Impact Assessment, Risk Assessment and Artificial Intelligence

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Introduction

Risks affecting development of Projects are driven by Financial, Technical, Environmental, Social and Governance factors

Context in BC:

- Only 1 out of 2 mining projects with approved EACs are built and operate; and 1 out of 4 is built in the predicted timeline (Collard,R. et.al., 2024)
- There are cases of mining projects generating residual impacts in a materially different way than predicted in the Environmental Assessments
- Environmental Assessment Act of 2018 requires that risks and uncertainties associated to effects of a project be considered in every assessment

Can Artificial Intelligence assist in assessing the risk of residual effects manifesting themselves in a worse manner than predicted in the Environmental Assessment?

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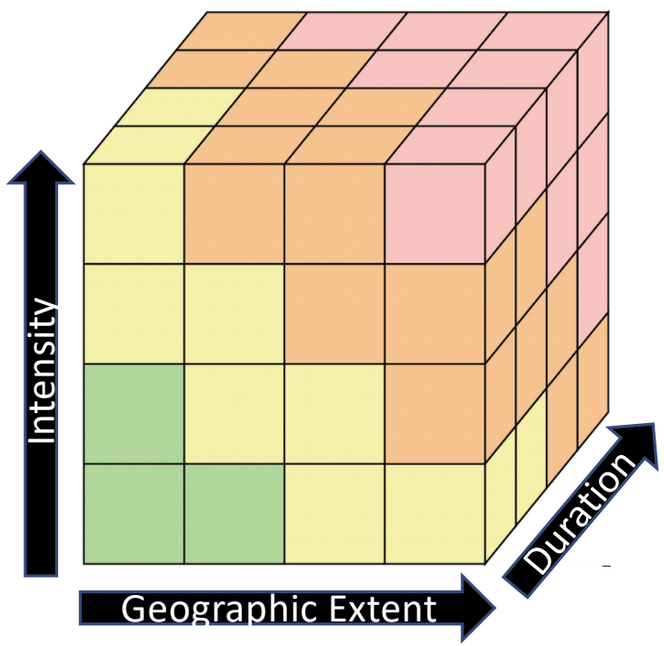
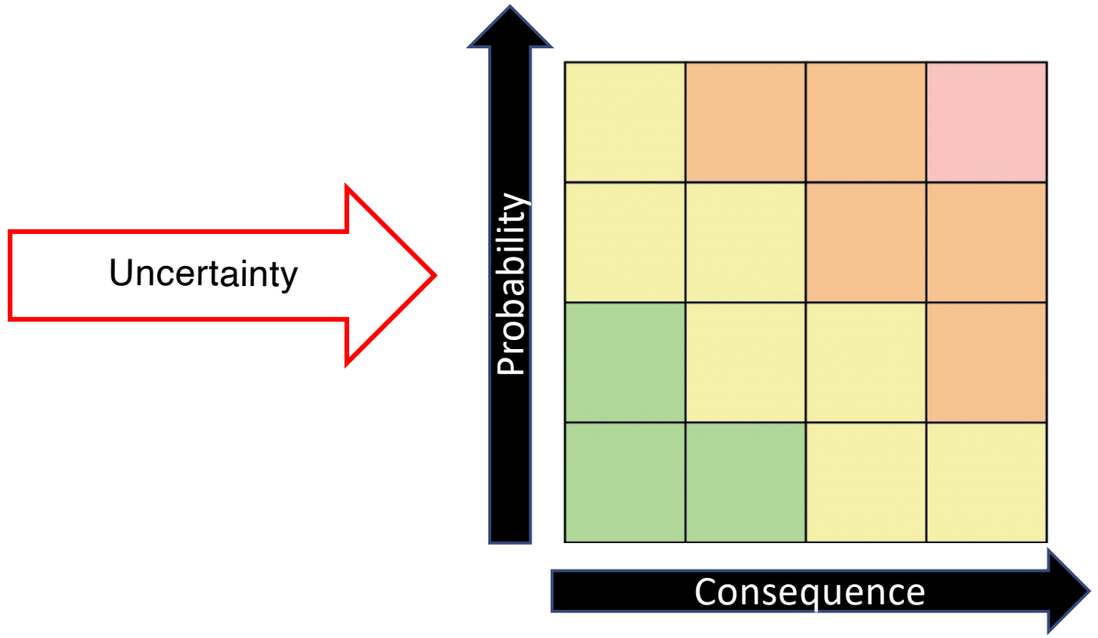
Impact Analysis and Risk Analysis

Impact Assessment 3D Matrix



The significance of a residual effect is driven by its magnitude, geographic extent and duration (Paredes, IAIA 2022)

Risk Assessment 2D Matrix



Risk is the effect of uncertainty on achieving objectives (ISO 14001)

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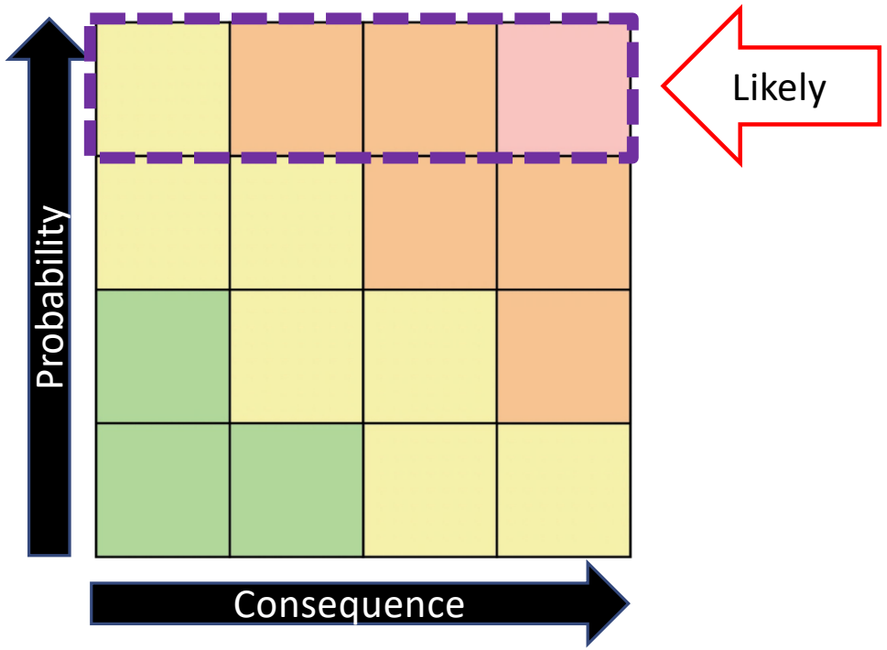
Risk is a Function of Probability and Consequence



Consequence as a function of uncertainty, magnitude, geographic extent and duration

Probability

Residual effects are considered likely; because the environmental assessment process discards interactions without the potential to generate effects

Residual effects could generate more severe consequences than anticipated

The higher the uncertainty, the higher the risk

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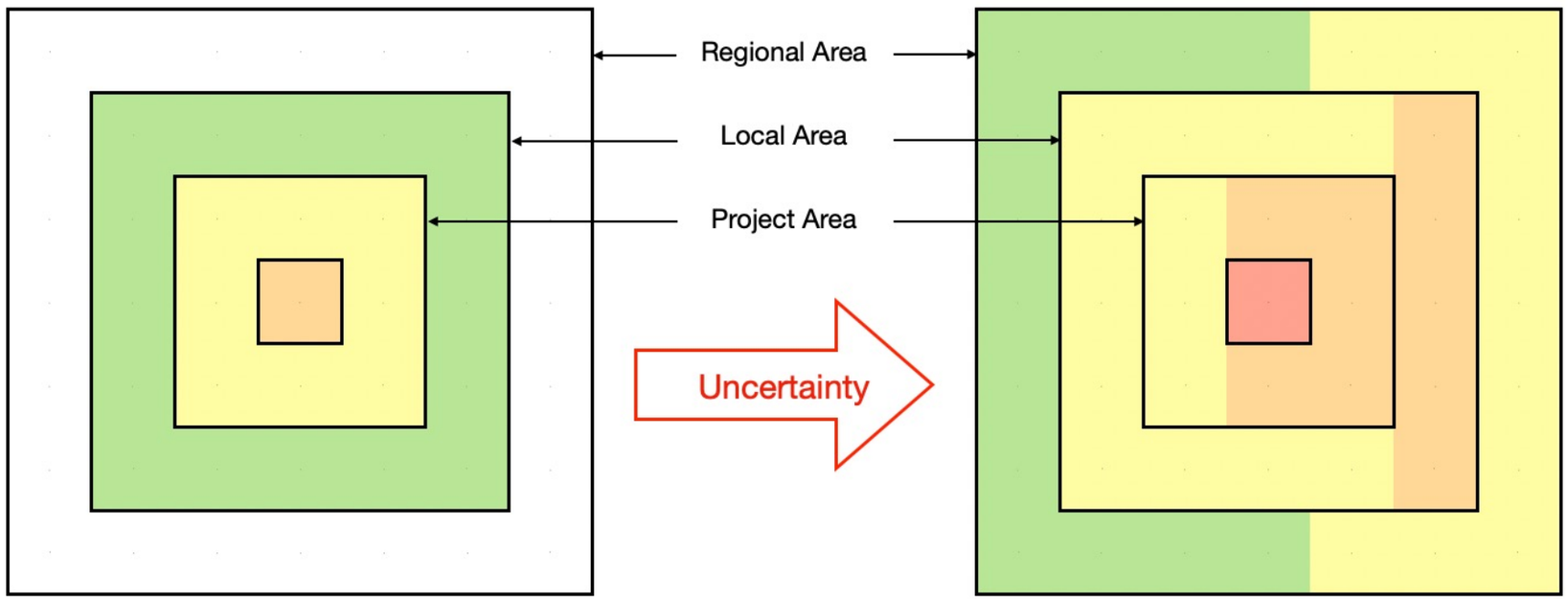
Risk is a Function of Probability and Consequence

Consequence

Uncertainty amplifies the residual effect; creating the potential for it to be of higher magnitude; larger geographic extent or longer duration; therefore, generating a more severe consequence



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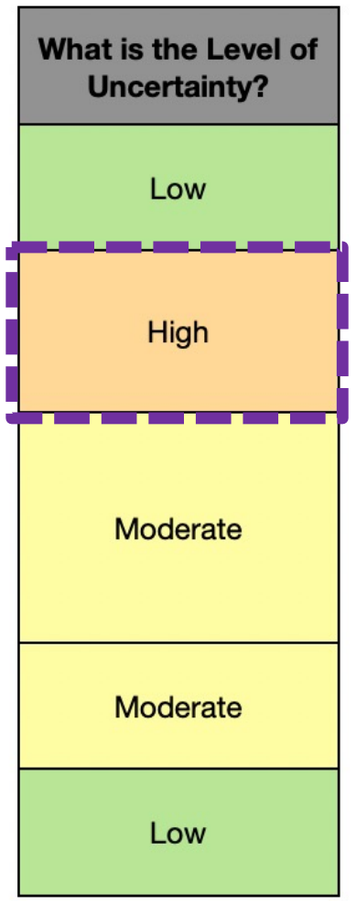
Characterization of Uncertainty

Factors Influencing Uncertainty	Sources of Uncertainty
Knowledge of the Valued Component	Limitations in the understanding of processes, interactions or behaviour. The mitigation is reduced when studies have been conducted during several years to understand the behavious of the VC
Mitigation Effectiveness	Mitigation effectiveness is difficult to predict because of complex systems or human behaviour. The uncertainty is reduced when the results of monitoring programs demostrate that mitigation measures are producing predicted results or achieving expected outcomes on the VC.
Modelling of the Effect	Inadequate, over-simplification, omission of processes. Uncertainty is reduced when appropriate models that chosen to predict the behaviour of the VC and/or conservative assumptions are used to set up modelling scenarios. Uncertainty is reduced when models are calibrated using information collected in the field. Also, uncertainty is mitigated when sensitivity analysis are conducted for modelling scenarios.
Data Used to Feed Models	Limitation is data availability or quality, spatial or temporal resoulution challenges, poorly known model parameters. Uncertainty is reduced when conservative assumptions are used to deal with information gaps
Interpretation of Results	Values or terms are interpreted differently by differently people. Uncertainty is reduced with Peer Review or Senior Review of the results of the assessment



Source: BC EAO Effects Assessment Policy, 2020

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Characterization of Uncertainty

Mitigation Effectiveness

- Existing operations can measure mitigation effectiveness based on environmental monitoring
- Environmental assessments rely on available information to estimate effectiveness of proposed mitigation
- Section 30 of BC Environmental Assessment Act requires reporting of mitigation effectiveness
- Global Industry Standard for Tailings Management requires regular reviews of management systems to assure effectiveness

Complex Systems

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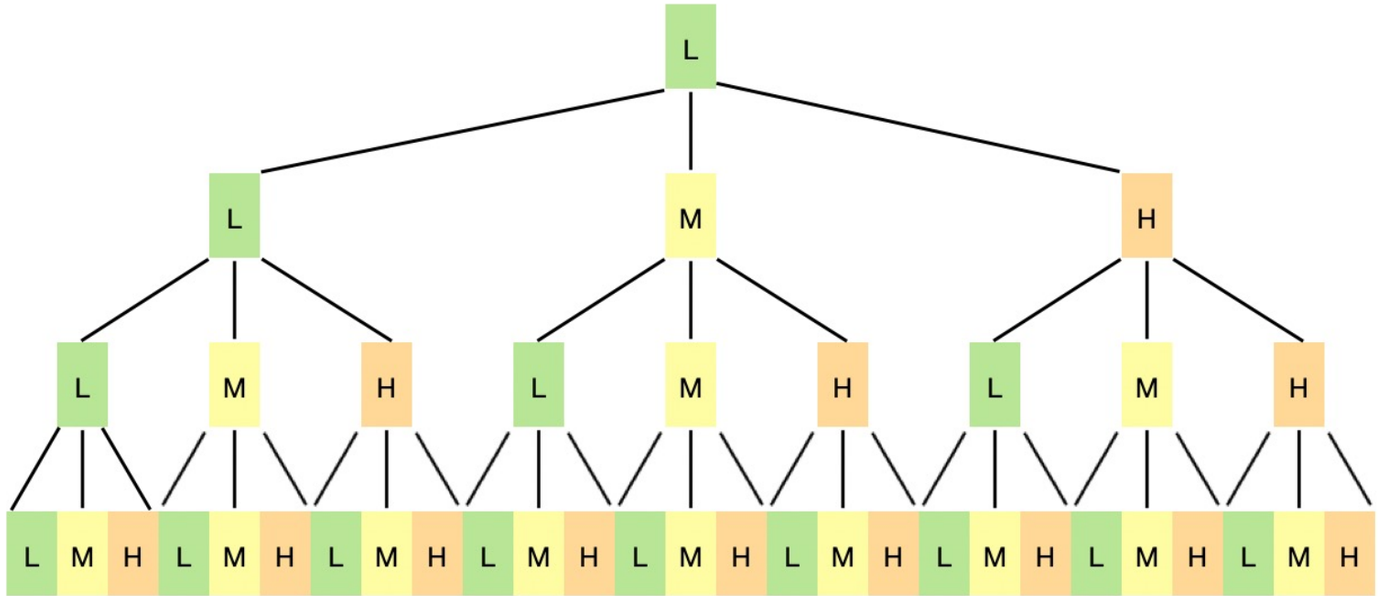
Artificial Intelligence

Machine Learning Algorithms
- **Supervised Learning Algorithms**
- Unsupervised Learning Algorithms
- Reinforcement Learning Algorithms

Supervised Learning Algorithms
- Linear Regression
- Logistic Regression
- **Decision Trees**
- Random Forests
- Support Vector Machines
- Neural Networks



A Decision Tree is proposed to derive the value of a **target variable (i.e. Consequence)** by using simple decision rules inferred from the data features **(i.e. Uncertainty, Magnitude, Geographic Extent and Duration).**

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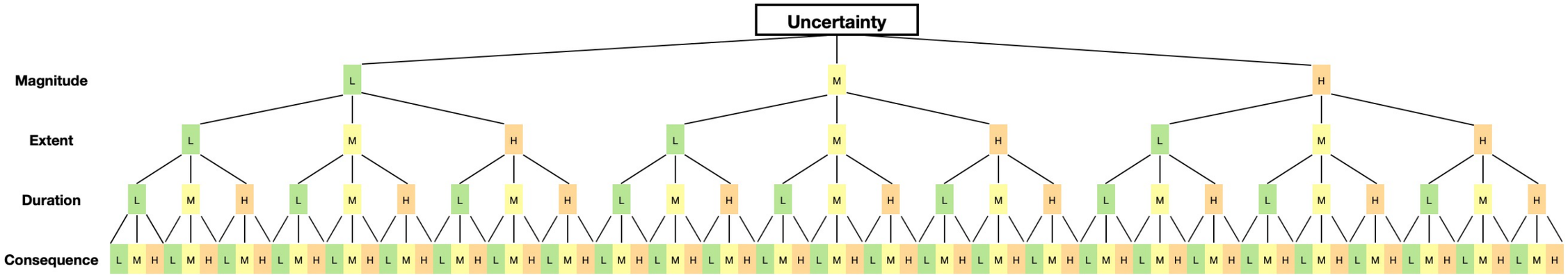
Supervised Learning Algorithms – Decision Trees

Uncertainty is the root node
Magnitude, Extent and Duration are intermediate nodes
Consequence is the terminal or decision node



$3^4 = 81$ possibilities
$4^4 = 256$ possibilities
$5^4 = 625$ possibilities

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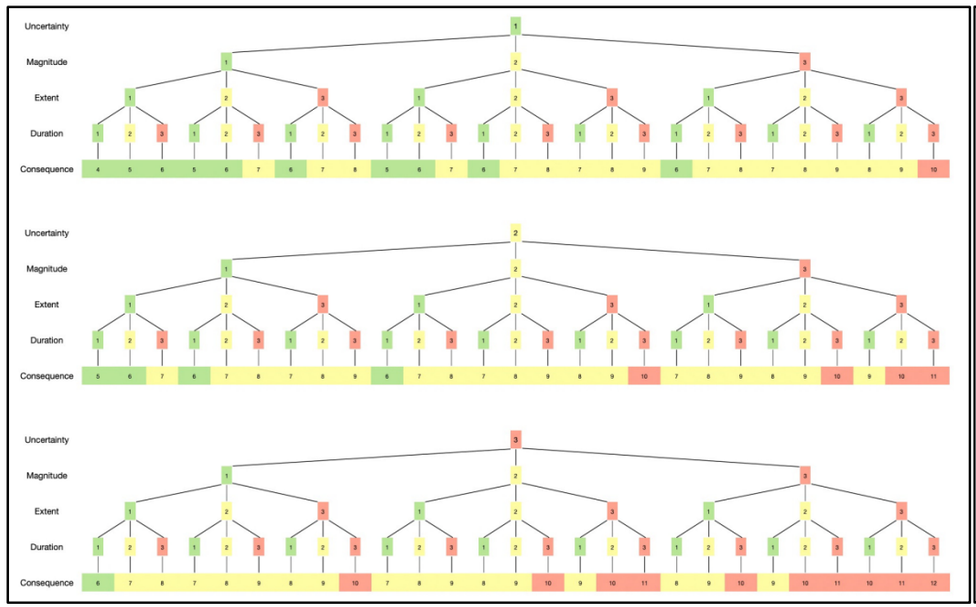
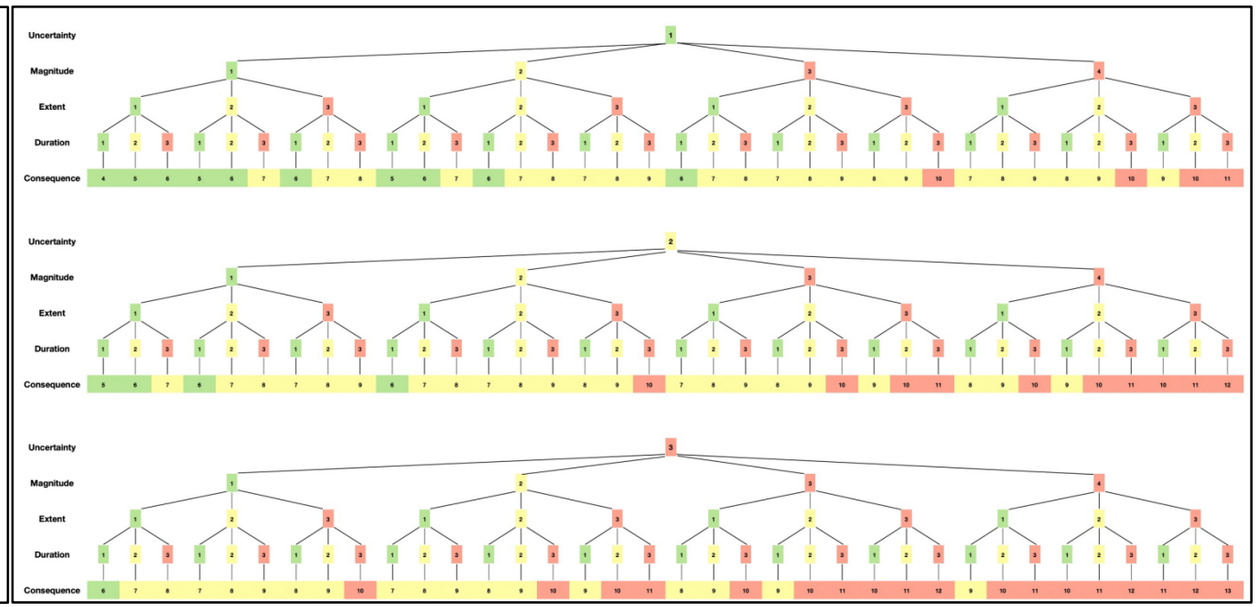
Supervised Learning Algorithms – Decision Trees





Uncertainty: Root node (3)
Magnitude: Internal node (3)
Extent: Internal node (3)
Duration: Internal node (3)
Consequence: Decision node (3)
243 options

Higher the uncertainty
then
higher the risk

Uncertainty: Root node (3)
Magnitude: Internal node (4)
Extent: Internal node (3)
Duration: Internal node (3)
Consequence: Decision node (3)
324 options

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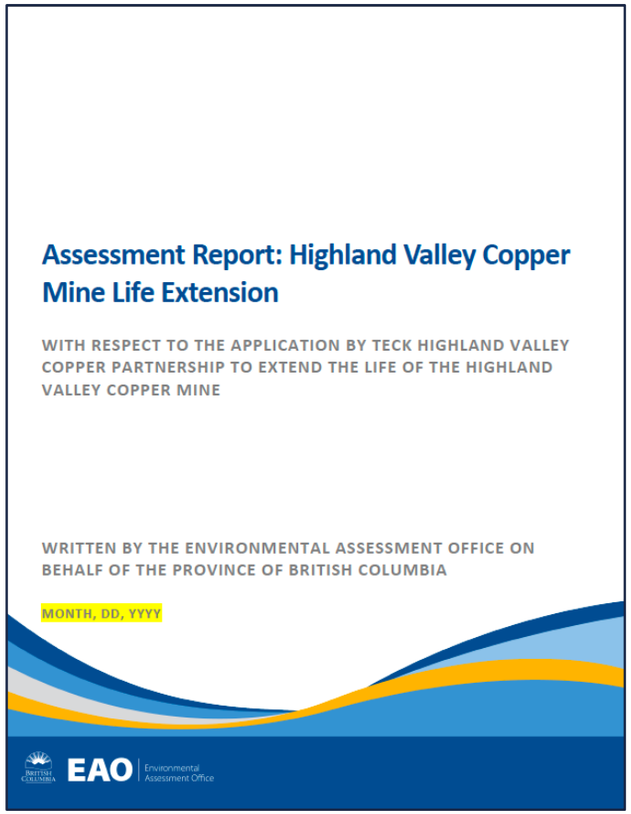
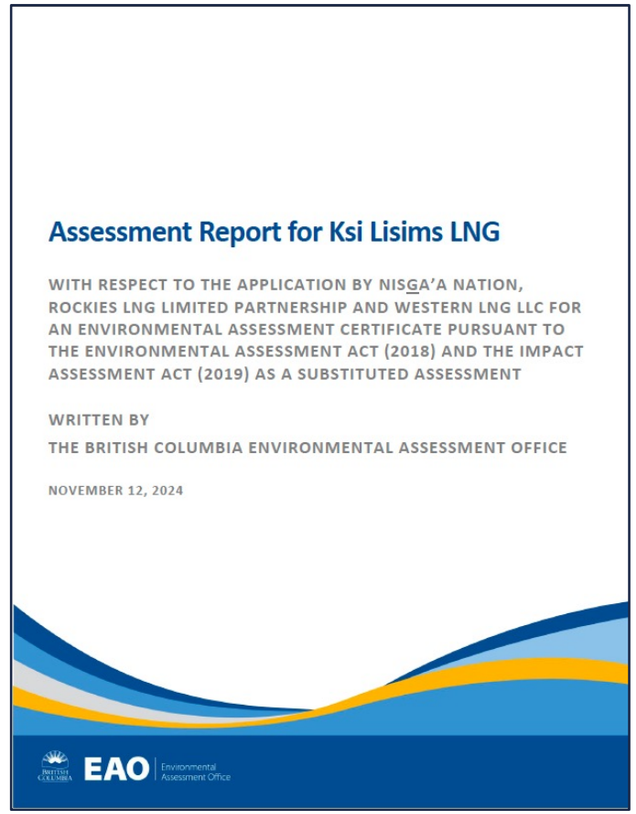
Project Cases Used for Comparative Analysis





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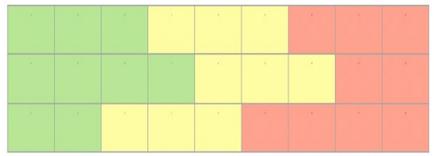
Algorithms and Criteria for Comparative Analysis

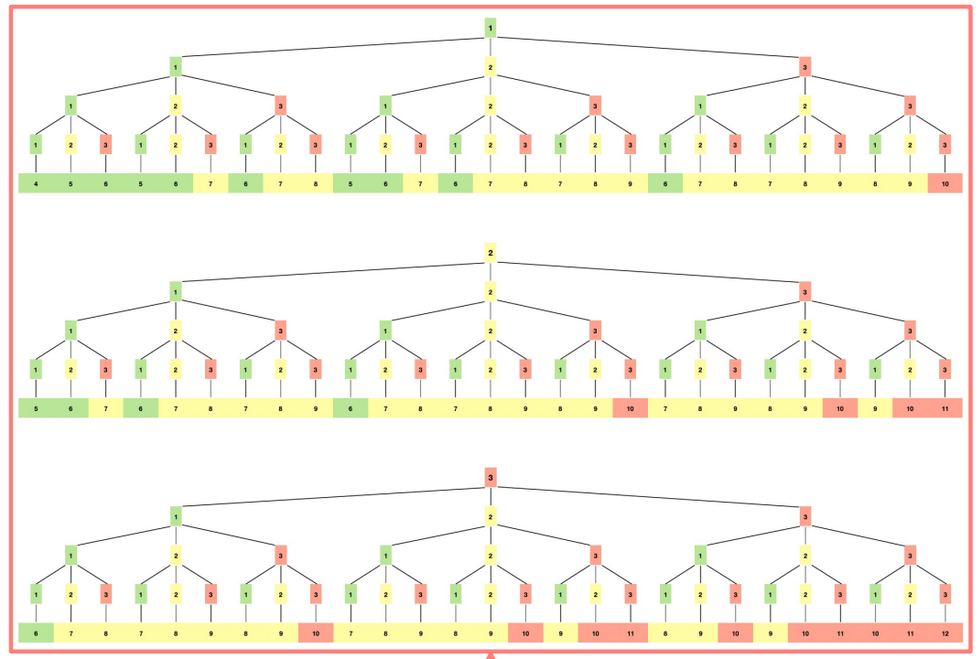
Six (6) algorithms were developed:

Two (2) equations to estimate consequence as a function of Uncertainty (U), Magnitude (M), Extension (E) and Duration (D):
(A1) C = ∑(U,M,E,D)
(A2) C = ∑(4xU,3xM,2xE,D)

Three (3) sets of criteria were applied to rank consequence:
(C1) Balanced Risk Tolerance
(C2) High Risk Tolerance
(C3) Low Risk Tolerance



Six (6) scenarios were run for comparative analysis:



1	2	3	4	5	6
A1-C1	A1-C2	A1-C3	A2-C1	A2-C2	A2-C3

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Comparative Analysis Results – Risk Rankings

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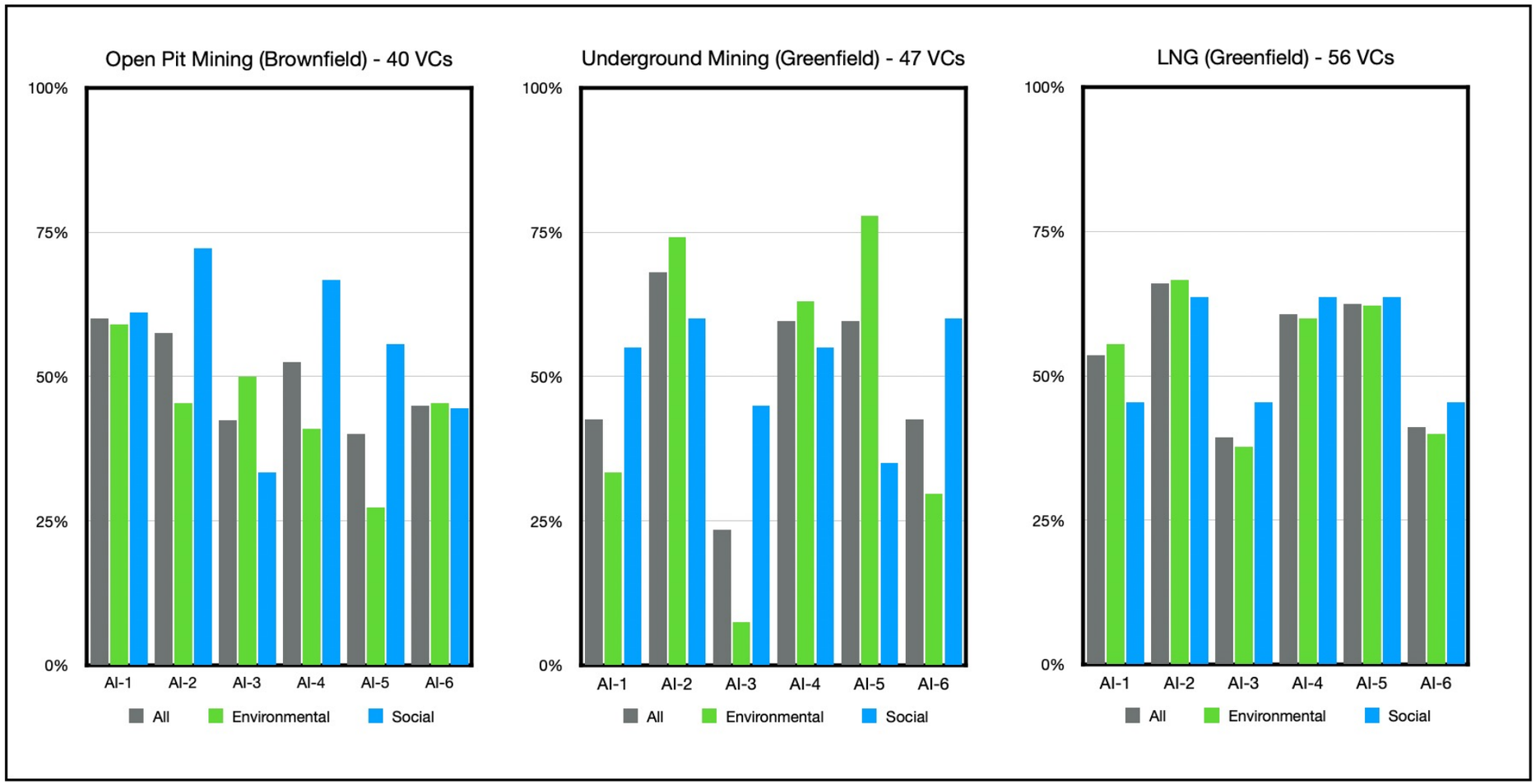
Comparative Analysis Results – Correlations



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Comparative Analysis Results – Open Pit Mining (Brownfield)

Valued Component	Human	AI1-C1	A1-C2	A1-C3	A2-C1	A2-C1	A2-C3
Air Quality	–	–	–	-	–	–	-
Noise	-	–	-	–	–	-	–
GW Quantity	–	-	-	-	-	-	-
GW Quality	–	-	-	-	-	-	-
GW Quantity (BASA)	–	–	–	-	–	–	-
Surface Water Quantity	–	-	-	-	-	-	-
Surface Water Quality	–	-	-	-	-	-	-
Surface Water Quantity (BASA)	–	–	-	–	-	-	–
Fish Health	–	–	-	–	-	-	–
Fish Habitat Quantity	–	–	–	–	–	-	–
Fish Habitat Quality	–	–	–	-	–	–	-
Fish Health (BASA)	-	–	–	–	–	-	–
Wildlife Habitat	-	-	–	-	–	–	-
Wildlife Movement	-	–	-	–	-	-	–
Wildlife Mortality	–	–	-	–	-	-	–
Wildlife Health	–	–	–	–	–	-	–
Terrestrial Ecosystem Abundance	–	–	–	–	–	-	–
Terrestrial Ecosystem Productivity	–	-	-	–	-	-	-
Wetland Ecosystems	-	–	–	-	–	–	-
Sensitive Ecosystems	–	–	–	–	–	-	–
Listed Ecological Communities	–	–	-	–	-	-	–
Plant Species of Interest	–	–	–	–	–	-	–
Health and Emergency Response Services	–	–	–	-	–	–	-
Food Security	–	–	–	–	–	-	–
Employment	–	–	–	–	–	-	–
Housing	–	–	–	-	–	-	–
Public Safety	-	–	-	–	–	-	–
Environmental Determinants of Health	–	–	–	-	–	–	-
Employment	-	–	–	-	–	–	-
Economic Benefits	–	–	–	–	–	-	–
Housing	–	–	-	–	-	-	–
Social Infrastructure	–	–	–	-	–	–	-
Traffic	-	–	-	–	-	-	–
Range and Forest Tenures	-	-	-	-	-	-	-
Traplines	-	–	–	–	–	-	–
Public Use and Access	-	–	–	-	–	-	–
Visual Resources	–	–	–	-	–	-	–
Archaeological Sites	-	–	-	–	-	-	–
Heritage Sites	–	–	-	–	-	-	–
Paleontological Sites	-	–	-	–	-	-	–

Valued Component	Human	AI1-C1	A1-C2	A1-C3	A2-C1	A2-C1	A2-C3
Groundwater Quantity	–	-	-	-	-	-	-
Groundwater Quality	–	-	-	-	-	-	-
GW Quantity (BASA)	–	–	–	-	–	–	-
Surface Water Quantity	–	-	-	-	-	-	-
Surface Water Quality	–	-	-	-	-	-	-
Wildlife Habitat	-	-	–	-	–	–	-

All artificial intelligence runs result in High risks for impacts to surface water and groundwater

Surface water and groundwater assessments were declared to have high levels of uncertainty

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Comparative Analysis Results – Underground Mining (Greenfield)

Valued Component	Human	A1-C1	A1-C2	A1-C3	A2-C1	A2-C2	A2-C3
Air Quality (SO2 & CO)							
Air Quality (NO2)							
Air Quality (PM)							
Low Frequency Noise							
Noise and Vibration							
Groundwater Quantity							
Groundwater Quality							
Surface Water Quantity							
Surface Water Quality							
Fish Health							
Fish Habitat							
Aquatic Resources							
Soil Quantity							
Soil Quality							
Terrain Stability							
Ecosystem Function							
Wetland Function							
Plant Communities of Interest							
Plant Species of Interest							
Amphibians							
Songbirds							
Raptors							
Bats							
Ungulates (Except Caribou)							
Southern Mountain Caribou							
Large Carnivores (Including Grizzly Bears)							
Medium Carnivores (including Wolverines)							
Private Property							
Tenured Land and Resource Use							
Access to Contemporary Land and Resource Use							
Conditions to Contemporary Land and Resource Use							
Public Land and Resource Use							
Enjoyment and Experience for Contemporary Use of the Land							
Lighting							
Visual Resources							
Traffic							
Housing and Accommodation							
Employment							
Economic Benefits							
Health Infrastructure and Services							
Population Health							
Human Health							
Ecological Health							
Plants Species of Cultural Significance							
Traditional Foods							
Indigenous Language and Culture							
District of Wells Arts Sector							

Valued Component	Human	A1-C1	A1-C2	A1-C3	A2-C1	A2-C2	A2-C3
Air Quality (PM)							
Groundwater Quality							
Surface Water Quantity							
Surface Water Quality							
Aquatic Resources							
Bats							
Southern Mountain Caribou							
Housing and Accommodation							
Health Infrastructure and Services							
Human Health							
Indigenous Language and Culture							

Two High risks identified by human analysis were linked to both High and Low levels of uncertainty

High risk tolerance criteria result in the highest correlation with human analysis; while low risk tolerance criteria result in the lowest correlation

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Comparative Analysis Results – LNG (Greenfield)

Valued Component	Human	AI1	AI2	AI3	AI4	AI5	AI6
Noise (Construction)	–			–			–
Noise (Operations)	–	–		–			–
Vibration (Construction)							
Air Quality (Construction)				–			–
Air Quality (Operations)		–	–	–	–		–
Groundwater Quantity				–			
Surface Water Quantity				–			
Surface Water Quality		–		–	–		–
Marine Water and Sediment Quality	–	–	–			–	
Marine Habitat		–	–	–	–	–	–
Marine Behaviour (Sensory Disturbances)	–	–	–		–	–	
Marine Mortality	–	–	–	–	–	–	–
Marine Northern Abalone (Species at Risk)	–	–		–			–
Marine Fish	–	–	–	–	–		–
Marine Mammals 1	–	–	–		–	–	
Marine Mammals 2		–	–		–	–	
Sea Turtle (Species at Risk)		–		–			–
Phytoplankton Density		–		–			–
Fresh Water Fish Habitat		–	–	–	–		–
Fresh Water Fish Health		–		–			–
Wildlife Habitat (Direct Loss)	–	–	–		–	–	–
Wildlife Habitat (Indirect Loss)		–	–		–	–	–
Wildlife Movement	–	–	–	–	–	–	
Wildlife Mortality	–	–	–		–	–	
Migratory Birds	–			–			
Grizzly Bear	–	–	–	–	–		–
Small Mammals/Furbearers		–	–		–	–	
Amphibians	–	–	–	–	–		–
Bats	–			–			–
Western Screech Owl				–			
Northern Goshawk	–			–			
Marbled Murrelet	–	–	–	–	–	–	–
Plant Species of Interest (Direct)		–		–			–
Ecological Communities of Interest	–	–	–	–	–		–
Wetlands	–	–	–		–	–	
Plant Species of Interest (Indirect)				–			
Ecological Communities of Interest (Indirect)		–		–			–
Wetlands			–			–	
Introduction of Invasive Species		–	–		–	–	
Species and Communities of Interests in Wetlands	–	–		–			–
Soil Acidification		–		–			–
Lichen							
Marine Navigation		–		–	–		–
Marine Fisheries	–	–	–		–	–	
Marine Aesthetic Conditions		–		–	–		–
Human Health from Air Quality		–		–			–
Human Health from Noise		–		–			–
Community Health		–	–	–	–	–	–
Community Wellness	–	–	–	–	–	–	–
Food Security	–	–	–	–	–	–	–
Health Services and Infrastructure	–	–	–	–	–	–	–
Regional Business	–	–	–	–	–	–	–
Regional Economy		–	–	–	–	–	–
Infrastructure and Services	–	–	–	–	–	–	–
Accommodation Availability and Affordability		–	–	–	–	–	–
Transportation Infrastructure		–	–	–	–	–	–

Valued Component	Human	AI1	AI2	AI3	AI4	AI5	AI6
Wetlands			–			–	
Introduction of Invasive Species		–	–		–	–	
Lichen							
Community Health		–	–	–	–	–	–

A higher number of High risks were identified by Human analysis when compared to most Artificial Intelligence outcomes

High risk assigned by Human Analysis were associated to High and Moderate levels of Uncertainty

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Conclusions

- Uncertainty can be used as an input for assessing risks derived from residual impacts potentially occurring differently than predicted in Environmental Assessments
- Artificial Intelligence tools can support Human Analysis; to improve consistency and transparency in the assessment of Risk
- Methods for characterization of uncertainty should be advanced; particularly when it relates to the effectiveness of proposed mitigation measures

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Let’s continue the conversation!

Post questions and comments via chat in the IAIA22 platform.

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