Best Achievable Technology Assessment Methodology for Mining Projects

(A methodology document supporting Best Achievable Technology Assessment Steps Fact Sheet)

Version 1, November 2024

Table of Contents

Acronyms

Acronym	Definition
AACE	The Association for the Advancement of Cost Engineering
BAT	Best Achievable Technology
BC	British Columbia
BMP	Best Management Practice
EMA	Environmental Management Act
IDZ	Initial Dilution Zone
LCCA	Life Cycle Cost Analysis
MA	Mines Act
NPV	Net Present Value
O&M	Operating and Maintenance
POCs	Parameters of Concern
POPCs	Parameters of Potential Concern
QP	Qualified Professional
TRA	Technology Readiness Assessment
TRL	Technology Readiness Level
WQG	Water Quality Guideline

1 Purpose of Methodology Document

This document complements the Best Achievable Technology Assessment Steps Fact Sheet (ENV 2021) and provide a detailed methodology for Best Achievable Technology (BAT) assessments for mining projects. This methodology must be followed, unless otherwise specified by the Ministry of Environment and Parks (ENV), when conducting a BAT assessment in support of a waste discharge application. This document is applicable to mining effluent discharges only. The Fact Sheet must be followed for the assessment of air or refuse discharge mitigation unless otherwise specified by ENV.

2 Introduction

When there are environmental concerns related to effluent discharges at a mine site, a BAT assessment must be conducted to identify the most effective and feasible technologies and practices for minimizing environmental impacts associated with a particular project or activity. This assessment must be conducted by a qualified professional (QP) who has demonstrated competence and experience in this field. Refer to the Mine Effluent Discharge Authorization Permit Application Development and Review Process Guidance Document (ENV, 2024c) to determine when a BAT assessment is required. At the pre-application phase of a project ENV will confirm with proponents if a BAT assessment is required and what specific information needs to be included.

3 Environmental Risks Management and Mitigation

3.1 Best Management Practices

There is a possible risk to the environment when mine effluent is discharged. However, if the pollutant source, pathway, or receptor (ENV, 2024c) can reliably be eliminated through source control and/or management practices, the risk to the environment may be eliminated. Best management practices (BMPs) are recommended techniques that have been demonstrated to be an effective and practical means of preventing or limiting harmful impacts to the environment. Implementation of BMPs such as mine design, operating methods, programs, technologies and mining processes, can fully or partially address pollutant sources and/or pathway components (ENV, 2021a).

Source control aims to prevent or reduce the production and/or release of parameters of potential concern (POPCs) (ENV, 2024a) from the mined material or disturbed area into the receiving environment. Source control measures can include various techniques and practices tailored to specific mining operations and environmental conditions. Proponents must implement source control measures including management practices and engineered controls into the mine plan prior to exploring treatment options. Refer to Joint Application Information Requirements Guidance Document (ENV, 2024b) for additional details on source control options.

3.2 Best Achievable Technology

For effluent discharges, water treatment options should be proposed when source control and water management measures are demonstrated to be insufficient to fully mitigate water quality concerns. When water treatment is proposed as a mitigation method for water quality, a BAT assessment may be required to support the proposed treatment technology.

BAT is a technology that has been evaluated for its feasibility, reliability, control-effectiveness, environmental impacts, and cost-effectiveness and is demonstrated to be best-suited to meet waste discharge standards for the protection of the environment and human health (ENV, 2021). The steps outlined in section 4 of this document must be followed to conduct a BAT assessment to identify the most suitable technology for mine effluent mitigation, unless otherwise specified by ENV.

4 Best Achievable Technology Assessment

4.1 Information Gathering

Information required to identify potential technologies and conduct a BAT assessment includes, but is not limited to, confirming the parameters of concern (POCs) in accordance with the Parameters of Concern Fact Sheet (ENV, 2024a), identifying the concentration of each parameter in the untreated effluent, determining the target concentration in the treated effluent (or minimum discharge standards), and confirming the design flowrate of the effluent requiring treatment.

Consider the following factors when defining the minimum target effluent concentrations:

- The discharged effluent must not be acutely toxic at the discharge point.
- The discharge must meet chronic BC water quality guidelines (BC WQGs), except where there is a defined initial dilution zone (IDZ).
- Where an IDZ is defined in the receiving environment, the discharge may cause some degree of chronic toxicity within the IDZ but it must not cause chronic toxicity at the edge (or terminus) of the IDZ. As per ENV guidance document (ENV, 2024c), the consideration of an IDZ is contingent upon the thorough evaluation of BMPs and a BAT assessment to confirm the POCs in the effluent cannot sufficiently be reduced to levels below chronic BC WQG levels. For further information, refer to Technical Guidance 11: Development and Use of Initial Dilution Zones in Effluent Discharge Authorization (ENV, 2019).

Table 1 can be used as a template to summarize the information required under this section.

Table 1 Table Template for Summarizing the flow, POCs, influent and target effluent concentrations.

<table>
<tr><th rowspan="2">Effluent Flowrate Requiring Treatment (m^3/hr)</th><th colspan="2">Minimum</th><th colspan="3">Average</th><th>Maximum</th></tr>
<tr><td colspan="2"></td><td colspan="3"></td><td></td></tr>
<tr><th rowspan="2">Parameters of Concern (POC)</th><th colspan="4">Untreated Concentration</th><th colspan="2" rowspan="2">Target Effluent Concentration</th></tr>
<tr><th>Minimum</th><th colspan="2">Average</th><th>Maximum</th></tr>
<tr><td>e.g., Total Aluminum (mg/L)</td><td></td><td colspan="2"></td><td></td><td colspan="2"></td></tr>
<tr><td></td><td></td><td colspan="2"></td><td></td><td colspan="2"></td></tr>
<tr><td></td><td></td><td colspan="2"></td><td></td><td colspan="2"></td></tr>
<tr><td></td><td></td><td colspan="2"></td><td></td><td colspan="2"></td></tr>
<tr><td></td><td></td><td colspan="2"></td><td></td><td colspan="2"></td></tr>
</table>

4.2 Identification of Technologies

Identify the technologies capable of reducing POC concentrations. Consider treatment technologies from comparable mining operations in your assessment. For each proposed technology or treatment process, which may involve multiple technologies, provide:

- a brief description of the treatment technology and its use in the mining industry;
- a description of any necessary ancillary technologies or infrastructures required (e.g. pre-treatment equalization, post-treatment solid/liquid separation, etc.);
- a high-level process flow diagram (excluding technologies that are screened out under 5.3); and
- a summary of advantages and disadvantages, including consideration for by products.

4.3 Screening for Technically Feasible Technologies

The options that are deemed technically infeasible considering the criteria listed below should be excluded from further consideration. Note, a rationale must be provided when screening out a technology.

4.3.1 Ability to Achieve Environmental Criteria

Evaluate each technology's ability to achieve the target effluent concentrations for any of the identified POCs. Technologies that only address specific POCs rather than all POCs may still be included in ongoing evaluation.

4.3.2 Proven Commercial Application

BAT technologies must have, at a minimum, a demonstration system operating at nearly full-scale in the same industry and under similar site-specific conditions and have well-understood risks. For emerging technologies, (technologies that have not been successfully implemented in similar site conditions), or as requested by ENV staff, a Technology Readiness Assessment (TRA) must be conducted in accordance with the Technology Readiness Assessment Interim Technical Guidance (ENV, 2022). A TRA report should be submitted with the BAT assessment when a TRA is completed. Technologies assessed at technology readiness level (TRL) 8 or 9 are considered proven technologies and are generally deemed acceptable to meet initial information requirements for Mines Act (MA) and/or Environmental Management Act (EMA) applications. Additional information may be requested as part of regulatory review processes. Technologies that have been assessed at TRL-7, or below, are research and development technologies. TRL-7 technologies may be acceptable to fulfill the information requirements for MA and/or EMA planning processes, but proponents are expected to conduct considerable work to collect site-specific data to support their application.

If a technology has been proven commercially but has not been tested under similar climate conditions, a prototype representing the final system configuration may be installed at the site and a report summarizing the results and efficacy of the technology under specific site conditions may accompany the BAT assessment report, as determined during the pre-application phase. Note that a waste discharge authorization is required prior to testing a technology if a discharge to the environment is proposed.

4.3.3 Operational Complexity

Factors relevant to the operation of the technology may include, but are not limited to, operator attendance requirement, chemical requirement, ease of process control, level of automation, level of expertise required to operate the system, maintenance requirements, and downtime expectations (for maintenance and part replacement). The QP must assess these factors in conjunction with site condition, and available resources to determine the feasibility of the technology for the specific application.

4.3.4 Miscellaneous Criteria

Other criteria to be considered when evaluating the feasibility of a technology includes the level of transparency in either the assessment or the mechanism of treatment, access to inputs (e.g., biofuels, natural gas, wind, nuclear, materials, consumables or products required), secondary waste production and lack of access to appropriate disposal options, adding or increasing other POCs to the point where there is no net benefit to treatment, compatibility of a technology with the needs of a facility or activity (e.g., a waste control technology that is too large for the size of facility or activity identified in the permit application), state or type of receiving environment (e.g., ocean, fish bearing waterbodies, hydrogeology, stressed airshed, etc.), and site specific conditions (e.g., the available space, climate, topography, geology, hydrogeology, etc.), as identified in ENV BAT Assessment Steps Fact Sheet (ENV, 2021).

4.4 BAT Assessment Criteria

Discuss and compare the technically feasible technologies identified under section 5.3 using the criteria outlined below. Assign a score factor between 1 and 5 to each assessment criterion, with 5 being the highest and 1 the lowest and provide a rationale for each score. Using Table 2, multiply the weight provided in Table 2 by the score to calculate the weighted score for each criterion for each technology. These weighted scores will be used in Section 5 to select the BAT. If the weights provided in Table 2 are not used for the assessment, the QP must provide a rationale to justify the proposed weights.

Table 2 Weight Distribution for Assessment Criteria

	Assessment Criterion	Weight	Score (1-5)	Weighted Score
4.4.1	**Reliability**	**20**		
4.4.1.1	*Risk Assessment*	*5*		
4.4.1.2	*Robustness*	*5*		
4.4.1.3	*Scalability*	*5*		
4.4.1.4	*Long-term Viability*	*5*		
4.4.2	**Control-Effectiveness**	**35**		
4.4.2.1	*Pollutant Reduction*	*15*		
4.4.2.2	*Toxicity Reduction*	*20*		
4.4.4	**Cost-Effectiveness**	**25**		
4.4.3.1	*Efficient Use of Existing Resources*	*3*		
4.4.3.4	*Life Cycle Cost Analysis*	*22*		
4.4.3	**Environmental Impacts**	**20**		
4.4.4.1	*Energy Efficiency*	*5*		
4.4.4.2	*Greenhouse Gas Emission*	*6*		
4.4.4.3	*Footprint*	*4*		
4.4.4.4	*Secondary Waste Production*	*5*		
	Total	**100**		

Notes:

Assign the full score to the technology for each sub-criterion that is not applicable to the assessment. For example, if the untreated effluent is not toxic, assign a score of 5 for the toxicity reduction sub-criterion 4.4.2.2.

4.4.1 Reliability

Reliability is the probability of each technology operating according to its specification under various operating conditions over the anticipated lifespan of the technology.

4.4.1.1 Risk Assessment

Conduct a risk assessment for the treatment technologies to identify the potential risks associated with implementation, operation, post-operation and maintenance. These risks may include but are not limited to, the likelihood of process failure, environmental and human health risks resulting from process failure, and risks associated with secondary waste production or effluent stability following treatment that may impact the environment and human health.

4.4.1.2 Robustness

Technology robustness is consistent and reliable performance under various conditions over the operational life of the technology. Evaluate technologies based on their ability to maintain effectiveness and performance under the fluctuations in operating conditions such as effluent quality (physical and chemical characteristics) and quantity (flow).

4.4.1.3 Scalability

The proponent must evaluate the scalability of each technology for future site expansions and its ability to handle increased loads of POCs and additional effluent flows. The proponent must assess the system's performance under increased loads and flow conditions and identify potential system modifications that might be required to accommodate changes effectively. Additionally, the proponent must evaluate if the site conditions such as available footprint, power, etc., can accommodate future expansions.

4.4.1.4 Long Term Viability

Long term viability evaluates the sustainability and performance effectiveness of the technologies over an extended period (i.e., decades). The proponent must discuss and compare longevity and expected lifespan for each technology.

4.4.2 Control Effectiveness

Compare the efficacy of each technology in removing the POCs. For existing facilities, rank the technologies by comparing to the control-effectiveness of the baseline technology currently in use.

4.4.2.1 Pollutant Reduction (achieving targets)

Discuss the efficacy of each technology in removing the POCs as percent pollutant removal and achievable effluent concentrations. Pollutant reduction scores can be assigned to each POC individually, and an average of the allocated scores for all POCs can be used to determine the final score of the technology.

The proposed scores shown in Table 3 can be used in the evaluation for pollutant reduction.

Table 3 Proposed Scores for Pollutant Reduction

Percent Pollutant Reduction (%)	Score (1-5)
0% to 20%	1
20% to 40%	2
40% to 60%	3
60% to 80%	4

80% to 100%	5

4.4.2.2 Toxicity Reduction

Mine effluent must not be acutely toxic to the most sensitive receptor in the receiving environment. If applicable, discuss how each treatment technology addresses the acute toxicity characteristics of the effluent by removing the POCs that are acutely toxic to the most sensitive user. Toxicity of treatment effluent post operation must also be considered, if applicable (e.g.: stability of selenium species due to changes in water temperature or redox conditions in the receiving environment).

4.4.3 Cost Effectiveness

4.4.3.1 Efficient Use of Existing Resources

When evaluating various technologies to identify the BAT, the QPs should consider the allocation and utilization of available resources and existing infrastructures to attain optimal environmental outcomes. For example, exploring options such as repurposing an existing pit as an equalization or settling pond, where feasible, should be investigated. Rank the technologies considering their ability to efficiently utilize the existing infrastructure and resources to optimize the performance.

4.4.3.2 Life Cycle Cost Analysis

4.4.3.2.1 Capital Cost

Provide a capital cost estimate for the treatment technologies including effluent treatment, by-products treatment or disposal, and ancillary equipment and infrastructure required for the operation of each technology. The capital cost estimate should be based on Class 5 AACE International Recommended Practices with a range of accuracy within -50% to +100% at a minimum and preferably based on Class 4 -30% to +50%.

4.4.3.2.2 Operating and Maintenance Costs

Provide an operating and maintenance (O&M) cost estimate, including the costs associated with the operation and maintenance of each technology, as well as the treatment and disposal of by-product(s) and any required ancillary equipment or infrastructure.

After estimating the capital and O&M costs for each technology, conduct a life cycle cost analysis (LCCA) spanning the next 100 years at minimum or the duration that treatment is predicted to be required, if less than 100 years. This analysis should include relevant costs incurred from acquisition through operation, maintenance, and eventual disposal or decommissioning of the technology, when applicable. After completing the LCCA for each technology, compare the results and rank the technologies based on the net present value (NPV). Assign the highest score to the technology with the lowest NPV and vice versa.

4.4.4 Environmental Impacts

4.4.4.1 Energy Efficiency

Conduct a qualitative evaluation and comparison of the technologies, considering their energy efficiency. Rank the technologies from most to least energy efficient, assigning the highest score (5) to the most energy efficient technology and the lowest score (1) to the least energy efficient technology.

4.4.4.2 Greenhouse Gas Emissions

Conduct a qualitative evaluation and comparison of the technologies, considering their greenhouse gas (GHG) emission levels based on their process, energy consumption, fuel use, chemical consumption, etc. Assign the highest score to the technologies with lowest GHG emission and lowest score to the technologies with highest GHG emission.

4.4.4.3 Required Footprint

Evaluate the footprint and site disturbance required for each technology, including the footprint for ancillary works such as pre and/or post-treatment in your assessment. Compare the technologies based on the footprint and score them from highest to lowest corresponding to the smallest to the largest footprint, respectively.

4.4.4.4 Secondary Waste Production

Identify the potential secondary wastes or by-products generated by each technology. Estimate the quantity of each by-product associated with the design flow and the required level of treatment. For each technology, evaluate and compare the quantity of the by-products, ease of disposal and the potential impacts of the by-products on the environment and human health. Briefly discuss each of these parameters and score the technologies considering these factors.

5 BAT Selection and Reporting

Select the BAT based on the weighted scores from the assessment criteria and professional judgement. Summarize the results of the assessment for each technology in a comprehensive report that includes the information outlined in Section 4, as well as the following:

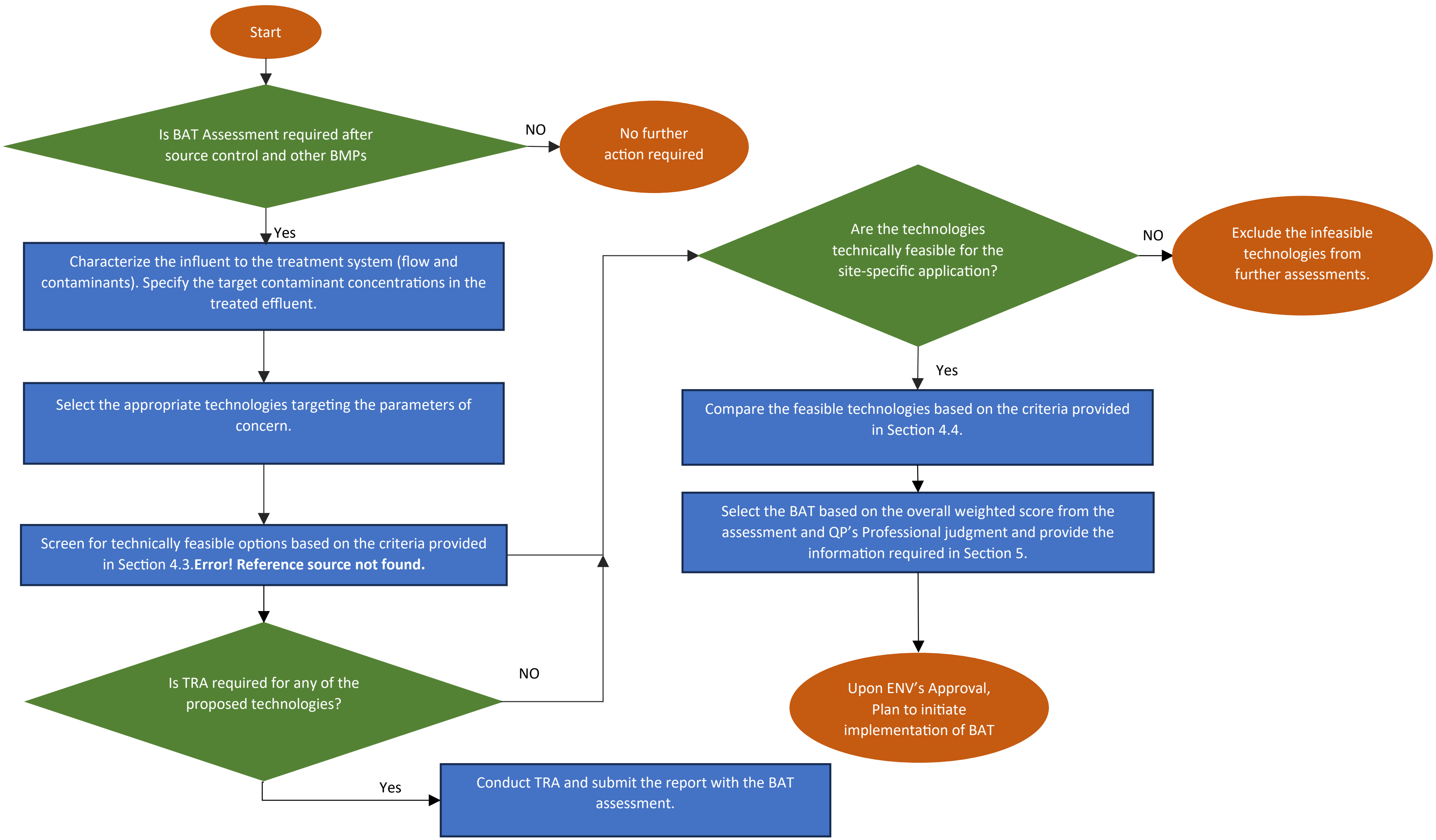
- a summary of technologies considered, including technologies deemed infeasible;
- a summary explaining why a given technology was deemed infeasible;
- a summary table that clearly present the results of the assessment for each considered technology (example shown in Table 4 below);
- a summary of the selected BAT or combination of BATs, with a detailed description of the treatment mechanism, incorporating a process flow diagram illustrating the proposed treatment process and ancillary works;
- justification of the selected BAT or combination of BATs and any trade-offs made amongst the rankings (e.g., reliability vs. cost-effectiveness); and
- a list of major equipment and chemicals required for the selected technology.

•

Table 4 Proposed Template for Summarizing Results

Assessment Criteria		**Technology 1**		**Technology 2**
Technical Feasibility		Feasible		Not feasible due to site geography
	Weight	Score	Weighted score	
Reliability				Not considered because not feasible
Risk Assessment	5	4	20	
Robustness	5	4	20	
Scalability	5	5	25	
Long-term Viability	5	4	20	
Control-Effectiveness				Not considered because not feasible
Pollutant Reduction	15	5	75	
Toxicity Reduction	20	5	100	
Cost-Effectiveness				Not considered because not feasible
Efficient Use of Existing Resources	3	2	6	
Life Cycle Cost Analysis	22	1	22	
Environmental Impacts				Not considered because not feasible
Energy Efficiency	5	2	10	
Greenhouse Gas Emission	6	3	18	
Footprint	4	4	16	
Secondary Waste Production	5	2	10	
Total Score	100		342	

6 BAT Assessment Process Flowchart



7 References

ENV. (2019). *Development and Use of Initial Dilution Zones in Effluent Discharge Authorizations.* BC Ministry of Environment and Climate Change Strategy.

ENV. (2021). *Best Achievable Technology Assessment Steps Fact Sheet.* BC Ministry of Environment and Climate Change Strategy.

ENV. (2021a). *Best Achievable Technology Assessment Policy to Inform Waste Discharge Standards.* BC Ministry of Environment and Climate Change Strategy.

ENV. (2022). *Technology Readiness Assessment Interim Technical Guidance.* BC Ministry of Environment and Climate Change Strategy.

ENV. (2024a). *Defining Parameters of Concern for Effluent Discharge Authorization Applications.* BC Ministry of Environment and Climate Change Strategy.

ENV. (2024b). *Joint Application Information Requirements (JAIR) Guidance Document.* BC Ministry of Environment and Climate Change Strategy.

ENV. (2024c). *Mine Effluent Discharge Authorizations Permit Application Development and Review Process.* BC Ministry of Environment and Climate Change Strategy.