WHITE PAPER

British Columbia Ministry of Transport and Infrastructure
Final Draft

Review of Land Use and Mitigation Guidance for Near-Roadway Land Uses

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1. EXECUTIVE SUMMARY

There has been increased public concern over near-road air quality as an environmental issue, resulting from a body of health studies linking adverse health effects to near-roadway exposures. These effects are attributed to increased exposure to particulate matter, gaseous criteria pollutants, and air toxics emitted by vehicle activity.

In response to these concerns, the British Columbia (B.C.) Ministry of Environment incorporated specific measures into their document *Develop with Care 2014: Environmental Guidelines for Urban and Rural Land Development in British Columbia* pertaining to the siting of new buildings that house susceptible populations (e.g., infants, children, pregnant women, the elderly and those with heart or lung disease). These measures include the provision for a 150 meter setback from "busy roads" (i.e., those with traffic volumes greater than 15,000 vehicles per day), or other building design considerations (location of building air intakes, and HEPA room air filters, or central building air filtration systems) when setbacks are infeasible. It is stressed that these measures are typically only applied to new development within the vicinity of busy roads, and not typically to roadway improvement projects in close proximity to existing development.

Additionally, in 2013, Metro Vancouver developed a report entitled *Reducing Exposure to Traffic Emissions*, recommending strategies to reduce residents' exposure to traffic-related air pollutants (TRAP) in the Lower Fraser Valley.

The above guidance largely agrees with a prior guidance document that the California Air Resources Board (CARB) published in 2005, recommending that no new sensitive receptors (homes, schools, daycare centers, playgrounds, and medical facilities) be sited within 500 feet (about 150 meters) of a freeway or high-traffic roadway. CARB's guidance has been adapted for other purposes as well, and has been seen as relevant to transportation projects such as new freeways and roadways, adding lanes to existing freeways and roadways, and new or redesigned freeway interchanges.

Policy makers have subsequently found that a strict adherence to the 500-foot (150-meter) zone would be overly conservative due to dramatic reductions in vehicle emissions forced by new exhaust emission standards (and particularly those that apply to 2007 model year and later heavy duty vehicles). Additionally, CARB's policy was found to be at odds with other land-use objectives intended to improve air quality, which include encouraging high-density, mixed use, and urban infill projects close to job centers.

To balance the concerns related to near-road air quality and health impacts with the benefits of urban in-fill and roadway projects intended to improve traffic flow, researchers have been motivated to study methods to reduce exposure to these pollutants. This whitepaper discusses the guidance and the science behind the guidance, and briefly summarizes the efficacy of the most widely implemented mitigation methods, which are the establishment of a vegetative barrier and/or construction of a sound wall to enhance dispersion of roadway pollutants.

2.1. BRITISH COLUMBIA MINISTRY OF ENVIRONMENT: DEVELOP WITH CARE 2014: ENVIRONMENTAL GUIDELINES FOR URBAN AND RURAL LAND DEVELOPMENT IN BRITISH COLUMBIA

In 2014, the B.C. Ministry of Environment (MoE) published *Develop with Care 2014: Environmental Guidelines for Urban and Rural Land Development in British Columbia*. The guidelines describe the provincial government's approach for maintaining environmental values during the development of urban and rural lands.

Within Section 2 (Community Planning and Land Management), Section 2.6 provides guidelines for air quality, which include providing for setbacks or mitigating impacts from major transportation routes. Citing near-road health impacts attributable to air quality, the guidelines recommends consideration of air quality impacts when siting buildings where people spend large amounts of time, but recognize that issues such as land availability, accessibility of facilities, and the desire for compact, walkable neighborhoods may render roadway setbacks infeasible in certain cases.

Specific guidance calls for the provision of a 150 m setback from "busy roads," especially for buildings that house susceptible populations (e.g., infants, children, pregnant women, the elderly and those with heart or lung disease). Busy roads are defined as those with traffic volumes of more than 15,000 vehicles/day. The guidance further recommends avoidance of siting buildings housing susceptible populations near truck routes and distribution centers (or the provision of additional setbacks). Where setbacks are not feasible, the guidelines recommend that specific design features be included in the new buildings to reduce exposure, such as placement of loading docks, air intakes, or additional air filtration.

Within Section 3 (Site Development and Management), Section 3.8 provides similar guidelines for air quality related to planning and/or rezoning decisions involving residential or institutional development near industrial facilities, busy traffic corridors, and other large air emission sources. The guidelines recommend not placing air intake systems near loading docks or on a side of a building near a busy traffic corridor. Where proximity to traffic is unavoidable, the guidelines recommend the use of high-efficiency particle air (HEPA) room cleaners or centralized air filtration.

2.2. METRO VANCOUVER: REDUCING EXPOSURE TO TRAFFIC EMISSIONS

In 2013, the Planning, Policy, and Environment Department of Metro Vancouver published a report entitled *Reducing Exposure to Traffic Emissions*. Citing a body of recent local studies linking proximity to higher traffic volume corridors (e.g. major roadways, truck routes, major bus routes, and bus and freight terminals) to adverse health impacts, the report provides recommended strategies to reduce residents' exposure to traffic-related air pollutants (TRAP) in the Lower Fraser Valley.

Appendix C of the report provides an evaluation matrix of 28 provincial and regional strategies for reducing exposure to TRAP. Under the heading of "Land Use Strategies," Item 2 recommends the "adoption of siting considerations (and designs) for medical, health, and long-term care facilities." Specific guidance calls for siting new facilities outside of higher TRAP exposure areas, but does not provide specific roadway setback distances (noting that higher TRAP exposure areas should be identified at the regional level).

Appendix C of the report also provides a matrix of 32 recommended municipal and local land use strategies for reducing exposure to TRAP. Under the heading of "Land Use Strategies," Item 2 recommends the development of best management practices that will mitigate exposure to TRAP in identified higher TRAP exposure areas, and under the heading of "Design Strategies," Item 6 recommends the implementation of best management practices for indoor air quality management for development/permit applications. And finally, Item 18 recommends the creation of barriers between emission sources and higher exposure TRAP exposure areas, although it is noted that this is not one of the "key recommended strategies" and was evaluated as having low effectiveness (but high practicality).

2.3. CALIFORNIA AIR RESOURCES BOARD: "LAND USE HANDBOOK"

In 2005, CARB published its *Air Quality and Land Use Handbook: A Community Health Perspective* (Land Use Handbook).[1] The purpose of the Land Use Handbook was to provide recommendations regarding the siting of new sensitive land uses near freeways and roads, distribution centers, rail yards, ports, refineries, chrome plating facilities, dry cleaners, and large gasoline dispensing facilities. These source types were selected based on CARB's jurisdiction to regulate mobile sources of air toxics as well as certain other stationary sources of toxic air contaminants. CARB's Land Use Handbook provides limited guidance with regard to mitigation, and no guidance with regard to new or modified freeway/road projects or mitigation measures that may reduce the health risk from these sources.

CARB's guidance with regard to freeways/roadways is to, "avoid siting new sensitive land uses within 500 feet [150 meters] of a freeway, urban roads with 100,000 vehicles/day, or rural roads with 50,000 vehicles/day."[2] CARB justifies these setback distances based on data showing that exposure is "greatly reduced at approximately 300 feet [90 meters]," and that "health risk attributable to the proximity effect was strongest within 1,000 feet [300 meters]."

2.4. ENVIRONMENT CANADA: EMISSION STANDARDS FOR 2007 AND LATER HEAVY DUTY ENGINES AND VEHICLES

On December 21, 2000 the US EPA signed emission standards for model year 2007 and later heavy-duty highway engines.[3] These standards were adopted by Environment Canada in 2003 within its On-Road Vehicle and Engine Emission Regulations.[4] The new emission standards lowered the allowable emission rate for Diesel particulate matter from 0.1 grams/brake horsepower-hour (applicable to 2004-2006 model year engines) to 0.01 grams/brake horsepower-hour (applicable to 2007+ model year engines)—a decrease of 90%—for all heavy duty Diesel vehicles with a gross vehicle weight rating (GVWR) of 8,500 lbs or greater. Diesel particulate emissions are often used as a surrogate for mobile source air toxic emissions (MSATs) from Diesel vehicles.

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[1] Available at: https://www.arb.ca.gov/ch/handbook.pdf

[2] Ibid. p. 10.

[3] Federal Register; Vol. 66, No. 12; Thursday, January 18, 2001

[4] SOR/2003-2

As a result of these standards, the overall health risk attributed to freeways and high-traffic roadways has decreased sharply over time, and will continue to do so as 2007+ model year heavy duty vehicles penetrate the fleet and displace older, higher-emitting vehicles. The studies on which CARB's Land Use Handbook were based represented the mobile source fleet date from 1997 to 2004, and therefore reflect a mobile source fleet that was subject to much less stringent standards at the time.

2.5. SACRAMENTO METROPOLITAN AIR QUALITY MANAGEMENT DISTRICT "ROADWAY PROTOCOL"

The Sacramento [California] Metropolitan Air Quality Management District (SMAQMD) recognized that strict adherence to CARB's Land Use Handbook guidance could effectively prohibit any new residence, school, daycare center, playground, or medical facility from being located near freeways in urbanized areas. This policy would be at odds with the air quality objectives of existing land use policy to promote high-density, mixed-use, and urban infill projects in close proximity to job centers. This, coupled with the reduction in toxic air contaminant emissions from heavy-duty vehicles with 2007 and newer model year engines, prompted SMAQMD to adopt its *Recommended Protocol for Evaluating the Location of Sensitive Land Uses Adjacent to Major Roadways* (Roadway Protocol).[5]

While SMAQMD's Roadway Protocol is applicable strictly within Sacramento County, California, it has been adopted for use by other local air quality regulatory agencies throughout California. The protocol provides a three-step procedure for evaluating health risks from vehicle exhaust within 500 feet of freeways and major roadways. If an acceptable level of risk can be demonstrated, the sensitive land use is approvable even if within 500 feet of the freeway or roadway.

The first step of the Roadway Protocol is to determine whether the project is within 500 feet of a freeway, urban roadway with a traffic volume greater than 100,000 vehicles/day, or a rural roadway with a traffic volume of greater than 50,000 vehicles/day. If so, the second step of the Roadway Protocol is to apply screening tables, which estimate the health risk at a receptor based on the distance from the nearest travel lane, peak hour traffic volume, and whether the receptor is upwind or downwind of the roadway. Separate screening tables are developed for east-west oriented roadways and north-south oriented roadways (reflecting predominant wind patterns in the greater Sacramento area). A screening cancer risk level of 276 in a million is deemed an acceptable risk, at or below which the sensitive land use is approvable.[6] If an acceptable risk level cannot be shown using the screening tables, the third step of the Roadway Protocol allows a project proponent to conduct a site-specific health risk assessment using a dispersion model such as CAL3QHCR.

SMAQMD's Roadway Protocol does not specifically address new or modified freeway/roadway projects, but does provide limited recommendations for mitigating health risk due to roadway traffic within the 500-foot zone. These include tiered vegetative plantings and the use of passive electrostatic building air filtration systems with low air velocities.

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[5] Available at: http://www.airquality.org/LandUseTransportation/Documents/Final%202011%20Recommended%20Roadway%20Protocol.pdf

[6] Consistent with California policy which is not routinely accepted elsewhere, the screening cancer risk assessment is based on the use of Diesel particulate matter as a surrogate for mobile source air toxics. This approach results in health-conservative results as compared with more widely-used risk screening techniques based on actual emissions of MSATs.

3.1. USEPA'S RECOMMENDATIONS FOR CONSTRUCTING ROADSIDE VEGETATION BARRIERS TO IMPROVE NEAR-ROAD AIR QUALITY

In July 2016, USEPA published its *Recommendations for Constructing Roadside Vegetation Barriers to Improve near-Road air Quality.*[7] The report recognizes the public health concerns related to near-road air quality and sets forth measures for near-term actions that can be taken to reduce impacts to be implemented in conjunction with longer-term vehicle emission reductions achieved through vehicle exhaust standards. This report postdates the B.C. MoE *Develop with Care 2014* document reviewed earlier, and as of the date of this white paper, it is unlikely that the MoE has reviewed and/or endorsed this USEPA report.

The near-term actions advocated in the report include the preservation and planting of roadside vegetation and the construction of roadside structures (such as noise barriers) for urban developers and facilities already subject to high pollution levels near roads. These mitigation methods complement existing pollution control programs and regulations, as well as provide measures to reduce impacts from sources that are difficult to control, such as brake and tire wear and re-entrained road dust.

According to the report, roadside vegetation has been shown to reduce exposure to air pollution through the interception of airborne particles and/or through the uptake of gaseous air pollutants by leaf stomata as well as improving air pollutant dispersion. Additionally, the report states that noise barriers combined with mature vegetation have been found to result in lower ultrafine particle concentrations along highways compared to an open field or a noise barrier alone.

Vegetation type, height, and thickness can all influence the extent of mixing and pollutant deposition experienced at the site. The USEPA report recommends species with the following characteristics:

- Minimal seasonal effects (no deciduous plants)
- Low allergen, low BVOC[8] producing, non-poisonous
- Urban hardy species
- Low maintenance
- Drought tolerant
- Native preferred
- Non- invasive species

[7] Available at: https://www.epa.gov/sites/production/files/2016-08/documents/recommendations_for_constructing_roadside_vegetation_barriers_to_improve_near-road_air_quality.pdf

[8] Biogenic volatile organic compounds

With regard to physical characteristics of vegetation and noise barriers, the USEPA report recommends the following characteristics:

- Height (preferably 5 meters or higher)
- Thickness (preferably 10 meters or greater; for vegetative barriers)
- Allows some air flow-through (porosity of 0.5 to 0.9; for vegetative barriers)
- No gaps in vegetation
- Vegetation should extend from the ground to the top of the canopy.
- Vegetation should extend past the target location (preferably by 50 meters or more)
- Solid sound barrier
- Vegetation (if used) should extend 1 meter (or higher) above the sound barrier

3.2. CONCEPTUAL RESEARCH STUDIES TO ASSESS THE FEASIBILITY OF NEAR-ROADWAY POLLUTION MITIGATION TECHNOLOGIES: VEGETATIVE BARRIERS

In a report entitled *Conceptual Research Studies to Assess the Feasibility of Near-Roadway Pollution Mitigation Technologies: Vegetative Barriers*, Sierra Research investigated the conceptual feasibility, design, benefits, and effectiveness of roadside barriers—and especially vegetative barriers—in reducing roadway air quality impacts on nearby receptors. The study was carried out by Sierra Research, with field sampling and related support by subcontractor T&B Systems of Valencia, California and prepared for the South Coast Air Quality Management District (SCAQMD).

The study was based primarily on computer modeling using results from AERMOD, a dispersion model approved by USEPA. The selection and application of the model was guided by an analysis of data from a brief (five day) field study that was conducted in Los Angeles County, California in June of 2012.

The pertinent conclusions of the study include the following:

- Roadside barriers, whether vegetative or other, have the potential to either increase or decrease near-roadway concentrations (compared to the case of no barrier), depending on a number of factors, including roadway height, barrier height, wind speed, and others. The effects of these and other factors upon dispersion are reasonably estimated based on modeling for the case of meteorology observed and configuration of the subject study site.

- Downwind measurements of NOx concentrations during the brief field study showed isopleth concentrations that were generally parallel to the freeway as expected. However, under the sea breeze conditions that were targeted in the monitoring program, the downwind study area tended to be in the wake downwash of the freeway and of one or more barriers, resulting in a complex pattern of downwind concentrations, both measured and modeled. In all cases, the highest monitored location was located immediately behind the vegetated barriers, which was also the closest sampling location to the freeway.

- For the study site, measurement data suggested, and modeling estimates tended to confirm, that a taller barrier resulted in lower ground-level concentrations in the downwind cavity, which is presumed to be due to greater dilution.

- Modeling results, which examined hypothetical barrier heights ranging from 33–100 feet, further suggested that as barriers were reduced in height, the modeled source concentrations increased and shifted closer to the freeway. Conversely, the taller a barrier was, the farther from the freeway the modeled contribution shifted, to the point where the maximum was no longer always right at the edge of the freeway, but further away. The distribution of impacts also broadened, forming zones where concentrations were heightened.

- For a hypothetical at-grade roadway that otherwise meets the specific conditions of the current study site, modeling results suggested that a barrier has a near-field air quality benefit, a (smaller) disbenefit at intermediate distances, and no significant effect at further distances.

- Other possible effects on measured concentrations from the subject vegetative barriers, such as pollutant removal by deposition, were considered, but no significant effects could be documented.

This study suggests that vegetative and/or noise barriers may not always achieve desired air quality and public health benefits, and need to be evaluated in the context of specific projects in specific locations.

3.3. CONGESTION-REDUCING ROADWAY PROJECTS

Generally, land use decisions and project-specific mitigation must be designed around existing roadways and existing roadway conditions. Additionally, roadway projects and improvements are never conducted solely to improve air quality for near-road sources. However, roadway projects that have the result of decreasing congestion can have the added benefit of improving air quality at near road locations.

Free flowing traffic traveling at normal (uncongested) highway speeds emit less pollutants on a per-mile basis. For example, according to the California Air Resources Board's current Emission Factor (EMFAC2014) model, heavy-duty diesel trucks operating in California emit approximately 88% less reactive organic gasses (ROG), 86% less carbon dioxide (CO), 60% less nitrogen oxides (NOx), and 41% less respirable/fine particulate matter (PM_{10}/$PM_{2.5}$) per mile, when travelling at a speed of 55 mph versus a speed of 15 mph.[9] Similar reductions can be expected for other vehicle classes, such as gasoline-fueled automobiles. Because Canada's exhaust emission standards are harmonized with both USEPA's and CARB's, similar reductions would be expected in British Columbia.

Lower emissions per mile are expected at higher speeds due to the advanced emission control systems present on newer automobiles. Exhaust after-treatment systems for both diesel and gasoline fueled vehicles rely on a driving cycle that produces enough heat in the exhaust to optimize the catalytic transformation and/or destruction of pollutants. During low engine loads that occur during idling or stop-and-go driving in congested conditions, the effectiveness of these catalysts is diminished.

Free-flowing traffic will also reduce particulate matter from tire and brake wear—two sources of emissions included in highway mobile source emission inventories. And additionally, free flowing traffic creates additional turbulent mixing and therefore better dispersion of pollutants compared to stop-and-go driving, although the increased turbulence has the propensity to re-entrain deposited particulate matter to the atmosphere. However, the overall near-road air quality benefits of congestion-reducing projects are expected to be significant.

[9] Derived from running exhaust emissions yielded by EMFAC2014 (v1.0.7) Web Database, statewide annual average for the 2016 calendar year, EMFAC2007 vehicle category of heave heavy-duty vehicles.