RioTinto

B.C. Works Sulphur Dioxide Environmental Effects Monitoring (SO_2 EEM) Program

Summary of the Terms of Reference for the 2026 Comprehensive Review

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Summary of the Terms of Reference for the 2026 Comprehensive Review

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1. About the Terms of Reference for the 2026 Comprehensive Review

The Sulphur Dioxide (SO_2) Environmental Effects Monitoring (EEM) Program for the B.C. Works Kitimat aluminum smelter tracks effects of the smelter on air, human health, vegetation, soils and aquatic ecosystems. The 2026 Comprehensive Review will review what has been learned from the program from 2019 to 2025, and the report will summarize what has been learned and what questions have been answered.

As required under the EEM Program, monitoring is defined and conducted by qualified professionals (QPs) who are experts in the fields of the individual monitoring programs.

The QPs are responsible for conducting and reporting on the Comprehensive Review.

The Detailed Terms of Reference for the 2026 Comprehensive Review has been prepared by the QPs to define the expectations for data gathering and analysis for each monitoring program, and the way the results will be communicated in the report. The Detailed Terms of Reference for the 2026 Comprehensive Review can be found at https://www.riotinto.com/en/operations/canada/bc-works.

Summary of the Terms of Reference for the 2026 Comprehensive Review

This Summary of the Terms of Reference presents an overview of the Comprehensive Review (CR), and what it will report, as set out by the QPs in the Detailed Terms of Reference. It also provides a brief overview of each program and a map of the monitoring sites of each program. Words and phrases that appear in [green] are defined in the Technical Glossary at the end of this document; more complete technical information on the EEM and Comprehensive Review can be found in the Detailed Terms of Reference.

Figure 1. Comprehensive Review Report Synopsis of Results published in 2020

The Environmental Effects Monitoring Program (EEM) is a program of monitoring the effects of sulphur dioxide (SO_2) from the B.C. Works smelter on human health and the environment. It is a condition of the B.C. Provincial P2 permit that allowed an increase in SO_2 emissions from the modernized smelter to a maximum of 42 tonnes per day (tpd). Its purpose is to conduct scientific studies to detect any effects of sulphur emissions, and set out measures to reduce any harm that occurs.

The EEM Program began in 2012 with Phase I studies that resulted in the Sulphur Dioxide Technical Assessment Report (STAR). Phase II covered monitoring from 2013 to 2019 and was the subject of the 2019 Comprehensive Review; the report of that CR was published in 2020. A summary of what was learned in, and recommendations from, the report of the 2019 Comprehensive Review is shown in the "Appendices" on page 23. The 2026 Comprehensive Review that is the subject of the present Terms of Reference covers Phase III monitoring activities from 2019 through 2025.

EEM studies monitor effects of sulphur emissions (the source) on air and four receptors – human health and three environmental receptors – that are exposed to sulphur through two exposure pathways. If any effects are observed, the level of harm to the receptor is evaluated using key performance indicators (KPI) and/or informative indicators, which are set for each receptor. Each KPI has threshold levels at which additional monitoring or mitigation are applied. The source, the

four receptors, and the pathways by which the receptors are exposed to the source, are depicted in "Figure 2. Source-Pathway-Receptor model" below.

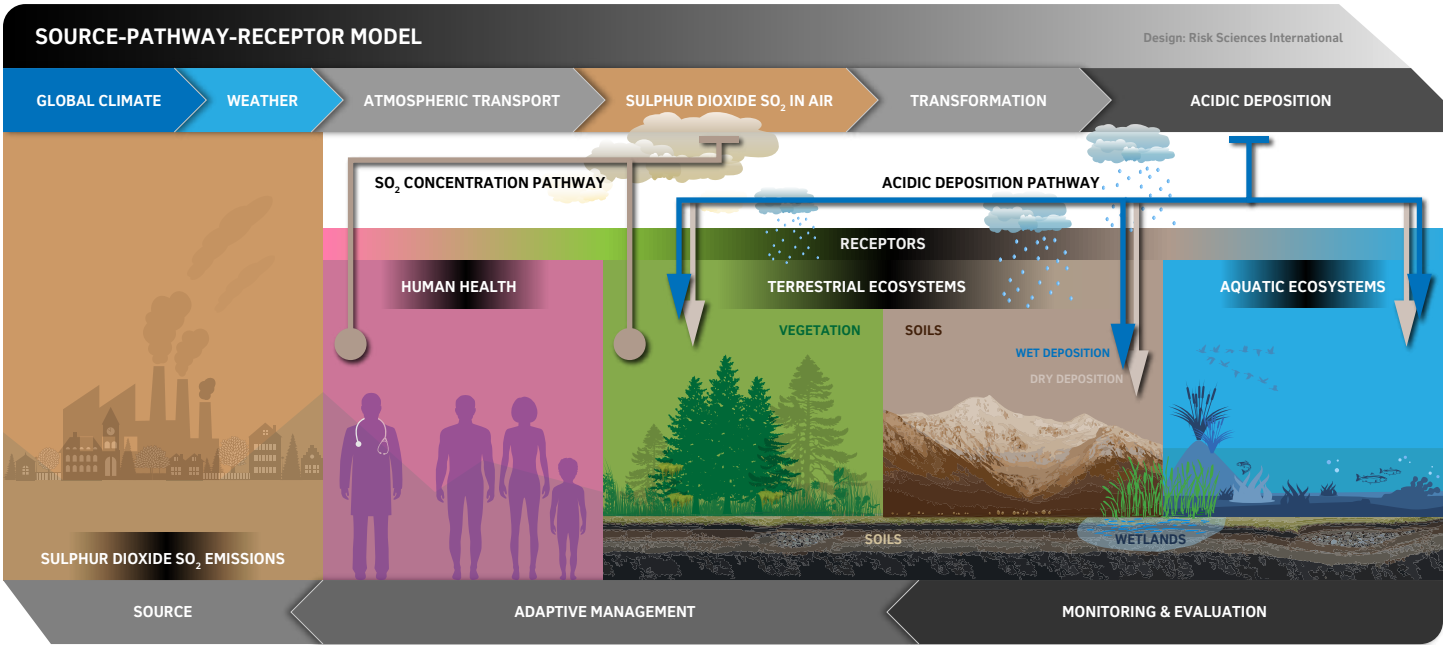
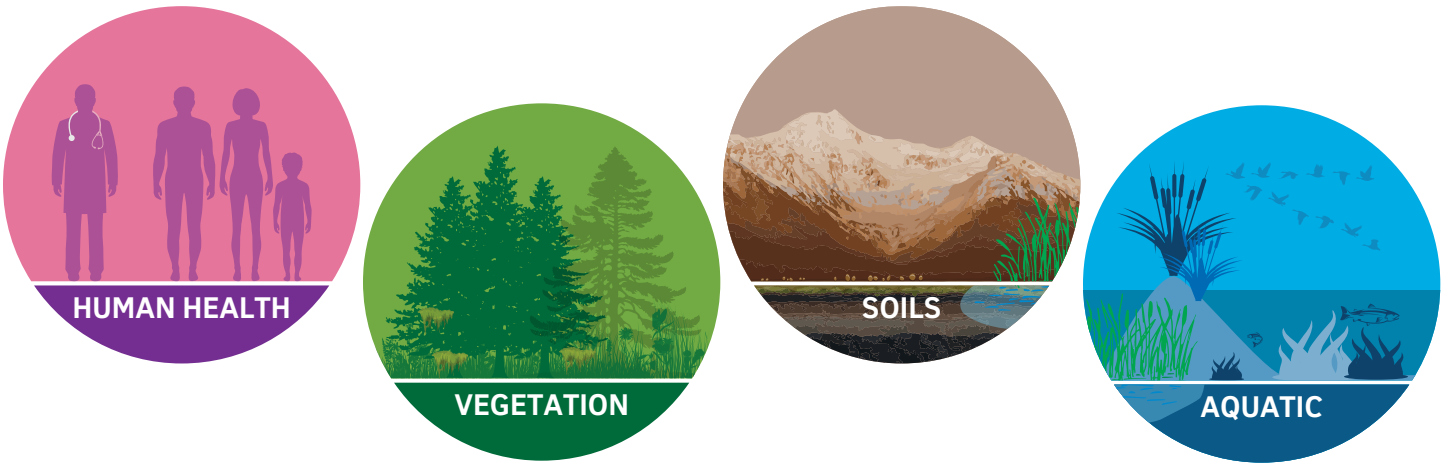


Figure 2. Source-Pathway-Receptor model

The Terms of Reference for the 2026 Comprehensive Review describe information that is to be provided in the report. The QPs will report on six monitoring studies. These include studies on the four receptors – also known as the four lines of evidence, as they provide the data for the EEM. The four receptors are:

- **Human health**
- **Terrestrial ecosystems — Vegetation**
- **Terrestrial ecosystems — Soils**
- **Aquatic ecosystems — Lakes**



There are two additional monitoring programs that will be reported on in the Comprehensive Review report:

- Atmospheric pathways, which produces data on sulphur concentrations throughout the airshed study area in support of the receptor programs.
- Climate change: The 2026 CR report will include a discussion of climate change, taking stock of QPs' own metrics and compiling available data, to identify any signals of effects.

Objectives of the 2026 Comprehensive Review report

For each receptor program, the 2026 CR report will provide an overview of the evolution of the program. The two main objectives are:

- To build on the knowledge gained in the 2019 SO_2 Comprehensive Review;
- To summarize what has been learned from the last seven years of monitoring, and describe which, if any, KPI thresholds have been exceeded.

In addition to the above, the 2026 CR report will also:

- Review the data from the four lines of evidence to develop a holistic understanding of the effects of SO_2 from the B.C. Works smelter on all four receptors;
- Recommend any changes that may be needed for KPIs after this CR, including measurement methods and thresholds, and explain the rationale for any changes;
- Develop a set of climate change indicators for the next Phase of the EEM;
- Recommend a date for the next Comprehensive Review.

The 2026 CR will not assess data or monitoring that are not part of the Phase III plan. A cumulative effects assessment of combined Rio Tinto and LNG project emissions, and the development of a cumulative effects approach, are also not in scope of this CR.

This Summary of the Terms of Reference provides an overview of the CR QP team's objectives and reporting of each program's monitoring through Phase III of the EEM, and describes how these will be presented in the Comprehensive Review report. Details for each program will be placed in appendices of the report.

This is done under four key headings:

- Objectives
- Methods
- Observations and adjustments to the EEM Program
- Recommendations for the EEM Program going forward

Facility production and emissions from 2019 to 2025

The CR report will describe the SO_2 emissions that are allowed under the permit, and data on SO_2 production and emissions from 2019 to 2025.

It will also discuss the variability of the rate of SO_2 emissions, and available related information.

2. Evaluation of KPIs against thresholds, informative indicators, and synthesis of results

The 2026 CR report will summarize results of the monitoring programs, and what has been learned from them.

Results pertaining to KPIs and informative indicators will be presented:

- For each monitoring program, whether any KPI thresholds were reached, and if so what was the response;
- Information on modifications to any KPIs or informative indicators, or to modelling or monitoring methods.

The questions that have been answered under the EEM Program, and those that remain to be answered, will be summarized, indicating:

- For each program, the questions that have been answered, those that remain to be answered, and new questions that have emerged.
- Details of answers will be provided in the relevant sections of the Comprehensive Review report.

3. Review results for atmospheric pathways

The Atmospheric Pathways Program includes two types of studies:

- Atmospheric SO_2 concentrations, which supports the SO_2 concentration pathway, is relevant to human health and vegetation;
- Wet and dry atmospheric sulphur deposition, which supports the acidic deposition pathway, is relevant to vegetation, soils and aquatic ecosystems.

These studies use a combination of modelling and monitoring methods.

Air dispersion modelling uses the CALPUFF model, a computer tool that forecasts the concentrations of SO_2 and deposition rates of total sulphur throughout the airshed from industrial emission sources.

Continuous (active) and passive SO_2 atmospheric monitoring measures concentrations of SO_2 in the air through a network of stations. The SO_2 atmospheric concentrations monitoring stations in Kitimat and Kitamaat Village are used to evaluate levels relative to the human health KPI. The network also provides information on the distribution of SO_2 and related deposition rates on vegetation, soils and water throughout the study region.

The Terms of Reference provide separate directions for reporting on atmospheric concentrations and atmospheric deposition.

There is no KPI for atmospheric pathways. There are three informative indicators:

- Atmospheric SO_2 concentrations
- Atmospheric S deposition
- Contribution of dry deposition to total deposition.

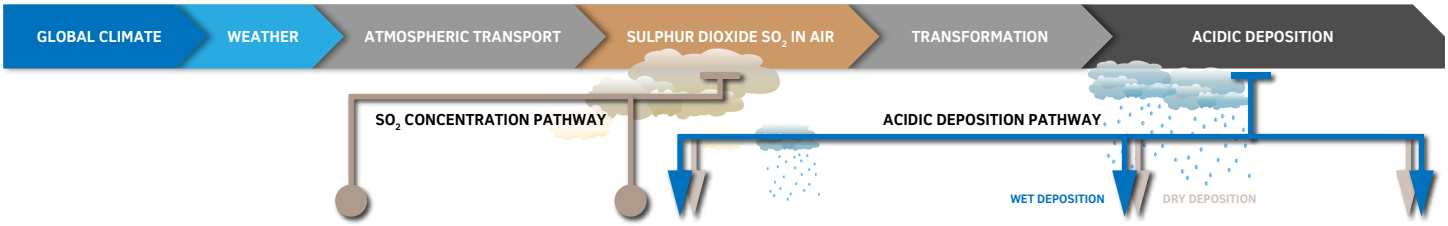


Figure 3. Atmospheric pathways

Atmospheric concentrations

The 2026 CR report will explain the importance of this program, and how the atmospheric concentrations component has evolved over the three phases of the EEM Program.

Objectives

The CR report will address the questions from the previous EEM: Does the CALPUFF model accurately represent recent SO_2 air concentrations?

Methods

The CR report will summarize the modelling and monitoring methods that were used in the analyses for this review.

The CR report will describe the collection of data for CALPUFF modelling, and why it is not necessary to redo the atmospheric modelling that was completed for the 2019 Comprehensive Review.

The CR QP team will use the 2019 CALPUFF model with corrected wind data and will compare the results of modelling with the results of monitoring.

Monitoring methods, including data collection from the SO_2 continuous (active) monitoring network, including stations at Haul Road, Riverlodge, Whitesail, Service Centre, and Kitamaat Village, will be described. The monitoring sites are shown on “Figure 5. SO2 EEM Program atmospheric pathways map” on page 8.

Figure 4. Riverlodge Monitoring Station

In the analyses of the monitoring data, the QPs will explain the optimization of the continuous air quality monitoring network. They will also:

- Examine trends in SO_2 concentrations at the continuous (active) monitoring sites;
- Evaluate passive sampler results and compare these to the continuous monitoring stations;
- Evaluate variations in SO_2 concentrations over time and across the study area.

Observations, and adjustments to the EEM Program

The 2026 CR report will provide an overview of results, and will summarize what has been learned from them. The QPs will explain if predicted patterns of SO_2 in residential areas and the Service Centre of Kitimat agree with recent measurements.

The CR report will describe any adjustments that have been made to modelling, monitoring, or the atmospheric SO_2 concentrations informative indicator, and any proposed changes to the SO_2 monitoring network.

Recommendations for the EEM Program going forward

The CR report will describe any changes recommended to monitoring methods, modelling methods, and to the SO_2 concentrations informative indicator.

Atmospheric deposition

The CR report will explain the importance of this component of the EEM, and how it has evolved through the three phases of the EEM.

Objectives

The QPs will address the questions from the SO_2 Technical Assessment Report (STAR) and from the Phase III plan.

Methods

The QPs will summarize all methods used.

For wet deposition, they will describe the data collected on rainfall chemistry by the National Atmospheric Deposition Program (NADP), as well as the data collected for modelling of dry deposition. The deposition monitoring network will be described.

The QPs will analyze three main aspects of deposition data:

- Wet deposition results for Haul Road (2012-2025) and Lakelse Lake (2013-2025), in terms of precipitation chemistry and deposition; and trends in wet deposition at Haul Road and Lakelse Lake;
- Dry deposition will be modelled using the Big-Leaf dry deposition model;
- Total deposition analysis: total sulphur deposition at Haul Road and Lakelse Lake will be evaluated.

Observations, and adjustments to the EEM Program

The QPs will provide an overview of results, and will summarize what has been learned from them. They will explain any changes they made to the informative indicators.

The QPs will explain knowledge that was gained from the studies, specifically related to variations in SO_2 and total sulphur deposition over time and across the Kitimat Valley, the contribution of dry to total deposition, and how deposition varies with precipitation.

Recommendations for the EEM Program going forward

The QPs will explain any changes recommended to monitoring methods, particularly whether to continue to monitor wet deposition at Haul Road and Lakelse Lake. They will explain any recommended changes to modelling methods and the informative indicators.

“Figure 5. SO2 EEM Program atmospheric pathways map” on page 8 shows the locations of the atmospheric concentrations monitoring sites and the wet deposition monitoring stations.

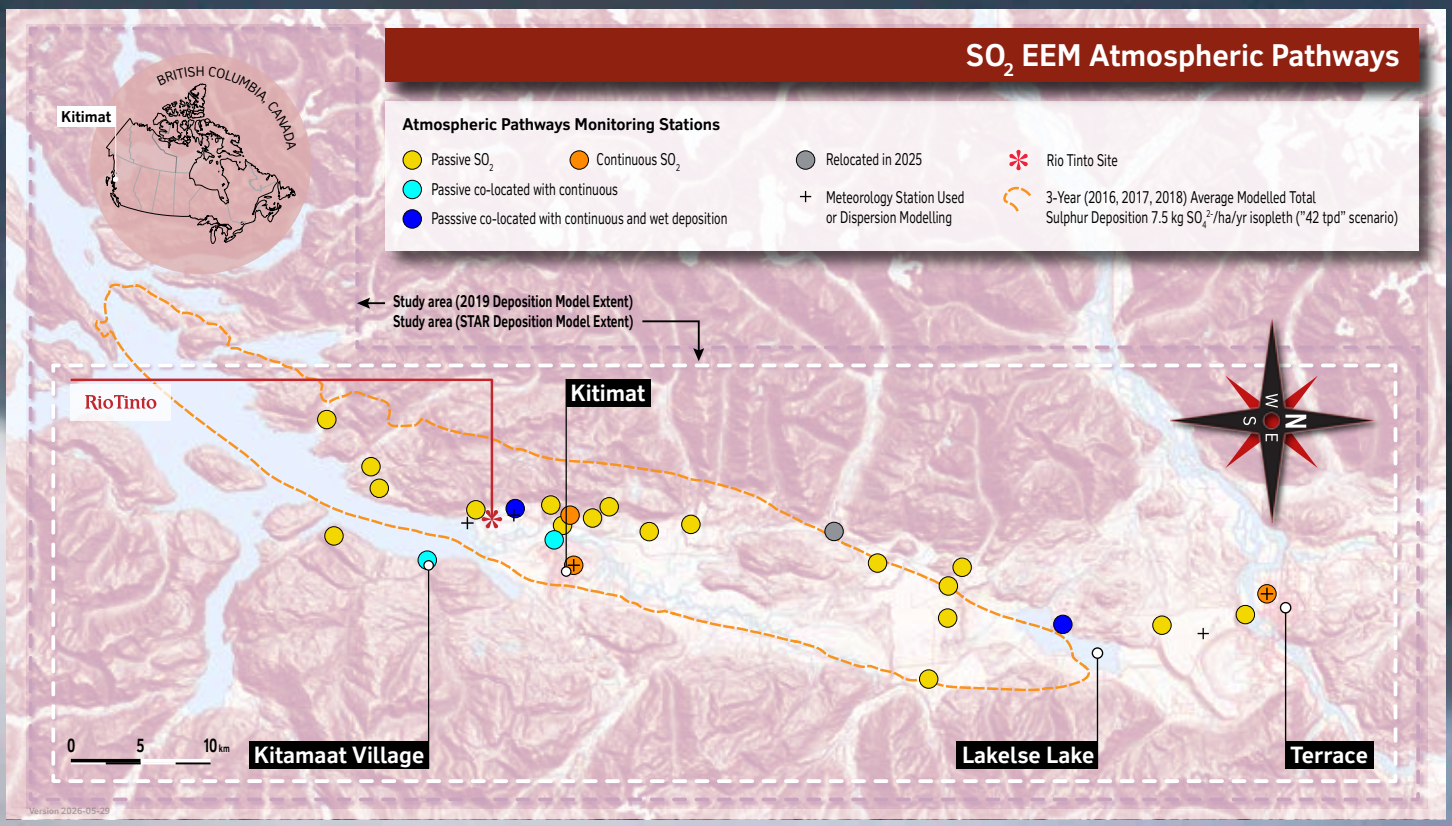


Figure 5. SO_2 EEM Program atmospheric pathways map

4. Review results for human health

The Human Health Monitoring Program involves monitoring SO_2 concentrations in the air and comparing them to the current KPI.

The KPI uses the Canadian Ambient Air Quality Standards (CAAQS) for SO_2 levels. The CAAQS, published by the Canadian Council of Ministers of the Environment, were based on a Health Canada risk assessment that determined that exposure to SO_2 is a respiratory irritant for asthmatics. As exposure to SO_2 below the CAAQS level is unlikely to cause asthmatic symptoms, the use of the CAAQS threshold as the human health KPI will protect the sensitive group of asthmatics.

The KPI for human health has changed since the current EEM began. In 2019, British Columbia's 1-hour interim SO_2 air quality objective of 75 ppb was in effect; in 2020, the Province applied the CAAQS, which set out a schedule for the adoption of increasingly stringent targets: the SO_2 threshold was 70 ppb in 2020, and it dropped to 65 ppb in 2025.

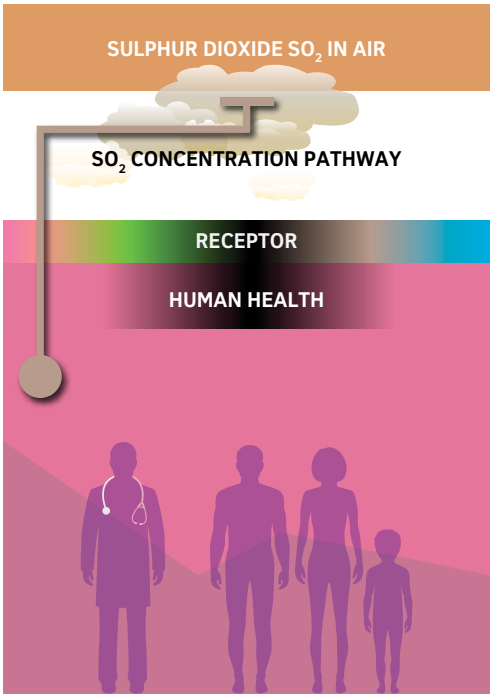


Figure 6. Human health is on the SO_2 concentration pathway.

Objectives

The goal of the review is to learn if any KPI thresholds were reached or exceeded. The Comprehensive Review will evaluate how much higher the CALPUFF model's predicted SO_2 levels are than measured levels. The CR QP team will explain that the Riverlodge monitoring station represents the highest concentrations within the Kitimat residential area: if it passes the CAAQS criteria, the other residential areas will also be below the CAAQS threshold.

Methods

The QPs will provide an overview of all methods used. Concentrations of SO_2 are measured at three monitoring stations in residential areas (two in Kitimat – Riverlodge and Whitesail – and one in Kitamaat Village), and at one monitoring station in the Service Centre commercial area. The KPI uses the outdoor air standard that is applicable in British Columbia, which has been adjusted over the time covered by the Comprehensive Review to reflect changes in the applicable standard. The table below shows the levels that applied in the years reported in the 2026 Comprehensive Review and describes the way the KPI results for the study period of 2019 – 2025 will be calculated.

Exposure year	Ambient air quality standard applied	KPI threshold (parts per billion)
2019	BC Interim Air Quality Objective	75 ppb
2020 - 2024	Canadian Ambient Air Quality Standards (CAAQS)	70 ppb
2025	CAAQS	65 ppb
Calculation of KPI results for 2019 – 2025 for the 2026 Comprehensive Review The 3-year average of KPI over 2023-2025 will be compared to 65 ppb for each site. The 3-year average for earlier years will be compared to the 70 ppb standard.		

Table 1. The KPI threshold for SO_2 concentrations, changing in time

The QPs will compare measured levels to the KPI threshold to determine if there have been any acceptable or unacceptable impacts to human health.

They will discuss the results of the optimization of the monitoring network, which showed that monitoring sites are adequately representing the distribution of SO_2 through the region. The monitoring sites are shown on "Figure 7. SO_2 EEM Program human health receptor map" below.

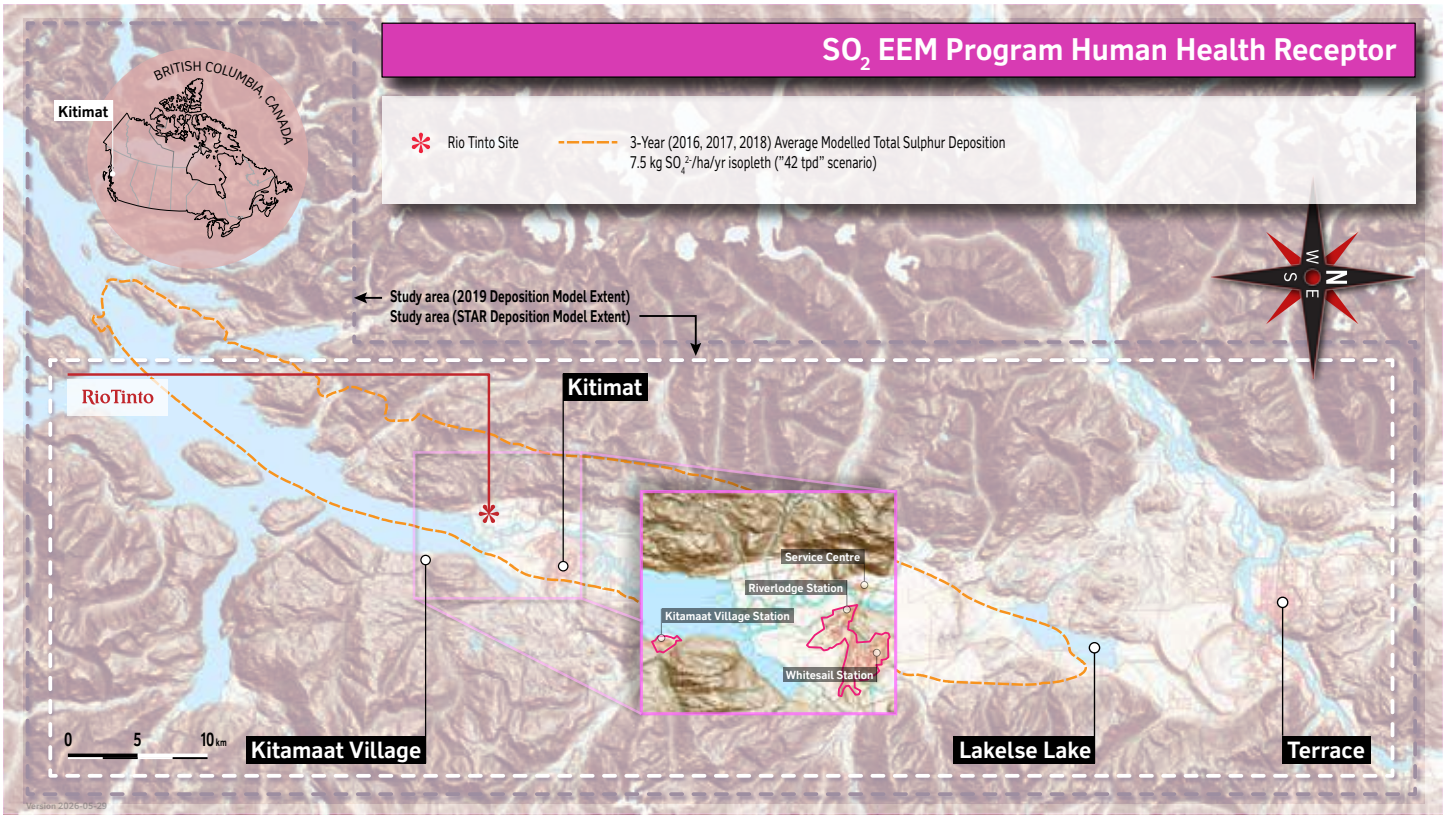


Figure 7. SO_2 EEM Program human health receptor map

Observations, and adjustments to the EEM Program

The CR QP team will summarize the main results from the monitoring stations. They will explain if a KPI threshold has been reached; and if so, what actions were taken, or need to be taken.

The QPs will describe any changes that have been made to the health KPI, including an explanation of the analysis that is done for exceptional events, such as temporary spikes (short-term elevations) in SO_2 concentrations. These could result from a number of factors, including weather conditions or local factors unrelated to the smelter.

Recommendations for the EEM Program going forward

The QPs will describe any changes they recommend to monitoring methods, frequency or extent, as well as any changes to the KPI and any recommended responses to exceedances of thresholds.

5. Review results for the vegetation component of terrestrial ecosystems

The Vegetation Monitoring Program (VMP) transitioned in 2021 to the Plant and Cyanolichen Monitoring Program (PCMP), under the broader terrestrial ecosystems monitoring program. This approach reflects the relationship between vegetation and the conditions in which it grows, such as soil acidity. The vegetation component of the terrestrial ecosystems program is on the SO_2 concentration pathway and the acidic deposition pathway, reflecting the fact that vegetation absorbs SO_2 directly from the air, and also takes up sulphur from wet and dry deposition.

The new PCMP focusses on vascular plants, cyanolichens, biodiversity, and culturally important plants, with a concern for differing effects of acidity on the various types of vegetation, and how such differences could affect biodiversity within the ecosystem. Some examples of culturally important species include edible plants such as blueberries and huckleberries, and plants with cultural, spiritual and medicinal value such as devil's club.

Monitoring activities were undertaken to determine the abundance and diversity of the cyanolichens and the health of the vascular plants in relation to exposure to sulphur. QPs will explain the focus of the PCMP on specific types of plants, and the relationship between the soils and vegetation.

The CR report will briefly present results of the VMP that have been reported elsewhere as well as results from the PCMP from 2021 through 2025.

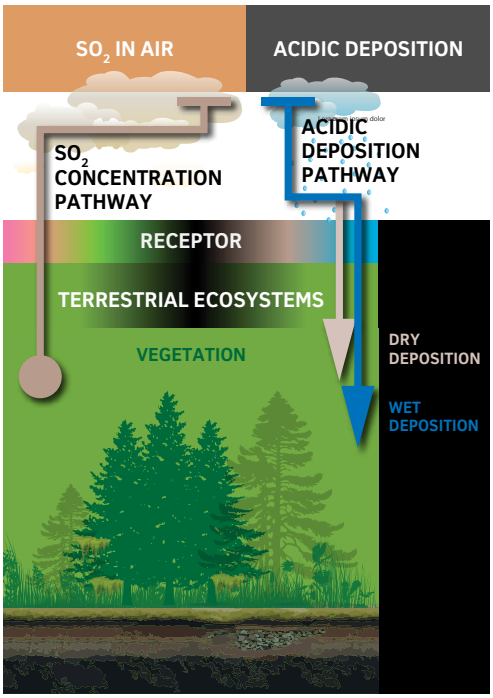


Figure 8. The vegetation component of the Terrestrial Ecosystems Monitoring Program

Objectives

The CR QP team set out to learn if any informative indicator thresholds were met. They also address the vegetation questions in the PCMP, and report on the effects of sulphur on vegetation through the VMP before the PCMP was implemented.

Key questions consider if there are any changes in species richness of cyanolichens and the health of vascular plants that differ from changes in other areas, due to SO_2 emissions and acid deposition.

Methods

The CR report will explain why there is no KPI for the PCMP, and will describe the three informative indicators that are applied to vegetation health, plant biodiversity, and cyanolichen biodiversity.

Field data collection activities include visual inspections of vegetation species, which look for signs of insect infestations, disease or injury. The QPs will describe the data they collected in the two periods of the monitoring program. Under the VMP in 2019 and 2020, they sampled western hemlock needles for sulphur levels; they will explain the timing and locations of these activities. Under the PCMP, from 2021 through 2025, they sampled vegetation health, plant biodiversity and cyanolichen biodiversity, and they will describe the timing and locations of these activities.

The analyses of observations from the sampling activities will include an evaluation of visual inspections of vegetation under the VMP and the PCMP, to assess the extent of insect infestation, disease or injury, and any relation these have to sulphur levels. The QPs will integrate these analyses with results from soils monitoring.

The QPs will do a spatial analysis to relate their results to sulphur levels modelled by CALPUFF, and to actual levels recorded at the monitoring sites. The monitoring sites are shown in "Figure 9. SO_2 EEM Program vegetation receptor map" below.

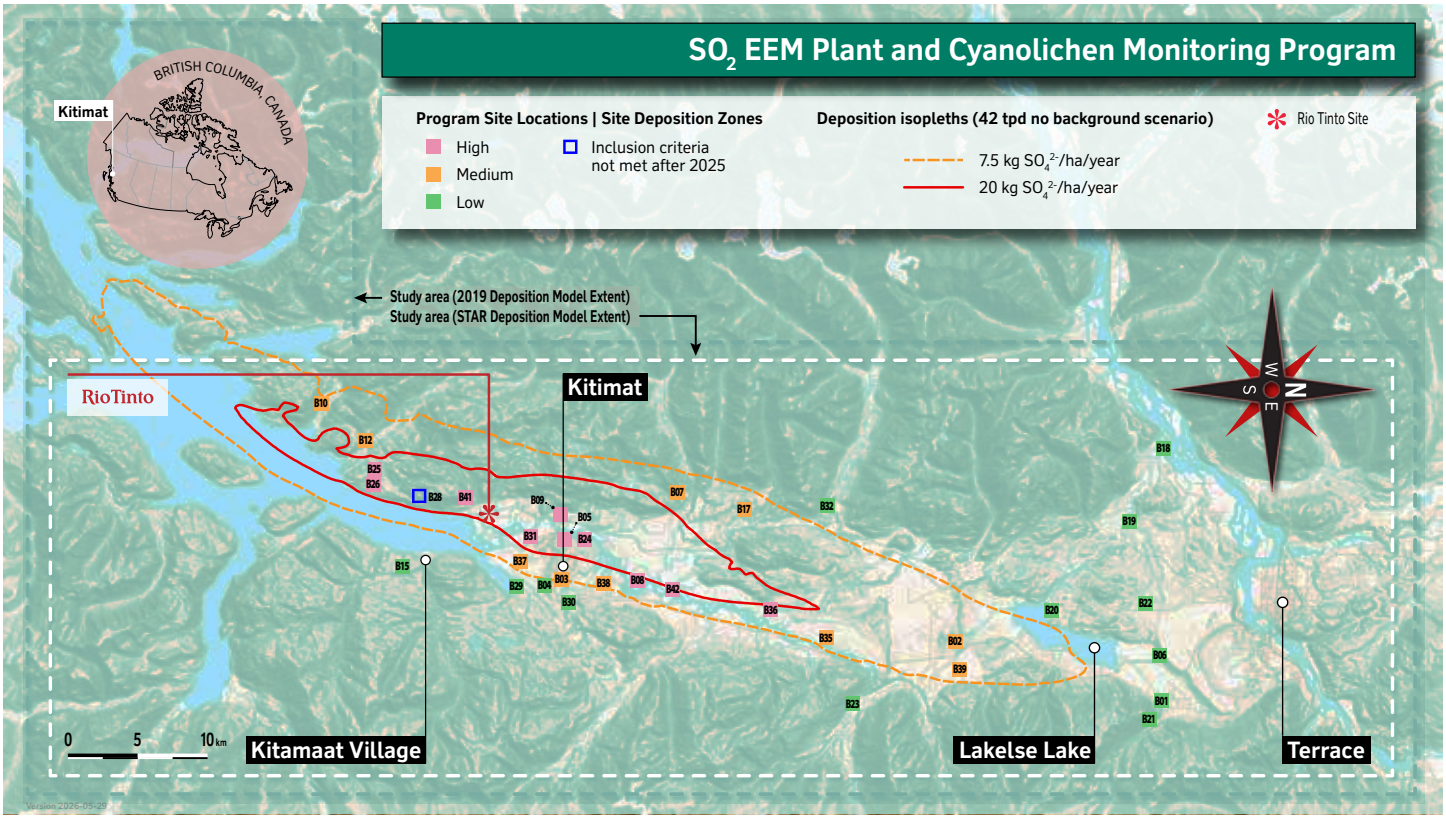


Figure 9. SO_2 EEM Program vegetation receptor map

Observations, and adjustments to the EEM Program

The QPs will provide an overview of the results of their vegetation inspections and will compare them to the informative indicators. They will describe any changes in the risk to vegetation from exposure to sulphur that were observed since the last Comprehensive Review.

They will review their methodology, including the methods, the categories they use, and the utility of the current informative indicators.

Recommendations for the EEM Program going forward

The QPs will describe the potential for adopting a key performance indicator for the PCMP, and how KPI thresholds could be developed over time as more data are collected.

They will also describe the need for any changes to plant and cyanolichen monitoring, including the need for changes to monitoring sites or analyses, and challenges in tracking plant biodiversity and detecting effects of climate change.

6. Review results for the soils component of terrestrial ecosystems

The soils component of the Terrestrial Ecosystems Monitoring Program is on the acidic deposition pathway. The chemical makeup of different soil types influences the degree to which the soil will acidify with exposure to sulphur deposition. Three permanent soil plots (two in the Kitimat Valley and one in Kemano) have been established to monitor for changes in soil acidity. Wetlands have been added to the soils monitoring program.

The soils monitoring program assesses the regional sensitivity of soils to acidic deposition which varies due to natural soil properties that can buffer against acidification. Critical loads are used to predict whether unacceptable soil acidification will occur under various SO_2 emission scenarios.

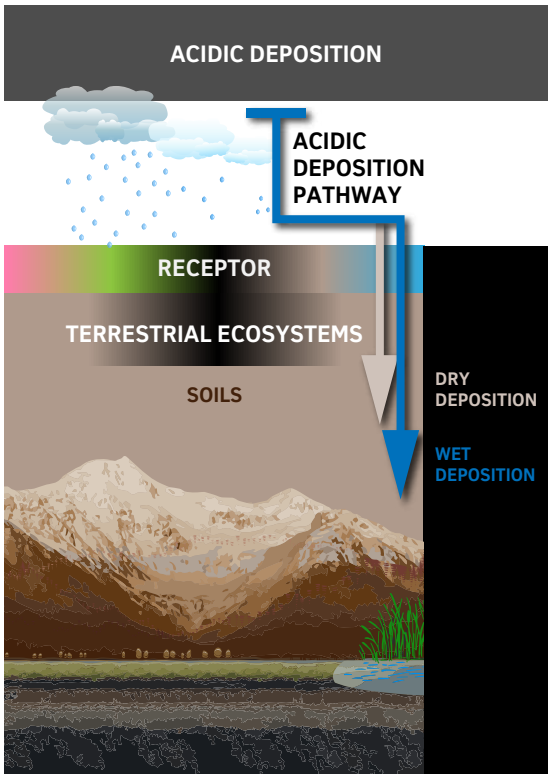


Figure 10. The soils component of the Terrestrial Ecosystems Monitoring Program

Objectives

A purpose of the Comprehensive Review is to learn if any KPI thresholds were reached, and if there is a risk of unacceptable soil acidification associated with sulphur deposition. In this review, the QPs will also evaluate how the solubility of aluminum that is naturally present in soil changes with soil pH, to assess its influence on critical loads through an uncertainty assessment; and how sensitive wetlands are to acidic deposition.

The CR report will describe the KPIs for soils, which are related to sulphur deposition, critical load exceedance risk and long-term soil acidification. It will also describe the informative indicators, which are related to soil chemistry factors.

Methods

The QPs will summarize the data they collected through sampling and analysis,.

They collected data through sampling at long-term soil plots, and in wetlands and upland forest sites, and will explain the rationale for the locations and frequency of sampling activities.

They will describe their analytic processes, related to:

- An evaluation of uncertainties in critical loads and their impact on exceedances for the entire study area;
- Changes in soil chemistry at the long-term monitoring plots.

The QPs will assess if there have been any acceptable or unacceptable impacts to soil, related to the KPIs. If any are observed, they will explain if they assessed them as caused by the B.C. Works smelter. The monitoring locations for the soils program are shown on “Figure 11. SO_2 EEM Program terrestrial ecosystems receptor map” on page 14.

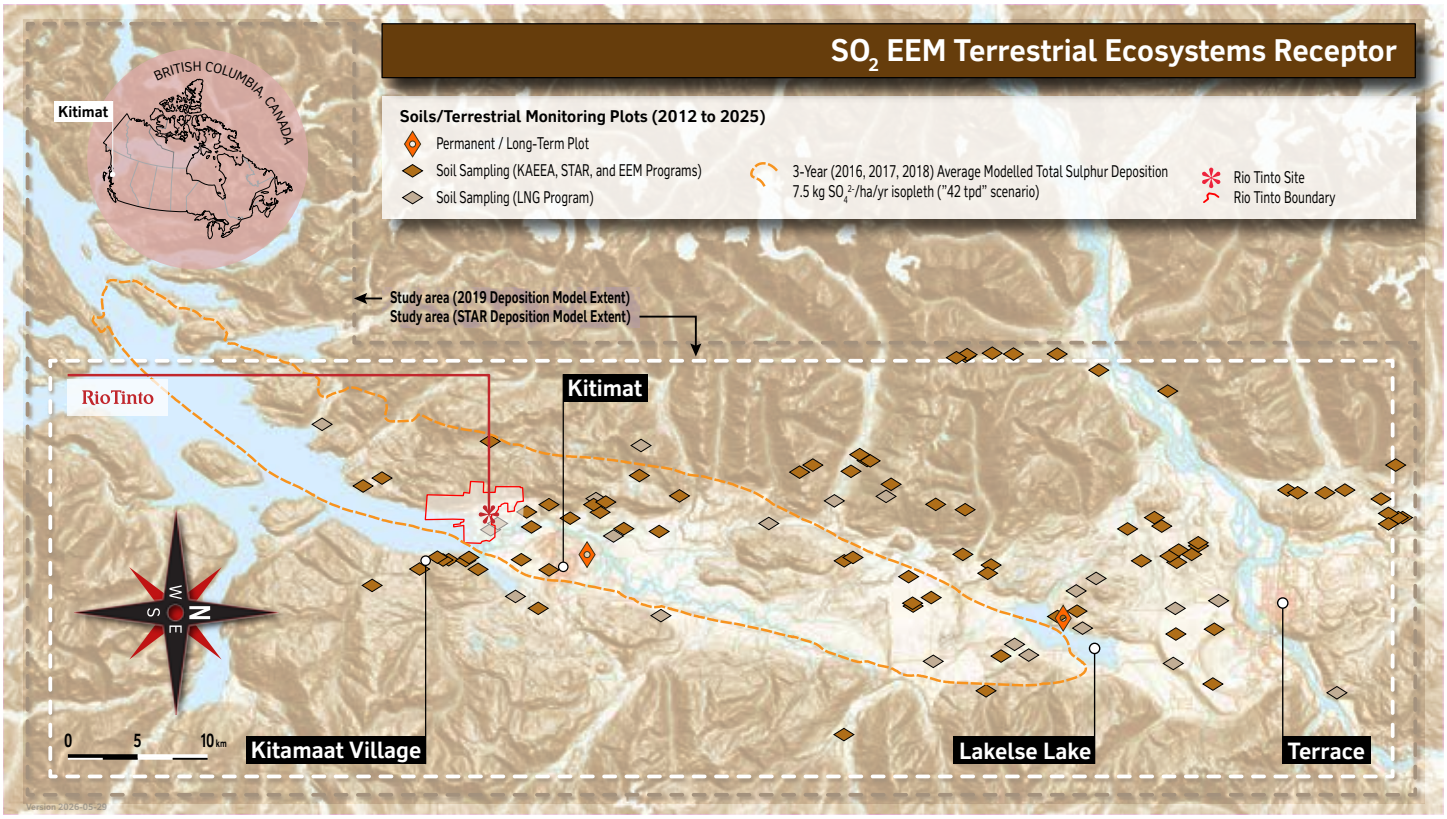


Figure 11. SO_2 EEM Program terrestrial ecosystems receptor map

Observations, and adjustments to the EEM Program

The QPs will summarize the data, and will describe any levels of exceedance, based on updated critical loads.

They will explain the geochemistry of wetland soils and upland forest soils, and how they influence the determination and mapping of critical loads. They will also report any changes in soil chemistry at the two long-term soil monitoring plots.

Conclusions will include assessments of whether the smelter has contributed to acidification of the ecosystem, and if there have been any acceptable or unacceptable impacts of the smelter on the terrestrial ecosystem.

Recommendations for the EEM Program going forward

The Comprehensive Review report will explain any changes recommended to monitoring methods, frequency or extent. It will also explain any changes recommended to KPIs or informative indicators, changes to thresholds, and responses to exceedances of thresholds.

7. Review results for aquatic ecosystems

The Aquatic Ecosystems Monitoring Program involves measurements of the water chemistry in lakes and streams in the study area. Water chemistry data track sulphate levels, the pH (level of acidity) of the water, and the acid neutralizing capacity (ANC) – the ability of lake water to neutralize acidity.

Objectives

The CR will address the questions and hypotheses from the STAR. The main questions that will be addressed are:

- How many of the seven to ten lakes that are potentially vulnerable to acidification actually acidified due to smelter operations, and to what extent?
- When the lakes are viewed as a group, is there evidence of acidification at a regional scale?
- What are the effects on lake chemistry of sulphur emissions, and of changes in emissions?

The CR report will explain the KPIs for aquatic ecosystems, as well as the informative indicators and additional informative indicators. It will explain if KPIs or informative indicator thresholds were reached.

The CR QP team will consider the effect of reducing the frequency of fall sampling from four to three events, and will also review the continued inclusion of existing lakes in the EEM Program.

They will discuss the complexity of lake chemistry dynamics, including several changes that occur simultaneously, and both natural and human-caused changes.

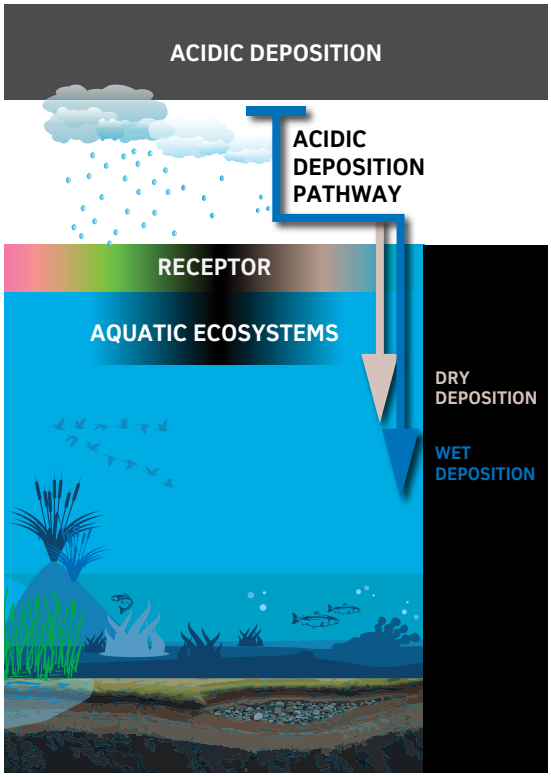


Figure 12. The aquatic component of the EEM Program

Methods

The QPs will explain the KPI, the informative indicators, and the additional informative indicators.

They will describe their sampling methods, locations and frequencies, and the data they collected on water chemistry. They will also explain their methods for assessing any impacts to water as acceptable or unacceptable, based on KPI thresholds, and will explore new methods of KPI evaluation that overcome some of the weaknesses of the current approach.

The QPs will describe the analyses they conducted on changes in water quality, and on patterns and trends in water chemistry over time. They will also evaluate their approach for assessing the causes of any acidification of water bodies and the lakes that are included in the EEM Program. The monitoring locations are shown in “Figure 13. SO_2 EEM Program aquatic ecosystems receptor map” on page 16.

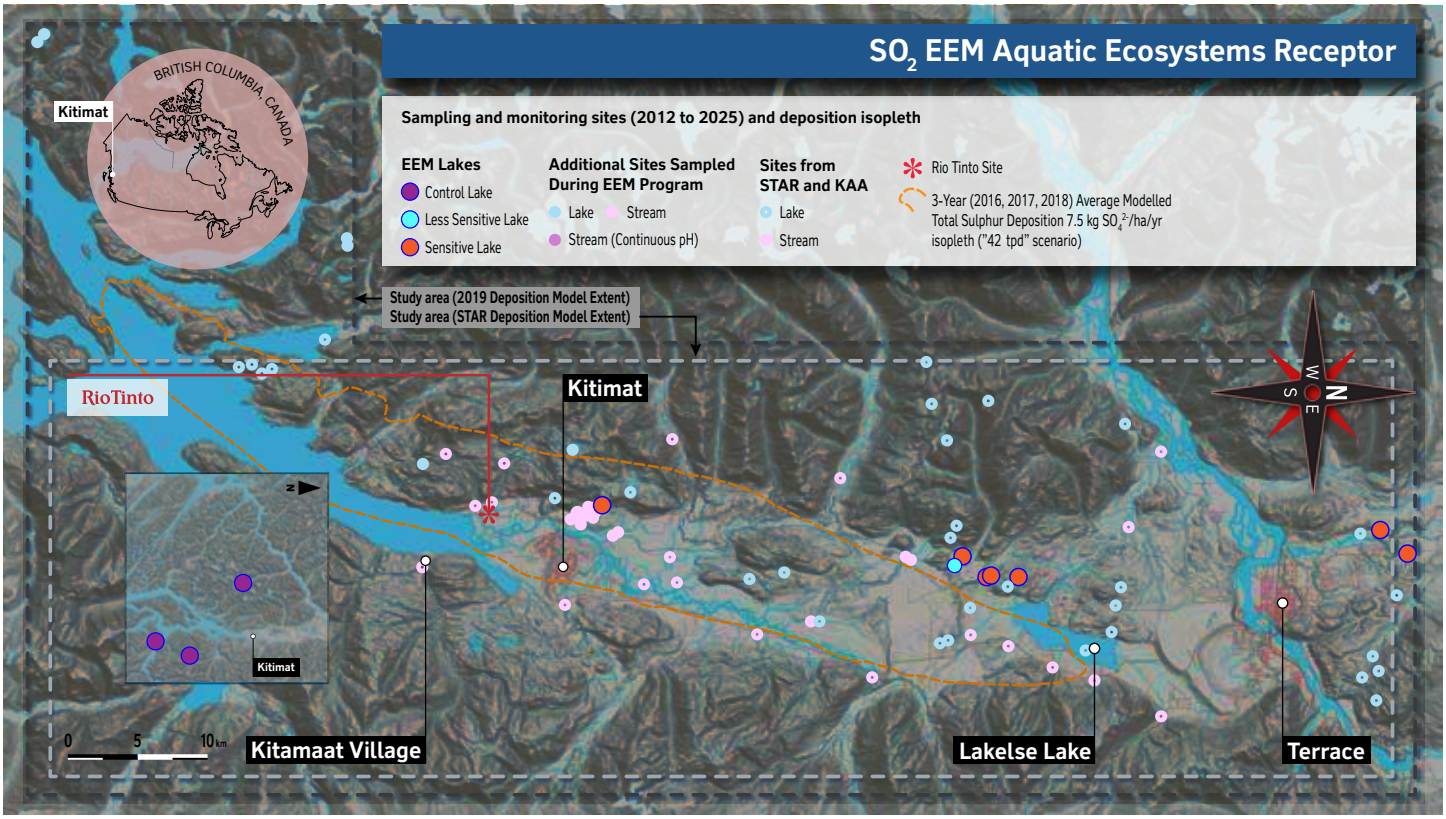


Figure 13. SO_2 EEM Program aquatic ecosystems receptor map

Observations, and adjustments to the EEM Program

The Comprehensive Review report will provide an overview of monitoring results.

The QPs will explain if any KPI thresholds were reached, and if so, what measures were taken.

They will explain what they learned about the effects of the smelter on aquatic ecosystems. This will include an explanation of their data on water sampling and water chemistry, and their new knowledge of the relation of water chemistry to the smelter. Previous questions on the status of fish populations in lakes that have acidified are no longer relevant, as the applicable lakes have not acidified. Pulling the results together, the QPs will provide a summary of changes in lake chemistry.

The CR report will note, in conclusion, if there is evidence that smelter emissions have contributed to increased acidity of aquatic ecosystems.

The QPs will explain any modifications that were made to the EEM Aquatic Ecosystems Program during Phase III.

Recommendations for the EEM Program going forward

The CR report will describe any recommended changes to the area and timing of future monitoring, and any changes to the KPIs or informative indicators.

These include the approach to the assessment of safety risks, the evaluation of new technologies, and modifications to both the sampling program and methods of data analysis.

8. Climate change

Objectives

This chapter of the Comprehensive Review report will describe the effects that climate change might have on the Kitimat Valley, and how these may interact with effects of SO_2 from the smelter. Key questions are:

- Is there any evidence that climate change could affect whether KPIs and informative indicators are reached or exceeded?
- What additional data might be included for a better understanding of the effects of climate change in the Kitimat Valley?

Methods

For this review, the CR QP team will use external information from government sources on historical and future climate indicators, as well as data from the EEM Program to show variability in current weather, and will select specific climate indicators that may affect KPIs. For example, the number of still air days could affect the human health KPI by increasing the concentration of SO_2. Examples of indicators that relate to the health of vegetation include an index of summer heat-moisture, the amount of precipitation falling as snow, total degree days above 5°C and solar irradiance. For aquatic ecosystems, the contrast between summer and fall precipitation could affect lake chemistry.

Several of these indicators are available for long-term historical periods, for future projections, and from the EEM Program. Historical data and future climate projections provide context for understanding the variation in weather observed since the start of the EEM Program. All of the QPs will be involved in selecting indicators that might be helpful for understanding climate change in the Kitimat Valley and interpreting the EEM data.

Observations

The QPs will present a summary of forecasts of climate change for the Kitimat Valley, addressing three key questions:

- What are the expected effects of climate change in the Kitimat Valley, based on long-term historical observations and future climate projections?
- Are recent observations of variability in weather from the EEM Program consistent with projected changes in climate?
- What studies may need to be done to better understand the interaction of the smelter and climate effects?

Recommendations going forward

The QPs will describe the climate change indicators and analyses that should be considered in the next monitoring cycle.

9. Holistic understanding of smelter effects on the environment and human health across all lines of evidence

The CR QP team will provide a map of all sampling and monitoring locations, and an overall summary of all observations across the four lines of evidence.

In this summary the QPs will compare their observed results to predictions, and will report if there are any trends towards unacceptable impacts across all lines of evidence. All KPIs and the associated thresholds will be summarized, and the results for all receptor programs over 2019 to 2025 will be described.

The QPs will summarize what was learned about the links between SO_2, human health and ecosystems. This will include an overview of the results on deposition-driven sulphur across vegetation, terrestrial ecosystems and aquatic ecosystems, and the effects of SO_2 concentrations in air on human health and vegetation.

10. Synthesis of recommendations

The QPs will provide a summary of recommendations in a table for each receptor, referencing the justifications for the recommendations in the individual receptor sections (3 to 7). The focus of this chapter is to integrate findings across all the lines of evidence.

11. Glossary

A

ACID
Water-based solution with a pH value less than 7.

ACID NEUTRALIZING CAPACITY (ANC).
The capacity of a solution to neutralize strong acids; an alkaline solution that neutralizes strong acids.

ACIDIC DEPOSITION
The transfer of acids from the air to soils and water, through precipitation (wet deposition – rain, snow, sleet, hail, fog droplets); or via particles (dry deposition).

ACIDIFICATION
The process by which something becomes acidic or is converted into an acid.

AIRSHED
A geographic area where the movement of air, and air pollutants, can be confined or channelled by local features such as mountains, and by weather conditions, such that all parts of the area have similar air quality conditions.

AMBIENT
Of the surrounding area or environment. Ambient air refers to the air in an area, as opposed to the air emitted at a specific source.

B

BIG-LEAF DRY DEPOSITION MODEL
Analytical model for estimating the dry deposition of SO_2 and particulate sulphate, giving the amounts deposited per hour. Uses measurements from continuous and passive air samplers, as well as weather conditions such as temperature, wind speed, relative humidity and precipitation.

C

CALPUFF
An advanced software-based modeling system for the simulation of atmospheric pollution dispersion, used for assessing long- range transport of pollutants and their impacts. Uses information on local physical characteristics, weather data and monitoring results to represent the movement of SO_2 in the air through the study region.

CRITICAL LOAD
A quantitative estimate of a receptor's exposure to one or more pollutants, below which no significant harmful effects occur. Specific critical loads will apply to individual receptors and pollutants.

CONTROL
In scientific studies, the inclusion of a group of samples that are not affected by the factors (variables) that are under study, to clarify that effects observed in the main samples result from the studied factors.

CYANOLICHEN
Lichens that have cyanobacteria (blue-green algae) as the photosynthesizing partner; they are thin organisms often found on rocks, or hanging from trees. Lichens are a combination of a fungus and a photosynthesizing partner that is algae and/or cyanobacteria. They absorb their nutrients from the air, and are thus sensitive to air pollution. Cyanolichens are particularly sensitive to air pollution and acidification, and are monitored to help track SO_2 concentrations and to observe any effects of atmospheric SO_2 on biodiversity.

D

DEPOSITION
The transfer of substances from the atmosphere to terrestrial or aquatic environments. May occur as dry or wet deposition. Dry deposition involves the settling of large particles and the transfer of smaller particles and trace gases. Wet deposition involves the transfer of particles through precipitation such as rain, snow or fog droplets.

I

INFORMATIVE INDICATOR
In the monitoring program, observable and measurable factors associated with the development of key performance indicators (KPIs).

K

KPI; KEY PERFORMANCE INDICATOR
A quantitative level of harm that can be associated with thresholds (of acidity or other factors) that trigger additional monitoring or mitigation measures.

M

MITIGATION
Actions taken to reduce the severity of an effect. A facility-based mitigation would reduce SO_2 emissions from the smelting operation sufficiently to reduce the unacceptable impact, and could be episodic or permanent as determined to be appropriate. Receptor-based mitigation refers to measures that can be applied to the receptor to protect it from the impacts of SO_2; an example is adding lime to soil to reduce acidity levels.

N

NADP: NATIONAL ATMOSPHERIC DEPOSITION PROGRAM.
The NADP is a US-based network of stations in the United States and a few locations in western Canada that measure the atmospheric deposition of acids, nutrients, and base cations in precipitation. Included in the NADP network are stations at Haul Road and Lakelse Lake; data from these stations can be viewed at https://nadp.slh.wisc.edu/data/sites/map/?net=NTN

NEUTRALIZE
The ability of a solution, or soil, to neutralize strong acids, due to its chemical composition.

P

PASSIVE SAMPLER
Passive SO_2 air concentration monitors. They sample SO_2 in one-month exposure periods.

PATHWAY
The means or route by which a receptor comes in contact with a substance; may be direct or indirect.

pH
Measure of how acidic or basic (alkaline) a substance is when it is in a water solution. Lower numbers (0-6) are more acidic, while higher numbers (8-14) are basic (alkaline). A neutral solution has a pH of 7.

Q

QP - QUALIFIED PROFESSIONAL
An individual who has accredited knowledge or skills in the area in which they are providing a service.

R

RECEPTOR
Something that is exposed to a hazard and may be at risk of associated effects. Four receptors studied under the EEM are humans, vegetation, soils and surface waters.

S

S – SULPHUR
A natural chemical element.

SAMPLING
The selection of examples from a population to include in a scientific study. The selection process may be random, to represent the larger population or system; or it may be targeted, to focus on individuals or types of interest.

SO_2 – SULPHUR DIOXIDE
Sulphur dioxide; a compound of sulphur and oxygen.

SOLAR IRRADIANCE
The amount of light energy from the sun as measured at a defined location on the earth. Solar irradiance varies with the seasons, and also throughout the day. Measurements of solar irradiance are used in weather forecasting.

STAR: SULPHUR DIOXIDE TECHNICAL ASSESSMENT REPORT.
The STAR was completed in 2013 as part of the regulatory process to amend the P2-00001 Multimedia Permit to increase the smelter's SO_2 emissions from 27 t/d to 42 t/d. The STAR reported on studies of the potential impacts of SO_2 emissions from the modernized Kitimat aluminum smelter on human health, vegetation, soils and aquatic ecosystems. It defined the criteria for the assessment of impacts to the receptors, and led to the establishment of the longer term EEM.

SULPHATE
SO_4, a compound of sulphuric acid.

T

THRESHOLD
A boundary level or magnitude at which an effect reaches a different or significant state; and / or at which a specified action begins or changes.

V

VASCULAR PLANTS
Include most species that people think of as plants, such as trees, shrubs and houseplants, that have specialized tissues that can transport water and materials, allowing some of them to grow large. Herbs, or herbaceous plants, are vascular plants that do not have a woody stem or trunk; most die back to the ground at the end of the growing season.

W

WETLANDS
Ecosystems where the soil is either permanently or temporarily saturated with water. They contain plants adapted to very wet soil. Examples of wetlands include marshes, swamps, bogs and shallow open water.

12. Appendices

Findings and Recommendations from the 2019 Comprehensive Review Report

Program	What was Learned 2013-2018	Key Recommendations for Phase III
SO_2 air concentrations and sulphur deposition monitoring (atmospheric pathways program)	**no KPI**	• Continue monitoring SO_2 levels in residential areas (Riverlodge and Kitamaat Village sites); and at Kitimat Haul Road station • Continue monitoring station at the Service Centre commercial area to provide information on the dispersion model performance • Continue passive sampling network in the Kitimat Valley; change some locations • Discontinue precipitation chemistry monitoring at the Haul Road station
Human Health	**KPI not exceeded** • average below 1ppb all sites, more than half the hours in the year • average of hours with highest daily concentration, less than 1ppb for more than half the days at each site 75 ppb threshold; this is 70 ppb in 2020 and decreases to 65 ppb in 2025.	• The CAAQS threshold replaces the initial 75 ppb threshold; this is 70 ppb in 2020 and decreases to 65 ppb in 2025.
Vegetation	**KPI not exceeded** • no visible injury to vegetation	• Establish a terrestrial ecosystem line of evidence, based on soils critical load KPI and informative indicators on plant biodiversity and plant health • Establish a monitoring program to detect long-term effects on terrestrial ecosystems, using plant biodiversity plots and monitoring lichen plots
Terrestrial Ecosystems	**KPI not exceeded** Area of exceedance less than 1% of study area, close to smelter • no change in soil conditions	• Conduct study on wetland geochemistry and sulphur storage capacity • Assess aluminum solubility in mineral soils • Long-term soil plots: the KPI should be base saturation in top 30 cm of mineral soil to assess soil chemistry changes; and return to 5-year sampling frequency.
Aquatic Ecosystems	**KPI not exceeded** • only one small fishless lake close to smelter shows signs of any acidifying change related to smelter emissions, and had before construction of new smelter.	The KPI should be changed to acid neutralizing capacity • Sampling and lake chemistry » Continue with the fall sampling of the 7 sensitive lakes. » Intensive sampling of one lake (LAK006) » Continue annual fall sampling, including the less sensitive lake (LAK016) and 3 control lakes, and discontinue sampling of the insensitive lakes (LAK 007, LAK024, and LAK034).

Table 2. Findings and recommendations from the 2019 Comprehensive Review Report

Additional Resources

B.C. Works Sulphur Dioxide Environmental Effects Monitoring Program. Phase III Plan for 2019 to 2025

- ESSA Technologies, J. Laurence, Balanced Ecological Management, Risk Sciences International, Trent University, and Trinity Consultants. 2021. Sulphur Dioxide Environmental Effects Monitoring Program for the Kitimat Modernization Project – Phase III Plan for 2019 to 2025, Draft V.2. Prepared for Rio Tinto, B.C. Works.

2019 Comprehensive Review (CR) report

- ESSA Technologies, J. Laurence, Risk Sciences International, Trent University, and Trinity Consultants. 2020. 2019 Comprehensive Review of Sulphur Dioxide Environmental Effects Monitoring for the Kitimat Modernization Project – Volume 1, V.3 Final. Prepared October 15, 2020 for Rio Tinto, B.C. Works, Kitimat, B.C.

EEM Plan, 2014

- ESSA Technologies, J. Laurence, Limnotek, Risk Sciences International, Trent University, and Trinity Consultants. 2014a. Sulphur Dioxide Environmental Effects Monitoring Program for the Kitimat Modernization Project. Program Plan for 2013 to 2018. Prepared for Rio Tinto Alcan, Kitimat, B.C. 99 pp.

Sulphur Dioxide Technical Assessment Report (STAR), 2013

- ESSA Technologies, J. Laurence, Limnotek, Risk Sciences International, Rio Tinto Alcan, Trent University, Trinity Consultants, and University of Illinois. 2013. Sulphur Dioxide Technical Assessment Report in Support of the 2013 Application to Amend the P2-00001 Multimedia Permit for the Kitimat Modernization Project. Volume 2: Final Technical Report. Prepared for Rio Tinto Alcan, Kitimat, B.C. 450 pp.

RTA / B.C. Works website

- https://www.riotinto.com/operations/canada/bc-works
- https://drive.google.com/drive/folders/1iMC6-dDTRKfpRoav0E0h1aoQ6XFGT1snGlossary

B.C. Works Sulphur Dioxide Environmental Effects Monitoring (SO_2 EEM) Program

Summary of the Terms of Reference for the 2026 Comprehensive Review