed to take advantage of the municipal 400 mm pipeline as an emergency supply source. Easy terrain and favourable pipeline route along the abandoned railway line. Good water quality.	Careful water management needed during low flows in the Arieş river if other abstractors are taking their licensed amount.

Note:

(*) Approximate elevation difference, not taking into account hydraulic losses; the actual pumping head may be higher

Table 5-28. Comparison of Water Supply Alternatives

Option	Description	Evaluated parameters *					Score (100 max)	Rank**
		Capital Cost	Operating Cost	Permitting / Environmental Impact / Possible delays	Reliability/ Dependence on 3rd parties	Flexibility to adapt to changed conditions		
1	Tap into the existing 400 mm pipeline	8	1	9	1	5	44	4
2	Abstraction from the Abrud River	8	7	3	1	1	40	5
3	Abstraction from the Aries River at Girde, new independent pipeline	2	2	5	4	4	34	6
4	Water abstraction at the existing Roşia Poieni holding tanks	5	3	10	2	1	53	2
5	Roşia Poieni to supply water under a water supply contract	10	1	10	1	1	50	3
6	Abstraction from the Aries River at Cimpeni (confluence) and construction of a new independent pipeline to the plant	7	9	8	10	10	85	1
	Assigned Weight	20	20	20	30	10		

6.4.2 General Water Management

The preferred option is described in Chapter 4.1, Sections .5.1 and .5.2 and is able to meet all the Project water management objectives, viz.:

- Providing sufficient water for process operations, while at the same time minimising fresh water requirements;
- Maintaining biological baseflows in Corna and Roşia streams;
- Keeping clean water and contact water separate as far as possible;
- Ensuring water meets appropriate standards prior to any release;

- Providing storage for two PMF probable maximum flood (PMF) events in the tailings management facility (TMF); and
- Providing options for treatment of low concentrations of cyanide during temporary cessation and closure, including water transferred from the Corna Valley to the mine pit system, and for any period when water discharge may be needed to correct a surplus in the water balance.

This is summarised in Exhibit 4.1.18.

Water treatment technology alternative options are described in Section 4.6, with the preferred option in Chapter 2 of EIA.

In the evolution of this preferred option a number of alternative strategies (A-F) were considered and ultimately rejected. These are described below and summarised in Exhibits 5.10 (A-F), and Table 5-27. The preferred option is a close variant of Strategy F.

STRATEGY A (Exhibit 5.10 A):

Normal Operating Condition

- Water in the TMF and secondary containment system would be contained and recycled in the process. The only exception would be during the optimisation of a semi-passive biological treatment system to be developed during operations and used in closure for treatment of TMF seepage.
- ARD treatment plant discharges to Rosia or Corna Valley.
- Water from the ARD treatment plant used for supplementing biological base flow in Rosia and Corna Streams.
- Includes assumption that site-specific standards could be negotiated for calcium, sulphate, and TDS.

Extreme Storm Event Condition

- Slight, short-term exceedences during an extreme storm event would have no impact on receiving water (Abrud River).
- Slight exceedences of iron and pH standard predicted and estimated from the Cetate Pond during 200-yr+ storm event.
- TMF contains extreme (PMP) storm events. Some discharge of treated water envisaged for removing excess water after PMP event.

Closure

- TMF seepage would be discharged through a semi-passive system designed to reduce nitrogen compounds including cyanide, with some metals and sulphate treatment.
- Calcium, sulphate and TDS also occur in the plant process water at levels above TN001 and would require site-specific standards. Sulphate and TDS would be reduced, but it may not be possible to reliably meet the TN001 standards.
- Pit water would be treated through a combination of in-situ active and passive treatment, and ex-situ treatment and discharge when needed (i.e., to meet biological baseflow).

Long-term passive in-situ and ex-situ treatment would be used to discharge water after pit lake system reaches hydraulic equilibrium.

- Residual ARD sources would be routed to pit lake system.
- The negotiated standards would allow for implementation of semi-passive biological treatment in the closure condition.

This strategy was rejected because full compliance with TN001 standards is not achieved, and operation would depend on site-specific relaxation of those standards.

STRATEGY B (Exhibit 5.10 B):

Same as Strategy A but incorporates:

- polishing ponds on the banks of Aries River,
- storage for 2 PMFs in the TMF,
- lower operating levels in the Cetate Dam,
- and a limestone spillway on the face of the Cetate dam.

Normal Operating Condition

- Treated ARD water piped to polishing ponds and blended with Aries River water and discharged.
- Additional Aries River water pumped to site to make up biological base flow, as needed.
- Reuse of treated ARD water on-site would be optimized to extent possible.
- TMF and SCS operation not modified except semi-passive system removed (without site-specific standards, it would likely not be viable).

Extreme Storm Event Condition

- Modelling indicates that with normal operating levels in the SCS (needed to maintain a hydraulic sink), TN001 standards would not be exceeded in the event of an extreme storm event with a spill over the SCS dam.
- Modelling indicates that with a lower operating level behind the Cetate Pond, storm event spills would meet standards with the possible exception of pH.
- With lower operating levels behind the Cetate Dam, spills would only occur with storm events greater that the 1:10,000 year, 24-hour storm event.
- The Cetate and SCD spillways would include limestone as a pH mitigation measure for extreme storm events.
- In reality, the pH of rainfall is less than the TN001 standards, and most extreme storm event runoff will not meet the TN001 standard for pH regardless of the presence or lack of impacts in runoff area.

Closure

- TMF seepage water would be pumped to pit lake system until standards are met in seepage or can be reliably treated in simple passive/semi-passive treatment system.
- Treated pit lake system discharge to Aries River polishing ponds until in-situ treatment reduces sulfate and other key constituents so that direct discharge can occur, or occur with simple passive/semi-passive polishing.
- Higher level of closure commitment than Plan A.

This strategy was rejected because TN001 compliant concentrations are only achieved by invoking dilution using the receiving water itself (i.e. the Arieş River). This is contrary to the TN001 regulations.

STRATEGY C (Exhibit 5.10 C):

Same as Strategy B but with a Freshwater Reservoir constructed below the Cetate Dam and blending ponds near Aries River are removed.

Normal Operating Condition

- Freshwater Reservoir would hold approximately 2 M m3 of fresh water pumped from the Aries River at start up, and during operation the reservoir would contain a combination of freshwater from the Aries River, Rosia Valley diversion water and ARD treatment plant discharge. (Capacity of Rosia Valley to contain this structure needs to be evaluated.)
- Recycling of ARD treatment plant water would be increased by discharging to freshwater reservoir.
- Blending of ARD treatment plant water, freshwater from Aries and diversions would be required to ensure water quality is suitable for freshwater uses.
- Excess freshwater from reservoir would be discharged to the Rosia Valley.
- The fresh water reservoir would be source for biological baseflows, reagent mixing water, fire water and possibly potable water, and as such, would need to be of suitable quality.
- Quality would be maintained by controlling the inflow of water pumped from the Aries River.
- The TMF would not be used as a source of start-up water, and it could be considered if modification of TMF starter dam to eliminate clay core is viable. However, seepage during early years when pond to close to dam face would have to be reviewed.

Extreme Storm Event Condition

- Storm water contingencies same as Strategy B, except freshwater reservoir would be mixing point for water discharge during a Cetate Dam spill event.

Closure

- Same as Strategy B, except that pumping from the Aries would be greater.
- In closure, the blending of water from the Aries would be more directly for dilution of treatment plant discharge. There are no freshwater needs for the site.

This strategy was also rejected, as for strategy B, because TN001 compliant concentrations are only achieved by invoking dilution using the receiving water itself (i.e. the Arieş River), even though this is carried out close to the Cetate Water Catchment Pond. The new reservoir would also require another substantial dam and land-take.

STRATEGY D (Exhibit 5.10 D):

This includes installation of a Reverse Osmosis (RO) plant in addition to the ARD treatment plant. The RO plant would be downstream of the ARD treatment plant and would act in a secondary (or polishing) capacity (i.e., treat for sulphate and TDS).

Normal Operating Condition

- Two options for use of plant exist.

1. Treating of a minimal portion of the ARD plant discharge, then blending it back to dilute the total discharge to below effluent standards – Option D1.
2. Treatment of a large or the total flow to produce a high quality effluent for potable or other uses (reagent mixing water). This could reduce the freshwater demand from the Aries River to that required to maintain the water balance – Option D2.

- Option D1:
    - Two-thirds to three-quarters of the ARD plant discharge would need to treated and blended back to reduce the sulphate concentration to less than 600 mg/L (i.e., up to 490 m3/hr).
    - Membrane life would be extended by only running the plant RO plant when a discharge is needed to maintain the water balance. Fresh water from Aries could be used for biological base flow or plant discharge (cost comparison would be needed to assess the trade-off between pumping and RO plant operating and maintenance costs).

- Option D2:
    - The RO plant would be run full time to provide potable, reagent mixing water, and water for discharge; however, flow may be reduced if non-potable uses can be supplied by straight ARD plant discharge.
    - Sale of water to outside utilities (possibly at a reduced price) could help offset operating costs.
    - Residuals (brine) from an RO plant would have to be managed in either evaporation ponds, TMF or off-site disposal or sale. Operation of evaporation ponds would require heating (distillation).
    - ARD plant would be a pre-treatment step that would increase membrane life if calcium is maintained at a low concentration. A portion of the ARD plant discharge, before RO, could be used on site as non-potable water.

- If needed, RO treatment would be effective in directly treating TMF seepage in removing cyanide and nitrogen compounds as well as sulphate, calcium and TDS.
- Differing versions of the RO process, as well as some ion exchange technologies, would be evaluated for this strategy.

Extreme Storm Event Condition

- Storm water contingencies same as Strategy B.

Closure

- TMF seepage water pumped to pit lake system until standards are met in seepage or can be treated in simple passive/semi-passive treatment system. Seepage would have to be blended with pit water going to ARD treatment plant so that calcium would be reduced.
- Pit lake system discharged through ARD/RO plant until in-situ treatment reduces sulphate and other key constituents so that direct discharge can occur, or occur with simple passive/semi-passive polishing.
- This strategy was rejected because of the high cost of an RO plant and introduction of additional waste products requiring special treatment, i.e., disposal of residual brine.

STRATEGY E (Exhibit 5.10 E):

This includes an RO plant with pre-treatment (no lime plant). With further testing it may be determined that a lime treatment plant could be eliminated altogether and replaced with an RO plant (with or without some level of pretreatment).

Normal Operating Condition

- Same as Strategy D, but with no ARD plant. Splitting and re-blending of treated water would be more difficult due to more variable influent concentrations and treatment of total flow is more like to be needed.

Extreme Storm Event Condition

- Storm water contingencies same as Strategy B.

Closure

- TMF seepage water pumped to pit lake system until standards are met in seepage or can be treated in simple passive/semi-passive treatment system (same as Strategy D).
- Pit lake system discharge through RO plant until in-situ treatment reduces sulphate and other key constituents so that direct discharge can occur, or occur with simple passive/semi-passive polishing.

This strategy was also rejected because of the high cost of an RO plant and introduction of additional waste management issues in connection with disposal of residual brine.

STRATEGY F (Exhibit 5.10 F):

Strategy F consists an ARD treatment plant with secondary treatment, such as chemical precipitation of sulphate with barium.

Normal Operating Condition

- Secondary treatment would consist of mixing tank, precipitation and clarification.
- Barium sulphate sludge would have to be managed. Possibly a saleable product - purity should be relatively good.
- Confirmation would be required that secondary treatment would also reduce TDS below standards.
- Cost of system with reagent cost may exceed RO.

Extreme Storm Event Condition

- Storm water contingencies same as Strategy B.

Closure

- Same as Strategy D.

The preferred option is a variant of Strategy F without direct pumping of compensation water for Roşia and Corna streams from the River Arieş.

Conclusions

Only strategies E and F are acceptable because they are the only ones that meet the required effluent standard without using clean water for dilution. Strategies E and F are very similar but Strategy F is clearly preferable because it avoids generation of a waste stream that would require special treatment. On this basis, a comparative environmental assessment with the other water management strategy options described above is not appropriate.

The preferred option (Exhibit 4.1.18 in Chapter 4.1) differs from Strategy F in its restriction of use of Aries water for assisting with Rosia and Corna compensation flow to extreme dry conditions.

Table 5-29. Water Management Strategy alternatives

Strategy	Description	Compliance objective	Comments
A	ARD plant with discharge to Rosia or Corna Valley	TN001 with site specific discharge standards for CN, Calcium, Sulphate, TDS	Includes assumption that site specific standards could be negotiated for Ca, Sulphate, and TDS. Rejected because full compliance with TN001 standards is not achieved, and operation would depend on site-specific relaxation of those standards.
B	Same as A but incorporates polishing ponds on the banks of Aries River, storage for 2 PMFs in the TMF, lower operating levels in the Cetate Dam and SCD, and a limestone spillway on the face of the Cetate dam	Meet all requirements for TN001 for normal operating conditions (NOC) and stormwater discharges	Active dilution required to meeting NOC discharges from the ARD plant. Rejected because TN001 compliant concentrations are only achieved by invoking dilution using the receiving water itself (i.e. the Arieş River). This is contrary to the TN001 regulations.
C	Same as B but with a Fresh Water Reservior constructed below the Cetate dam which would hold approximately 2M m3 of fresh water pumped from the Aries River. The fresh water reservoir would be source for biological baseflows, reagent mixing water, fire water and possibly potable water.	Meet all requirements for TN001 for normal operating conditions (NOC) and stormwater discharges	Developed to comply with all TN001 standards for normal operating conditions as well as storm water discharges. Still basically a dilution system. Could consider modification of TMF starter dam to eliminate clay core - however, would have to look at seepage during early years when pond to close to dam face. Rejected, because TN001 compliant concentrations are only achieved by invoking dilution using the receiving water itself (i.e. the Arieş River), even though this is carried out close to the Cetate Water Catchment Pond. The new reservoir would also require another substantial dam and land-take.
D	Same as Strategy A with RO plant in addition to Lime Treatment Plant	Meet all requirements for TN001 for normal operating conditions (NOC) and stormwater discharges	RO plant would be added below lime treatment plant to treat Sulphate, Calcium and TDS. Residuals from plant would have to be managed (brine) in either evap. ponds, TMF or off site disposal. Rejected on grounds of cost of RO plant and introduction of additional waste-related impacts in connection with disposal of residual brine.
E	Same as Strategy A with RO plant and pre-treatment (no lime plant)	Meet all requirements for TN001 for normal operating conditions (NOC) and stormwater discharges	With further testing it may be determined that lime treatment plant could be eliminated all together and replaced with RO plant. See Strategy D for other comments. Rejected on grounds of cost of RO plant and introduction of additional waste-related impacts in connection with disposal of residual brine.
F	Within the Corna Valley watershed, the TMF would be designed for storage of 2 PMF storms. If required, excess water in the TMF would be pumped through the treatment plant to achieve discharge standards for TN001. The SCD pond would be operated at a sufficiently low level to allow for natural dilution from storm water runoff to achieve TN001 standards for any water flowing over the spillway. Within the Rosia valley watershed, the ARD primary and secondary water treatment systems will be designed to achieve TN001 standards for normal operating conditions. The Cetate dam pond will be operated at sufficiently low levels to allow for natual dilution from any storm water runoff to achieve TN001 standards.	Meet all requirements for TN001 for normal operating conditions (NOC) and stormwater discharges	Other secondary treatment may include optimization of pH and Lime addition to reduce calcium concentrations in discharge, addition of barium and sodium carbonate to precipitate sulfate and calcium. Secondary treatment system will be designed to meeting all TN001 standards. However, as a contingency for variations in inflow chemistry some limited mixing with freshwater will be planned to ensure compliance with TN001. Preferred option is variant of Plan F without direct pumping of compensation water for Roşia and Corna streams from the River Arieş.

6.5 Power Supply Alternatives

Power supply options evaluated for the Roşia Montană Project include the following:

- Dedicated Power Plant: RMGC could seek to develop a new coal- or gas-fired power station for the supply of electricity to the mining operation: This alternative is costly and would cause unnecessary environmental and social impacts, given the current overcapacity, as described in Section 4.10.
- Obtain Power via Market Tender: RMGC could tender to the power market for the most favourable supply option with currently licensed suppliers. This is difficult under current market conditions in Romania, however and therefore has been rejected as a power supply alternative.
- Obtain power from Electrica: Power could be obtained from Electrica as a “Franchise Customer” at the regulated tariff, or RMGC could obtain accreditation as an “Eligible Consumer” and negotiate a supply contract (also from Electrica).

Obtaining power from Electrica (with provisions for onsite stationary diesel backup emergency power for critical systems) is considered the most viable alternative for the Roşia Montană Project. Excess capacity presently exists, so it is preferable for the Project to purchase power rather than permit and build an independent power plant, especially considering the array of environmental and social impacts that would be associated with power plant construction and operation. Also, Electrica already operates the existing 110 kV overhead power line from Zlatna to Roşia Poieni, which bisects the project site. This line has the capacity to meet existing demands plus all anticipated project needs.

The existing line will be relocated to skirt the western side of the Project site (to avoid crossing mine haul roads), and a new spur line will be built to connect to the primary substation building at the plant site. Electric power will be distributed to the site at 20 kV. Overhead lines will be used as the primary method of distribution, but buried cables will be installed in high traffic areas where appropriate. The operation will, on average, require approximately 50 MW of power, with a peak demand of 55MW. Monitoring of primary electrical systems and the integrity of the substation building will be undertaken on a daily basis during mine operations. Backup power generators will be provided for emergency operations of the process plant (see ESMS Plans, Plan G, Cyanide Management Plan) and other critical systems.

A comparative environmental assessment of the two basic options is summarised in Table 5-30

Table 5-30. Impacts of Viable Alternative Power Supply Options compared to Selected Option

Environmental Issues	Options	
	Purpose-built electrical power station	Electrical power purchased from existing supplier
Water flows and quality	Impacts arising from water demand for cooling; potential for flow disturbance and water contamination from run-off from operational areas	Marginal increase in impacts from increasing production at existing power plants
Air quality	Power station emissions add to local impacts	As above
Noise and vibration	Construction and operational noise sources introduced	As above
Soil	Additional land take directly impacts soils; potential for fall-out from air emissions	No impact
Biodiversity	Land take will impact habitats	No impact
Landscape	Visual impact	No impact
Socio-economic issues	Possible additional local employment and potential for future use post-closure	Extended power grid may be useable post-closure
Cultural heritage	Land take may have implications	No impact
Transportation issues	Signficant additional impacts related to construction and operational traffic	No impact
Transboundary impacts	No significant issues raised	

6.6 Construction Rock Supply Alternatives

Aggregate materials required for Project construction will be extracted from onsite quarries. Aggregate consumption will be highest during the construction phase. An assessment of available on-site aggregate material for the Project identified a possible shortfall in non-acid generating rock material at critical construction stages. To address the shortfall in such rock (sandstone, limestone, or andesite), on-site and off-site alternative material sources were considered.

Four sources were identified for supply of aggregate for construction of the Corna dam and water management dams, as well as for earthworks and concrete production. These include three quarry sites (the Şulei quarry, a limestone outcrop, and the Pig Valley quarry), and the pre-strip open pit, as shown in Exhibit 5.5. Although existing regional quarries (i.e. the Roşia Poieni copper mine quarry, Rosioira quarry, or Almaşu-Mare quarry) could also potentially be used as back-up sources, **the preferred alternative is to rely on on-site quarry operations** to augment aggregate needs over and above that generated by the scheduled mining programme, providing the requisite volume can be made available when required.

Use of onsite quarries eliminates transportation-related and other impacts associated with the use of offsite sources. Of the sites considered within the Project boundary, the Pig Valley and Şulei sites are the preferred locations for RMGC to develop new quarries. This takes into account a preference for use of previously impacted land. Both quarries are necessary, as the Şulei Quarry andesite is not suitable for use as an aggregate source. However, it can supply the required volumes for construction requiring non-acid generating material. The Pig Valley quarry site can provide the required volume of sandstone that can be used for concrete, roadbase aggregate, and rockfill for dam construction and foundation preparations at the process plant site. The Şulei and Pig Valley quarries are therefore considered to be the preferred alternative.

Alternatives to the Sulei and Pig Valley quarries were considered include excavating from the various limestone outcrops near the project area, or using materials from the pre-stripping open pit areas. **Both of these alternatives are rejected because the quality of the aggregate at these sites does not meet technical requirements for their intended use.**

As noted above, selection of preferred sub-options for an on-site quarry was made on the basis of suitability of the material because all of the sites are located within a similar environmental setting with minimal risk of significant impact. Table 5-31 sets out a summary of the comparative environmental assessment of the two principal options of on-site and off-site aggregate sources.

Table 5-31. Impacts of Alternative Quarry Rock Supply Options compared to Selected Option

Environmental Issues	Options	
	On-site aggregate source	Off-site aggregate source
Water flows and quality	Potential for impacts arising from land take and run-off from operational areas	Same potential for impact as on-site sources, but assumed to be a permitted quarry with appropriate environmental controls
Air quality	Potential for impacts arising from quarry operations and truck haulage	As above
Noise and vibration	Potential for impacts arising from quarry operations including blasting and truck haulage	As above
Soil	Additional land take directly impacts soils	As above
Biodiversity	Land take will impact habitats	As above
Landscape	Visual impact	Impact already in place
Socio-economic issues	Neutral in terms of socio-economic impact	
Cultural heritage	Land take may have implications	Same potential for impact as on-site sources, but assumed to be a permitted quarry with appropriate environmental controls
Transportation issues	No impact	Significant additional impacts related to transport of quarry rock on public roads
Transboundary impacts	No significant issues raised	

7 Project Closure Alternatives

7.1 Approach

Numerous options are available for the development of an appropriate mine closure strategy for the Roşia Montană Project. The general approach to Mine closure and Rehabilitation has been presented in the Mine Rehabilitation and Closure Management Plan. The alternatives on mine closure presented below will be described under the following basic considerations:

Alternatives will be derived for the following main objects:

- the four open pit operations,
- the tailings management facility (TMF),
- and the waste rock dumps.

The clean-up measures for the production facilities including the removal of buildings, surface structures, scrap material and equipment, the removal of all hazardous or designated substances, the demolition of concrete structures and the area clean-up are straightforward remediation measures, and there is usually not a real alternative to the activities described in the Mine Rehabilitation and Closure Management Plan as the preferred remediation option.

Alternatives must fulfil the general and minimum requirements of closure. According to EU and international regulations, rehabilitation means "the treatment of the land affected by a waste facility in such a way as to restore the land to a satisfactory state, with particular regard to soil quality, wild life natural habitats, freshwater systems, landscape and appropriate beneficial uses" (see Mine Rehabilitation and Closure Management Plan). Options, which are not in compliance with national and EU/ international guidelines or regulations, are not valid alternatives for discussion here. This is especially true for the so called “No action” or “Zero”-alternative which is not a valid option for closure.

Alternatives discussed must each be significant alternatives (i.e., not minor variations).

7.2 Closure of open pit operations

7.2.1 Options

Pit closure options can be primarily distinguished according to the degree of backfill, as follows:

- “BC”: complete backfill by transfer mining or waste rock relocation, including soil cover construction
- “BP”: partial backfill, including soil cover construction, ,
- “F”: no backfill, mine flooding, leading to the development of a pit lake.

Variants a) and b) can be further distinguished according to

- additional source control measures implemented within the relocation technology, e.g. waste rock segregation and/or alkali addition.
- the cover design.

Variants b) and c) may be differentiated with reference to additional pit wall stabilization / mitigation measures.

Since there are four individual open pits to be closed and remediated, the alternatives for the various mines cannot be discussed independently but must be understood as an integrated closure strategy. This is a usual approach and BAT for large mine closure projects.

7.2.2 Preferred remediation strategy

The preferred remediation option for the closure of the open pit mines in the Roşia Montană Project is a progressive backfill/restoration strategy, comprising (a) the complete backfill of the Jig pit, (b) the partial backfill of the Orlea and Cîrnic pits, all by transfer mining, and (c) the flooding of the Cetate pit. Jig, Orlea and Cîrnic pits will be covered with a vegetated soil cover.

Due to the backfill regime where PAG material will be placed at the bottom and covered with at least 10 meters of NAG material, potential for ARD generation will be low (see Mine Rehabilitation and Closure Management Plan). Therefore the cover design for Jig, Orlea and Cîrnic pits foresees a thin-layer cover comprising the following:

- 10 cm topsoil;
- 20 cm subsoil of clayey silt.

7.2.3 Discussion of alternatives

The possible alternatives will be discussed for each single open pit operation for the purposes of clarity. The following alternatives will be considered:

BC-1	complete backfill by transfer mining or waste rock relocation, including waste rock segregation and construction of a simple vegetated thin layer soil cover of 30 cm thickness
BC-2	complete backfill by transfer mining or waste rock relocation, without waste rock segregation, construction of a vegetated soil cover acting as an oxygen barrier, consisting of 10 cm topsoil, 80-140 cm subsoil, and 30-40 cm compacted clayey layer
BP-1d	partial backfill by transfer mining or waste rock relocation, including waste rock segregation, construction of a simple thin layer soil cover of 30 cm thickness, ensuring free drainage
BP-1w	partial backfill by transfer mining or waste rock relocation, including waste rock segregation, construction of a simple thin layer soil cover of 30 cm thickness, including the implementation of a pond or wetland on top of the backfill
BP-2d	partial backfill by transfer mining or waste rock relocation, without waste rock segregation, construction of a vegetated soil cover acting as an oxygen barrier, consisting of 10 cm topsoil, 80-140 cm subsoil, and 30-40 cm compacted clayey layer, ensuring free surface runoff
BP-2w	partial backfill by transfer mining or waste rock relocation, without waste rock segregation, construction of a vegetated soil cover acting as an oxygen barrier, consisting of 10 cm topsoil, 80-140 cm subsoil, and 30-40 cm compacted clayey layer, implementation of a pond or wetland on top of the backfill
F	no backfill, mine flooding, leading to the development of a pit lake

For the Jig pit option BC-1 has been chosen as the preferred variant. The Jig Pit will be completely backfilled under a waste rock segregation scheme, covered and revegetated. It will blend almost perfectly into the surrounding landscape and will probably hardly be visible as mining heritage at all. This option includes the highest passive security in terms of ARD prevention and also induces the lowest efforts for after-care. After-uses are the same as for the surrounding landscape.

Alternative BC-2 is not preferred, for the following reasons:

- this alternative is more costly compared to BC-1 due to the thicker cover construction, and
- segregation of waste material according to its acid generation potential (BC-1) is BATv, is environmentally advantageous and saves effort in mine closure with respect to the management of ARD.

The remaining alternatives (BP-1d to BP-2 w and F) are not preferred, since complete backfill is the most advantageous option, as long as it is possible as a transfer mining operation.

For the **Orlea and Cîrnic pits** option BP-1d has been chosen as the preferred remediation option which means partial backfilling and creation of a free draining surface that will require minimal after-care, in line with BAT. Surface water flowing from the area will either be intercepted in the Cetate dam for treatment as appropriate or discharged to the environment if quality is satisfactory. Any water seeping through the cover will be captured by the underlying mine workings and also led to the Cetate dam.

The BP-1w option, including wetlands creation was not selected. Wetlands forming on top of a partially backfilled pit have been successfully used for ARD neutralisation in backfilled open pits. However, the Roşia Montană pits are relatively exposed in position and have a small catchment so that it is likely any ponds and wetland would dry out completely for long periods. This option does not appear practicable at this stage, however, this approach may be re-examined and trialled during operations.

The BP-2w variant is not the preferred option since it leads to higher implementation costs and does not include segregation of waste material according to its acid generation potential (see discussion above).

Option F has been excluded as a preferred option, since the backfilling options are more advantageous, as long as they are based on a transfer mining operation.

Complete backfill options (BC-1 and BC-2) would need further backfilling of waste rock from the waste dumps. However, the pit walls are very steep so that large amounts of waste material would be required to create a geotechnically stable landscape form, leading to excessive costs. This much material is not available in the material balance of the transfer mining concept, so that waste rock material would have to be handled twice. The disadvantages of backfilling the Orlea and Cîrnic pits further than is foreseen in the mine plan are, in principle as follows:

- Noise, air quality: If material has to be handled twice (which would be necessary in case of further backfilling the Orlea and Cîrnic pits, there would be additional noise and an additional negative impact on air quality during the hauling of material.
- Cost: Backfilling the Orlea and Cîrnic pits would incur considerable extra cost due to double-handling waste material.

For the **Cetate pit** option F offers an opportunity to create a unique landscape with a pit lake, new ecological habitats, recreational and cultural opportunities. According to the hydraulic model of the pits, the water table in the Cetate pit will rise to a final level of between 715 and 745 m a.s.l. With the lake bottom at 650 m a.s.l., the lake will have a depth of 65-95 meters. Due to the natural mineralogical conditions at the site, there is some potential that water with low pH and elevated metal content may be generated by the pit walls. Non-neutral pond water and elevated mineralization provide ecological niches for plants and animals with particular requirements. Water management must carefully be planned so that the water quality does not pose any hazard. Based on the after-use scenarios which are currently envisaged, vegetated pit walls are the preferred option, using hydroseeding or climbing plants.

Numerous scientific and industrial activities and the attention of governments and the mining industry are devoted to the sustainable management of pit lakes, and both established methods and scientific progress will provide a site-specific solution to the management of the Cetate pit lake. Pit lake water management includes in-pit treatment by lime addition which has proved a successful option provided that the generation and inflow of low-pH water can be minimized. This is achieved by fast flooding after the end of active mining, stabilising the pit walls, and preventing oxidation of the sulphide-rich portions of the pit walls (see Mine Rehabilitation and Closure Management Plan.)

Alternatively, the Cetate pit can be backfilled using waste rock from the waste dumps (options BC and BP). This would have the following advantages:

- Generation of low-pH runoff from sulphide-rich parts of the pit walls would be further reduced.
- Reduced risk of unregulated landfill in the pit ("fly tipping").
- Backfilling takes 2-4 years after which closure is completed, whereas creation of the pit lake will take 5-30 years, depending on the final lake level.

However, there are numerous disadvantages in backfilling the Cetate pit:

- Landscape: From the point of view of a diversified landscape and the availability of protected habitats, given that all other pits in the project footprint have been fully or partially backfilled, a lake is clearly preferable.
- Biodiversity: backfilling of the Cetate pit would remove the opportunity to create habitats that are scarce in this area, i.e. cliff walls (suitable for nesting raptors, for example) and pit lake to support aquatic fauna and flora;
- Noise, air quality: If the Cetate pond were backfilled, there would be additional noise and an additional negative impact on air quality during the hauling of material.
- Cost: Backfilling the Cetate pit would incur additional cost of the order of 100 million US$. This is an order of magnitude more than the cost estimated for long-term pit water management.
- Inter-dependence with other closure and remediation activities: The open Cetate pit serves as a reservoir for TMF free water which is removed from the impoundment area within a short time in order to start consolidation and covering of the TMF in the shortest possible way. Backfilling of the Cetate pit would bar this option, unless extra water treatment capacity is installed.
- Loss of mineable reserves: Backfilling of the pit would complicate the recovery of reserves which could become viable in the future.

Conclusions

Selection of a preferred option for pit closure requires a considered evaluation of economic, technical and environmental issues. The selected option is preferred because of its optimum balance of these factors. Table 5-32 summarises the assessment of impact on a comparative basis, of the options discussed above

Table 5-32. Impacts of Alternative Pit Closure Options compared to Selected Option

Environmental Issues	Closure of open pit operations Options			
	Option 1 BC-1/BC-2	Option 2 BP-1d/BP-2d	Option 3 BP-1w/BP-2w	Option 4 F
	Selected option for Jig pit (BC-1)	Selected option for Orlea and Cîrnic pits (BP-1d)		Selected option for Cetate pit
Water flows and quality	Average seepage water flow rate about 200-250 mm/a (BC-1) or lower (BC-2), pit wall reactions excluded; water quality benign due to waste rock segregation and minimization of oxygen ingress (BC-2)	Average seepage water flow rate about 200-250 mm/a (BP-1d) or lower (BP-2d), free drainage; water quality benign due to waste rock segregation and minimization of oxygen ingress (BP-2d); partially exposed pit walls may lead to ARD-influenced surface waters	Average seepage water flow rate about higher than under option 2, water quality benign due to waste rock segregation and minimization of oxygen ingress (BC-2); partially exposed pit walls may lead to ARD-influenced surface waters, temporary ponding/ wetland formation on top of backfill	Pit lake formation, exposed pit walls may lead to ARD-influenced surface waters, mitigation measures are a hand
Air quality	No significance			
Noise and vibration	No significant difference between the options since final landforms are a direct result of the (transfer) mining operation, no additional handling of waste rock, minor differences due to cover construction activities under options 1 - 3			
Soil	Land take for open will completely be offset, final landscape can be restored to a quasi-pre-mining situation	Land take for open pit will partly remain over the long term, cover construction and revegetation will mitigate this		Land take for open pit will remain over the long term, pit lake replaces former terrestric
Biodiversity	Opportunity to design/ develop terrestrial habitats to a quasi-pre-mining situation	Opportunity to design/ develop varied terrestrial habitats, cliff walls support special flora and fauna	Opportunity to enhance biodiversity by designing/ developing terrestrial-semiaquatic habitats, cliff walls support special flora and fauna	Opportunity to develop an aquatic habitat which is scarce in the area to support aquatic fauna and flora, and fauna bound to steep cliff walls
Landscape	Post-mining close to pre-mining landscape	Diversified post-mining landscape with a variety of terrestrial landforms	Diversified post-mining landscape with a variety of terrestrial and semiaquatic landforms	Pit lake diversifies post-mining landscape
Socio-economic issues	No significant difference between the options			
Cultural heritage	No significance			
Transportation issues	No significant difference between the options since final landforms are a direct result of the (transfair) mining operation, no additional handling of waste rock, minor differences due to cover construction activities under options 1 - 3			
Transboundary impacts	No significance			

7.3 Tailings management facility – main embankment and impounded tailings

7.3.1 Closure Options

The possible closure alternatives for the TMF include the following options:

IS-D1	“dry” in-situ remediation which includes removal of all technical facilities, freewater replacement, (partial) technical dewatering of the tailings, reshaping of the TMF’s inner and outer contour and placement of a thin layer soil cover of 30-50 cm thickness on top of the tailings surface
IS-D2	“dry” in-situ remediation which includes removal of all technical facilities, freewater replacement, (partial) technical dewatering of the tailings, reshaping of the TMF’s inner and outer contour and placement of a vegetated soil cover acting as an oxygen barrier, consisting of 10 cm topsoil, 80-140 cm subsoil, and 30-40 cm compacted clayey layer
IS-W	“wet” remediation option, the TMF would be stabilized under maintenance of the freewater cover of the decant pond, whereas the beaches and the dam must be covered according to options IS D1 or IS D2
R	"relocation" option, i.e. removing the tailings and storing them in another, safe place.

7.3.2 Preferred remediation option

The preferred remediation option for the TMF is option IS D2. This option includes the construction of a surface water discharge channel along the north side of the tailings impoundment after cessation of ore processing. The discharge channel will be used once the cover system is installed so that clean surface water can be discharged from the tailings impoundment's final closure configuration to a point downstream of the TMF embankment (see *Mine Rehabilitation and Closure Management Plan)*. Installation of the surface water channel will also minimize infiltration through the cover system and into the tailings. The final form of the tailings impoundment with the discharge channel will be configured in such a manner that it will accommodate the runoff from the Probable Maximum Precipitation (PMP) event in order to ensure that the embankment will not be overtopped.

A soil cover will be placed over the tailings basin which will act as an efficient oxygen barrier to prevent ARD generation. This option has been chosen as the preferred solution since it is BAT to *prevent* acidification of tailings in the first place and only then to manage (treat) any ARD. Initially, acidification will not be an issue, but with decreasing pore water level in the tailings body during closure, it may become a problem, as the geochemical analyses of the tailings material indicate. If oxygen diffusion is effectively suppressed, acidification can be prevented. Therefore design principles are applied which primarily aim at the control of oxygen ingress after closure (for details see *Mine Rehabilitation and Closure Management Plan)*. The cover design will include:

- 10 cm topsoil
- 80-140 cm subsoil of clayey silt
- 30-40 cm subsoil of compacted clayey silt as an oxygen barrier.

The soil cover will consist of locally available soil. Test cover sections will be constructed at the site to verify cover section performance and finalise its design (see *Mine Rehabilitation* *and Closure Management Plan)*. In areas where the fine-grained tailings may be too soft to support a soil cover, geotextile will be placed on top of the tailings prior to soil cover placement. If needed, a geogrid will be applied in addition to the geotextile to improve stability of the tailings surface for heavy machinery. Once a soil and vegetative cover has been established there will be limited need for long-term maintenance and inspection.

7.3.3 Discussion of alternatives

Option **IS-D1** cannot be chosen as a the preferred remediation option, since a simple thin layer cover may allow oxygen ingress which in turn could lead to ARD-generation under the site specific conditions. Alternative IS D1 is therefore not in compliance with BAT, which calls for ARD-prevention. For further discussion on the cover design and performance see *Mine Rehabilitation and Closure Management Plan.*

Alternative IS-W includes a wet cover with a decant system or spillway channel; this alternative would involve flooding the surface of the tailings impoundment. The wet cover would remove the potential for dust generation and also limit oxygen ingress into the tailings, which would minimise ARD generation. However, this is not the preferred alternative because during dry years, the surface of the tailings may be exposed and generate dust and acid rock drainage. In addition, there is the risk that the dam may be overtopped during extreme precipitation conditions. Furthermore, under this closure method, the tailings would remain saturated and would be inherently less stable than the drained tailings deposits of the dry closure option. This increase the burden of after-care and as such, would not be a BAT solution.

The **R-alternative** which means relocation of tailings to another safer place is considered to be appropriate only under a clear set of boundary conditions:

- Tailings relocation as a relevant alternative is usually restricted to closure projects of the “intervention” type, where the remediation goal defined cannot be achieved using an alternative in-situ-stabilization option. Under such circumstances relocation may be the only appropriate alternative.
- A suitable disposal site is available which offers enough volume to store the wastes to be relocated. In order to minimize the consumption of land, the new disposal site should not be virgin but should already contain wastes of some sort which need to be remediated in any case.
- If the relocation is one of other possible options, cost-benefit-considerations have to be performed. In such cases, relocation can prove to be the best available option if the following apply:
    - the amount of waste to be transported is small, and the ratio of waste volume to contaminated area is also small,
    - the distance between the waste object and the disposal site is not too high, typically less than 10 km; and
    - the technical and infrastructural pre-conditions for a relocation are more or less fulfilled, i.e. relocation does not cause very high extra costs which are connected with the remediation measure itself (e.g. for road construction).

None of these pre-conditions are fulfilled for the Roşia Montană Project, so the relocation option is not BAT and is not considered further.

7.3.4 Conclusions

Analysis of potential options for TMF closure indicates that the selected dry closure option is the only approach that can be demonstrated to be BAT. A comparative evaluation of environmental impact between the options discussed above is therefore not warranted.

7.4 Waste Rock Stockpiles

7.4.1 Closure Options

In terms of the overall closure strategy it is the preferred solution to partially use the waste rock for progressive restoration as pit backfill. Under this overall plan, waste rock from the initial phases of mining will either be used for construction or placed in stockpiles. However, as soon as the void space is available as successive open pits are exhausted, waste rock will be excavated from the active pit and backfilled directly to the completed open pits (transfer mining). The material will be segregated, regraded and covered. In this section, only the closure alternatives for the remaining waste rock, which will not be used in construction or to directly backfill open pit operations and which therefore must be stored in the Cetate and Cîrnic dumps, will be discussed. The alternatives options for storage of this rock include the following:

IS-1	in-situ stabilization, based on a waste rock dump construction scheme including waste rock segregation, regrading the stockpiles to a 2.5H:1V slope and construction of a simple vegetated thin layer soil cover of 30 cm thickness;
IS-2	in-situ stabilization, without waste rock segregation, involving regrading the stockpiles to a 2.5H:1V slope, construction of a vegetated soil cover acting as an oxygen barrier, consisting of 10 cm topsoil, 80-140 cm subsoil, and 30-40 cm compacted clayey barrier;
R	"relocation" option, i.e. removing the waste rock and storing it in another, safe place.

7.4.2 Preferred remediation option

The preferred remediation option for the Cîrnic and Cetate waste rock stockpiles is option IS-1. Due to RMGC's operational segregation strategy involving the stack-dumping of large parts of PAG waste rock and the selective covering of end-dumped PAG material, seepage from the waste rock stockpiles is forecast to be benign. The design criteria therefore call for a simple waste rock stockpile cover only. The design criteria for this cover type to ensure safety and physical and biological stability are as follows:

- prevention of inadvertent access to the waste rock;
- support of vegetation;
- improvement of visual appearance;
- prevention of dust blow from the stockpiles;
- erosion control.

The minimum thickness for achieving the design criteria for NAG material is 30 cm, consisting of 10 cm topsoil and 20 cm subsoil of clayey silt.

If PAG material must be end-dumped separately without encapsulation by NAG material, the design criteria additionally include the following:

- minimization of water infiltration into the wastes;
- minimization of oxygen entry to the wastes.

To achieve these additional design criteria, the cover must be significantly thicker, and possess sufficient long-term stability of its hydraulic and gas transport properties.

7.4.3 Discussion of alternatives

Alternative **IS-2** does not foresee PAG/NAG segregation, and therefore needs a cover which acts as an oxygen and infiltration barrier. This option is not preferred, for the following reasons:

- this alternative is more costly compared to IS-1 due to the thicker cover construction; and,
- segregation of waste material according to its acid generation potential (IS-1) is BAT, is environmentally advantageous and saves effort in mine closure with respect to the management of ARD.

Alternative **R** provides for relocation of the waste rock to a secondary disposal area, which could be Orlea, Cetate or Cîrnic open pits, or the TMF. It has already been noted above that relocation leads to significant extra costs which are not compensated by the sufficient environmental benefits. Therefore a waste rock relocation strategy, which would mean double handling of the material, cannot be considered to be BAT and a viable alternative.

7.4.4 Conclusions

The selected alternative is the only option for waste rock stockpiling that can be considered BAT for application at Roşia Montană and comparative environmental assessment of the options discussed here is not justified.