APPENDIX 21-I

Human Health Risk Assessment

February 2018
Report No. 1536607/2000/2219

NEXTBRIDGE INFRASTRUCTURE

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1. INTRODUCTION

This appendix presents the Human Health Risk Assessment (HHRA) for the East-West Tie Transmission Project (the Project) and includes an assessment of potential human health risks associated with changes in environmental quality due to contaminant releases from the Project. Potential human health risks from noise and electromagnetic fields from the Project are not evaluated as part of an HHRA which evaluates potential risks associated with contaminant exposures only.

The HHRA follows the risk assessment framework endorsed by provincial and federal regulatory agencies (MOE 2005; Health Canada 2012). The framework provides a structured and clear approach for evaluating potential risks to human health from environmental stressors such as contaminants.

The scope of the HHRA includes the assessment of potential human health risks from inhalation of contaminants emitted to air during the construction phase of the Project. No other exposure pathways or phases of the Project are considered relevant to the evaluation of potential human health risks as described in Sections 3.3 and 4.2 of this appendix. The HHRA evaluates the potential risks to human health from short-term (or acute) and long-term (or chronic) inhalation exposure to contaminants and from exposure to particulate matter (PM) (i.e., diesel particulate matter [DPM], particulate matter less than 10 micrometres (µm) in diameter [PM_{10}] and particulate matter less than 2.5 µm in diameter [$PM_{2.5}$]) that are emitted to air. The HHRA relies upon the results of the air quality assessment (Section 9 of the Environmental Assessment [EA] Report), specifically predicted concentrations of contaminants (including DPM, PM_{10}, and $PM_{2.5}$) in air.

2. HUMAN HEALTH RISK ASSESSMENT FRAMEWORK AND APPROACH

2.1 Framework

The HHRA follows the risk assessment framework endorsed by provincial and federal regulatory agencies (MOE 2005; Health Canada 2012). The framework provides a structured and clear approach for evaluating potential human health risks, if any, to people associated with changes in environmental quality due to contaminant releases from a project. For there to be a potential health risk, the following three conditions must be met:

- A receptor (i.e., people) must be present.
- There must be a way by which the receptor can come into contact with the contaminant (i.e., an exposure pathway).
- A contaminant must be present at concentrations that could be harmful.

These three conditions are illustrated in Figure 21.I-1, where potential human health risks may occur only when the three conditions are met.

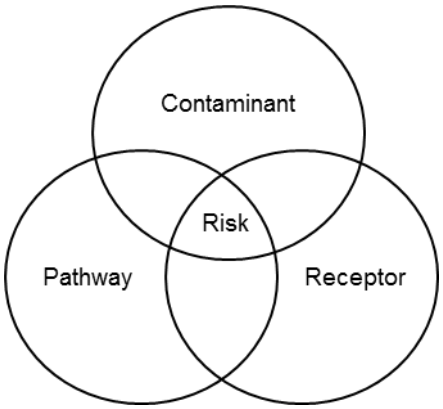


Figure 21-I-1: Three Conditions for Potential Health Risk

To determine whether these conditions are present, the risk assessment framework used in Ontario (e.g., MOE 2005) and Canada (e.g., Health Canada 2012) typically involves four sequential components, as described below:

1) **Problem formulation**: The problem formulation involves developing a focused understanding of how changes in environmental quality as a result of contaminant releases from a project might affect the health of people. The problem formulation identifies the following: a representative set of receptors (i.e., people) that may be present near the Project; the pathways by which receptors may be exposed to contamiants released by the Project (e.g., inhalation of ambient air); and the contaminants released by the Project that may be present at levels harmful to receptors (i.e., contaminants of potential concern [COPCs]). The information from the problem formulation is summarized in a conceptual site model (CSM) which illustrates the pathways of the COPCs from their sources, through the relevant environmental media to the identified receptors.

2) **Toxicity assessment:** The toxicity (or hazard) assessment provides the basis for assessing what is an acceptable or safe exposure to the COPCs and what level of exposure to the COPCs may adversely affect the health of receptors. For an inhalation assessment, this involves identification of the concentrations in air that people can be exposed to without experiencing adverse health effects. These values are called toxicity reference values (TRVs). For people, consideration is given to both non-carcinogenic and carcinogenic effects. These values are used as benchmarks for comparison with estimated concentrations of COPCs in air during risk characterization.

3) **Exposure assessment**: The exposure assessment determines the amount of COPC to which receptors are exposed via each relevant exposure pathway identified in the problem formulation. For an inhalation assessment, exposure is expressed as estimated concentrations of COPCs in air. This permits the evaluation of exposure relative to the TRVs that are also expressed in this way.

4) **Risk characterization:** The final component of a risk assessment determines the potential for adverse health effects or risks to occur. This is determined by comparing the estimated exposures received by the receptors (i.e., estimated concentrations of COPCs in air from the exposure assessment) with the level of exposure that is determined to be acceptable or safe (i.e., the TRVs from the toxicity assessment). The characterization of risks includes consideration of the uncertainty and conservatism in the risk assessment.

2.2 Approach

The HHRA provided herein evaluates the potential risks to human health from inhalation exposure to contaminants and from exposure to PM (i.e., DPM, PM_{10}, and $PM_{2.5}$) that are emitted to air from the Project. The assessment evaluates contaminants emitted to air that may pose a health risk following short-term or acute exposure by people (e.g., 1-hour and 24-hour) and contaminants that may pose a health risk following long-term or chronic exposure by people (e.g., annual). Predicted air concentrations averaged over a 1-hour period and a 24-hour period were used to evaluate potential risks from acute exposure and predicted air concentrations averaged over an annual period were used to evaluate potential risks from chronic exposure.

The following cases were evaluated in the HHRA:

- The **"Base Case"** evaluates potential human health risks from measured ambient background air concentrations from existing environmental activities.
- The **"Project Case"** evaluates potential human health risks from predicted air concentrations associated with the construction of the Project.
- The "**Base + Project Case**" evaluates potential human health risks from measured ambient background air concentrations from existing environmental activities in addition to predicted air concentrations associated with the construction of the Project.

3. SITE CHARACTERIZATION

3.1 Regional Setting

The Project will be located in the Province of Ontario (Figure 1-1 of the amended EA Report). The Project extends from the Municipality of Shuniah near the City of Thunder Bay to east of the Municipality of Wawa. The Project crosses a rugged and varied topography that reflects the underlying geology of the Precambrian Canadian Shield. The majority of the Project is located on provincial Crown land. From west to east, the Project traverses the Lakehead, Black Spruce, Lake Nipigon, Kenogami, Pic River, Big Pic, White River, and Algoma Forest Management Units. The Project is in seven tertiary watersheds—Black Sturgeon, Nipigon, Jackpine, Little Pic, Pic, White, and Michipicoten-Magpie—and crosses more than 1,000 water bodies. The Project crosses provincial parks, areas of natural and scientific interest, and conservation reserves. Recreational activities that occur in the region include hunting, trapping, fishing, camping, and berry picking. Hiking, use of off-road vehicles, cross-country skiing, snowmobiling, aquatic recreational activities (canoeing, kayaking, and boating), and use of recreational properties also occurs in the region. Eighteen Indigenous communities with rights and interests in the Project are located in the region. Traditional activities that occur in the region include wildlife harvesting (hunting and trapping), traditional fish harvesting, and traditional plant harvesting. Culturally important sites and areas such as canoe routes have also been identified in the region.

The study area for the HHRA uses the study areas identified in the air quality assessment (Section 9 of the amended EA Report) because the HHRA relies upon the results of the air quality assessment. The study areas for air quality are defined by a representative 5 kilometre (km) segment of the preferred route right-of-way (ROW). Air concentrations in this representative 5 km segment were predicted to a distance of approximately 2 km on either side of the preferred route centreline. This approximately 5 km long, 4 km wide area is the air quality Local Study Area (LSA). A separate air quality Regional Study Area (RSA) was not considered necessary in the air quality assessment because the air quality LSA is large enough to encompass predicted changes in air quality. The human health LSA for the HHRA is the same approximately 5 km long, 4 km wide area that is the air quality LSA. A separate human health RSA was not considered necessary for the HHRA because the human health LSA is considered large enough to encompass potential human health risks from the Project.

3.2 Existing Environment

The existing (or baseline or background) conditions of the environment must first be understood to determine the incremental changes in the environment due to contaminant releases from the Project. A detailed description of the existing environment as it relates to air quality and which was relied upon in the HHRA is provided in Section 9 of the amended EA Report. In brief, in Ontario, regional air quality is monitored through a network of air quality monitoring stations operated by the Ministry of the Environment and Climate Change (MOECC) and Environment and Climate Change Canada (ECCC) National Air Pollution Surveillance Network (NAPS). Existing air quality was characterized using background air concentrations from the closest monitoring station in the vicinity of the Project, which is the Thunder Bay Monitoring Station located at 421 James Street South in the City of Thunder Bay. This monitoring station is located approximately 12 km away from the nearest part of the Project footprint. There are no other active monitoring stations within 100 km of the Project for which sufficient data were available.

For this assessment, the data from 2009 to 2013 were used, which is the most recent five -year period for which all data are quality assured by ECCC. The 90th percentile of the 1-hour, 8-hour, and 24-hour measurements were used to represent background air concentrations. The annual average concentration was used for annual background levels. For further discussion, refer to Section 9 of the amended EA Report.

A summary of available background air concentrations used in the HHRA is provided in Table 21-I-1.

Table 21-I-1: Summary of Background Air Concentrations

Criteria Air Contaminant	Averaging Period	Background Concentration (µg/m³)
TSP	24-hour	35.7
	Annual	18.4
PM_{10}	24-hour	17.8
$PM_{2.5}$	24-hour	8.9
	Annual	4.6
NO_X (expressed as NO_2)	1-hour	32.0
	24-hour	26.4
	Annual	14.8
SO_2	1-hour	15.7
	24-hour	13.1
	Annual	5.2
CO	1-hour	520
	8-hour	460

Note: Data are taken from the Thunder Bay Monitoring Station, where data are available. Where data are not available, the regional average for Ontario was used.

µg/m^3 – micrograms per cubic metre; TSP = total suspended particulate; PM_{10} = particulate matter less than 10 microns; $PM_{2.5}$ = particulate matter less than 2.5 microns; NO_x = nitrogen oxides, NO_2 = nitrogen dioxide; SO_2 = sulphur dioxide; CO = carbon monoxide.

3.3 Project Environment

The HHRA used predicted concentrations of contaminants in environmental media, as determined by other components of the amended EA Report, to determine potential human health risks associated with changes in environmental quality due to contaminant releases from the Project. Specifically, the HHRA relied upon predicted air concentrations provided by the air quality discipline.

The development of the Project is planned to occur during two phases (Section 5.2.1 of the amended EA Report):

- **construction phase:** the period from the start of construction to the start of operation (approximately two years); and
- **operation phase:** encompasses operation and maintenance activities throughout the life of the Project, which is anticipated to be indefinite.

In the air quality assessment, the assessment of Project effects on air quality considered effects that occur during the construction phase as emissions are considered to be largest during this phase of the Project. Emissions during the operation phase will be negligible (Section 9 of the amended EA Report). This timeframe was considered to be sufficient to capture the effects of the Project on air quality. Therefore, the HHRA considers the same timeframe (i.e., the construction phase) in the evaluation of potential human health risks from inhalation of contaminants emitted to air from the Project.

The details of the air quality modelling are provided in Section 9 of the amended EA Report. In brief, the air quality assessment identified that Project activities during the construction phase of the Project, such as land clearing, material handling and storage, vehicular exhaust, and reclamation of temporary access roads and staging areas, could result in changes in ambient concentrations of indicator compounds such as oxides of nitrogen (NO_x), carbon monoxide (CO), sulphur dioxide (SO_2), total suspended particulates (TSP), PM_{10}, $PM_{2.5}$, and fugitive dust emissions. Taking into consideration the implementation of mitigation measures outlined in Section 9.7 and using a number of conservative assumptions, air concentrations over a representative 5 km segment of Project construction were predicted at approximately 100 m intervals from the centreline of the preferred route to the outer boundary of the air quality LSA (to a distance of approximately 2 km on either side of the preferred route centreline) using a screening dispersion model. Air concentrations were predicted based on a 1-hour averaging period and converted to a 24-hour averaging period using conversion factors. Annual air concentrations were also predicted. The predicted air concentrations represent maximum air concentrations and are provided in Attachment 21-IA, Table 1 (predicted 1-hour air concentrations), Table 2 (predicted 24-hour air concentrations), and Table 3 (predicted annual air concentrations).

4. PROBLEM FORMULATION

As described in Section 2.0 of this appendix, the problem formulation identifies the following:

- a representative set of receptors (i.e., people) that may be present near the Project;
- the pathways by which receptors may be exposed to contaminants released by the Project (e.g., inhalation of ambient air by people); and
- the contaminants released by the Project that may be present at levels harmful to receptors (i.e., COPCs).

The information from the problem formulation is summarized in a CSM, which illustrates the pathways of the COPCs from their sources, through the relevant environmental media to the identified receptors.

4.1 Human Health Receptors

Human health receptors may include people living in (e.g., residents), working in or visiting (e.g., recreational users) the area that may be exposed to COPCs within the human health LSA (as noted previously the human health LSA is the air quality LSA). These receptors include people of all ages, including people at sensitive life stages such as infants, children, and the elderly. Therefore, it was assumed that people may reside in the human health LSA and a resident was selected as a human health receptor.

Workers were not identified as human health receptors because it is assumed that worker health will be protected through compliance with appropriate workplace practices following requirements defined in the Ontario *Occupational Health and Safety Act* and other applicable regulatory instruments.

No other human health receptors of concern were identified.

4.2 Exposure Pathways

Exposure pathways are the means by which receptors come into contact with COPCs. In order for an exposure pathway to exist, a contaminant source, a release mechanism, transport media, and a receptor must be present. Incomplete and/or negligible pathways were not evaluated in the HHRA. Rationale for inclusion or exclusion of potential pathways in the HHRA is provided in Table 21-I-2.

Table 21-I-2: Potential Exposure Pathways and Rationale for Inclusion/Exclusion in the Human Health Risk Assessment

Exposure Pathway	Evaluated in HHRA?	Rationale
Inhalation of air	Yes	People may be exposed to airborne contaminants released to air during the construction phase of the Project.
Inhalation of dust	No	Airborne contaminants may deposit to soil and people may inhale soil dust particulates; however, emissions from the Project are anticipated to be minimal due to their short duration and intermittent frequency. As a result, the assessment focused on concentrations of contaminants and fugitive dust in air.
Ingestion of groundwater as drinking water	No	Most of the groundwater LSA is not serviced by municipal water supply; therefore, it is anticipated that many residences and businesses in the area depend on groundwater for domestic purposes, such as drinking water supply (Section 8 of the amended EA Report). However, effects to groundwater quality as a result of the Project are not expected to be significant (Section 8 of the amended EA Report).
Ingestion of surface water	No	Effects to surface water quality as a result of the Project are expected to be negligible (Section 7 of the amended EA Report); therefore, ingestion of surface water (incidentally or as drinking water) by people was not evaluated in the HHRA.
Dermal contact with surface water	No	If people swim or bathe in potentially affected water bodies, they would not receive significant exposures through this route relative to water ingestion. In addition, effects to surface water quality as a result of the Project are expected to be negligible (Section 7 of the amended EA Report).
Ingestion of fish	No	Effects to surface water quality as a result of the Project are expected to be negligible (Section 7 of the amended EA Report). Therefore, effects to fish tissue quality are also expected to be negligible.
Ingestion of soil	No	Airborne contaminants may deposit to soil and people may incidentally ingest soil; however, emissions from the Project are anticipated to be minimal due to their short duration and intermittent frequency. As a result, the assessment focused on concentrations of contaminants and fugitive dust in air.
Dermal contact with soil	No	Airborne contaminants may deposit to soil and people may come into dermal contact with the soil; however, emissions from the Project are anticipated to be minimal due to their short duration and intermittent frequency. As a result, the assessment focused on concentrations of contaminants and fugitive dust in air.

Table 21-I-2: Potential Exposure Pathways and Rationale for Inclusion/Exclusion in the Human Health Risk Assessment

Exposure Pathway	Evaluated in HHRA?	Rationale
Ingestion of plants	No	People may consume plants (traditional plants and garden produce) that have received airborne deposition or that have taken up contaminants deposited to the soil from the air; however, emissions from the Project are anticipated to be minimal due to their short duration and intermittent frequency. Herbicide application may be used to control invasive plants and people may consume vegetation that has received herbicide application; however, with the implementation of mitigation measures, exposures by people are not expected. As a result, the assessment focused on concentrations of contaminants and fugitive dust in air.
Ingestion of animals	No	People may consume animals harvested from areas near the Project; however, emissions from the Project are anticipated to be minimal due to their short duration and intermittent frequency. As a result, the assessment focused on concentrations of contaminants and fugitive dust in air.

HHRA = human health risk assessment; LSA = Local Study Area; EA = Environmental Assessment.

Based on the rationale provided in Table 21-I-2, inhalation of COPCs in air emitted during the construction phase of the Project was identified as a complete pathway of exposure to human receptors and was evaluated in the HHRA.

4.3 Contaminants of Potential Concern

COPCs are identified as those contaminants released by the Project that have the potential to be harmful to people. Emissions from construction are primarily composed of fugitive dust and diesel combustion products from the movement and operation of construction equipment and vehicles (refer to Section 9 of the amended EA Report). Based on this, the air quality assessment identified criteria air contaminants and fugitive dust as the types of contaminants that would likely be emitted to air during Project construction. DPM, which is a potential human health concern, may also be emitted to air during Project construction given the use of diesel in construction equipment and vehicles. The following contaminants were considered further in the HHRA:

- criteria air contaminants (NO_x, CO, SO_2, TSP, PM_{10}, $PM_{2.5}$); and
- DPM.

4.3.1 Contaminant Screening Process

The list of contaminants that would likely be emitted to air during Project construction was used to identify COPCs in air for the HHRA using a contaminant screening process. Maximum predicted 1-hour, 24-hour, and annual air concentrations were compared to corresponding 1-hour, 24-hour, and annual air quality thresholds selected from various regulatory agencies (details on the selection of air quality thresholds, including the regulatory agencies that were consulted, are provided in Section 4.3.2 of this appendix). The following approach was used to identify COPCs in air:

- Contaminants with predicted concentrations below thresholds were not identified as COPCs. Comparison to air quality thresholds was considered to represent a conservative evaluation of the potential for the predicted concentrations to elicit adverse effects. Therefore, COPCs with concentrations less than thresholds were considered to pose negligible risk to human health and were not identified as COPCs for the HHRA;
- If the predicted concentration was greater than the threshold, the contaminant was identified as a COPC and carried forward in the HHRA; and
- Contaminants without thresholds were discussed further

4.3.2 Selection of Air Quality Thresholds

Available air quality thresholds from the following regulatory agencies were compiled and reviewed:

- Canadian Council of Ministers of the Environment (CCME 1999, 2000, 2013);
- Ontario Ministry of the Environment (MOE 2012);
- World Health Organization (WHO 2000, 2005);
- California Office of Environmental Health Hazard Assessment (California Environmental Protection Agency [CalEPA] 2016);
- Agency for Toxic Substances and Disease Registry (ATSDR 2016); and
- Texas Commission on Environmental Quality (TCEQ 2016).

Each of these agencies has derived air quality thresholds based upon a prescribed level of protection. Most often, these air quality thresholds are presented as air concentrations at and below which health (or other effects such as odour) are not expect to occur and may incorporate additional safety factors. Therefore, a predicted air concentration that is greater than its threshold indicates that a health effect is possible but not certain. Further assessment is required to determine the likelihood of that health effect occurring.

The air quality thresholds have been derived by each regulatory agency to achieve a target risk level that is considered to be protective of human health. The regulatory agencies set their target risk level based on science policy decisions on what is an acceptable risk to human health. In setting target risk levels for acute exposures, regulatory agencies consider non-carcinogenic and irritant health effects of contaminants, with the target risk level being defined as a hazard quotient (HQ). In setting target risk levels from chronic exposures, regulatory agencies consider both carcinogenic and non-carcinogenic effects of contaminants, with the target risk level for carcinogens being defined by an incremental lifetime cancer risk level. Air quality thresholds can be converted to a different target risk level by using a ratio of the threshold and the target risk and determining what threshold would generate the desired risk level. The lowest (i.e., most conservative) of the available thresholds for each of the 1-hour, 24-hour, and annual averaging periods were selected as the air quality thresholds.

The available and selected 1-hour, 24-hour, and annual air quality thresholds are presented in Attachment 21-IB, Tables 1, 2, and 3, respectively. The toxicological endpoints (e.g., cardiovascular disease, respiratory effects) and a summary of the supporting technical rationale for the thresholds (if available) are also included in the tables. Air quality thresholds for an 8-hour averaging time have been developed for CO by the CCME (1999), MOE (2012), and WHO (2000). An 8-hour averaging time is considered an acute exposure time and these values have been included in Attachment 21-IB, Table 1 for the 1-hour averaging time.

4.3.3 Contaminant Screening Results

The detailed screening of predicted maximum 1-hour, 24-hour, and annual air concentrations against selected air thresholds is provided in Attachment 21-IA, Tables 1, 2, and 3, respectively. The results of the contaminant screening are summarized in Table 21-I-3, specifically the identified COPCs, corresponding averaging periods, and the modelled locations for which exceedances of the selected air thresholds were found.

Table 21-I-3: Contaminants of Potential Concern

COPC	Averaging Period	Modelled Location(s) With Exceedance(s)
NO_x (as NO_2)	1-hour	Approximately 100, 200, and 300 m from preferred route centreline
PM_{10}	24-hour	Approximately 100 m from preferred route centreline
DPM	Annual	Approximately 100, 200, 300, 400, 500, and 600 m from preferred route centreline

COPC = contaminant of potential concern; NO_x = nitrogen oxides; NO_2 = nitrogen dioxide; DPM = diesel particulate matter; PM_{10} = particulate matter less than 10 microns; m = metres.

There are no 1-hour air quality thresholds available for CO, NO_x, TSP, PM_{10}, or $PM_{2.5}$. These are discussed further below:

- Nitrogen oxides are the sum of NO_2 and nitric oxide (NO). Emissions of NO_x consist mainly of NO, with some NO_2. In ambient air, NO converts to NO_2 (MOE 2012). Nitrogen dioxide has adverse health effects at much lower concentrations than NO (MOE 2012). Therefore, the 1-hour air quality threshold for NO_2 was adopted as the threshold for NO_x.
- While no 1-hour air quality thresholds are available for TSP, PM_{10}, and $PM_{2.5}$, there are 24-hour and/or annual air quality thresholds available for these substances. Therefore, TSP, PM_{10}, and $PM_{2.5}$ were screened for the 24-hour and annual averaging periods only.
- For the 1-hour averaging period, the selected air quality threshold for screening for CO was based on an 8-hour averaging time (discussed further below). Therefore, the predicted air concentrations for CO were converted from a 1-hour to 8-hour averaging time using the equation below (which is reproduced from MOE 2009), before comparison with the air quality threshold for CO.

$$C_1 = C_0 \times \left(\frac{t_0}{t_1}\right)^n$$

  Where:

  - C_0 = concentration at the averaging period t_0 (micrograms per cubic metre ($\mu g/m^3$));
  - C_1 = concentration at the averaging period t_1 ($\mu g/m^3$);
  - t_0 = the shorter of:
    - The averaging period that the approved dispersion model was designed to be used for (hours); and,
    - The specified averaging period (h).
  - t_1 = the longer of:
    - The averaging period that the approved dispersion model was designed to be used for (hours); and,
    - The specified averaging period (h).
  - n = 0.28, the default stability dependent exponent (MOE 2009).

There are no 24-hour air quality thresholds available for CO, NO_x, and DPM. These are discussed further below:

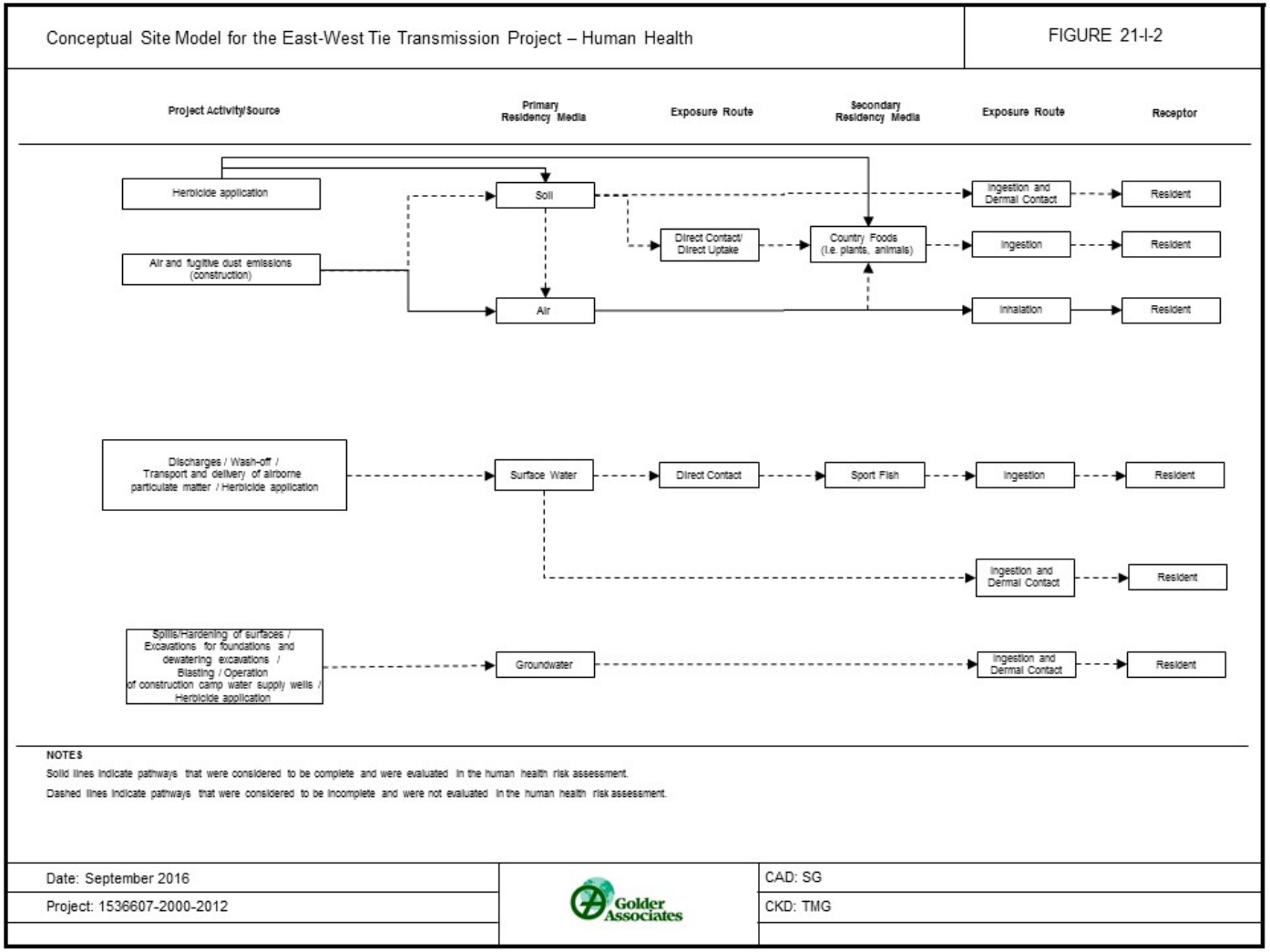
- The 24-hour air quality threshold for NO_2 was adopted as the threshold for NO_x based on the rationale provided previously for the 1-hour air quality threshold.
- CO was screened based on an 8-hour averaging period only.

- For DPM, an air quality threshold was available for the annual averaging period; therefore, this contaminant was screened with respect to this averaging period only.

There are no annual air quality thresholds available for NO_x and CO. As discussed previously for the 1-hour and 24-hour averaging periods, CO was screened based on an 8-hour averaging period only and the air quality threshold for NO_2 was adopted for NO_x.

4.4 Conceptual Site Model

A CSM was developed for human health to summarize the results of the problem formulation. The CSM considers the parameters that occur in the Project footprint at concentrations above air quality thresholds (i.e., COPCs), the environmental media in which the exceedances occur (e.g., air), people that may use human health LSA, how these people may use the human health LSA, and how people using the human health LSA may come in contact with the COPCs. The CSM for human health is provided in Figure 21-I-2.



Note: Solid lines indicate pathways that were considered to be complete and were evaluated in the human health risk assessment. Dashed lines indicate pathways that were considered to be incomplete and were not evaluated in the human health risk assessment.

Figure 21-I-2: Conceptual Site Model for the East-West Tie Transmission Project – Human Health

5. TOXICITY ASSESSMENT

The toxicity (or hazard) assessment component of the HHRA involves the classification of the potential harmful effects of COPCs and the estimation of the amounts of COPCs that can be tolerated by human receptors without resulting in adverse health effects (i.e., TRVs). It provides a basis for the interpretation of exposure estimates from the exposure assessment (Section 6.0 of this appendix).

5.1.1 Contaminant Classification

Contaminants are quantitatively evaluated in a risk assessment based on their ability to cause cancer or non-cancer health effects. Contaminants that are considered to cause health effects other than cancer (i.e., non-cancer health effects) are considered to be threshold contaminants; that is, there is an acceptable health-based limit or threshold below which exposure to the contaminant does not cause adverse health effects. Contaminants that are considered to be cancer causing are considered non-threshold contaminants; that is, there is no acceptable health-based limit or threshold below which exposure to the contaminant does not cause adverse health effects. Any level of exposure to carcinogens is assumed to theoretically pose a potential for adverse health effects. Therefore, regulatory agencies classify contaminants based on their mode of action as threshold or non-threshold contaminants.

5.1.2 Dose-Response Assessment

With respect to an inhalation assessment, TRVs for non-carcinogenic contaminants are called reference concentrations (RfCs). RfCs are estimates of continuous inhalation exposure by the human population (including sensitive subgroups) to a contaminant that is likely to be without an appreciable risk of harmful effects over a lifetime.

One-hour and 24-hour air quality thresholds provided by regulatory agencies were reviewed and the lowest (i.e., most conservative) of the thresholds were selected for use in the identification of COPCs for this assessment. These thresholds were also used as the RfCs for comparison with the predicted 1-hour and 24-hour concentrations in the assessment of potential risks from acute exposure. This is with the exception of PM_{10} for the 24-hour averaging period. For PM_{10}, the lowest threshold is the Canadian National Ambient Air Quality Objective (NAAQO) of 25 µg/m^3. The RfC selected for PM_{10} for this assessment is the WHO guideline. The WHO guideline for PM_{10} (50 µg/m^3) is based on the WHO $PM_{2.5}$ guideline of 25 µg/m^3 and an assumed $PM_{10}/PM_{2.5}$ ratio of 2. The WHO recommends that the guideline is adjusted based on the site-specific $PM_{10}/PM_{2.5}$ ratio which better reflects local conditions. For the 24-hour averaging periods, the average $PM_{10}/PM_{2.5}$ ratio for all modelled locations was 2.5. Therefore, the WHO guideline was adjusted by the site-specific ratio, yielding a guideline of 63 µg/m^3. The WHO guideline was selected as the RfC for the 24-hour averaging period for the following reasons:

a) It is based upon long-term health effects of $PM_{2.5}$, which has been more reliably associated with health effects than PM_{10} (Health Canada and Environment Canada 1999).

b) It incorporates site-specific data in terms of the $PM_{10}/PM_{2.5}$ ratio.

c) It serves as better comparison for the predicted PM_{10} concentrations at the modelled locations.

In the assessment of potential risks from chronic exposure (i.e., non-carcinogenic and carcinogenic), available TRVs for the identified COPCs were compiled from the following agencies:

- MOE (2011, 2012);
- Health Canada (2010);
- US EPA (2016) Integrated Risk Information System database;
- CalEPA (2016);
- Agency for Toxic Substances and Disease Registry (ATSDR 2016);
- Netherlands National Institute of Public Health and the Environment (RIVM 2001); and
- WHO (2000, 2005).

The most conservative (i.e., lowest) of the available RfCs were selected for the assessment. The selected RfCs for the acute and chronic assessments, including critical effects and the sources from which the RfCs were obtained are summarized in Table 21-I-4. Details on the selected RfCs for the 1-hour and 24-hour averaging periods are provided in Attachment 21-IB, Tables 1 and 2. Details on the selected RfCs for the annual averaging period are provided in Attachment 21-IC, Table 1.

Table 21-I-4: Reference Concentrations and Critical Effects

COPC	Averaging Period	RfC (µg/m^3)	Critical Effect(s)	Source
NO_x (as NO_2)	1-hour	190	Health	TCEQ 2016
PM_{10}	24-hour	63	Health and environment	WHO 2005
DPM	Annual	5	Pulmonary inflammation and histopathology	US EPA 2016

COPC = contaminant of potential concern; µg/m^3 = micrograms per cubic metre; NO_x = nitrogen oxides; NO_2 = nitrogen dioxide; DPM = diesel particulate matter; PM_{10} = particulate matter less than 10 microns; RfC = reference concentration.

With respect to an inhalation assessment, TRVs for carcinogenic chemicals are called Inhalation Unit Risks (IUR), which are estimates of the increase in lifetime cancer risk attributed to a lifetime of exposure to a chemical in the human population (including sensitive subgroups). The only carcinogenic COPC carried for assessment is DPM. The selected IUR for DPM for assessment of chronic exposures is summarized in Table 21-I-5. Details on the selected IUR for the annual averaging period is provided in Attachment 21-IC, Table 2.

Table 21-I-5: Inhalation Unit Risk and Critical Effects

COPC	Averaging Period	IUR (µg/m^3)$^{-1}$	Critical Effect(s)	Source
DPM	Annual	3.0 E-4	Lung tumour formation in laboratory animals	CalEPA 2016

COPC = contaminant of potential concern; (µg/m^3)$^{-1}$ = micrograms per cubic metre; DPM = diesel particulate matter.

6. EXPOSURE ASSESSMENT

The exposure assessment estimates the amount of COPC to which each human health receptor is exposed via inhalation of COPCs in air. For the Base Case, the exposure estimates for the identified COPCs are the background air concentrations identified in Section 3.2 of this appendix.

The predicted maximum 1-hour, 24-hour, and annual air concentrations were used as the concentrations to which human receptors would be exposed via inhalation during the construction phase of the Project (i.e., for the Project Case). The predicted concentrations for the identified COPCs at all modelled locations are provided in Attachment 21-IA, Tables, 1, 2, and 3. The maximum predicted concentrations of all modelled locations with exceedances of the air quality thresholds were used as the exposure estimates.

The sums of the exposure estimates for the Base Case and the Project Case were used as the exposure estimates for the Base + Project Case. The exposure estimates used in the HHRA are summarized in Table 21-I-6.

Table 21-I-6: Exposure Estimates

COPC	Averaging Period	Exposure Estimate ($\mu g/m^3$)		
		Base Case	Project Case	Base + Project Case
NO_x (as NO_2)	1-hour	32.0	364	396
PM_{10}	24-hour	17.8	32	50
DPM	Annual	-	1.9	1.9

COPC = contaminant of potential concern; $\mu g/m^3$ = micrograms per cubic metre; NO_x = nitrogen oxides; NO_2 = nitrogen dioxide; DPM = diesel particulate matter; PM_{10} = particulate matter less than 10 microns; "-" = background concentration not available.

7. RISK CHARACTERIZATION

Risk characterization determines the potential for risks or adverse health effects to occur. This is assessed by comparing the estimated exposures (from the exposure assessment) with those exposures that are determined to be acceptable or safe (from the toxicity assessment). The characterization of risks includes consideration of the uncertainty and conservatism in the HHRA.

Potential non-carcinogenic risks to people were characterized using an HQ approach. The HQ is the ratio of the exposure likely to be incurred by people and the amount of exposure that is considered to be safe (i.e., the RfC). An HQ of less than one indicates the level of exposure likely to be incurred by people is less than the level of exposure shown to adversely affect the health of people. An HQ of greater than one indicates that the level of exposure likely to be incurred by people may exceed the level of exposure where adverse effects on people may occur. That is, HQs of less than one indicate that risks to people are not expected and HQs of greater than one indicate the potential for risks to people. COPCs with HQs greater than one are evaluated further through review of the uncertainty and conservatism in the assessment.

Potential carcinogenic risks to people were characterized by calculating incremental lifetime cancer risks (ILCRs). An ILCR is the product of the exposure (i.e., independent of background sources; Health Canada 2012) to be incurred by the person and the cancer risk per unit exposure to the COPC. No health risk is predicted if the ILCR is less than one-in-one million (one-in-1,000,000), per MOE guidance (MOE 2011).

An ILCR less than or equal to one-in-one million (1-in-1,000,000) indicates that the estimated exposure is associated with negligible health effects; conversely, when the ILCR is greater than one-in-one million, this does not necessarily indicate that adverse health effects will occur, but that the assumptions and conservative approach relied upon in the HHRA should be further scrutinized.

Incremental lifetime cancer risks were calculated for carcinogenic COPCs (i.e., DPM) as shown by the following equation (Health Canada 2012):

$$ILCR_{inh} = C_{air}\ X\ F\ X\ IUR$$

Where:

- $ILCR_{inh}$= incremental lifetime cancer risk due to inhalation of COPC in air (unitless);
- C_{air} = COPC concentration in air ($\mu g/m^3$);
- F = Fraction of time exposed (i.e., years of exposure/80 years in a lifetime); and
- IUR = inhalation unit risk ($[\mu g/m^3]^{-1}$)

Note, as described in Section 2.2 of this appendix, emissions to air from the Project are expected to only occur during the construction phase of the Project. The construction phase is expected to extend over approximately two years; therefore, people at any particular location within the ROW would only be expected to be exposed to emissions from the Project for approximately two years. In terms of evaluating carcinogenic exposures, the fraction of time exposed to Project emissions is two years of an 80 year lifetime (Health Canada 2012).

It is also noted that in addition to the ILCRs provided for the Project Case, Lifetime Cancer Risks (LCRs) are provided for the Base Case and Base + Project Case. Lifetime Cancer Risks are similar to ILCRs in that they provide an estimate of cancer risk associated with a carcinogenic COPC, except that they provide an estimate of cancer risk not just related to an incremental change in risk level but also of other sources (e.g. background). There are no regulatory benchmarks available for LCRs which makes interpretation of the values problematic. Therefore, LCRs are presented to provide context only to the Project Case ILCRs that were calculated and compared to the target of one-in-one million.

7.1 Risk Estimates

The calculated HQs for COPCs for the Base, Project and Base+Project cases are provided in Table 21-I-7.

Table 21-I-7: Hazard Quotients

COPC	Averaging Period	Hazard Quotient		
		Base Case[(a)]	Project Case	Base + Project Case
NO_x (as NO_2)	1-hour	0.17	**1.9**	**2.1**
PM_{10}	24-hour	0.28	0.51	0.79
DPM	Annual	—	0.38	0.38

Note: **Bolded** and shaded cells indicate an exceedance of the target hazard quotient of one.

a) Background air concentrations were not available for some COPCs; therefore, hazard quotients were not calculated for the Base Case for those COPCs.

COPC = contaminant of potential concern; NO_x = nitrogen oxides; NO_2 = nitrogen dioxide; DPM = diesel particulate matter; PM_{10} = particulate matter less than 10 microns.

The calculated HQs for the Base Case were below the target HQ of one for all COPCs. The calculated HQs for NO_x (as NO_2) for the 1-hour averaging period for the Project Case and Base + Project Case were greater than the target HQ of one, indicating the potential for risks to people from acute or short-term exposure to this COPC.

The calculated LCRs for COPCs for the Base and Base+Project cases and ILCRs for the Project case are provided in Table 21-I-8.

Table 21-I-8: Lifetime Cancer Risks Incremental Lifetime Cancer Risks for the Annual Averaging Period

COPC	Averaging Period	Lifetime Cancer Risks		
		Base Case[(a)] (LCR)	Project Case (ILCR)	Base + Project Case (LCR)
DPM	Annual	—	**1.64E-05**	1.64E-05

Note: **Bolded** and shaded cells indicate an exceedance of the target ILCR exceeds benchmark of 1.0E-06.
a) Background air concentrations were not available for some COPCs; therefore, a LCR was not calculated for the Base Case for DPM.
COPC = contaminant of potential concern; DPM = diesel particulate matter; LCR = lifetime cancer risks.

The calculated ILCR for DPM for the annual-hour averaging period for the Project Case was greater than the target ILCR for 1.0E-06, indicating the potential for risks to people from chronic or long-term exposure to this COPC

7.2 Uncertainty Assessment

The assessment of potential human health risks followed the risk assessment framework, which involves four sequential components. There are uncertainties that are inherent to each component of the framework. These uncertainties influence the final assessment of potential human health risk. Where uncertainties exist, a conservative approach was taken such that the assessment likely overestimates the potential risks to human health. Uncertainties related to the HHRA and the potential implications that these uncertainties may have on the interpretation of risks are discussed in Table 21-I-9.

Table 21-I-9: Uncertainties in the Human Health Risk Assessment

Source of Uncertainty	Direction
Human health TRVs are generally based on the most sensitive endpoints, with the application of uncertainty factors to protect sensitive subpopulations. The uncertainty associated with TRVs is highly dependent on the number of studies available and whether the key study was based on humans (low uncertainty) or small mammals (high uncertainty). When few studies are available and the studies available are conducted using animals as test organisms, several types of uncertainty factors are applied to account for this uncertainty (e.g., factors for inter- and intra-species sensitivity). As such, use of the TRVs may overestimate toxicity.	May overestimate risk
The TCEQ short-term effects screening level (ESL) was selected as the 1-hour air quality threshold and RfC for NO_2 (190 µg/m^3) for the assessment of potential acute health effects in the HHRA. The TCEQ short-term ESL was adopted from the US NAAQS for NO_2. This value was selected because it was the lowest (i.e., most stringent) of the available thresholds/RfCs. However, the CCME and Ontario MOECC, the relevant federal and provincial jurisdictions for the Project, provide an NAAQO and AAQC of 400 µg/m^3 (desirable level) and 400 µg/m^3, respectively. Maximum predicted 1-hour air concentrations of NO_x (as NO_2; 390 µg/m^3) are less than the provincial and federal thresholds/RfCs.	May overestimate risk

Table 21-I-9: Uncertainties in the Human Health Risk Assessment

Source of Uncertainty	Direction
Most toxicity studies used to derive TRVs are conducted on single contaminants but exposures are rarely limited to single contaminants. Exposures are generally to more than one contaminant (i.e., contaminant mixtures). Contaminants in a mixture may interact in four general ways to cause a response in a receptor: (i) non-interacting – contaminants in the mixture do not produce a response in combination with each other. The toxicity of the mixture is the same as the toxicity of the most toxic contaminant in the mixture; (ii) additive – contaminants in the mixture have similar targets and modes of action but do not interact. The toxicity of the mixture is simply the sum of toxicity for the individual contaminants; (iii) synergistic – there is a positive interaction among the contaminants in the mixture such that the response is greater than would be expected if the contaminants acted independently or in an additive manner; and, (iv) antagonistic – there is a negative interaction among the contaminants in the mixture such that the response is less than would be expected if the contaminants acted independently or in an additive manner.	May under- or overestimate risk
Exposures to people were determined based on predicted maximum concentrations of COPCs in air. Statistics on the predictions (e.g., 98th, 95th, or 75th percentiles of the predicted concentrations), which would provide a reasonable maximum estimate of exposures taking into account the variability in concentrations across a site, would result in lower exposures to human health receptors.	May overestimate risk
The exposure assessment relies on predicted air concentrations provided by the air quality discipline. A number of conservative assumptions were used in the air quality modelling such that predicted concentrations have likely been overestimated. For a summary of the conservative assumptions used in the air quality modelling, refer to Section 9 of the amended EA Report.	May overestimate risk
The calculated risk estimates assume that a receptor will be present at the exact time and place where the maximum concentration of a parameter is released (i.e. acute: 1-hour, 24-hours) and/or assumes that the receptor will remain present in these conditions for the entire length of the exposure period (i.e. chronic: 1-year). However, releases of parameters as a result of construction will be transient in nature as the construction activities will not remain in one place along the transmission line, and parameters will not always be released at the maximum concentrations used to calculate risk. The maximum concentrations used to calculate risk, when they do occur, could occur anywhere along the transmission line at any time during the 2 year construction phase. The likelihood of a receptor being present at the exact time and exact place of the release (i.e., 1-hour and 24-hour) of the maximum concentration and/or or be present (i.e., 1-year) in the entire length of the evaluated exposure period is considered to be negligible (refer to Section 8).	Overestimates risk

AAQC = Ambient Air Quality Criteria; CCME = Canadian Council of Ministers of Environment; COPC = contaminant of potential concern; EA = environmental assessment; ESL = effects screening level; HHRA = human health risk assessment; HQ = hazard quotient; LSA = Local Study Area; MOECC = Ministry of the Environment and Climate Change; NAAQO = National Ambient Air Quality Objective; NO_2 = nitrogen dioxide; NO_x = nitrogen oxides; RfC = reference concentration; TCEQ = Texas Commission on Environmental Quality; TRV = toxicity reference value; US NAAQS = United States National Ambient Air Quality Standard; µg/m^3 = micrograms per cubic metre.

8. CONCLUSIONS

During Project construction, the potential for non-carcinogenic health risks were identified from short-term or acute exposure to NO_x (as NO_2; 1-hour) when construction emissions were considered alone (i.e., Project Case) and in combination with existing conditions (i.e., ambient background air concentrations; Base + Project Case). For NO_x (as NO_2), HQs of 1.9 and 2.1 were calculated for the Project Case and Base + Project Case, respectively.Note that, although potential the for non-carcinogenic health risks from NO_x were identified in the HHRA,in order for the potential for a short-term or acute health effect to be likely, there is a low likihood of any receptor being exposed when the following points are considered:

- Exposures and health risks to people were determined based on predicted maximum concentrations of NO_x (as NO_2) in air. The maximum concentrations may occur anywhere along a representative 5 km segment of Project construction and are not necessarily representative of concentrations at a specific location (e.g., a

residence or commercial/industrial building). Furthermore, for a potential health effect to occur, a person must be present at the exact location and time that the predicted maximum concentration is occurring.

- For example, during project construction, concentrations of NO_X (as NO_2) above the health-based TRV (i.e., HQ >1) are predicted to occur 2% of the time modelled over the five-year air quality modelling period; thus, 98% of the time the concentration of NO_x (as NO_2) is anticipated to meet the health based TRV (i.e., HQ <1). Moreover, as noted above, the location of the maximum concentration was not predicted to occur at a specific location along the transmission line but represents instead the maximum concentration produced along a representative 5 km segment of the transmission line construction area; consequently, in order for a risk to occur, a receptor must be present during the exact time (i.e., hour) and location when the maximum concentration of NOx (as NO_2) occurs over the five-year modelled period. The likelihood of these conditions occurring is considered to be negligible and unacceptable short-term or acute risks to human health are not expected.

During Project construction, the potential for carcinogenic health risks were identified from long-term or chronic exposure to DPM when construction emissions were considered alone (i.e., Project Case). For DPM, an ILCR of 1.64E-05 was predicted. Note that, although the potential for carcinogenic health risks from DPM were identified in the HHRA, in order for the potential for a long-term or chronic health effect to be likely, there is a low likihood of any receptor being exposed when the following points are considered:

- Exposures and health risks to people were determined based on predicted maximum annual average concentrations of DPM in air. The maximum annual aveage concentration of DPM is not representative of a specific location (e.g., a residence or commercial/industrial building), but represents the annual average concentration of DPM along a representative 5 km segment of Project construction.
- With respect to any carcinogenic exposures, a person would need to be exposed at the maximum annual average concentration of DPM in the 5 km segment continuously for a one-year period of construction for the potential for predicted health risk (i.e., ILCR = 1.64E-05) to exist. Given the transient nature of project construction activities along the representative 5 km segment, a continuous receptor exposure to the maximum annual average concentration of DPM over 1 year is not expected.
- Note that the maximum annual average DPM concentration of 1.9 µg/m³ is lower than the published mean DPM exposure in the United States (2 µg/m³) and published levels from vehicular emissions (20 to 25 µg/m³; Ghio et al. 2012).

Overall, given the uncertainties noted in Table 21-I-7 and in the points listed above, potential health risks to people from emissions of contaminants to air during the construction phase of the Project are not expected.

9. FOLLOW-UP, INSPECTION, AND MONITORING PROGRAMS

Follow-up, inspection, and monitoring programs are not recommended based on the results of the HHRA.

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ATTACHMENT 21-IA

Air Quality Predictions and Screening

February 2018
Project No. 1536607/2000/2219

NEXTBRIDGE INFRASTRUCTURE

Table 1: 1-Hour Air Quality Predictions and Screening

Contaminant	Air Quality Threshold	Distance from ROW Centreline (m)																			
		100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000
SO_2	26.2	7.80E-01	4.97E-01	3.71E-01	3.01E-01	2.52E-01	2.17E-01	1.87E-01	1.68E-01	1.53E-01	1.37E-01	1.28E-01	1.20E-01	1.11E-01	1.03E-01	9.69E-02	9.19E-02	8.63E-02	8.23E-02	7.87E-02	7.50E-02
CO[(a)]	6000	4.64E+02	2.96E+02	2.21E+02	1.80E+02	1.50E+02	1.29E+02	1.11E+02	1.00E+02	9.12E+01	8.18E+01	7.62E+01	7.13E+01	6.64E+01	6.12E+01	5.78E+01	5.47E+01	5.14E+01	4.90E+01	4.69E+01	4.47E+01
NO_x (as NO_2)	190	**3.64E+02**	**2.32E+02**	1.73E+02	1.41E+02	1.18E+02	1.01E+02	8.73E+01	7.84E+01	7.15E+01	6.41E+01	5.97E+01	5.59E+01	5.21E+01	4.80E+01	4.53E+01	4.29E+01	4.03E+01	3.84E+01	3.68E+01	3.51E+01
TSP	NV	2.56E+02	1.63E+02	1.22E+02	9.91E+01	8.29E+01	7.12E+01	6.14E+01	5.52E+01	5.03E+01	4.51E+01	4.20E+01	3.93E+01	3.67E+01	3.38E+01	3.19E+01	3.02E+01	2.84E+01	2.71E+01	2.59E+01	2.47E+01
Diesel Particulate Matter	63	2.30E+01	1.47E+01	1.10E+01	8.91E+00	7.45E+00	6.40E+00	5.52E+00	4.96E+00	4.52E+00	4.06E+00	3.78E+00	3.53E+00	3.29E+00	3.04E+00	2.86E+00	2.71E+00	2.55E+00	2.43E+00	2.33E+00	2.22E+00
PM_{10}	NV	8.88E+01	5.66E+01	4.23E+01	3.43E+01	2.87E+01	2.47E+01	2.13E+01	1.91E+01	1.74E+01	1.56E+01	1.46E+01	1.36E+01	1.27E+01	1.17E+01	1.10E+01	1.05E+01	9.83E+00	9.37E+00	8.96E+00	8.55E+00
$PM_{2.5}$	NV	3.24E+01	2.06E+01	1.54E+01	1.25E+01	1.05E+01	9.00E+00	7.76E+00	6.97E+00	6.36E+00	5.70E+00	5.31E+00	4.97E+00	4.63E+00	4.27E+00	4.03E+00	3.82E+00	3.58E+00	3.42E+00	3.27E+00	3.12E+00

1.30E+01 = greater than 1-hour air quality threshold and therefore retained as a COPC.

Note: All air concentrations are in units of µg/m^3.

a) The threshold is based on an 8-hour averaging time. The maximum 1-hour predictions were converted to 8-hour averaging times using the following equation: $C_1 = C_0 * (t_0/t_1)^{0.28}$ (MOE 2009).

CO = carbon monoxide; COPC = contaminant of potential concern; µg/m^3 = microgram per cubic metre; NO_x = nitrogen oxides; NO_2 = nitrogen dioxide; NV = no value; $PM_{2.5}$ = particulate matter less than 2.5 microns; PM_{10} = particulate matter less than 10 microns; ROW = right-of-way; SO_2 = sulphur dioxide; TSP = total suspended particulates.

Table 2: 24-Hour Air Quality Predictions and Screening

Contaminant	Air Quality Threshold	Distance from ROW Centreline (m)																			
		100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000
SO_2	125	2.77E-01	1.83E-01	1.39E-01	1.11E-01	9.40E-02	8.32E-02	7.50E-02	6.84E-02	6.30E-02	5.85E-02	5.46E-02	5.11E-02	4.78E-02	4.46E-02	4.16E-02	3.91E-02	3.70E-02	3.52E-02	3.34E-02	3.16E-02
CO	NV	1.65E+02	1.09E+02	8.30E+01	6.66E+01	5.60E+01	4.96E+01	4.47E+01	4.08E+01	3.79E+01	3.49E+01	3.25E+01	3.05E+01	2.85E+01	2.66E+01	2.48E+01	2.33E+01	2.21E+01	2.10E+01	1.99E+01	1.89E+01
NO_X (as NO_2)	200	1.30E+02	8.57E+01	6.50E+01	5.22E+01	4.39E+01	3.89E+01	3.50E+01	3.20E+01	2.94E+01	2.73E+01	2.55E+01	2.39E+01	2.23E+01	2.08E+01	1.95E+01	1.83E+01	1.73E+01	1.64E+01	1.56E+01	1.48E+01
TSP	120	9.12E+01	6.03E+01	4.58E+01	3.68E+01	3.09E+01	2.74E+01	2.47E+01	2.25E+01	2.07E+01	1.92E+01	1.80E+01	1.68E+01	1.57E+01	1.47E+01	1.37E+01	1.29E+01	1.22E+01	1.16E+01	1.10E+01	1.04E+01
Diesel Particulate Matter	NV	8.20E+00	5.42E+00	4.12E+00	3.31E+00	2.78E+00	2.46E+00	2.22E+00	2.02E+00	1.86E+00	1.73E+00	1.61E+00	1.51E+00	1.41E+00	1.32E+00	1.23E+00	1.16E+00	1.10E+00	1.04E+00	9.87E-01	9.35E-01
PM_{10}	25	**3.16E+01**	2.09E+01	1.59E+01	1.27E+01	1.07E+01	9.48E+00	8.54E+00	7.79E+00	7.18E+00	6.66E+00	6.22E+00	5.82E+00	5.44E+00	5.08E+00	4.74E+00	4.46E+00	4.22E+00	4.01E+00	3.80E+00	3.60E+00
$PM_{2.5}$	25	1.15E+01	7.62E+00	5.78E+00	4.65E+00	3.91E+00	3.46E+00	3.12E+00	2.84E+00	2.62E+00	2.43E+00	2.27E+00	2.12E+00	1.99E+00	1.85E+00	1.73E+00	1.63E+00	1.54E+00	1.46E+00	1.39E+00	1.31E+00

1.30E+01 = greater than 24-hour air quality threshold, and therefore retained as a COPC.

Note: All air concentrations are in units of µg/m^3.

CO = carbon monoxide; COPC = contaminant of potential concern; µg/m^3 = microgram per cubic metre; NO_x = nitrogen oxides; NO_2 = nitrogen dioxide; NV = no value; $PM_{2.5}$ = particulate matter less than 2.5 microns; PM_{10} = particulate matter less than 10 microns; SO_2 = sulphur dioxide; TSP = total suspended particulates; ROW = right-of-way.

Table 3: Annual Air Quality Predictions and Screening

Contaminant	Air Quality Threshold	Distance from ROW Centreline (m)																			
		100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000
SO_2	30	6.55E-02	4.28E-02	3.23E-02	2.62E-02	2.20E-02	1.90E-02	1.67E-02	1.49E-02	1.34E-02	1.22E-02	1.12E-02	1.03E-02	9.55E-03	8.88E-03	8.28E-03	7.75E-03	7.27E-03	6.84E-03	6.44E-03	6.08E-03
CO	NV	3.90E+01	2.55E+01	1.93E+01	1.56E+01	1.31E+01	1.13E+01	9.94E+00	8.87E+00	8.00E+00	7.29E+00	6.68E+00	6.15E+00	5.69E+00	5.29E+00	4.94E+00	4.62E+00	4.33E+00	4.07E+00	3.84E+00	3.62E+00
NO_X (as NO_2)	40	3.06E+01	2.00E+01	1.51E+01	1.22E+01	1.03E+01	8.87E+00	7.80E+00	6.95E+00	6.28E+00	5.71E+00	5.23E+00	4.82E+00	4.46E+00	4.15E+00	3.87E+00	3.62E+00	3.40E+00	3.19E+00	3.01E+00	2.84E+00
TSP	60	2.15E+01	1.41E+01	1.06E+01	8.60E+00	7.23E+00	6.24E+00	5.49E+00	4.90E+00	4.42E+00	4.02E+00	3.68E+00	3.39E+00	3.14E+00	2.92E+00	2.72E+00	2.55E+00	2.39E+00	2.25E+00	2.12E+00	2.00E+00
Diesel Particulate Matter	0.50	**1.93E+00**	**1.26E+00**	**9.55E-01**	**7.73E-01**	**6.50E-01**	**5.61E-01**	4.93E-01	4.40E-01	3.97E-01	3.61E-01	3.31E-01	3.05E-01	2.82E-01	2.62E-01	2.45E-01	2.29E-01	2.15E-01	2.02E-01	1.90E-01	1.80E-01
PM_{10}	25	7.45E+00	4.87E+00	3.68E+00	2.98E+00	2.50E+00	2.16E+00	1.90E+00	1.70E+00	1.53E+00	1.39E+00	1.28E+00	1.18E+00	1.09E+00	1.01E+00	9.43E-01	8.83E-01	8.28E-01	7.78E-01	7.33E-01	6.92E-01
$PM_{2.5}$	8.8	2.72E+00	1.78E+00	1.34E+00	1.09E+00	9.14E-01	7.88E-01	6.93E-01	6.18E-01	5.58E-01	5.08E-01	4.65E-01	4.29E-01	3.97E-01	3.69E-01	3.44E-01	3.22E-01	3.02E-01	2.84E-01	2.67E-01	2.52E-01

1.30E+01 = greater than annual air quality threshold, and therefore retained as a COPC.

Note: All air concentrations are in units of µg/m^3.

CO = carbon monoxide; COPC = contaminant of potential concern; µg/m^3 = microgram per cubic metre; m = metres; NO_x = nitrogen oxides; NO_2 = nitrogen dioxide; NV = no value; $PM_{2.5}$ = particulate matter less than 2.5 microns; PM_{10} = particulate matter less than 10 microns; SO_2 = sulphur dioxide; TSP = total suspended particulates; ROW= right-of-way.

ATTACHMENT 21-IB

Air Quality Thresholds

February 2018
Project No. 1536607/2000/2219

NEXTBRIDGE INFRASTRUCTURE

Table 1: 1-Hour Air Quality Thresholds

Contaminant	1-Hour Air Quality Thresholds [µg/m^3]							Basis of Air Quality Threshold
	Canadian NAAQO[a]	ON MOE AAQC[b]	WHO AQG[c,d]	CalEPA REL[e]	ATSDR MRL[f]	TCEQ ESL[g]	TCEQ ESL[g] Adjusted	
Carbon monoxide	**6000**[i]	15700[i]	10000[i]	23000	n/a	40100	NR	NAAQO - health and environment
								MOE - health
								WHO - effects other than cancer or odour/annoyance: The threshold was selected based on COHb levels. To protect non-smoking, middle-aged and elderly populations with documented or latent heart diseases, and fetuses of non-smoking pregnant women from untoward hypoxic effects, a COHb level of 2.5% should not be exceeded
	15000[i]							CalEPA - The CalEPA threshold is based on effects of angina in people with known cardiovascular diseases that are exercising heavily
								TCEQ - health, criteria pollutant, must meet US NAAQS for CO of 35 ppm
Nitrogen dioxide	400	400	200	470	n/a	**190**	NR	NAAQO - health and environment
								MOE - health. NO_x are defined to be the sum of NO_2 and NO. Emissions of NO_x consist mainly of NO, with some NO_2. In ambient air, NO converts to NO_2. NO_2 has adverse health effects at much lower concentrations than NO. Therefore the AAQC is based on the health effects of NO_2
								WHO - The WHO threshold is based on an increase in bronchial responsiveness in asthmatics.
	1000							CalEPA - The CalEPA threshold is based on increased airway reactivity in asthmatics
								TCEQ - health, criteria pollutant, must meet US NAAQS for NO_2 of 100 ppb
Nitrogen oxides (NO_x)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	No 1 hour thresholds are available
Sulphur dioxide	450	690	500[h]	660	**26.2**	200	NR	NAAQO - health and environment
								MOE - health and vegetation
								WHO - The WHO threshold is based on changes in pulmonary function and respiratory symptoms
								CalEPA - The CalEPA threshold was based on an equivalent 1 h concentration of 0.25 ppm. This value was derived from a consensus value from several studies. An uncertainty factor of 1 was applied. This REL is the California AAQS
	900							ATSDR - The MRL was based on a minimal LOAEL of 0.01 ppm for bronchoconstriction in exercising asthmatics. An uncertainty factor of 9 was applied
								TCEQ - health, criteria pollutant, must meet US NAAQS for SO_2 of 75 ppb
$PM_{2.5}$	n/a	n/a	n/a	n/a	n/a	n/a	n/a	No 1 hour thresholds are available
PM_{10}	n/a	n/a	n/a	n/a	n/a	n/a	n/a	No 1 hour thresholds are available
Diesel particulate matter	n/a	n/a	n/a	n/a	n/a	19	**63**	TCEQ - PM_{10}, health
Total suspended particulate	n/a	n/a	n/a	n/a	n/a	n/a	n/a	No 1 hour thresholds are available

Source: Centre for Disease Control and Prevention. (2003). Conversion Calculator. The National Institute for Occupational Safety and Health Publication No. 2004-101. Internet Site, last updated October 2003, accessed 7 September 2016 from http://www.cdc.gov/niosh/docs/2004-101/calc.html.

Notes:

Target hazard quotient = 1.0.

Selection criteria:

The lowest air threshold was selected as the threshold for screening in the HHRA.

200	= selected threshold for screening in the HHRA

a) CCME (Canadian Council of Ministers of the Environment). 1999. Canadian Environmental Quality Guidelines. Canadian National Ambient Air Quality Objectives (NAAQO).

b) MOE (Ontario Ministry of the Environment). 2012. Ontario's Ambient Air Quality Criteria (AAQC). Standards Development Branch. The MOE AAQCs are based on health, odour, vegetation, soiling, visibility, corrosion or other effects. The MOE does not provide background information on how the AAQCs were derived on a contaminant basis.

c) WHO (World Health Organization). 2000. Air Quality Guidelines (AQG) for Europe, 2nd Ed. World Health Organization Regional Publications, European Series, No. 91. Copenhagen.

d) WHO. (2005). WHO Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide. Global Update, Summary of Risk Assessment.

e) CalEPA (California Environmental Protection Agency). 2016. Acute, 8-Hour and Chronic Reference Exposure Levels (REL). Office of Environmental Health Hazard Assessment, Air Toxicology and Epidemiology. Internet Site, last updated June 2016, accessed 7 September 2016 from http://oehha.ca.gov/air/allrels.html.

f) ATSDR (Agency for Toxic Substances and Disease Registry). 2016. Minimal Risk Levels (MRL). Internet Site, last updated November 2016, accessed 4 November 2016 from http://www.atsdr.cdc.gov/mrls/mrllist.asp. The ATSDR defines acute exposure as 14 days or less.

g) TCEQ (Texas Commission on Environmental Quality). 2016. Effects Screening Levels. Internet Site, last updated September 2015, accessed 7 September 2016 from http://www.tceq.texas.gov/toxicology/esl. The TCEQ ESLs are based on health, odour/nuisance potential, and vegetation effects. The TCEQ ESLs are based on a hazard quotient = 0.3 for non-carcinogens and were therefore adjusted with the following equation: threshold (µg/m^3) = TCEQ value x 3.333. The TCEQ does not provide background information on how the ESLs were derived for all contaminants. All ESLs are interim, unless otherwise stated.

h) 10 minutes.

i) 8 hour. Air concentrations given in ppm were converted to µg/m^3 with the following equation: X (ppm) = Y (mg/m^3)*(24.45/MW)*1000.

AAQS = ambient air quality standard; CO = carbon monoxide; COHb = carboxyhemoglobin; h = hour; LOAEL = lowest observed adverse effect level; µg/m^3 = microgram per cubic metre; MRL = minimal risk level; NO = nitric oxide; NO_2 = nitrogen dioxide; NO_x = nitrogen oxides; n/a = not available; NR = not required; $PM_{2.5}$ = particulate matter less than 2.5 microns; PM_{10} = particulate matter less than 10 microns; ppm = parts per million; ppb = parts per billion; SO_2 = sulphur dioxide; US NAAQS = United States National Ambient Air Quality Standards.

Table 2: 24-Hour Air Quality Thresholds

Contaminant	24-Hour Air Quality Thresholds [µg/m³]						Basis of Air Quality Threshold
	Canadian NAAQO[a]	ON MOE AAQC[b]	WHO AQG[c,d]	CalEPA REL[e]	ATSDR MRL[f]	TCEQ ESL[g] Adjusted	
Carbon monoxide	n/a	n/a	n/a	n/a	n/a	n/a	No 24-hour thresholds were available
Nitrogen dioxide	**200**	200	n/a	n/a	n/a	n/a	NAAQO - health and environment
	300						MOE - health. NO_x are defined to be the sum of NO_2 and NO. Emissions of NO_x consist mainly of NO, with some NO_2. In ambient air, NO converts to NO_2. NO_2 has adverse health effects at much lower concentrations than NO. Therefore the AAQC is based on the health effects of NO_2
Nitrogen oxides (NO_x)	n/a	n/a	n/a	n/a	n/a	n/a	No 24-hour thresholds were available
Sulphur dioxide	150	275	**125**	n/a	n/a	n/a	NAAQO - health and environment
	300						MOE - health and vegetation
							WHO - effects other than cancer or odour/annoyance: The WHO threshold is based on exacerbation of symptoms among panels of selected sensitive patients at 250 µg/m³. An uncertainty factor of 2 was applied
$PM_{2.5}$	27	30	**25**	n/a	n/a	n/a	NAAQO – The 2013 Canadian Ambient Air Quality Standard represents a balance between achieving the best health and environmental protection possible and the feasibility and costs of reducing pollutant emissions; a value of 28 µg/m³ is effective in 2015 and a value of 27 µg/m³ is effective in 2020. These values are applicable to the 3-year average of the annual 98th percentile of the daily 24-hour average concentrations
							MOE - The MOE value is not technically an AAQC, but is the CWS for $PM_{2.5}$. The CWS is a long-term goal of minimizing risk that fine PM poses on human health and the environment. The MOE recommends that contribution of $PM_{2.5}$ from a single facility be less than 25 µg/m³ (24 h) to achieve the CWS target
							WHO - The WHO AQG is based on a $PM_{2.5}$:PM_{10} ratio of 0.5. Therefore, the AQG reflects the relationship between the distributions of 24-h means (and its 99th percentile) and annual average concentrations
PM_{10}	**25**	50	50 (63)	n/a	n/a	n/a	NAAQO - a reference level above which there are demonstrated effects on human health and/or the environment; guideline established in 1998
							MOE - interim AAQC, provided for decision making
							WHO - Based on the $PM_{2.5}$ guideline and an assumed $PM_{10}/PM_{2.5}$ ratio of 2. It is recommended that a different value for this ratio, which better reflects local conditions, be employed when setting local guidelines. For the 24-hour averaging period, the average $PM_{10}/PM_{2.5}$ ratio for the Project is 2.5. The PM_{10} guideline was adjusted by this Project-specific ratio and is shown in parentheses
Diesel particulate matter	n/a	n/a	n/a	n/a	n/a	n/a	No 24-hour thresholds were available
Total suspended particulate	**120**	120	n/a	n/a	n/a	n/a	NAAQO - health and environment
	400						MOE - visibility

Source: Centre for Disease Control and Prevention. (2003). Conversion Calculator. The National Institute for Occupational Safety and Health Publication No. 2004-101. Internet Site, last updated October 2003, accessed 19 February 2013 from http://www.cdc.gov/niosh/docs/2004-101/calc.html.

Notes:

Air concentrations given in ppm were converted to µg/m³ with the following equation: X (ppm) = Y (mg/m³)*24.45/MW.

Target hazard quotient = 1.0.

Selection criteria:

The lowest air threshold was selected as the threshold for screening in the HHRA.

200	= selected threshold for screening in the HHRA.

a) CCME (Canadian Council of Ministers of the Environment). 1999. Canadian Environmental Quality Guidelines. Canadian National Ambient Air Quality Objectives (NAAQO).

b) MOE (Ontario Ministry of the Environment). 2012. Ontario's Ambient Air Quality Criteria (AAQC). Standards Development Branch. The MOE AAQCs are based on health, odour, vegetation, soiling, visibility, corrosion or other effects. The MOE does not provide background information on how the AAQCs were derived on a contaminant to contaminant basis.

c) WHO (World Health Organization). 2000. Air Quality Guidelines (AQG) for Europe, 2nd Ed. World Health Organization Regional Publications, European Series, No. 91. Copenhagen.

d) WHO. 2005. WHO Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide. Global Update, Summary of Risk Assessment.

e) CalEPA (California Environmental Protection Agency). 2016. Acute, 8-Hour and Chronic Reference Exposure Levels (REL). Office of Environmental Health Hazard Assessment, Air Toxicology and Epidemiology. Internet Site, last updated June 2016, accessed 7 September 2016 from http://oehha.ca.gov/air/allrels.html.

f) ATSDR (Agency for Toxic Substances and Disease Registry). 2016. Minimal Risk Levels (MRL). Internet Site, last updated March 2016, accessed 7 September 2016 from http://www.atsdr.cdc.gov/mrls/mrllist.asp.

The ATSDR defines intermediate exposure as 15 to 365 days.

g) TCEQ (Texas Commission on Environmental Quality). 2015. Effects Screening Levels. Internet Site, last updated September 2015, accessed 7 September 2016 from http://www.tceq.texas.gov/toxicology/esl. The TCEQ ESLs are based on health, odour/nuisance potential, and vegetation effects. The TCEQ ESLs are based on a hazard quotient = 0.3 for non-carcinogens and were therefore adjusted with the following equation: threshold (µg/m³) = TCEQ value x 3.333. The TCEQ does not provide background information on how the ESLs were derived for all contaminants. All ESLs are interim, unless otherwise stated.

AQG = Air Quality Guideline; CWS = Canada-wide Standard; h = hour; m^3 = cubic metre; µg/m³ = microgram per cubic metre; MRL = minimal risk level; NO_2 = nitrogen dioxide; NO_x = nitrogen oxides; n/a = not available; $PM_{2.5}$ = particulate matter less than 2.5 microns; PM_{10} = particulate matter less than 10 microns; ppm = parts per million; REL = Reference exposure level.

Table 3: Annual Air Quality Thresholds

Contaminant	Annual Air Quality Thresholds (µg/m^3)							Basis of Air Quality Threshold
	Canadian NAAQO[a]	ON MOE AAQC[b]	WHO AQG[c,d]	CalEPA REL[e]	ATSDR MRL[f]	TCEQ ESL[g]	TCEQ ESL[g] Adjusted	
Carbon monoxide	n/a	n/a	n/a	n/a	n/a	n/a	n/a	No annual thresholds were available
Nitrogen dioxide	60	n/a	**40**	n/a	n/a	99.73	NR	NAAQO - health and environment
								WHO - effects other than cancer or odour/annoyance: The WHO guideline was derived based on outdoor epidemiological studies that found exposures to NO_2 in ambient air associated with increased respiratory symptoms and lung function decreases in children
	100							TCEQ - health, criteria pollutant, must meet US NAAQS. Texas defers to the US NAAQS for NO_2
Nitrogen oxides (NO_x)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	No annual thresholds were available
Sulphur dioxide	**30**	55	50	n/a	n/a	n/a	n/a	NAAQO - health and environment
								MOE - health and vegetation
	60							WHO - effects other than cancer or odour/annoyance: A LOAEL of 100 µg/m^3 for respiratory symptoms and illnesses or differences in lung function values was the basis for the WHO threshold
$PM_{2.5}$	**8.8**	n/a	10	n/a	n/a	n/a	n/a	NAAQO – The 2013 Canadian Ambient Air Quality Standard represents a balance between achieving the best health and environmental protection possible and the feasibility and costs of reducing pollutant emissions; a value of 10 µg/m^3 is effective in 2015 and a value of 8.8 µg/m^3 is effective in 2020. This value is applicable to the 3-year average of the annual average concentrations
								WHO - The AQG is based on cardiopulmonary and lung cancer mortality
PM_{10}	n/a	n/a	**20 (25)**	n/a	n/a	n/a	n/a	WHO - Based on the $PM_{2.5}$ guideline and an assumed $PM_{10}/PM_{2.5}$ ratio of 2. It is recommended that a different value for this ratio, which better reflects local conditions, be employed when setting local guidelines. For the annual averaging period, the average $PM_{10}/PM_{2.5}$ ratio for the Project is 2.5. The PM_{10} guideline was adjusted by this Project-specific ratio and is shown in parentheses
Diesel particulate matter	n/a	n/a	n/a	5	n/a	0.15	**0.50**	CalEPA - The chronic REL was based on respiratory effects
								CalEPA - The unit risk was based on lung cancer risk in occupationally exposed individuals
								TCEQ - PM_{10}, health
Total suspended particulate	**60**	60	n/a	n/a	n/a	n/a	n/a	NAAQO - health and environment
	70							MOE - visibility

Source: Centre for Disease Control and Prevention. (2003). Conversion Calculator. The National Institute for Occupational Safety and Health Publication No. 2004-101. Internet Site, last updated October 2003, accessed 7 September 2016 from http://www.cdc.gov/niosh/docs/2004-101/calc.html.

Notes:

Air concentrations given in ppm were converted to µg/m^3 with the following equation: X (ppm) = Y (mg/m^3)*24.45/MW.Target HQ = 1.0.

Target cancer risk = 1E-06.

Selection criteria:

The lowest air threshold was selected as the threshold for screening in the HHRA.

200	= selected threshold for screening in the HHRA

a) CCME (Canadian Council of Ministers of the Environment). 1999. Canadian Environmental Quality Guidelines. Canadian National Ambient Air Quality Objectives (NAAQO).

b) MOE (Ontario Ministry of the Environment). 2012. Ontario's Ambient Air Quality Criteria (AAQC). Standards Development Branch. The ON MOE AAQCs are based on health, odour, vegetation, soiling, visibility, corrosion or other effects.

c) WHO (World Health Organization). 2000. Air Quality Guidelines (AQG) for Europe, 2nd Ed. World Health Organization Regional Publications, European Series, No. 91. Copenhagen.

d) WHO. 2005. WHO Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide. Global Update, Summary of Risk Assessment.

e) CalEPA (California Environmental Protection Agency). 2016. Acute, 8-Hour and Chronic Reference Exposure Levels (REL). Office of Environmental Health Hazard Assessment, Air Toxicology and Epidemiology. Internet Site, last updated June 2016, accessed 7 September 2016 from http://oehha.ca.gov/air/allrels.html. The CalEPA OEHHA provides carcinogenic unit risks. Unit risks (based on a risk level of 1E-06) were adjusted to a risk based concentration and used as a screening value with the following formula: threshold (µg/m^3) = 1E-06/unit risk (per µg/m^3).

f) ATSDR (Agency for Toxic Substances and Disease Registry). 2016. Minimal Risk Levels (MRL). Internet Site, last updated March 2016, accessed 7 September 2016 from http://www.atsdr.cdc.gov/mrls/mrllist.asp. The ATSDR defines chronic exposure as 365 days or more.

g) TCEQ (Texas Commission on Environmental Quality). 2015. Interoffice Memorandum, September 2015 Effects Screening Levels (ESL). Toxicology Division for Air Permitting. The TCEQ ESLs are based on health, odour/nuisance potential, and vegetation effects. The TCEQ ESLs are based on an HQ = 0.3 for non-carcinogens Thresholds were adjusted with the following equation: threshold (µg/m^3) = TCEQ value x 3.333. The TCEQ does not provide background information on how the ESLs were derived for all contaminants. All ESLs are interim, unless otherwise stated.

AQG = Air quality guideline; LOAEL = lowest observed adverse effect level; µg/m3 = microgram per cubic metre; MRL = minimal risk level; NO_2 = nitrogen dioxide; n/a = not available; NR = not required; $PM_{2.5}$ = particulate matter less than 2.5 microns; PM_{10} = particulate matter less than 10 microns; REL = reference exposure level; TSP = total suspended particulates; US NAAQS = United States National Ambient Air Quality Standards.

ATTACHMENT 21-IC

Reference Concentrations and Inhalation Unit Risks

February 2018
Project No. 1536607/2000/2219

NEXTBRIDGE INFRASTRUCTURE

Table 1: Reference Concentrations for the Evaluation of Non-Carcinogenic Long-term or Chronic Effects

COPC	Reference Concentration (µg/m³)								Toxicological Endpoint and Derivation
	MOE RfC[a]	MOE AAQC[b]	Health Canada TC[c]	US EPA RfC[d]	CalEPA REL[e]	ATSDR MRL[f]	RIVM TCA[g]	WHO AQG[h]	
DPM	NV	NV	NV	**5**	5	NV	NV	NV	The US EPA RfC is based on a chronic rat inhalation study by Ishinishi et al. (1988). Rats were either exposed to 0.11, 0.41, 1.18 or 2.32 mg/m³ DPM from a light-duty engine or to 0.46, 0.96, 1.84 or 3.72 mg/m³ DPM from a heavy-duty engine for 16 h/d, 6 d/w for 30 months. A NOAEL of 0.46 mg/m³ for pulmonary inflammation and histopathology was selected as the critical effect. The NOAEL was adjusted for a human equivalent concentration, resulting in an adjusted NOAEL of 0.144 mg/m³. An uncertainty factor of 30 was applied (3 for interspecies extrapolation and 10 for interindividual human variation in sensitivity).
									The CalEPA has adopted the US EPA RfC as the chronic REL. See above for endpoints and derivation.

0.002 = selected RfC for use in the evaluation of potential non-carcinogenic chronic effects in the human health risk assessment

a) MOE (Ontario Ministry of the Environment). 2011. Rationale for the Development of Soil and Ground Water Standards for Use at Contaminated Sites in Ontario. April 15, 2011. Standards Development Branch.

b) AAQC (Ontario Ministry of the Environment). 2012. Ontario's Ambient Air Quality Criteria (AAQC). Standards Development Branch.

c) Health Canada. 2010. Federal Contaminated Site Risk Assessment in Canada. Part II: Health Canada Toxicological Reference Values and Chemical-Specific Factors. Version 2.0. September 2010. Contaminated Sites Division, Safe Environments Directorate.

d) US EPA (United States Environmental Protection Agency). 2016. Integrated Risk Information System. Last updated 9 September 2016, Accessed 14 September 2016 from http://www.epa.gov/iris.

e) CalEPA (California Environmental Protection Agency). 2016. Office of Environmental Health Hazard Assessment Acute, 8-hour and Chronic Reference Exposure Level (REL) Summary. Last updated 28 June 2016, Accessed 14 September 2016 from http://oehha.ca.gov/air/general-info/oehha-acute-8-hour-and-chronic-reference-exposure-level-rel-summary.

f) ATSDR (Agency for Toxic Substances and Disease Registry). 2016. Minimal Risk Levels (MRL) for Hazardous Substances. Last updated March 2016, Accessed 14 September 2016 from http://www.atsdr.cdc.gov/mrls/mrllist.asp.

g) Rijksinstituut Voor Volksgezondheid en Milieu (National Institute of Public Health and the Environment) (RIVM). 2001. Re-evaluation of human-toxicological maximum permissible risk levels. March 2001.

h) WHO (World Health Organization). Air Quality Guidelines (AQG) for Europe, 2nd Ed. World Health Organization Regional Publications, European Series, No. 91. Copenhagen.

AAQC = Ambient Air Quality Criteria; AQG = Air Quality Guideline; COPC = contaminant of potential concern; d/w = day/week; h/d = hour/day; DPM = Diesel Particulate Matter; MRL = minimal risk level; NOAEL = no observed adverse effect level; NV = no value; REL = Reference Exposure Level; RfC = reference concentration; TC = tolerable concentration; TCA = tolerable concentration in air; µg/m³ = microgram per cubic metre.

Table 2: Inhalation Unit Risks for the Evaluation of Carcinogenic Long-term or Chronic Effects

COPC	Reference Concentration (µg/m³)								Toxicological Endpoint and Derivation
	MOE RfC[a]	MOE AAQC[b]	Health Canada TC[c]	US EPA RfC[d]	CalEPA IUR[e]	ATSDR MRL[f]	RIVM TCA[g]	WHO AQG[h]	
DPM	NV	NV	NV	NV	**3.0E-04**	NV	NV	NV	The CalEPA IUR is based on lung tumor formation findings from five chronic rat studies which evaluated F344 or Wistar rats at various exposure levels. Based on the results of the selected studies, CalEPA estimated cancer unit risk factors based on the relationship between ambient air concentrations and lung tumor formation and an analysis of lung tumor formation as a function of cumulative lung burden. The range of estimated cancer unit risk factors was estimated to be 1.0E-05 to 3.0E-04. The IUR for DPM was selected as the highest value of the estimated range.

3.0E-04	= selected IUR for use in the evaluation of potential carcinogenic chronic effects in the human health risk assessment

a) MOE (Ontario Ministry of the Environment). 2011. Rationale for the Development of Soil and Ground Water Standards for Use at Contaminated Sites in Ontario. April 15, 2011. Standards Development Branch.

b) AAQC (Ontario Ministry of the Environment). 2012. Ontario's Ambient Air Quality Criteria (AAQC). Standards Development Branch.

c) Health Canada. 2010. Federal Contaminated Site Risk Assessment in Canada. Part II: Health Canada Toxicological Reference Values and Chemical-Specific Factors. Version 2.0. September 2010. Contaminated Sites Division, Safe Environments Directorate.

d) US EPA (United States Environmental Protection Agency). 2016. Integrated Risk Information System. Last updated 15 November 2017, Accessed 13 December 2017 from http://www.epa.gov/iris.

e) CalEPA (California Environmental Protection Agency). 2016. Air Resources Board and Office of Environmental Health Hazard Assessment Acute. Consolidated Table of OEHHA/ARB Approved Risk Assessment Health Values. Last updated 23 February 2017, Accessed 13 December 2017 from https://www.arb.ca.gov/toxics/healthval/healthval.htm.

f) ATSDR (Agency for Toxic Substances and Disease Registry). 2016. Minimal Risk Levels (MRL) for Hazardous Substances. Last updated March 2016, Accessed 14 September 2016 from http://www.atsdr.cdc.gov/mrls/mrllist.asp.

g) Rijksinstituut Voor Volksgezondheid en Milieu (National Institute of Public Health and the Environment) (RIVM). 2001. Re-evaluation of human-toxicological maximum permissible risk levels. March 2001.

h) WHO (World Health Organization). Air Quality Guidelines (AQG) for Europe, 2nd Ed. World Health Organization Regional Publications, European Series, No. 91. Copenhagen.

AAQC = Ambient Air Quality Criteria; AQG = Air Quality Guideline; COPC = contaminant of potential concern; d/w = day/week; h/d = hour/day; DPM = Diesel Particulate Matter; IUR = inhalation unit risk; MRL = minimal risk level; NOAEL = no observed adverse effect level; NV = no value; REL = Reference Exposure Level; RfC = reference concentration; TC = tolerable concentration; TCA = tolerable concentration in air; µg/m³ = microgram per cubic metre.