Go/No-Go Risk of Catastrophic Consequence (Preliminary Assessment)

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Executive Summary

One of the tools that a number of companies in the mining industry have been applying is a "screen' in the past decade – screening for the risks of acid rock drainage at potential mine developments. The primary driver for most analyses done by companies is economics – how to maximize return on investment. The paper begins by looking at the screening procedure used by one mining company, Rio Tinto, which published a version of its screening criteria in 2011.

The paper then proposes utilizing a new set of criteria based on an assessment of likely potential catastrophic flaws to provide an initial Go/No-Go environmental evaluation of mining projects. The Go/No-Go criteria developed are used to evaluate a proposed mining development from a public agency perspective. These criteria are developed on the same framework as that utilized by the mining industry to evaluate its risk of developing potential mining projects with the potential for acid rock drainage, but the focus of the Go/No-Go criteria is on how a public agency might apply this same sort of screening procedure to potential mine developments in its jurisdiction.

A public body has responsibilities that are more diverse than a mining company. In addition to providing an economic return to society for the extraction of a non-renewable resource, a public agency must also weigh the costs of mining on competing economic values (fishing, recreation, agriculture, water supply, etc.), and the more difficult-to-quantify economic values (wildlife, wilderness, public health, clean environment, etc.) that are often viewed as non-quantifiable, but are nonetheless public responsibilities.

Each Go/No-Go criterion is associated with the risk for a potential 'catastrophic' outcome (possible, not necessarily probable), related to the development of a particular orebody, and a particular mine-type. For the purposes of these criteria, a catastrophe is loosely defined as an event that could produce a significant impact to many people, or the environment, that a company or the government would most probably not be able to mitigate. Catastrophic failures are based on fact – real catastrophes that have occurred in similar mine-development scenarios (i.e. similar ore types, potential mine types, waste storage failures, etc.). The values assigned to criteria are based on the historical performance of similar developments, which pose potential significant risk to public economic and difficult-to-quantify economic values.

A case study approach has been employed to test the application of both the Rio Tinto models for predicting risk for acid metaliferous drainage, and the Go/No-Go criteria, in order to get a comparison of the different criteria being applied to the same case study mineral deposit.

The case study that will be used is Bald Mountain, a massive sulfide copper deposit in north-central Maine. The Bald Mountain deposit consists of two types of ore, a gold bearing gossan zone overlying a copper and zinc bearing massive sulfide zone. In 1990 the first mine proposal was for an open pit mine to recover the gold, copper and zinc ores. In 1997 a second, smaller open pit mine was proposed to mine just the gossan ore.

Tables in the Appendices document the evaluation using the criteria from Rio Tinto and the Go/No-Go assessment for both the 1997 mining proposal for gossan ore (Small Gossan Open Pit Gold), and the 1990 evaluation of an open pit mine to take both the gossan and the massive sulfide (Large Open Pit Massive Sulfide Copper).

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The Rio Tinto model provides an evaluation at two levels in the pre-mine process. The first level can be performed at relatively early stage of exploration by the project staff, and is called a Preliminary Assessment. This assessment is based on early drill data and geochemical test results. The second level, at what would be late-stage exploration, is called a Detailed Assessment. At the Detailed Assessment stage there is detailed drill information, geochemical testing, as well as the implementation of mitigation measures in the preliminary mine design. The Detailed Assessment is performed by technical experts.

The Go/No-Go criteria are meant to flexible enough to use at a preliminary stage of exploration, like the Rio Tinto Rio Tinto Preliminary Assessment, but also be adaptable enough to use advanced exploration information like acid metaliferous drainage predictive modeling, static and kinetic testing results, and preliminary mine plans, if those are available to inform the process.

The information/data would be incomplete by today's standards, but the amount of information on the potential waste and the mine proposals made by the two companies give enough information to apply both Rio Tinto's Preliminary and Detailed Assessments, and the Go/No-Go Risk of Catastrophic Consequence model.

For Rio Tinto's Preliminary Assessment evaluation, the Large Open Pit Massive Sulfide Copper project has a "Very High" hazard risk rating, and the Small Gossan Open Pit Gold project yields a "High" hazard risk rating.

For Rio Tinto's Detailed Assessment evaluation, the Large Open Pit Massive Sulfide Copper project has a "Very High" hazard risk rating, and the Small Gossan Open Pit Gold project also yields a "Very High" hazard risk rating.

For the Go/No-Go Risk of Catastrophic Consequence model, the Large Open Pit Massive Sulfide Copper project has a "Very High" hazard risk rating, and the Small Gossan Open Pit Gold project yields a "High" hazard risk rating.

All three models utilize the same hazard ranking developed for the Rio Tinto assessments. The Rio Tinto hazard ranking was developed with the assistance of an independent panel of mining experts, and was 'calibrated' against a number of well-known mines.

The "Go/No-Go" criteria developed for this paper are similar, but still different, in objective to that developed in Rio Tinto's Preliminary and Detailed Assessments – predicting potential issues that could impact water quality. Rio Tinto's models are aimed at evaluating potential impacts from acid and metalliferous drainage. The "Go/No-Go" criteria, concentrating on the area of expertise of this paper's author aims at a broader range of potential impacts and considerations that would be addressed in the review of a comprehensive mine plan. While the set of Go/No-Go criteria developed in this paper focuses on water quality, but does not address issues like hydrology, air quality, reclamation, wildlife, etc., this set of Go/No-Go criteria do allow a comparison between the Go/No-Go criteria and the Rio Tinto Assessments, and the results of that comparison are relatively good.

A significant potential limitation of the application of the Go/No-Go criteria might be the limitations of an agency to apply the result gained from the Go/No-Go process to 'guide' an applicant or mining proposal – something that could require both a legal backstop and political will.

These Go/No-Go criteria are admittedly a partial first step. That is, the criteria proposed in this paper are also focused mainly on environmental risk to water quality, when a full evaluation would also need to take other environmental risks (to habitat, wildlife, fisheries, etc.), as well as social and more traditional economic considerations.

Introduction

Among the many problems facing a company in the mining industry are competition from a global marketplace, hundreds of millions to billions of dollars of upfront investment required to open a new facility, rapid changes in the political and social climates of its operating facilities, and limited access to the locations where its resources are located. As a result these companies have developed a number of screens to apply to potential developments in order to both provide corporate stability and to maximize economic return on investment.

One of the tools that a number of companies in the mining industry have been applying is a new 'screen' in the past decade – screening for the risks of acid rock drainage at potential mine developments. If acid rock drainage becomes a significant issue at a mine, especially if water treatment is required after mine closure, the cost indemnifying for this treatment could easily run into the hundreds of millions of dollars. In addition, there is rising pressure from civil society to require regulatory agencies to deny permit applications for mines that will require post-closure water treatment because it the amount of money set aside to fund this treatment is insufficient,[2] then the public must either provide the funding (tax revenue) for treatment, or bear the environmental costs of not treating acid mine drainage.

Although there are a number of companies that have developed their own acid rock drainage screening procedures, most of these companies have been reluctant to publish these procedures, mostly in an attempt to maintain a competitive advantage by keeping these procedures proprietary.

The focus of this paper is on how a public agency might apply this same sort of screening procedure to potential mine developments in its jurisdiction. The screening process would have a somewhat different orientation than the screening procedure being applied by the mining industry. From the industry standpoint protecting economic returns and viability is the primary goal. A public body has responsibilities that are more diverse. Providing an economic return to society for the extraction of a non-renewable resource is an important driver of the screening process. But in addition, a public agency with land management responsibilities must also weigh the costs of mining on competing economic values (fishing, recreation, agriculture, water supply, etc.), and the more difficult-to-quantify economic values (wildlife, wilderness, public health, clean environment, etc.) that are often viewed as non-quantifiable, but are nonetheless public responsibilities.

If a number of the responsibilities of a public agency are non-quantifiable, then how can this agency develop a set of screening criteria that it can apply to a mining proposal? One approach would be to attempt to identify potential 'catastrophic' outcomes, based on the historical performance of similar developments, which pose potential significant risk to public economic and difficult-to-quantify economic values.

This paper proposes using a set of Go/No-Go criteria to evaluate a proposed mining development from a public agency perspective. These criteria are developed on the same framework as that utilized by the mining industry to evaluate its risk of developing potential mining projects with the potential for acid rock drainage.

These Go/No-Go criteria are admittedly a partial first step. That is, there are not only a number of different approaches that could be used in developing screening criteria like this, but the criteria proposed in this paper are also focused mainly on environmental risk to water quality, when a full evaluation would also need to take other environmental risks (to habitat, wildlife, fisheries, etc.), as well as social and more traditional economic considerations.

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[2] At present New Mexico and Michigan are the only states in the US that prohibit mines that would require perpetual water treatment.

The paper begins by looking at the screening procedure used by one mining company, Rio Tinto, which published a version of its screening criteria, then using a proposed mine as a case study to compare the Rio Tinto and Go/No-Go screening criteria.

Background

Go/No-Go criteria have been proposed and utilized in the land planning context for some time.[3] The application of these criteria result from land planning designations of country, regional, or local recognition of existing resources (parks, wildlife, water, recreation, etc.) that can be identified before any mining project is proposed.

An earlier paper proposed utilizing a set of criteria to provide an initial Go/No-Go environmental evaluation of mining projects to provide a timely assessment of likely potential catastrophic flaws.[4] This proposal takes the Go/No-Go criteria a step further. A fully informed initial evaluation of environmental risk needs information on the magnitude of potential environmental risk, and a preliminary model of how a mineral deposit might be developed. An evaluation at this level is best informed after an initial drilling program has been completed, in order to provide mineralogical samples to evaluate both mineral development potential and potential environmental risk. An initial drilling program might typically involve 2-5 years of exploration activity.

However, before the drilling program advances to the stage where the drilling program is providing in-fill information on the orebody (i.e. size, grade, and geotechnical data) there is enough information available to provide an initial Go/No-Go evaluation.

Rio Tinto Models

Rio Tinto Preliminary Assessment (Order of Magnitude/Exploration)

In 2011, Green and Borden of Rio Tinto (Australia) published a description of both a Preliminary and Detailed assessment of the "Geochemical Risk Assessment Process for Rio Tinto's Pilbara Iron Ore Mines."[5] Although the risk of acid rock drainage is generally thought to be related to metal sulfide deposits, iron mines (generally iron oxide deposits) also face this same problem due to mining of overburden and waste rock that may contain sulfide mineralization. Iron sulfides are not only the most common sulfide minerals, but they are also the most common source of acid that starts the acid rock drainage/metals leaching contamination cycle.

In their paper Green and Borden describe a four-step process used by Rio Tinto to evaluate the risks associated with Acid and Metalliferous Drainage (AMD – not to be confused with, but related to, Acid Mine Drainage). The first stage of the process is to provide a preliminary assessment of AMD risk, "During the order of magnitude or exploration phase of a mining project …"[6]

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[3] Miranda et al. (2003: 46–47); FOE-I (2002); Dudley and Stolton (2002: 9, 12)
[4] Chambers (2014)
[5] Green and Borden, Rio Tinto (2011)
[6] Green and Borden, Rio Tinto (2011), p 371

This is accomplished by calculating a "Preliminary AMD Hazard Score" based on the following factors:[7]

Table 1: Rio Tinto Preliminary Assessment (Order of Magnitude/Exploration)

		Total
o Geology (45%)		
• Ore deposit type	30%	
• Host and country rock neutralisation potential	10%	
• Known ARD issues on site	5%	45%
o Incipient ARD Risk (5%)		
• Operational age	5%	5%
o Scale of Disturbance (25%)		
• Total waste stored on site	15%	
• Footprint of disturbed area	10%	25%
o Transportation pathways (10%)		
• Water availability	7%	
• Metal release to the environment	3%	10%
o Sensitivity of the receiving environment (15%)		
• Proximity to perennial/ephemeral water bodies	5%	
• Alkalinity of water body or groundwater	5%	
• Distance to closest protected/permanently inhabited area	5%	15%
		====
		100%

The data required to evaluate these criteria are all available at a relatively early stage of exploration. And even though these criteria were developed for an iron ore deposit, they apply equally as well to metal deposits.

Rio Tinto Detailed Assessment (Pre-Feasibility/Feasibility/Mining)

At a following stage Rio Tinto performs a technical AMD and geochemical risk assessment evaluation which would require data corresponding to that available at the exploration stage, and which would be required before beginning an environmental impact statement/assessment and/or mine preliminary feasibility study. For a mining company this is basically the point at which they are asking themselves whether it is worth the investment to move on to these relatively expensive stages of the mine development process.

The evaluation matrix utilized by Green and Borden for the Detailed Assessment gets corresponding more sophisticated, and involves not only more complex and expensive data collection, but a broader and more detailed analysis of the data to inform the ratings in the matrix.[8]

As with Rio Tinto's Preliminary Assessment, the criteria developed by Green and Borden apply equally to iron and other metal mines.

[7] Green and Borden, Rio Tinto (2011), p 371
[8] Green and Borden, Rio Tinto (2011), p 375-387

Table 2: Rio Tinto Detailed Assessment (Pre-Feasibility/Feasibility/Mining)

Item	**Possible Points**	**Total Points**
o Geochemical Hazard (Interrogate the drill hole database)		
• Waste sulfur risk		
□ Total number of waste samples with S>0.1% is less than 3%	0	
□ Total number of waste samples with S>0.1% is between 3% and 10%, less than 0.5% of samples have S>0.3%	2	
□ Total number of waste samples with S>0.1% is between 3% and 10%	7	
□ Total number of waste samples with S>0.1% is greater than 10%	10	10
• Ore grade sulfur risk		
□ Ore grade material will not be stockpiled	0	
□ Total number of ore grade samples with S>0.1% is less than 3%	0	
□ Total number of ore grade samples with S>0.1% is between 3% and 10% but less than 0.5% of the samples have S>0.3%	2	
□ Total number of ore grade samples with S>0.1% is between 3% and 10%	4	
□ Total number of ore grade samples with S>0.1% is greater than 10%	5	5
• Spatial distribution of sulfur		
□ Sulfur < 0.1%	0	
□ Sulfur scattered throughout the pit and through numerous lithologies	3	
□ Sulfur concentrated within one or two lithologies	5	5
• Chemical enrichment		
□ No enrichment of contaminants	0	
□ Enrichments of contaminants that are unlikely to mobilise into groundwater	1	
□ Enrichments of contaminants that are likely to mobile into groundwater	5	5
o Mine Planning Hazard		
• Potentially Acid Forming (PAF) material management		
□ No special waste management needed	0	
□ PAF waste dumps will be in-pit	2	
□ PAF waste dumps will be in pit and out of pit	4	
□ PAF waste dumps will be out of pit	5	5
• Bulk neutralisation potential ratio of entire rock mass to be disturbed or exposed		
□ <1	5	
□ 1 to 3	3	
□ >3	0	5
• Potentially Acid Forming (PAF) rock mass disturbed or exposed		
□ < 3% of the total disturbed mass	0	
□ 3 to 10% of the total disturbed mass	5	
□ > 10% of the total disturbed mass	10	10
o Water Management Hazard		
• Pit backfilling		
□ Pit will not be backfilled	5	
□ Pit will be backfilled below the post mining water table	4	
□ Pit will be backfilled to above the post mining water table but below ground surface	2	
□ Waste will be used to cover PAF exposures	2	
□ Pit will be backfilled to ground level	0	5
• Water discharge		
□ No releases of water	0	
□ 0 to 80 ML (21.3 M gallons)/day	1	
□ 80-160 ML (21.3- 42.3 M gallons)/day	2	
□ > 160 ML (42.3 M gallons)/day	3	3
• Surface water management		
□ Isolated pit	0	
□ Catchment area above the pit	5	
□ Creek flow	7	7
• Water treatment during operation		
□ No water treatment or special management for AMD needed	0	
□ Water treatment or special water management may be needed during operation	3	
□ Water treatment or special water management will be needed during operation	5	5
• Final void management		
□ No PAF rock exposures likely on final pit shell	0	
□ Less than 3% PAF exposed	2	
□ 3% to 10% PAF exposed	7	
□ Greater than 10% PAF exposed	10	10
		====
		75

Go/No-Go Criteria

The Go/No-Go criteria developed for this paper start with a different set of different hypotheses than those of Rio Tinto. The Rio Tinto criteria developed for the Preliminary and Detailed Assessments are aimed exclusively at Acid and Metalliferous Drainage, and ultimately at the potential impact of AMD on the economic cost of a mining project.

These hypotheses for the Go/No-Go criteria are oriented toward a public agency review of a potential mine, as opposed to a company review, of a potential mine proposal. From an agency perspective:

- A public agency would not have the ability to collect its own data, as would a private sector company.
- An agency has very limited control over the timing of a pre-development or development application that is submitted for review.
- An agency must give more weight to a much broader range of potential impacts to existing resources, and to future generations, than a company which is concerned primarily how these factors impact the economic bottom line of a project.
- An agency has a much more limited range of options in its ability to manage the direction of a prospective project. It has very limited authority to require that additional money be spent by the mining applicant, and it often has limited or no ability to deny a project at the early stages of a prospective project.

The Go/No-Go criteria start with the assumption that they are all based on risks that could potentially lead to a catastrophic situation. A catastrophic event is the potential event that might precipitate an agency veto of a mine permit application.

For the purposes of these criteria, a catastrophe is loosely defined as an event that could produce a significant impact to many people, or the environment, that a company or the government would most probably not be able to mitigate. Catastrophic failures are based on fact – real catastrophes that have occurred in similar mine-development scenarios (i.e. similar ore types, potential mine types, waste storage failures, etc.).

The relative risk of a potential catastrophe does not need to be high. That is, an event with a low probability of occurrence but with high impact effects must still be considered in the context of the potential impact.

The Go/No-Go criteria are meant to flexible enough to use at a preliminary stage of exploration, like the Rio Tinto Rio Tinto Preliminary Assessment, but also be adaptable enough to use advanced exploration information like AMD predictive modeling, static and kinetic testing results, and preliminary mine plans, if those are available to inform the process.

Table 3, below, lists the Go/No-Go Risk of Catastrophic Consequence (Preliminary Assessment) criteria. There are ten different criteria, with a maximum of 10 points assigned to each category, and with a maximum score of 100 points, as with the Rio Tinto assessments.

Fewer points mean less risk, so the lower a score, the lower the risk.

Table 3: Go/No-Go Risk of Catastrophic Consequence (Preliminary Assessment)

Go/No-Go Risk of Catastrophic Consequence Score	**Possible Points**	**Total Points**
o Hydrology - risk permanent damage to lakes, streams, or wetlands by:		
• Dewatering/Water table drawdown		
Is it is likely that mine dewatering will be required which would cause drawdown to the point where water levels would threaten springs, groundwater uses (e.g. drinking water wells), or stream flows that would jeopardize aquatic life?		
□ Little or no likelihood	0	
□ Moderate risk or not well-understood hydrology	5	
□ Likely or significant risk	10	10
• Contamination		
Is there a likelihood, related to orebody type, mine location, and mining method, that contamination from the minesite might exceed water quality standards for human health, aquatic life, or water quality standards for other designated water uses off the minesite?		
□ Underground mine, sulfide sulfur <0.3%, at least some CaCO3, no surface water within 2000 m	0	
□ Sulfide sulfur >0.3%, some CaCO3, no surface water within 2000 m	5	
□ Open pit mine, sulfide sulfur >0.3%, little or no CaCO3, surface water within 2000 m	10	10
o Geochemistry		
• Permanent water treatment predicted		
Will the amount and/or concentration of seepage water after mine closure require collection and active water treatment for the foreseeable future? If it cannot be demonstrated that a self-sustaining natural closure can be attained, then allowing mining would place an unreasonable risk on the public		
□ No post-closure water treatment required	0	
□ Passive post-closure water treatment required, no maintenance or replacement required	5	
□ Active post-closure water treatment likely	10	10
• Long term storage of acid generating/metals leaching waste in an oxidizing environment		
If potentially acid generating (PAG) and/or metals leaching (ML) waste, including tailings, waste rock, and mine workings, cannot be permanently placed in an environment where acid rock drainage and/or metals leaching can be permanently prevented, then it would not be safe to proceed with a mine.		
□ No PAG/ML predicted from tailings, waste rock, or mine workings	0	
□ Accepted technology to contain or mitigate PAG tailings, waste rock, or mine workings	5	
□ No accepted technology to contain or mitigate PAG tailings, waste rock, or mine workings	10	10
o Mine Tailings Disposal - tailings dam design, contaminants, and amount of tailings		
• Tailings Dam Seismic Risk		
Is it likely that a tailings dam can be engineered to withstand a Maximum Credible Earthquake (MCE) no farther than 10 kilometers from the dam site? Numerical modeling must be used to verify the seismic stability of the dam design. If a tailings dam location cannot located in a place that allows these design criteria to be implemented, then it would not be safe to proceed with a mine.		
□ Downstream dam construction, MCE < 10km, numerical modeling, < 10 Mtons non-acid generating tailings, double liner with leak detection	0	
□ Centerline dam construction, MCE < 10km, numerical modeling, > 10 Mtons non-acid generating tailings	5	
□ Upstream dam construction, did not use the MCE, pseudo-static modeling, > 100 Mtons acid generating tailings, no liner	10	10
• Tailings Dam Hydrologic Risk		
During mining operations a tailings impoundment must be able to hold the maximum probable flood (PMF) event, plus snowmelt (if any), and have adequate freeboard remaining to withstand wave action and storm surge at the same time. If a tailings dam location cannot located in a place that allows these design criteria to be implemented, then it would not be safe to proceed with a mine.		
□ Tailings impoundment and permanent water diversion structures engineered for PMF	0	

- □ Tailings impoundment engineered for PMF, permanent water diversion structures not engineered for PMF 5
- □ Tailings impoundment and permanent water diversion structures cannot be engineered for PMF 10 10

- o Waste dump design
  - Long term stability

    Can waste rock dumps be designed to withstand maximum credible earthquake and probable maximum precipitation events? If a waste rock dump location cannot positioned in a place that allows these design criteria to be implemented, then it would not be safe to proceed with a mine.

    - □ Waste dumps designed to withstand MCE < 10 Km, numerical modeling 0
    - □ Waste dumps designed to withstand MCE < 10 Km, pseudo-static modeling 5
    - □ Angle of repose waste dumps, static modeling 10 10
  - Waste dump cover design

    Will the waste rock dump(s) require a designed cover to shed water, minimize infiltration, and/or promote reclamation revegetation? If a waste rock dump location cannot positioned in a place that allows these design criteria to be implemented, then it would not be safe to proceed with a mine.

    - □ Top liner with drainage barrier, 3:1 < slopes, growth material of sufficient thickness to prevent root penetration 0
    - □ Evapo-transpiration cover, 2.5:1 slope 5
    - □ Waste dumps left in an as-is condition 10 10
  - Waste dump seepage collection

    All waste rock dumps that are predicted to have contaminants in the seepage should have passive seepage collection systems for the long term collection of seepage. If a waste rock dump location cannot be positioned in a place that allows this design criteria to be implemented, then it would not be safe to proceed with a mine.

    - □ Waste dump(s) are located where it is physically possible to collect seepage, and a passive seepage collection has been/will be engineered. 0
    - □ Waste dump(s) are located where it is possible to collect seepage, but there will be no engineered seepage collection system, or active pumping will be required. 5
    - □ Waste dump(s) are designed or located such that seepage collection is/cannot reasonably be expected to be accomplished 10 10
- o Reclamation
  - The costs of reclamation, closure, and all post-closure expenses must be conservatively calculated and placed in trust prior to these obligations are incurred by a mining operation.

    If the potential mine design suggests that the cost of reclamation would pose a financial burden that is significantly greater than that for similar mines, and would be difficult for the mine operator to meet, then it is unlikely that the mine could proceed.

    - □ A closure surety has been calculated, and it is reasonable that the amount can be provided by the company proposing the mine. 0
    - □ No closure surety has been calculated, but appears practicable that the amount estimated can be provided by the company proposing the mine. 5
    - □ The closure cost estimated/calculated does not appear to be an amount that is practicable for the company proposing the mine to provide. 10 10

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Go/No-Go Risk of Catastrophic Consequence Hazard Score (maximum) 100

Hazard Rankings from Green and Borden, Rio Tinto (2011), p. 387

- A score of 30 or less receives a Low Risk of Catastrophic Consequence hazard ranking. These sites are the least likely to have a significant Risk of Catastrophic Consequence.
- A score between 30 and 50 receives a Moderate hazard ranking. These sites are more likely to have a significant Risk of Catastrophic Consequence.
- A score of 51 to 65 receives a High Risk of Catastrophic Consequence hazard ranking.
- A score of 66 or higher receives a Very High ranking. High and Very High sites pose a significant environmental, financial and/or reputational Risk of Catastrophic Consequence.

** Note: For the Go/No-Go Risk of Catastrophic Consequence Hazard Rating has followed the low/moderate/high/very high rating values set by Rio Tinto for their AMD Hazard Score.*

Once a total score is determined by filling in the criteria matrix, a hazard ranking is assigned. Green and Borden of Rio Tinto used a hazard ranking that can be seen at the bottom of the Go/No-Go Risk of Catastrophic Consequence (Preliminary Assessment) table.

A score of 30 or less receives a Low Risk of Catastrophic Consequence hazard ranking. These sites are the least likely to have a significant Risk of Catastrophic Consequence. A score between 30 and 50 receives a Moderate hazard ranking. These sites are more likely to have a significant Risk of Catastrophic Consequence. A score of 51 to 65 receives a High Risk of Catastrophic Consequence hazard ranking. A score of 66 or higher receives a Very High ranking. High and Very High sites pose a significant environmental, financial and/or reputational Risk of Catastrophic Consequence.

In terms of using their hazard ranking, Green and Borden note:

> *"... because it is specific to iron ore deposits in the Pilbara region, the hazard score is conservative and is likely to over-estimate the risk when compared against porphyry copper or some coal deposits."*[9]

For comparison and standardization purposes, the Go/No-Go Risk of Catastrophic Consequence criteria use the same hazard ranking as that used by Rio Tinto. As noted above, Green and Borden clearly gave some consideration to their hazard ranking system being used in other mining situations, including copper sulfide mining.[10] They also consider their assumptions to be 'conservative' (quotation above), which is an appropriate approach for a public agency with multiple resource considerations.

Bald Mountain Case Study

In order to test the application of the Go/No-Go criteria, as with the Rio Tinto paper, a case study approach has been employed. In addition to testing the Go/No-Go criteria, the Rio Tinto Preliminary Assessment and Detailed Assessment criteria will also be applied in order to get a comparison of the different criteria being applied to the same case study mineral deposit.

The case study that will be used is Bald Mountain, a massive sulfide copper deposit in north-central Maine.

The Bald Mountain ore-body occurs on the west side of No-Name Ridge; a peak that rises from the surrounding valleys at an elevation of about 900 feet to a crest elevation of 1,500 ft. This peak is one of a chain that trends north-south through the project area. The chain is dissected by a series of valleys, the axes of which generally trend southwest on the west side of the chain and southeast or east on the other. Two valleys to the east of the mine peak have tend northwest to southeast. The orientation of the valleys along the chain of peaks reflects the underlying geology: a series of linear features, joints and faults or other geological discontinuities.[11]

The Bald Mountain deposit consists of two types of ore, a gold bearing gossan zone overlying a copper and zinc bearing massive sulfide zone. In the early 1990's the first mine proposal was for an open pit mine to recover the gold, copper and zinc ores. There is approximately 1.2 million tons of gold-bearing ore in the gossan zone. Following mining of the gossan zone, approximately 22 million tons of massive sulfide ore could be mined for copper and zinc, and some gold would also be recovered. Cyanide would probably be required in the gold extraction process and as a depressant in the copper and zinc flotation process.[12]

The overall waste to ore stripping ratio was estimated to be approximately 1.7:1, resulting in approximately 39 rnillion tons of mine rock. Acid generation, due to the natural oxidation of sulfide

[9] Green and Borden, Rio Tinto (2011), p 382
[10] Green and Borden, Rio Tinto (2011), pp 366, 382
[11] Paraphrased from SRK (1990a), p 3-1
[12] Paraphrased from SRK (1990a), p 2-1

minerals contained in the tailings, open pit walls and some of the mine rock, would need to be controlled during both the operating and post decommissioning period to prevent adjacent surface and groundwaters from being adversely affected.[13]

In the late 1990's a second, smaller open pit mine was proposed to mine just the gossan ore.[14] The wall rock from the open pit would be acid generating, and although the rock from the gossan itself would not be acid generating, there would be significant potential to leach arsenic from the gossan waste.

Although the information is dated, and would be incomplete by today's standards, the amount of information on the potential waste and the mine proposals made by the two companies give enough information to apply both Rio Tinto's Preliminary and Detailed Assessments, and the Go/No-Go Risk of Catastrophic Consequence model.

Tables in the Appendices document the evaluation using the criteria from both the 1997 mining proposal for gossan ore only (Small Gossan Open Pit Gold), and the 1990 evaluation of an open pit mine to take both the gossan and the massive sulfide (Large Open Pit Massive Sulfide Copper). The rationale for assigning a risk rating number is given alongside the rating, with reference to the document which contains the data/information on which the rating is based.

Bald Mountain / Rio Tinto Preliminary Assessment

The application of the Rio Tinto Preliminary Assessment criteria to the Bald Mountain 1990 and 1997 mine proposals can be seen in Appendix A: "Rio Tinto Preliminary Assessment of Bald Mountain, Maine (Order of Magnitude/Exploration)."

Criteria Rating Summary:

(1) Deposit Type (Appendix A – Page 1): This is a massive sulfide deposit with total sulfur greater than 10%. This is one of the worst types of deposits in terms of risk to water quality, and the Large Open Pit Massive Sulfide Copper project was given the maximum thirty out of a possible thirty (30/30) points.

On the other hand, the gossan-only mine has very little acid mine drainage potential, but there is a large amount of residual arsenic that can be easily mobilized when mined. The Small Gossan Open Pit Gold project was given 19/30 points.

(2) Neutralization potential (Appendix A – Page 1): The waste rock for both the Large and Small pits contains less than 5% calcium carbonate ($CaCO_3$), so both projects receive a maximum 10/10 points.

(3) Known AMD issues (Appendix A – Page 1): The Small project has both AMD and arsenic issues, and was assigned 4\5 points; the Large project is faced with more AMD and the same arsenic issues, and was give 5/5 points.

(4) AMD risk (Appendix A – Page 2): Both projects are 'new' and by the terms of the Rio Tinto criteria must receive the maximum 5/5 points.

(5) Total waste stored on site (Appendix A – Page 2): the Small Gossan Open Pit Gold project anticipates less than 50 M tonnes of waste, and was given 1/15 points.

The Large Open Pit Massive Sulfide Copper project would have slightly more than 50 M tonnes of waste, and received 5/15 points.

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[13] Paraphrased from SRK (1990a), Executive Summary, p vi

[14] Black Hawk Mining (1997)

(6) Project footprint (Appendix A – Page 2): both projects are less than 250 hectares in extent, and were assigned 1/10 points.

(7) Precipitation/evapotranspiration ratio (Appendix A – Page 2): The average ratio of precipitation to evaporation is greater than 1.5:1 (this area receives significant precipitation, and there is little evaporation for much of the year), so both projects receive the maximum 10/10 points.

(8) Proximity to surface water (Appendix A – Page 3): Bald Mountain Brook is near the pit location for both projects. The Small Gossan Open Pit Gold project would about 2,000 feet away, and received 3/5 points.

The Large Open Pit Massive Sulfide Copper project would have a tailings pond in the upper reaches of Bald Mountain Brook, so received 5/5 points.

(9) Groundwater alkalinity (Appendix A – Page 3): The groundwater alkalinity is 16 mg/L, so both projects receive 3/5 points.

(10) Distance to protected/inhabited area (Appendix A – Page 3): The ore body and appurtenant facilities are not in the proximity of protected or inhabited areas, so both projects receive 0/5 points.

The total score for the Small Gossan Open Pit Gold project is 56, which gives it a "High" Hazard Ranking according to the Hazard Rankings from Green and Borden (Appendix A – Page 4).

Similarly, the Large Open Pit Massive Sulfide Copper project has a total score of 74, and a "Very High" Hazard Rating.

Bald Mountain / Rio Tinto Detailed Assessment

There is not as much data on either project available as Rio Tinto had in its analysis of the iron ore mine in Australia, but there is more data than is required for the Rio Tinto Preliminary Assessment. There is sufficient data to make the Detailed Assessment, as is shown by the explanations and references in Appendix B: "Rio Tinto Detailed Assessment of the Bald Mountain, Maine, (Pre-Feasibility/Feasibility/Mining)."

The Rio Tinto Preliminary Assessment utilizes information on the geology and preliminary geochemistry of the deposit. The Rio Tinto Detailed Assessment relies on more detailed data on the geochemistry of the deposit, and information on the preliminary mine design. Even though the data from Bald Mountain is old, and the mine design preliminary, this information is sufficient to fit the requirements of the Detailed Assessment.

Criteria Rating Summary:

(1) Waste sulfur (Appendix B – Page 1): The waste rock for the Small Gossan Open Pit Gold project is just above the cutoff requirement for Sulfur (S) > 0.1%. The waste rock for the Large Open Pit Massive Sulfide Copper project runs 5% - 40% sulfide sulfur for most of the samples, which is the high end of the requirement scale. Both projects receive 10/10 points.

(2) Ore grade sulfur (Appendix B – Page 1): The ore of the Small Gossan Open Pit Gold project, like the waste rock, has S > 0.1%. The Large Open Pit Massive Sulfide Copper project is a massive sulfide deposit with S > 40%. Both deposits receive 5/5 points.

(3) Spatial distribution of sulfur (Appendix B – Page 1): For both projects the S > 0.1% and appears to be distributed through most of the waste rock in the pit and much of the wall rock. Both deposits receive 5/5 points.

(4) Contaminants (Appendix B – Page 2): There is a significant possibility of mobilizing arsenic in mining the gossan deposit (both projects), and the Large Open Pit Massive Sulfide Copper project

would mine a copper-zinc massive sulfide orebody high in pyrite and pyrrhotite, so mobilization of metals by acid formation is likely. Both deposits receive 5/5 points.

(5) PAF waste management (Appendix B – Page 2): Potentially Acid Forming (PAF – tailings and waste rock, mine wall rock, and tailings) waste rock would be placed in the mined out pit and submerged for the Small Gossan Open Pit Gold project. In the Large Open Pit Massive Sulfide Copper project waste rock would be deposited in the tailings impoundment, and the remainder backfilled into the pit, and submerged at mine closure. Both deposits receive 2/5 points.

(6) Bulk neutralization of entire rock mass (Appendix B – Page 2): The Net Neutralization Potentials (NNP) of all the rock in both projects, even the material from the gossan pit, have NNP < 1, so receive the maximum points for this category, 5/5.

(7) PAF rock exposed (Appendix B – Page 2): More than 10% of the total mass of rock disturbed (ore and waste) for both projects would be Potentially Acid Forming (PAF). Both deposits receive 10/10 points.

(8) Pit backfilling (Appendix B – Page 3): The pits in both projects would be backfilled and flooded, and they would overflow. These characteristics give them 4/5 points.

(9) Amount of water discharged (Appendix B – Page 3): It was estimated that for the Small Gossan Open Pit Gold project 58 gpm, or 85,500 gallons/day. For the Large Open Pit Massive Sulfide Copper project the discharge was estimated to be between 92-720 gpm. A discharge of 720 gpm is approximately 1 million gallons per day. This gives both projects 1/3 points.

(10) Surface water management (Appendix B – Page 3): For both the projects, the catchment area above the pits is estimated to be in excess of 200 acres. Since neither pit would intercept a stream, both deposits receive 5/7 points.

(11) Water treatment during operation (Appendix B – Page 3): Both projects would likely require water treatment both during operation and post-closure. As a result both deposits receive 5/5 points.

(12) PAF rock final management (Appendix B – Page 4): For the Small Gossan Open Pit Gold project acid producing waste rock will be placed against the footwall rock slope of the mine pit, buried in a layer of till, and submerged at closure. For the Large Open Pit Massive Sulfide Copper project pit wall rock not submerged will be covered with hanging wall rock and till. Both deposits receive 0/10 points.

The Detailed Assessment score for both the Small Gossan Open Pit Gold project and Large Open Pit Massive Sulfide Copper project is 57.

Rio Tinto then calculates a Combined Hazard Score for both the Preliminary and Detailed Assessments. The Combined Hazard Score gives more weight to the Detailed Assessment, which is logical since the amount and quality of data and information available at the Detailed Assessment level is much greater than that of the earlier Preliminary Assessment. Green and Borden did not explain how they weighted the Preliminary Assessment Score in calculating the Combined Hazard score, but it appears they have given it a 25% weight compared to the Detailed Assessment score in the Combines Hazard Score, so that is what has been assumed here.

The Combined Hazard Score for the Small Gossan Open Pit Gold project is 71. The Hazard Ranking associated with this is score is "Very High." (see Appendix B – Page 4)

The Combined Hazard Score for the Large Open Pit Massive Sulfide Copper project is 76. The Large Open Pit Massive Sulfide Copper project has a higher Combined Hazard Score because the Preliminary Assessment score for the Large Open Pit Massive Sulfide Copper project was higher than that for the

Small Gossan Open Pit Gold project. The Hazard Ranking associated with the score for the Large Open Pit Massive Sulfide Copper project is also “Very High.”

Go/No-Go Risk of Catastrophic Consequence

The application and references for the classifications made for the Go/No-Go Risk of Catastrophic Consequence criteria to the Bald Mountain site can be seen in Appendix C: “Go/No-Go Risk of Catastrophic Consequence of the Bald Mountain, Maine, (Preliminary Assessment).”

These criteria are focused on identifying the risk associated with potential catastrophic events (possible, not necessarily probable) associated with development of a particular orebody, and a particular mine-type. The values assigned to criteria are based on historical data about these orebodies and mine-types. The point values assigned, although based on real data, are admittedly subjective.

Criteria Rating Summary:

(1) Water table drawdown (Appendix C – Page 1):

Small Gossan Open Pit: No groundwater studies appear to have been performed in conjunction with the 1995 Black Hawk mining proposal. A DEP/LURC review of the 1997 Bald Mountain Project Application for Mining expressed concern that a drop in groundwater of up to 8 feet over 4 years could potentially occur, and could even be permanent, and have detrimental impacts to wetlands immediately contiguous with the mine site.[15] The hydrology of the deposit is not well defined, especially related to fracture systems in the pit area. The project was assigned 4/10 points.

Large Open Pit Massive Sulfide Copper: A number of investigators have indicated that the groundwater volumes removed by mining will be minimal, but some of these assumptions were questioned in a subsequent evaluation of the proposed large open pit mine.[17] There is concern that dewatering the pit may affect nearby wetlands,[18] and more detailed hydrologic information was requested. The hydrology of the deposit is not well defined, especially related to fracture systems in the pit area. The project was assigned 6/10 points.

(2) Likelihood of contaminants from orebody (Appendix C – Page 1): Both deposits have significant potential to leach arsenic from the gossan ore and waste, and the larger project would mine a massive sulfide orebody, which are known to be prolific acid producers. Both projects were given 9/10 points.

(3) Perpetual water treatment (Appendix C – Page 2): It is likely that active water treatment will be required post-closure for both projects, despite optimistic but unsupported predictions of passive treatment for the Small Gossan Open Pit Gold project. Both projects were given 10/10 points.

(4) Potentially Acid Forming waste in oxidizing environment (Appendix C – Page 2): The mine plan for the Small Gossan Open Pit Gold project predicts that seepage from the tailings and overflow from the flooded pit will have contaminant levels, and flows, low enough to allow land application of the effluent post-closure. Unfortunately this prediction is not substantiated by technical reports or data. In fact the existing data would tend to go against this assumption. Because there is existing technology that could possible address the contamination and flows from this project, it has been given 5/10 points – but it could easily be higher.

The Large Open Pit Massive Sulfide Copper project faces a more difficult situation in that the flows it must treat would be larger, and as a result land application of the effluent is not practical. The technology available was judged not to be able to treat this effluent to contaminant levels that

[15] Maine DEP/LURC (1998), p 6
[17] SRK (1990a), p. ix
[18] Maine DEP/LURC (1998), p 6

would be allowed for nearby surface waters. This was in 1990, and the available technologies are somewhat better today, but also corresponding more expensive, so the Large project is given 10/10 points.

(5) Tailings dam seismic risk (Appendix C – Page 3): For the Small Gossan Open Pit Gold project a landfill-type storage design was proposed. These landfills can be designed to relatively stable seismically, and the proposed facility would have a clay liner with internal drainage system, so should not contain/restrain saturated material which could flow into a nearby waterbody if the landfill failed. The Small Gossan Open Pit Gold project would have 1.2 million tons of tailings. No geotechnical analysis proposed for the landfill, no top barrier-liner, and was given 4/10 points.

The geomorphology of the Bald Mountain area for the Large Open Pit Massive Sulfide Copper project is such that a downstream dam could be constructed if desired/required, and the seismic risk is not high. A double liner was proposed for both the gossan and massive sulfide tailings, but most engineering companies today still use pseudo-static modeling for tailings dam seismic evaluations. The Large Open Pit Massive Sulfide Copper project was expected to generate about 1.2 million tons of gossan tailings, 22 million tons of massive sulfide tailings. This project was given 6/10 points.

(6) Tailings dam hydrologic risk (Appendix C – Page 4): Small Gossan Open Pit: There is only a preliminary discussion of protection of the tailings landfill for a probable maximum flood, but since it is above rather than in the floodplain, it should not be threatened. The design work for the diversions has not been done, and the hydrology of the area needs to be better understood.

There is sufficient room in the Bald Mountain area to construct a tailings dam and permanent diversion structures for the Large Open Pit Massive Sulfide Copper project facilities to withstand the probable maximum flood if desired/required. However, most engineering companies today design permanent water diversions for the 100-yr/24-hr event.

Both projects were given 5/10 points.

(7) Waste dump long term stability (Appendix C – Page 4): Potentially acid forming waste rock for the Small Gossan Open Pit project would be placed in the mined out pit and submerged.

Tailings and waste rock for the Large Open Pit Massive Sulfide Copper project would either be placed in the tailings pond or in the pit at closure, so the seismic risk rating is the same as for the tailings dam seismic risk rating.

Both projects were given 3/10 points.

(8) Waste dump cover design (Appendix C – Page 5): Large Open Pit Massive Sulfide Copper: PAG waste rock would either be placed in the tailings pond or in the pit at closure, with a water cover for the pit and marshland cover for the tailings ponds. The project was given 5/10 points.

Potentially acid forming waste rock for the Small Gossan Open Pit project would be placed in the mined out pit and submerged. Non-acid generating waste rock would be placed in the area of the topsoil stockpile for use during reclamation. Potential metals leaching issues with waste rock used in reclamation, and with metals leaching from waste rock permanently placed in topsoil stockpile area. The project was given 7/10 points.

(9) Waste dump seepage collection (Appendix C – Page 6): Potentially acid forming waste rock for the Large Open Pit Massive Sulfide Copper project would be placed in the pit at closure with a water cover, but fractures in the pit walls could provide pathways for contaminated water to leave the pit. Due to the potential issue with pit seepage and arsenic, this project was given 5/10 points.

Potentially acid forming waste rock for the Small Gossan Open Pit project would be placed in the mined out pit and submerged. Non-acid generating waste rock would be placed in the area of the topsoil stockpile. The Small Gossan Open Pit project would face the same issue as the Large Open Pit Massive Sulfide Copper project, but would also need to be concerned about unanticipated seepage issues with the non-acid generating waste rock. This project was given 7/10 points.

(10) Closure and post-closure financial surety (Appendix C – Page 6): Small Gossan Open Pit project expects final water quality of appropriate characteristics to allow land application. However, this projection is not supported by water quality predictions from existing reports. Land application for water from the small pit is not substantiated with appropriate water quantity and quality studies.

Water treatment after closure is likely for the Large Open Pit Massive Sulfide Copper project. Arsenic contamination through groundwater is a significant risk. There is also a risk that water treatment might not be effective enough to meet water quality standards.

Both projects were given 9/10 points.

The Go/No-Go Risk of Catastrophic Consequence score for the Small Gossan Open Pit Gold project is 63, and for the Large Open Pit Massive Sulfide Copper project is 68.

Hazard Ranking

The Go/No-Go Risk of Catastrophic Consequence utilizes the same hazard ranking developed for the Rio Tinto assessments. The advantage of using the Rio Tinto hazard ranking is that it was developed with the assistance of an independent panel of mining experts, and was 'calibrated' against a number of well-known mines.[19] The results for Bald Mountain can then be compared to those of Green and Borden.

The disadvantage is that when applying the hazard ranking to the Go/No-Go Risk of Catastrophic Consequence the criteria are similar, but still different, and to be accurate a hazard ranking should be independently developed for the Go/No-Go criteria. However, developing a new hazard ranking scale was beyond the scope of this paper.

Table 4: HAZARD RISK RANKING COMPARISON

	RTIO AMD Hazard Score			
Assessment Method	**Small Gossan Open Pit Gold Project**		**Large Open Pit Massive Sulfide Copper Project**	
Rio Tinto Preliminary Assessment (Order of Magnitude/Exploration)	56	High Risk	74	Very High Risk
Rio Tinto Combined Detailed & Preliminary Assessment (Pre-Feasibility/Feasibility/Mining)	71	Very High Risk	76	Very High Risk
Go/No-Go Risk of Catastrophic Consequence (Preliminary Assessment)	63	High Risk	68	Very High Risk

Hazard Rankings from Green and Borden, Rio Tinto (2011), p. 387

- A score of 30 or less receives a Low Risk of Catastrophic Consequence hazard ranking. These sites are the least likely to have a significant Risk of Catastrophic Consequence.
- A score between 30 and 50 receives a Moderate hazard ranking. These sites are more likely to have a significant Risk of Catastrophic Consequence.
- A score of 51 to 65 receives a High Risk of Catastrophic Consequence hazard ranking.
- A score of 66 or higher receives a Very High ranking. High and Very High sites pose a significant environmental, financial and/or reputational Risk of Catastrophic Consequence.

[19] Green and Borden, Rio Tinto (2011), p 371.

Table 4 offers a comparison of the two preliminary proposals for mine development at Bald Mountain, Maine, (Small and Large open pits) when analyzed by the three methods (Rio Tinto Preliminary & Detailed Assessments, and Go/No-Go Risk of Catastrophic Consequence).

The Large Open Pit Massive Sulfide Copper Project, c1990, rated Very High in all three analyses. The Small Gossan Open Pit Gold Project, c1997, rated High in the Rio Tinto Preliminary Analysis and the Go/No-Go analyses, and Very High in the Rio Tinto Detailed Assessment. This does show a degree of consistency between the results of the different analyses, and also fits with a basic understanding of the type of orebody being proposed for development (massive sulfide copper/zinc, with gold gossan), the climate in which development would occur (precipitation greater than evapotranspiration), and the associated hydrological/geochemical challenges (clean water trout streams with little buffering capacity, and nearby wetlands) – a combination which would suggest a high risk potential for the proposed open pit developments.

It is interesting to note that the Rio Tinto "Preliminary AMD Hazard Score," which is performed at what would be comparable to the initial exploration stage (the Rio Tinto properties evaluated were expansions of existing mines), results in "moderate" risk in the Green and Borden paper.[20] However, when the conducted the next stage evaluation, the Detailed Assessment, Green and Borden had not only significant additional technical information, comparable to that produced at the advanced exploration stage, but also the ability to incorporate modifications to the development proposal itself that mitigated some of the initial concerns. As a result, the "Detailed AMD Hazard Score" was assessed then assessed to be "Low" risk.[21] When Rio Tinto's Preliminary and Detailed Assessments were performed for Bald Mountain, there were no 'modifications' made to the mine proposals between assessments, and this probably led to similar/same evaluation results in the Preliminary and Detailed Assessments of Bald Mountain.

The issue of a potential underground development of the Bald Mountain orebody should also be mentioned. A combination of selective backfill combined with adit plugs could significantly lessen the potential for contaminated seepage both to surface and groundwater, and could also lessen, or perhaps even eliminate, the need for long term water treatment. However, this evaluating this approach would take a significant amount of engineering investigation, couples with the application of the latest technologies in water treatment and mine seepage prevention – a task that is beyond the purview of this paper.

[20] Green and Borden, Rio Tinto (2011), Fig. 4. Example of the use of preliminary AMD Hazard score to assess a site
[21] Green and Borden, Rio Tinto (2011), Fig. 7. Example of the use of the detailed AMD Hazard score to assess a site

Summary/Conclusions

A set of “Go/No-Go” criteria have been developed based on the assumptions that:

(1) there is possibility of potentially causing a catastrophic event if some critical aspect of the development went wrong;

(2) the technical information available to analyze a potential mining development will be limited, and will vary significantly in quality and quantity between potential deposits;

(3) these criteria might be used by a regulatory agency which will be limited in its ability to deny a permit for exploration or even development;

(4) the agency will not be able to dictate or even control the timing of an application for a permit that would force the evaluation envisioned in the Go/No-Go criteria; and,

(5) while a mining application is driven almost entirely by economic considerations, the agency’s mandate is driven by a broader range of considerations, some of which are difficult or impractical to quantify in economic terms.

The “Go/No-Go” criteria developed for this paper are similar, but still different, in objective to that developed in Rio Tinto’s Preliminary and Detailed Assessments – predicting potential issues that could impact water quality. Rio Tinto’s models are aimed at evaluating potential impacts from Acid and Metalliferous Drainage. The “Go/No-Go” criteria would ultimately be aimed at a broader range of potential impacts and considerations, but the criteria developed for this paper concentrate on the potential impacts to water quality, the area of expertise of this paper’s author. So while this makes the set of Go/No-Go criteria developed in this paper incomplete, it does allow a comparison between the Go/No-Go criteria and the Rio Tinto Assessments, and the results of that comparison are relatively good.

A significant potential limitation of the application of the Go/No-Go criteria might be the limitations of an agency to apply the result gained from the Go/No-Go process to ‘guide’ an applicant or mining proposal – something that could require both a legal backstop and political will.

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Appendix A

Rio Tinto
Preliminary Assessment
of the
Bald Mountain, Maine

(Order of Magnitude/Exploration)

Rio Tinto Preliminary Assessment (Order of Magnitude/Exploration)

Rio Tinto AMD Hazard Score	Possible Points	Bald Mountain Data	Bald Mtn Points
o Geology (45)			
• re deposit type (30)		Massive sulfide deposit high in pyrite and pyrrhotite. (SRK, 1992, Sections 3.6 and 3.7) Gossan deposit footwall material is acid generating. (Lorax, 1997, p. 3-7) High probability of arsenic contamination with any development of gossan: "... reductions in arsenic concentrations overtime can not be forecast." (Lorax, 1997, p. 4-1)	
• Formation by active surficial processes in equilibrium with the atmosphere.	*0**		
o Enriched formations, and/or channel and detrital ore bodies mined above water table only.	*7**		
o Enriched formations, and/or channel and detrital ore bodies mined below the water table.	*14**		
o Enriched formations mined below the water table.	*19**	Small Gossan Open Pit Gold: Gossan ore and waste rock ≈ 0.2% sulfur (SRK, 1992, Tables 4 & 5, pp. 11-12)	19
o Formation is directly associated with low-grade (< roughly 10 % total sulphur) acid generating sulphide mineralisation.	*23**		
o Formation is directly related to high-grade (> roughly 10% total sulphur) or very reactive acid generating sulphide mineralisation.	*30**	Large Open Pit Massive Sulfide Copper: Massive sulfide is ≈ 40% sulfur, with the primary minerals pyrite and pyrrhotite (SRK, 1990b, Table 2)	30
• Host and country rock neutralisation potential (10)			
o > 50% $CaCO_3$*	*0**		
o > 25% $CaCO_3$ to < 50% $CaCO_3$*	*3**		
o > 5% CaCo3 to < 25% $CaCO_3$*	*7**		
o < 5% $CaCO_3$	10	Both Scenarios - Large Open Pit Massive Sulfide Copper, Small Gossan Open Pit Gold: Gossan mine rock ≈ 1% $CaCO_3$ (SRK 1992, Table 5, p. 12); Large Open Pit Massive Sulfide Copper: wall rocks ≈ 1% $CaCO_3$ (SRK 1992: Table 9, p. 14; Table 12, p. 17; Table 16, p. 22)	10
• Known ARD issues on site (5)			
o No ARD and/or Metals Leaching issues likely on site*	*0**		
o Potential for ARD and/or Metals Leaching, but sufficient $CaCO_3$ neutralization available*	*3**	Small Gossan Open Pit Gold: Low sulfide content ore, but metals leaching of arsenic is likely	4
o Known ARD and/or Metals Leaching issues on site*	*5**	Large Open Pit Massive Sulfide Copper: Massive sulfide orebody with known arsenic in gossan.	5

Rio Tinto Preliminary Assessment (Order of Magnitude/Exploration)

Rio Tinto AMD Hazard Score	Possible Points	Bald Mountain Data	Bald Mtn Points
o Incipient ARD Risk (5)			
• Operational age			
o New operations or a significant change to an existing operation (such as the recent initiation of mining below the water table) will be assigned the highest score.	5	Both Scenarios - Large Open Pit Massive Sulfide Copper, Small Gossan Open Pit Gold: Both proposals are new operations	5
o Scale of Disturbance (25)			
• Total waste stored on site (15)			
o - less than 50 million tonnes*	*0**	Small Gossan Open Pit Gold: 1.2 million tons (Wardwell 1997a, p. ii)	1
o - 50-250 million tonnes	5	Large Open Pit Massive Sulfide Copper: 62.2 million tons (SRK 1990a, p. vi)	5
o - 250-1,000 million tonnes*	*10**		
o - greater than 250 million tonnes*	*15**		
• Footprint of disturbed area (10)			
o - less than 250 hectares (618 acres)*	*0**	Both Scenarios - Large Open Pit Massive Sulfide Copper: tailings (130 ac), pit (30 ac), mine plant (30 ac) (Wardwell, 1997b, pp. 5,7); Small Gossan Open Pit Gold: tailings (20 ac), pit (25 ac), mine plant (16 ac) (Wardwell, 1997b, pp. 5,7), soil/waste rock stockpiles (~10 ac) (estimate), land application area (211 ac) (Maine DEP/LURC, 1998, p. 2).	1
o - 250-1000 hectares (618 - 2471 acres)	*5**		
o - greater than 1000 hectares (2471 acres)*	*10**		
o Transportation pathways: Existing Operation /Exploration-Development (10)			
• Water availability/Metals Release to the Environment (7/10)			
Average local precipitation divided by areal potential evapotranspiration.			
o < 1/10 ratio: mining above the water table exclusively.	0/0		
o < 1/10 ratio: mining below the water table in an aquitard or an isolated aquifer.	1/2		
o < 1/10 ratio: mining below the water table in a rock mass that is connected to a regionally significant aquifer.	2/3		
o 1/10 to 1/3 ratio: mining above the water table exclusively.	1/2		
o 1/10 to 1/3 ratio: mining below the water table in an aquitard or an isolated local aquifer.	2/3		

Rio Tinto Preliminary Assessment (Order of Magnitude/Exploration)

Rio Tinto AMD Hazard Score	Possible Points	Bald Mountain Data	Bald Mtn Points
o 1/10 to 1/3 ratio: mining below the water table in a rock mass that is connected to a regionally significant aquifer.	3/5		
o 1/3 to 1/2 ratio	3/5		
o 1/2 to 1.5/1 ratio	6/8		
o > 1.5/1 ratio	7/10	Both Scenarios - Large Open Pit Massive Sulfide Copper, Small Gossan Open Pit Gold: Site precipitation is 39.4 in/yr, evaporation and evapotranspiration is 19.7 in/yr (SRK 1990a, Table 7-1, p. 7-5). Ratio precipitation/evaporation = 2:1	10
o Sensitivity of the receiving environment (15)			
• Proximity to perennial/ephemeral water bodies			
o >2000 metres (1.24 miles)	0		
o <500- 2000 metres (547 yards-1.24 miles)	*3**	Small Gossan Open Pit Gold: Distance from the pit to Bald Mountain Brook ≈ 2000 ft (Black Hawk Mining, 1997, Fig. 1.3)	3
o <500 metres (547 yards / 1641 ft)	*5**	Large Open Pit Massive Sulfide Copper: Tailings impoundment intercepts Bald Mountain Brook (SRK, 1990a, Figure 3.2)	5
• Alkalinity of water body or groundwater			
o >35 mg/L as CaCO3	0*		
o <0-35 mg/L as CaCO3*	*3**	Both Scenarios - Large Open Pit Massive Sulfide Copper, Small Gossan Open Pit Gold: Mean Alkalinity (mg/L as CaCO3) = 16 mg/L (SRK, 1990a, Table 3.5, p. 3-19)	3
o <0 mg/L as CaCO3*	*5**		
• Distance to closest protected/permanently inhabited area			
o <2000 metres (1.24 miles)*	*0**	Both Scenarios - Large Open Pit Massive Sulfide Copper, Small Gossan Open Pit Gold: No protected areas or habitations noted.	0
o <500-2000 metres (547 yards-1.24 miles)*	*3**		
o <500 metres (547 yards)*	*5**		
	=====		=====
RTIO AMD Hazard Score (maximum)	***100***	**Small Gossan Open Pit Gold:**	**56**
		Hazard Ranking:*	**High**
		Large Open Pit Massive Sulfide Copper:	**74**
		Hazard Ranking:*	**Very High**

Rio Tinto Preliminary Assessment (Order of Magnitude/Exploration)

Rio Tinto AMD Hazard Score	Possible Points	Bald Mountain Data	Bald Mtn Points
Hazard Rankings from Green and Borden, Rio Tinto (2011), p. 387			
- A score of 30 or less receives a Low Risk of Catastrophic Consequence hazard ranking. These sites are the least likely to have a significant Risk of Catastrophic Consequence.			
- A score between 30 and 50 receives a Moderate hazard ranking. These sites are more likely to have a significant Risk of Catastrophic Consequence.			
- A score of 51 to 65 receives a High Risk of Catastrophic Consequence hazard ranking.			
- A score of 66 or higher receives a Very High ranking. High and Very High sites pose a significant environmental, financial and/or reputational Risk of Catastrophic Consequence.			
* *Note: In this and other instances Green and Borden have not given a detailed account of how this category is broken down, they have only presented a single rating and value for the category. Based on the way they divided other categories, there have been some assumptions made about how to divide and assign values to these categories.*			

Appendix B

Rio Tinto

Detailed Assessment of the

Bald Mountain, Maine

(Pre-Feasibility/Feasibility/Mining)

Rio Tinto Detailed Assessment (Pre-Feasibility/Feasibility/Mining)

RTIO Detailed AMD Hazard Score	Possible Points	Bald Mountain Data	Bald Mtn Points
o Geochemical Hazard (Interrogate the drill hole database)			
• Waste sulfur risk			
□ Total number of waste samples with S>0.1% is less than 3%	0		
□ Total number of waste samples with S>0.1% is between 3% and 10%, less than 0.5% of samples have S>0.3%	2		
□ Total number of waste samples with S>0.1% is between 3% and 10%	7		
□ Total number of waste samples with S>0.1% is greater than 10%	10	Both Scenarios - Large Open Pit Massive Sulfide Copper, Small Gossan Open Pit Gold: Gossan ore and waste rock ≈ 0.2% sulfur (SRK, 1992, Tables 4 & 5, pp. 11-12), and assumes that supergene ore not mined; Large open pit massive sulfide is ≈ 40% sulfur, with the primary minerals pyrite and pyrrhotite (SRK, 1992, Tables 7,9,12,16, pp. 13,14,17, 22)	10
• Ore grade sulfur risk			
□ Ore grade material will not be stockpiled	0		
□ Total number of ore grade samples with S>0.1% is less than 3%	0		
□ Total number of ore grade samples with S>0.1% is between 3% and 10% but less than 0.5% of the samples have S>0.3%	2		
□ Total number of ore grade samples with S>0.1% is between 3% and 10%	4		
□ Total number of ore grade samples with S>0.1% is greater than 10%	5	Both Scenarios - Large Open Pit Massive Sulfide Copper, Small Gossan Open Pit Gold: Gossan ore and waste rock ≈ 0.2% sulfur (SRK, 1992, Table 4, p. 11), and assumes that supergene ore not mined; Large open pit massive sulfide is ≈ 40% sulfur, with the primary minerals pyrite and pyrrhotite (SRK, 1992, Table 8, p. 14)	5
• Spatial distribution of sulfur			
□ Sulfur < 0.1%	0		
□ Sulfur scattered throughout the pit and through numerous lithologies	3		
□ Sulfur concentrated within one or two lithologies	5	Both Scenarios - Large Open Pit Massive Sulfide Copper, Small Gossan Open Pit Gold: S > 0.1% and appears to be distributed through most of the waste rock in the pit and much of the wall rock. (SRK, 1992, Tables 4, 5, 7, 8, 9, 11, 12, 16, pp. 13, 14, 17, 22)	5

Rio Tinto Detailed Assessment (Pre-Feasibility/Feasibility/Mining)

RTIO Detailed AMD Hazard Score	Possible Points	Bald Mountain Data	Bald Mtn Points
• Chemical enrichment			
□ No enrichment of contaminants	0		
□ Enrichments of contaminants that are unlikely to mobilise into groundwater	1		
□ Enrichments of contaminants that are likely to mobile into groundwater	5	Both Scenarios - Large Open Pit Massive Sulfide Copper, Small Gossan Open Pit Gold: Gossan deposit footwall material is acid generating. (Lorax, 1997, p. 3-7) High probability of arsenic contamination with any development of gossan: "... reductions in arsenic concentrations overtime can not be forecast." (Lorax, 1997, p. 4-1); Massive sulfide deposit high in pyrite and pyrrhotite. (SRK, 1992, Sections 3.6 and 3.7)	5
o Mine Planning Hazard			
• Potentially Acid Forming (PAF) material management			
□ No special waste management needed	0		
□ PAF waste dumps will be in-pit	2	Both Scenarios - Large Open Pit Massive Sulfide Copper, Small Gossan Open Pit Gold: Small Pit - PAG waste rock would be placed in the mined out pit and submerged. (Black Hawk Mining, 1997, p. 90); Large Pit - Tailings and waste rock would be deposited in the tailings impoundment. (SRK, 1990a, p. 7-1)	2
□ PAF waste dumps will be in pit and out of pit	4		
□ PAF waste dumps will be out of pit	5		
• Bulk neutralisation potential ratio of entire rock mass to be disturbed or exposed			
□ <1	5	Both Scenarios - Large Open Pit Massive Sulfide Copper, Small Gossan Open Pit Gold: Gossan pit - all 3 gossan mine rock samples <1 (SRK 1992, Tables 4 & 5, pp. 11, 12); all 6 Massive Sulfide Copper pit wall rocks samples <1 (SRK 1992: Table 9, p. 14; Table 12, p. 17; Table 16, p. 22)	5
□ 1 to 3	3		
□ >3	0		
• Potentially Acid Forming (PAF) rock mass disturbed or exposed			
□ < 3% of the total disturbed mass	0		
□ 3 to 10% of the total disturbed mass	5		
□ > 10% of the total disturbed mass	10	Both Scenarios - Large Open Pit Massive Sulfide Copper, Small Gossan Open Pit Gold: Gossan pit - all 3 gossan mine rock samples <1 (SRK 1992, Table 5, p. 12); all 6 Massive Sulfide Copper pit wall rocks samples <1 (SRK 1992: Table 9, p. 14; Table 12, p. 17; Table 16, p. 22)	10

Rio Tinto Detailed Assessment (Pre-Feasibility/Feasibility/Mining)

RTIO Detailed AMD Hazard Score	Possible Points	Bald Mountain Data	Bald Mtn Points
o Water Management Hazard			
• Pit backfilling			
□ Pit will not be backfilled	5		
□ Pit will be backfilled below the post mining water table	4	Both Scenarios - Large Open Pit Massive Sulfide Copper, Small Gossan Open Pit Gold: Gossan Pit PAG waste rock would be placed in the mined out pit and submerged. (Black Hawk Mining, 1997, p. 90); Massive Sulfide Copper pit PAG waste rock placed in the pit at closure with a water cover. (SRK 1990a, p. 6-20)	4
□ Pit will be backfilled to above the post mining water table but below ground surface	2		
□ Waste will be used to cover PAF exposures	2		
□ Pit will be backfilled to ground level	0		
• Water discharge			
□ No releases of water	0		
□ 0 to 80 ML (21.3 M gallons)/day	1	Both Scenarios - Large Open Pit Massive Sulfide Copper, Small Gossan Open Pit Gold: Gossan mine = 58 gpm (Wardwell 1997a, p. 85); Massive Sulfide discharge = 92 - 720 US gpm (SRK 1990a, p. 8-4)	1
□ 80-160 ML (21.3-42.3 M gallons)/day	2		
□ > 160 ML (42.3 M gallons)/day	3		
• Surface water management			
□ Isolated pit	0		
□ Catchment area above the pit	5	Both Scenarios - Large Open Pit Massive Sulfide Copper, Small Gossan Open Pit Gold: Gossan Pit catchment area ≈ 200 acres, since the pit area is 16 ac compared to 30 ac for the massive sulfide pit (Wardwell, 1997b, p. 5); Massive Sulfide Copper pit = 210 acre (418 ac with pit) catchment area. (SRK 1990a, p. 6-17)	5
□ Creek flow	7		
• Water treatment during operation			
□ No water treatment or special management for AMD needed	0		
□ Water treatment or special water management may be needed during operation	3		
□ Water treatment or special water management will be needed during operation	5	Both Scenarios - Large Open Pit Massive Sulfide Copper, Small Gossan Open Pit Gold: Gossan Pit - treatment required during operations and for some time after closure (Wardwell, 1997a, pp. 75-76); Massive Sulfide Copper pit - treatment required during operations and after closure (SRK 1990a, pp. 8-4, 9-7)	5

Rio Tinto Detailed Assessment (Pre-Feasibility/Feasibility/Mining)

RTIO Detailed AMD Hazard Score	Possible Points	Bald Mountain Data	Bald Mtn Points
• Final void management			
◻ No PAF rock exposures likely on final pit shell	0	Both Scenarios - Large Open Pit Massive Sulfide Copper, Small Gossan Open Pit Gold: Gossan Pit - acid producing waste rock will be placed against the footwall rock slope of the mine pit, buried in a layer of till, and submerged at closure (Wardwell, 1997a, pp. 88-89); Massive Sulfide Copper pit wall rock not submerged, to be covered with hanging wall rock and till (SRK 1990a, pp. 8-4, 9-7).	0
◻ Less than 3% PAF exposed	2		
◻ 3% to 10% PAF exposed	7		
◻ Greater than 10% PAF exposed	10		
	=====		
Detailed AMD Hazard Score Maximum Points	**75**		
RIO TINTO DETAILED AMD HAZARD SCORE			
Small Gossan Open Pit:		**Large Open Pit Massive Sulfide Copper:**	
Preliminary Assessment Score	56	Preliminary Assessment Score	74
Detailed Assessment Score	57	Detailed Assessment Score	57
Combined Hazard Score (100 maximum)	**71**	**Combined Hazard Score (100 maximum)**	**76**
Risk Ranking*	**Very High**	**Risk Ranking***	**Very High**
Hazard Rankings from Green and Borden, Rio Tinto (2011), p. 387			
* The combined AMD hazard score is derived by adding the individual scores relating to the preliminary assessment, detailed geochemistry, mine planning and water management.			
- A score of 30 or less receives a Low Risk of Catastrophic Consequence hazard ranking. These sites are the least likely to have a significant Risk of Catastrophic Consequence.			
- A score between 30 and 50 receives a Moderate hazard ranking. These sites are more likely to have a significant Risk of Catastrophic Consequence.			
- A score of 51 to 65 receives a High Risk of Catastrophic Consequence hazard ranking.			
- A score of 66 or higher receives a Very High ranking. High and Very High sites pose a significant environmental, financial and/or reputational Risk of Catastrophic Consequence.			
Note: Green and Borden did not explain how they weighted the Preliminary Assessment Score in calculating the Combined Hazard Score, but it appears they have given it a 25% weight in the Combines Hazard Score, so that is what has been assumed here.			

Appendix C

Go/No-Go
Risk of Catastrophic Consequence
of the
Bald Mountain, Maine

(Preliminary Assessment)

Go/No-Go Risk of Catastrophic Consequence (Preliminary Assessment)

Go/No-Go Risk of Catastrophic Consequence Score	Possible Points	Bald Mountain Data	Bald Mtn Points
o Hydrology - risk permanent damage to lakes, streams, or wetlands by:			
• Dewatering/Water table drawdown			
Is it is likely that mine dewatering will be required which would cause drawdown to the point where water levels would threaten springs, groundwater uses (e.g. drinking water wells), or stream flows that would jeopardize aquatic life?			
□ Little or no likelihood	0		
□ Moderate risk or not well-understood hydrology	5	Small Gossan Open Pit Gold: No groundwater studies were performed in conjunction with the Black Hawk mining proposal, but since the pit for this project would be significantly smaller than the pit proposed for large open pit massive sulfide copper, it would follow that the groundwater impacts for the smaller pit would be less. The hydrology of the deposit is not well defined, especially related to fracture systems in the pit area.	4
□ Likely or significant risk	10	Large Open Pit Massive Sulfide Copper: "… a number of investigators (Woodward-Clyde Consultants, 1982; Budo, 1988) have indicated that the groundwater volumes removed by mining will be minimal, it would appear that the only groundwater impact of potentially major significance will be that due to tailings pond seepage, ..." (SRK 1990a, p. 9-2). The hydrology of the deposit is not well defined, especially related to fracture systems in the pit area.	6
• Contamination			
Is there a likelihood, related to orebody type, mine location, and mining method, that contamination from the minesite might exceed water quality standards for human health, aquatic life, or water quality standards for other designated water uses off the minesite?			
□ Underground mine, sulfide sulfur <0.3%, at least some CaCO3, no surface water within 2000 m	0		
□ Sulfide sulfur >0.3%, some CaCO3, no surface water within 2000 m	5		
.	10	Small Gossan Open Pit Gold: Gossan deposit footwall material is acid generating. (Lorax, 1997, p. 3-7) High probability of arsenic contamination with any development of gossan: "... reductions in arsenic concentrations overtime can not be forecast." (Lorax, 1997, p. 4-1) Large Open Pit Massive Sulfide Copper: Massive sulfide deposit high in pyrite and pyrrhotite. (SRK, 1992, Sections 3.6 and 3.7)	9

Go/No-Go Risk of Catastrophic Consequence (Preliminary Assessment)

Go/No-Go Risk of Catastrophic Consequence Score	Possible Points	Bald Mountain Data	Bald Mtn Points
o Geochemistry			
• Permanent water treatment predicted			
Will the amount and/or concentration of seepage water after mine closure require collection and active water treatment for the foreseeable future? If it cannot be demonstrated that a self-sustaining natural closure can be attained, then allowing mining would place an unreasonable risk on the public			
□ No post-closure water treatment required	0		
□ Passive post-closure water treatment required, no maintenance or replacement required	5		
□ Active post-closure water treatment likely	10	Small Gossan Open Pit Gold: "Water will continue to be collected and treated for an indefinite period following reclamation of the open pit, tailings landfill, and plant site." (Wardwell, 1997a, p. 76) Large Open Pit Massive Sulfide Copper: "After closure the mine rock will be placed in the pit which will flood and discharge to Bald Mountain Brook through surface overflow and near-surface groundwater. The leaching of the backfilled rock waste and the contamination of highwall seepage with oxidation products are concerns and may represent a fatal flaw." (SRK, 1990a, p. x)	10
• Long term storage of acid generating/metals leaching waste in an oxidizing environment			
If potentially acid generating (PAG) and/or metals leaching (ML) waste, including tailings, waste rock, and mine workings, cannot be permanently placed in an environment where acid rock drainage and/or metals leaching can be permanently prevented, then it would not be safe to proceed with a mine.			
□ No PAG/ML predicted from tailings, waste rock, or mine workings	0		
□ Accepted technology to contain or mitigate PAG tailings, waste rock, or mine workings	5	Small Gossan Open Pit Gold: The geochemistry work done by Lorax does not demonstrate that contaminant concentrations will diminish over time to levels that will not require active treatment. (Lorax, 1997, p. 4-1)	5

Go/No-Go Risk of Catastrophic Consequence (Preliminary Assessment)

Go/No-Go Risk of Catastrophic Consequence Score	Possible Points	Bald Mountain Data	Bald Mtn Points
□ No accepted technology to contain or mitigate PAG tailings, waste rock, or mine workings	10	Large Open Pit Massive Sulfide Copper: "It is our opinion that under the proposed mine development plan, there are two areas of substantial technical concern which may prove to be fatal flaws. These concerns relate to water quality in the receiving environment, both during operation and following mine closure." (SRK, 1990a, p. 12-1)	10
o Mine Tailings Disposal - tailings dam design, contaminants, and amount of tailings			
• Tailings Dam Seismic Risk			
Is it likely that a tailings dam can be engineered to withstand a Maximum Credible Earthquake (MCE) no farther than 10 kilometers from the dam site? Numerical modeling must be used to verify the seismic stability of the dam design. If a tailings dam location cannot located in a place that allows these design criteria to be implemented, then it would not be safe to proceed with a mine.			
□ Downstream dam construction, MCE < 10km, numerical modeling, < 10 Mtons non-acid generating tailings, double liner with leak detection	0		
□ Centerline dam construction, MCE < 10km, numerical modeling, > 10 Mtons non-acid generating tailings	5	Small Gossan Open Pit Gold: A landfill-type storage design was proposed for the tailings incorporating a single clay liner with an internal drainage system. (Black Hawk Mining, 1997, p. 88) The deposit contains approximately 1.2 million tons of ore. (Black Hawk Mining, 1997, Executive Summary, p. ii). No geotechnical analysis proposed for the landfill, no top barrier-liner (Wardwell, 1997a, p 82).	4
□ Upstream dam construction, did not use the MCE, pseudo-static modeling, > 100 Mtons acid generating tailings, no liner	10	Large Open Pit Massive Sulfide Copper: The geomorphology of the Bald Mountain area is such that a downstream dam could be constructed if desired/required (SRK 1990a, Fig. 3-2), and the seismic risk is not high (USGS OFR 2008-1128). A double liner was proposed for both the gossan and massive sulfide tailings (SRK, 1990a, Executive Summary, p. vii), but most engineering companies today still use pseudo-static modeling for tailings dam seismic evaluations. The Large Open Pit Massive Sulfide Copper project was expected to generate about 1.2 million tons of gossan tailings, 22 million tons of massive sulfide tailings. (SRK, 1990a, Executive Summary, p. vi)	6

Go/No-Go Risk of Catastrophic Consequence (Preliminary Assessment)

Go/No-Go Risk of Catastrophic Consequence Score	Possible Points	Bald Mountain Data	Bald Mtn Points
• Tailings Dam Hydrologic Risk			
During mining operations a tailings impoundment must be able to hold the maximum probable flood (PMF) event, plus snowmelt (if any), and have adequate freeboard remaining to withstand wave action and storm surge at the same time. If a tailings dam location cannot located in a place that allows these design criteria to be implemented, then it would not be safe to proceed with a mine.			
□ Tailings impoundment and permanent water diversion structures engineered for PMF	0		
□ Tailings impoundment engineered for PMF, permanent water diversion structures not engineered for PMF	5	Small Gossan Open Pit Gold: There is only a preliminary discussion of protection of the tailings landfill for a PMP event: "Riprapped sideslope drainage channels located transverse to the landfill final grades will be used to convey runoff collected in the bench ditches to the landfill perimeter. Final sizing of the bench ditches, drainage channels, and geocomposite drainage net will be completed as part of final design." (Black Hawk Mining, 1997, p. 88) Large Open Pit Massive Sulfide Copper: The geomorphology of the Bald Mountain area is such that there is sufficient area to construct a tailings dam and permanent diversion structures to withstand the PMF if desired/required. (SRK 1990a, Fig. 3-2) However, most engineering companies today design permanent water diversions for the 100-yr/24-hr event.	5
□ Tailings impoundment and permanent water diversion structures cannot be engineered for PMF	10		
o Waste dump design			
• Long term stability			
Can waste rock dumps be designed to withstand maximum credible earthquake and probable maximum precipitation events? If a waste rock dump location cannot positioned in a place that allows these design criteria to be implemented, then it would not be safe to proceed with a mine.			
□ Waste dumps designed to withstand MCE < 10 Km, numerical modeling	0		

Go/No-Go Risk of Catastrophic Consequence (Preliminary Assessment)			
	Possible		Bald Mtn
Go/No-Go Risk of Catastrophic Consequence Score	**Points**	**Bald Mountain Data**	**Points**
□ Waste dumps designed to withstand MCE < 10 Km, pseudo-static modeling	5	Small Gossan Open Pit Gold: PAG waste rock would be placed in the mined out pit and submerged. (Black Hawk Mining, 1997, p. 90) Some remaining concerns with PMF management. Large Open Pit Massive Sulfide Copper: Tailings and waste rock would be deposited in the tailings impoundment, so the seismic risk rating is covered under the tailings dam seismic risk rating above. (SRK, 1990a, p. 7-1) Some remaining concerns with PMF management.	3
□ Angle of repose waste dumps, static modeling	10		
• Waste dump cover design			
Will the waste rock dump(s) require a designed cover to shed water, minimize infiltration, and/or promote reclamation revegetation? If a waste rock dump location cannot positioned in a place that allows these design criteria to be implemented, then it would not be safe to proceed with a mine.			
□ Top liner with drainage barrier, 3:1 < slopes, growth material of sufficient thickness to prevent root penetration	0		
□ Evapo-transpiration cover, 2.5:1 slope	5	Large Open Pit Massive Sulfide Copper: PAG waste rock would either be placed in the tailings pond or in the pit at closure, with a water cover for the pit and marshland cover for the tailings ponds. (SRK 1990a, p. 6-20). Potential ML issue with NAG waste rock permanently placed on topsoil stockpile location. . (Black Hawk Mining, 1997, p. 90).	5
□ Waste dumps left in an as-is condition	10	Small Gossan Open Pit: PAG waste rock would be placed in the mined out pit and submerged (Black Hawk Mining, 1997, p. 90). NAG waste rock would be placed in the area of the topsoil stockpile for use during reclamation (Black Hawk Mining, 1997, p. 90). Potential ML issues with waste rock use in reclamation, and with ML from waste rock permanently placed in topsoil stockpile area.	6

Go/No-Go Risk of Catastrophic Consequence (Preliminary Assessment)

Go/No-Go Risk of Catastrophic Consequence Score	Possible Points	Bald Mountain Data	Bald Mtn Points
• Waste dump seepage collection			
All waste rock dumps that are predicted to have contaminants in the seepage should have passive seepage collection systems for the long term collection of seepage. If a waste rock dump location cannot be positioned in a place that allows this design criteria to be implemented, then it would not be safe to proceed with a mine.			
□ Waste dump(s) are located where it is physically possible to collect seepage, and a passive seepage collection has been/will be engineered.	0		
□ Waste dump(s) are located where it is possible to collect seepage, but there will be no engineered seepage collection system, or active pumping will be required.	5	Large Open Pit Massive Sulfide Copper: PAG waste rock placed in the pit at closure with a water cover, but fractures in the pit walls could provide pathways for contaminated water to leave the pit. (SRK 1990a, p. 6-20)	5
□ Waste dump(s) are designed or located such that seepage collection is/cannot reasonably be expected to be accomplished	10	Small Gossan Open Pit Gold: PAG waste rock would be placed in the mined out pit and submerged. NAG waste rock would be placed in the area of the topsoil stockpile. (Black Hawk Mining, 1997, p. 90). No seepage collection in stockpile area.	7
o Reclamation			
• The costs of reclamation, closure, and all post-closure expenses must be conservatively calculated and placed in trust prior to these obligations are incurred by a mining operation.			
If the potential mine design suggests that the cost of reclamation would pose a financial burden that is significantly greater than that for similar mines, and would be difficult for the mine operator to meet, then it is unlikely that the mine could proceed.			
□ A closure surety has been calculated, and it is reasonable that the amount can be provided by the company proposing the mine.	0		
□ No closure surety has been calculated, but appears practicable that the amount estimated can be provided by the company proposing the mine.	5		

Go/No-Go Risk of Catastrophic Consequence (Preliminary Assessment)			
	Possible		**Bald Mtn**
<u>Go/No-Go Risk of Catastrophic Consequence Score</u>	**<u>Points</u>**	**<u>Bald Mountain Data</u>**	**<u>Points</u>**
□ The closure cost estimated/calculated does not appear to be an amount that is practicable for the company proposing the mine to provide.	10	Small Gossan Open Pit Gold: Final water quality of appropriate quality to allow land application, with or without further treatment is not supported by water quality predictions (Lorax, 1997, p. 4-1). Land application for water from the small pit is not substantiated with appropriate water quantity and quality studies. Large Open Pit Massive Sulfide Copper: Water treatment after closure is likely (SRK 1990a, p. 11-1). Arsenic contamination through groundwater is a significant risk (SRK 1990a, p. 11-1). Water treatment could be ineffective (SRK 1990a, p. 11-1).	9
	=====		=====
Go/No-Go Risk of Catastrophic Consequence Hazard Score (maximum)	100	**Small Gossan Open Pit Gold:**	**63**
		Hazard Ranking:	**High**
		Large Open Pit Massive Sulfide Copper:	**68**
		Hazard Ranking:	**Very High**
<u>Hazard Rankings from Green and Borden, Rio Tinto (2011), p. 387</u>			
- A score of 30 or less receives a Low Risk of Catastrophic Consequence hazard ranking. These sites are the least likely to have a significant Risk of Catastrophic Consequence.			
- A score between 30 and 50 receives a Moderate hazard ranking. These sites are more likely to have a significant Risk of Catastrophic Consequence.			
- A score of 51 to 65 receives a High Risk of Catastrophic Consequence hazard ranking.			
- A score of 66 or higher receives a Very High ranking. High and Very High sites pose a significant environmental, financial and/or reputational Risk of Catastrophic Consequence.			
** Note: For the Go/No-Go Risk of Catastrophic Consequence Hazard Rating has followed the low/moderate/high/very high rating values set by Rio Tinto for their AMD Hazard Score. .*			