Fine Particulate Matter in New Brunswick:
Enhancing NPRI for Effective Monitoring & Mitigation

*National Pollutant Release Inventory (NPRI) Working Group
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Abstract

Fine particulate matter (PM$_{2.5}$) poses significant health and environmental challenges globally and within New Brunswick, Canada. This report delves into the nature of PM$_{2.5}$, its adverse effects, primary emission sources in New Brunswick, and the role of Canada's National Pollutant Release Inventory (NPRI) in monitoring these emissions. By critically assessing the NPRI's effectiveness and limitations, we propose targeted recommendations to enhance its capacity for mitigating PM$_{2.5}$-related risks in New Brunswick.

1   Fine Particulate Matter PM$_{2.5}$

Particulate matter (PM) is found in all indoor and outdoor environments and is a major contributor to air pollution. Unlike single-pollutant toxins, "particulate matter" is an umbrella term describing the aerosolised particle mixture of various substances like nitrates, sulfates, organic chemicals, metals, and other soil and dust particles. It can be directly emitted by primary sources (either natural or anthropogenic) or formed as secondary particles through atmospheric chemical reactions.[1] *Fine* particulate matter (PM$_{2.5}$) refers to airborne particles with a diameter of 2.5 micrometers or smaller.

Owing to the variability in sources, the measuring, tracking, and predicting of PM$_{2.5}$ pollution is a complex undertaking. Its small size allows particulate matter to remain suspended in the atmosphere for extended periods and travel long distances, contributing to regional and even global health and air quality issues.[2] This widespread dispersal is closely monitored; in Canada, inhalable particulate matter measuring 2.5 µm or less – known as PM$_{2.5}$ – is strictly regulated under the Canadian Ambient Air Quality Standards (CAAQS)[3] as part of Canada's national Air Quality Management System (AQMS).

2   Health and Environmental Impacts of PM$_{2.5}$

Unlike larger particles which can be filtered out in the nose or throat, PM$_{2.5}$ is able to bypass the body's natural defenses. This ability of PM$_{2.5}$ to penetrate deep into the respiratory system and bypass the blood-brain barrier makes it particularly hazardous. Multi-year studies[4] have linked PM$_{2.5}$ to more adverse health effects than any other common air pollutant.

Exposure to PM$_{2.5}$ is strongly associated with respiratory conditions such as asthma, chronic obstructive pulmonary disease (COPD), cardiovascular diseases, stroke, and premature death.[5] Additionally, the International Agency for Research on Cancer (IARC) identified an increased risk of lung cancer prolonged exposure, and studies have shown that even short-term inhalation can provoke acute respiratory symptoms and increase non-accidental mortality.[6] Vulnerable populations, including children, the elderly, and individuals with pre-existing health conditions are

particularly at risk. Pregnant people should also take precautions, as prenatal exposure has been linked with neurological and developmental delays.

Unsurprisingly, the health costs associated with $PM_{2.5}$-related illnesses (eg: hospitalizations, medication, and lost productivity) place a significant economic burden on the province's healthcare system. Good air quality reduces adverse health effects, avoids unnecessary hospital visits, improves work and school productivity.[7] For all of these reasons, the World Health Organization (WHO) strongly recommends strict air quality guidelines[8] to minimise $PM_{2.5}$ exposure.

Beyond the human health risks, $PM_{2.5}$ is known to interfere in climate dynamics and contribute significantly to environmental degradation, including (but not limited to) reduced air quality and visibility. Depending on its composition, $PM_{2.5}$ in the atmosphere may either scatter solar radiation (leading to atmospheric cooling), or absorb it, resulting in warming. Suspended $PM_{2.5}$ particles act as cloud condensation nuclei, altering cloud formation, characteristics, and their lifespan. Changes in cloud properties affect their capacity to reflect both short-wave and long-wave radiation, further altering the Earth's radiative balance.

At ground level, snow and ice coated with PM absorbs more sunlight, causing it to warm and melt prematurely. Metal and inorganic $PM_{2.5}$ deposits in soil and water lead to nutrient balances and contribute to acidification, impeding plant growth as well as reducing crop yields.[9] The Earth's ecological integrity is dependent on a delicate environmental balance; even apparently minor habitat alterations due to $PM_{2.5}$ deposition have the potential to precipitate the decline of sensitive plant and animal species ultimately leading to an irreversible loss of biodiversity.

3 $PM_{2.5}$ Emissions in New Brunswick

New Brunswick's $PM_{2.5}$ emissions originate from human activity as well as natural sources, with clear regional variations across urban and rural environments. Urban centres, for example, experience higher levels due to transportation and industrial activity, whereas rural New Brunswick is impacted by the pervasiveness of residential wood burning. This method of home heating is a major source of unrestricted $PM_{2.5}$ emissions during the winter months;[10] Health Canada estimates that wood-burning homes are responsible for 21% of $PM_{2.5}$ emitted across the country annually, compared to 12% from all transportation (on-road and off-road) combined.[11] Due to these increased heating demands and stagnant atmospheric conditions, the heating months typically record higher $PM_{2.5}$ levels. While summer spikes increasingly occur during forest fire events, the majority of $PM_{2.5}$ emissions in the region stem from human activity.

Industrial facilities – despite emissions fluctuations tied to economic activity – are consistent contributors to the province's $PM_{2.5}$ burden. In an effort to understand the sources of air pollution in New Brunswick, improve the air quality, and encourage the considerate use of resources, power generation facilities, pulp and paper mills, oil refineries, manufacturing plants and other such institutions are strictly regulated and require operating approval from the Department of Environment and Local Government (DELG).[12]

4   Current Policies for Monitoring PM$_{2.5}$ Emissions

As part of DELG oversight, approvals holders work with provincial inspectors to implement pollution reduction plans. Standard emissions control measures can include the use of scrubbers and filters, Continuous Emission Monitors (CEMs), opacity monitors to measure smoke density, and/or in-stack air quality monitors.[13] In order to maintain their operating approvals, facilities must use stack sampling procedures prescribed by DELG and regularly submit these samples along with any air quality sensor measurements for independent auditing to verify the integrity of the data.[14]

In addition to provincial oversight, New Brunswick adheres to federal 'right-to-know' legislation and public disclosure principles through the Canadian Ambient Air Quality Standards (CAAQS) for PM$_{2.5}$ and follows the reporting requirements of the National Pollutant Release Inventory (NPRI). Established in 1993 under the Canadian Environmental Protection Act (CEPA), the NPRI mandates that facilities meeting specific emissions thresholds report their annual pollutant releases to Environment and Climate Change Canada (ECCC). The NPRI is Canada's primary database for tracking pollutants (including PM$_{2.5}$) from these industrial facilities[15], and CEPA is authorised to levy penalties against companies who fail to meet reporting requirements.[16] The data is publicly accessible and is used by policymakers, researchers, and the public as a starting point to monitor air pollution trends and predict health and environmental impacts to determine if action is required.

5   Assessing the Accuracy and Limitations of NPRI Data

The NPRI plays a critical role in identifying major PM$_{2.5}$ emission sources, however it has been criticized for its lack of standardised emissions reporting procedures.[17] Variations in estimation methodologies and a reliance on self-reported data from each emitter can lead to inconsistencies, and there is a risk of underreporting or miscalculation.

5.1   Reporting Thresholds

NPRI PM$_{2.5}$ air releases are estimates reported from sampled *stack* emissions measured in tonnes/year of exceedance over the established NPRI reporting thresholds. What isn't clear, however, is how this threshold was established. Once facilities surpass the lower reporting threshold, the lack of a corresponding upper threshold by which to regulate and limit their emissions is deeply problematic. Without an upper limit, there is no way for the public to discern how hazardous a release is, and companies are free to exceed the reporting threshold by any order of magnitude. One 17-year analysis[18] of the NPRI as a tool for pollution control policy tool in pulp and paper mills found that NPRI reporting had little-to-no influence on management practices, and that no facility showed any significant reduction in harmful emissions.

CAAQS management levels, on the other hand, are expressed as the recommended maximum ambient PM$_{2.5}$ concentration measured in average μg/m³ over 1-hr, 8-hr, 24-hr, and annual recording periods. CAAQS national guidelines are concerned with *ambient* air pollutants. Every

management level is colour coded (either green, yellow, orange, or red) to clearly represent the relative health risk of each level and inform provinces and territories of which actions should be taken.[19] Regrettably, much like the NPRI, the CAAQS are non-binding goals which merely set targets for air quality – as yet nothing more than a precursor to enforceable national ambient air quality standards actionable under federal law.[20]

5.2   Underreporting of Condensable Particulate Matter

Particulate matter in the NPRI emissions reporting can be classified as either filterable, or condensable. *Filterable* PM refers to PM which is directly emitted and captured as a solid or liquid particle on the filter during a stack sampling. *Condensable* PM is PM directly emitted in vapour form, but which quickly cools and condenses into solid and/or liquid particles in the ambient air immediately after leaving the stack. Because stack vapours react upon cooling in the outside air, the formation of condensable PM is variable based on the air temperature of a given day.[21] Condensable particulates make up a large portion of primary particulate emissions, yet under the 2022-2024 *Guide for Reporting to the NPRI*, only filterable particulate matter is required to be reported.[22] Facilities who report stack or point releases of particulate matter must indicate if their reported emissions include condensable PM, but the Guide specifies that condensable PM should *not* be included in the final release calculations.

While NPRI contributors must indicate instances where it is not possible to distinguish the quantities of sampled filterable versus condensable $PM_{2.5}$, this practice of excluding condensable $PM_{2.5}$ makes it difficult to understand the total contributions and impact these facilities have on local/regional air quality. Accurately measuring both filterable and condensable $PM_{2.5}$ is vital to ensure that emissions do not violate CAAQS guidelines.

Smaller commercial emitters who fall below NPRI reporting thresholds are likewise not included, leaving gaps in the dataset which further hinder the use of NPRI data in creating a comprehensive $PM_{2.5}$ pollution profile in New Brunswick.[23] This gap highlights the need for complementary monitoring approaches; enhancing the NPRI to include a broader range of emission sources could improve its utility in air quality management.

5.3   Data Reconciliation: NPRI, CAAQS, and NAPS

Emissions monitoring is intended to ensure that facilities who release criteria air contaminants are operating within the recommended air quality standards for the region. However, without cross-analysis using other sources to convert NPRI tonnes/year into a rate of emission with consideration to its toxicity, direct comparisons of NPRI data with the CAAQS is not possible.

Additionally, the NPRI does not provide real-time air quality data, and does not lend itself to identifying location-based pollution that helps monitor air quality. The duration and intensity of pollutant exposure on a population is greatly affected by meteorological conditions, and while it

is understood that industrial emissions will have impacts over a larger area than just the point of release, the NPRI's annual reporting system lacks the granularity needed to identify short-term localised pollution spikes. Specific air quality events, such as temperature inversions which trap pollutants near the surface, cannot be determined by NPRI reporting alone.

The National Air Pollution Surveillance (NAPS) program is a nationwide network of urban and rural air quality monitoring stations operated by ECCC. Nine NAPS stations in New Brunswick provide real-time $PM_{2.5}$ measurements with corresponding meteorological variables such as ambient temperature and humidity, barometric pressure, wind speed, and wind direction. The data from these, and ten $PM_{2.5}$ sensors operated by commercial emitters can be accessed via the DELG Air Quality Data Portal online.[24]

While 2022 air quality monitoring results showed that all monitoring stations met CAAQS objectives[25], a more detailed analysis incorporating a comparison between annual NPRI releases and hourly NAPS data would help to quantify the relationship between in-stack $PM_{2.5}$ sampling and the variables which produce high PM2.5 concentrations in nearby ambient air.

5.4   Transboundary and close-proximity sources

Not all air pollutants in New Brunswick originate within the province. Major weather systems moving up the Atlantic seaboard transport $PM_{2.5}$ from the United States, and along our border with Maine there are several facilities in such proximity to one another that they cannot reasonably be considered as separate entities in terms of their emissions. The Twin Rivers Paper Company, for example, operates two pulp and paper mills: one out of Edmundston, NB and one in Madawaska, ME. Located on either side of the Canada-US border, the two are separated by approximately 1km as the crow flies. Because they fall under different reporting jurisdictions, the emissions from one are not considered when assessing the air quality impacts of the other.[26]

The Canada-U.S. Air Quality Agreement of 1991 was originally created to address the threat of acid rain posed by sulphur dioxide and nitrogen oxide emissions. The agreement did not address $PM_{2.5}$ releases until a joint assessment report was published in 2013,[27] which highlighted the need for improved $PM_{2.5}$ tracking and information sharing in border communities. A follow-up review of the transboundary agreement conducted by ECCC in 2023[28] found a greater transport of $PM_{2.5}$ from the U.S. to Canada (compared to Canada to U.S transmission) and that transboundary $PM_{2.5}$ had larger than expected health impacts often extending hundreds of kilometres from the border. The review recommended updates to address these emergent concerns.

If the interactions between $PM_{2.5}$ in close border communities have such far-reaching effects, then it is also important that the NPRI view close-proximity facilities within the province not as isolated polluters, but instead as an accumulative source of $PM_{2.5}$. In Saint John, for example, there are two pulp and paper mills and one refinery operating within the city limits. Assessing

single-source pollutant releases without regard to contributing sources of $PM_{2.5}$ may not adequately reflect the local human and environmental health risks.[29]

5.5   Incentives

Indeed, without additional information to express each facility's product volume as a function of its $PM_{2.5}$ emissions, it is impossible for the NPRI to effectively inform the enforcement of any air quality standard. If NPRI measurement practices were updated to require reporting of production-to-emission ratios, it would be possible to identify contributors whose elevated releases may stem from poor management or outdated technology.

Imposing large fines against inefficient, unsustainable facilities when elevated $PM_{2.5}$ is detected would incentivise an ecosystem which promotes innovation and greener practices; updating technology and equipment would become a more affordable alternative than maintaining the status quo and face paying repeat penalties. The NPRI currently imposes fines only for late reporting or failure to disclose emissions above its reporting thresholds.

Another strategy to regulate high $PM_{2.5}$ emissions is to penalise the burning of certain materials. The University of New Brunswick's Central Heating Plant (Fredericton Campus), for example, primarily employs natural gas and biomass combustion, however it also continues with the controversial burning of heavy fuel oil Bunker C.[30] The use of Bunker C in marine vessels has been banned in Canada[31] due to its devastating environmental impacts. Disincentivising the use of such heavy pollutants will facilitate the transition to cleaner, greener methods of production.

6   Recommendations

To improve $PM_{2.5}$ monitoring and air quality protections in New Brunswick, several enhancements to the NPRI and broader air quality policies are recommended:

- **Expand Reporting Requirements**: Expand NPRI reporting requirements to capture smaller emitters and include best-estimates for non-industrial contributors such as residential heating and transportation to form a comprehensive emissions inventory. Without these additions, policymakers may struggle to design comprehensive risk assessment and mitigation strategies which address the full scope of $PM_{2.5}$ pollution. Additionally, the temporal limitations of the NPRI's annual release data can be overcome by mandating more frequent reporting.
- **Enhanced Industrial Monitoring and Expanded Data Collection:** Implement real-time air quality monitoring systems for all industrial facilities. Invest in additional off-site, in-community air quality monitoring infrastructure to identify emission hotspots.
- **Enhance Verification Processes**: Strengthen self-reported data and ECCC in-house modelling through the introduction of independent site audits and standardized measurement protocols would improve data reliability and reporting accuracy and increase public trust in the NPRI.

- **Integrate Cross-Analysis Technologies**: Develop software to allow publicly-available comparisons between NPRI facility reports with NAPS air quality sensors, CAAQS guidelines, and ECCC satellite data/atmospheric modeling. A multi-variable analysis of the NPRI will provide a more complete understanding of $PM_{2.5}$ sources, distribution and true health & environmental impacts.
- **Strengthen Standards and Incentivise Emissions Reduction**: Enforce stricter regulations on industrial sources. Implementing upper threshold limits on air pollutants, with financial consequences for facilities who exceed them will promote emissions reduction technologies to significantly reduce $PM_{2.5}$ levels.

By implementing these recommendations, New Brunswick can enhance its $PM_{2.5}$ management strategies, leading to better air quality and improved public health outcomes.

7 Conclusion

$PM_{2.5}$ pollution poses serious health and environmental challenges in New Brunswick, requiring coordinated efforts to monitor and reduce emissions. While the NPRI plays a vital role in cataloguing industrial pollution, addressing its limitations through expanded reporting and improved monitoring, verification and cross-analysis processes is essential. By implementing select improvements, New Brunswick can develop more effective strategies to reduce $PM_{2.5}$ levels and protect public health and the environment.

8 Closing

This report was prepared by Leah Hemhill, PgDPH, and reviewed by Melanie Langille, M.Env.Sc and member of the Non-Governmental Organization (NGO) Working Group of the NPRI.

Respectfully submitted

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