Appendix C – Trillium Line EA Addendum Supplementary Terrestrial Information (Ellwood Diamond, Walkley Yard, Bowesville and Limebank) Air Quality Report

REPORT

NATURAL ENVIRONMENT & SPECIES AT RISK REPORT – TERRESTRIAL

Ottawa Light Rail Transit Project (Stage 2)

Trillium Line EA Addendum Supplementary Information (Ellwood Diamond, Walkley Yard, Bowesville and Limebank)

Presented to:

City of Ottawa
160 Elgin Street
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1. INTRODUCTION

This report provides background information to the Terrestrial Natural Environment and Species at Risk (SAR) information presented in the Trillium Addendum to the Environmental Project Report (EPR). This addendum is for the following areas:

- Elwood Diamond
- Walkley Yard Maintenance and Storage Facility
- Bowesville Station and Park and Ride
- Limebank Extension

As part of the Ottawa Light Rail Transit (OLRT) Stage 2 project, Capital Transit Partners 2 (CTP2) Morrison Hershfield Limited (MH) was retained by the City of Ottawa to complete a terrestrial Species at Risk impact assessment. The project area falls within the Ministry of Natural Resources and Forestry (MNRF) Kemptville District, as well as the jurisdictional boundaries of the Rideau Valley Conservation Authority (RVCA).

This technical memorandum provides an outline of the terrestrial SAR and SAR habitat existing conditions based on background information and field investigations, as well as an assessment of the potential impacts that could result from the proposed project addendums. It also recommends mitigation measures to protect SAR within and adjacent to the project area. This memorandum was prepared at a 30% level of detail design for the proposed works, therefore, all potential environmental permitting and approvals required for this undertaking will be carried out based on existing design plans. As a result, a final assessment of impacts will be required to ensure that any design changes that may result in new impacts beyond what was assessed at the 30% design are addressed.

2. TERRESTRIAL HABITAT EXISTING CONDITIONS

2.1 Methodology

In order to determine the species to consider for the present analysis, background information from a variety of sources and the results of previous studies were reviewed for occurrence records of SAR within 10 km of the project area. The detailed outline of the methodology used for background data collection can be found in Section 2 of the *Natural Environment & Species at Risk Report – Terrestrial - Ottawa Light Rail Transit Project (Stage 2) - Confederation Lines West and East and Trillium Line* (CTP2, 2017). As well, information related to Environmentally Sensitive Areas (ESA), provincially rare and regionally significant species, provincially Significant Wildlife Habitats, and Natural Heritage Features was gathered from a variety of background resources, and is also documented in Section 2 of the same document.

2.2 Background

Upon review of background sources, a number of SAR were identified as having the potential to occur within or adjacent to the project area. Government documents were then reviewed for detailed information on the habitat requirements of these SAR. These documents included Status Reports, Recovery Strategies, and Management Plans published by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), the Committee on the Status of Species At Risk in Ontario (COSSARO), Environment and Climate Change Canada (ECCC), and the MNRF. A natural areas and features information request was sent to the MNRF – Kemptville District office on February 24th, 2017 and a response was received on July 18th, 2017. Another Information Request specific to the Bowesville Station and Limebank Extension was sent on November 15th, 2017, and a response was received on January 31st, 2018. These are included in Attachment A.

Once the habitat requirements of these species were identified, the presence of habitat which met these requirements within the project area was verified using a combination of desktop review of aerial imagery and field investigations. Only those species that had suitable habitat present within the vicinity of the project area were considered for 2017 field investigations. A total of 14 species met the habitat availability criteria and are listed in Table 1 (below) together with their federal (under the *Species at Risk Act*; SARA) and provincial (under the *Endangered Species Act, 2007*; ESA 2007) statuses, where END – Endangered, *NAR – Not at Risk, **NS – No Status, THR – Threatened, and SC – Special Concern. Other SAR such as Chimney Swift (*Chaetura pelagica*) and Common Nighthawk (*Chordeiles minor*) may occur incidentally in the area, however no nesting habitat was observed within the study area, therefore impacts to these species are not expected as a result of this project.

Table 1: Species at Risk Likely to Occur within the project area

Species Name	SARA Status	ESA 2007 Status	Habitat Requirements	Background Source
PLANTS				
Butternut (*Juglans cinerea*)	END	END	• Grows best on rich, moist, well-drained loams often found on stream bank sites but may be found on well-drained gravelly sites, especially those of limestone origin (COSEWIC, 2003)	• Habitat verified during 2017 field surveys
INVERTEBRATES				
Monarch (*Danaus plexippus*)	SC	SC	• Breeding - farmlands, along roadsides and in ditches, open wetlands, dry sandy areas, short and tall grass prairie, river banks, irrigation ditches, arid valleys, south-facing hillsides, and gardens – where Milkweed (*Asclepias* sp.) grows • Nectaring (pre-migration) – spatially may overlap with breeding habitat but needs to contain nectar sources such as Goldenrods (*Solidago* spp.), asters (*Doellingeria, Eurybia, Oclemena,* and *Symphyotrichum* spp.), and various clovers (*Trifolium* spp.) (COSEWIC, 2010a)	• Ontario Butterfly Atlas – square 18VR42
HERPETOFAUNA				
Blanding's Turtle (*Emydoidea blandingii*)	THR	THR	• Primarily shallow water - adults generally found in open or partially vegetated sites, whereas juveniles prefer areas that contain thick aquatic vegetation including sphagnum, water lilies and algae • Nest in loose substrates - sand, organic soil, gravel and cobblestone • Overwinter in permanent pools about 1 m deep, or slow flowing streams (COSEWIC, 2005)	• Ontario Reptile and Amphibian Atlas - square 18VR42

Species Name	SARA Status	ESA 2007 Status	Habitat Requirements	Background Source
Eastern Milksnake (*Lampropeltis triangulum*)	SC	*NAR	• Open habitats, including rock outcrops and meadows • Barns, sheds and houses in rural landscapes • Regions where forest cover is relatively high (COSEWIC, 2014)	• Ontario Reptile and Amphibian Atlas - square 18VR42
Eastern Musk Turtle (*Sternotherus odoratus*)	THR	SC	• Aquatic except when laying eggs • Shallow, slow-moving water • Diet consists of molluscs and insects • Hibernates underwater, burying themselves in mud when the water temperature dips below 10^0C • Nests typically in rotting vegetation in sun, but nesting sites are variable (COSEWIC, 2012a)	• Ontario Reptile and Amphibian Atlas - square 18VR42
Snapping Turtle (*Chelydra serpentina*)	SC	SC	• Slow-moving water with soft mud bottom & dense aquatic vegetation - ponds, sloughs, shallow bays or river edges and slow streams, or areas combining several of these wetland habitats (COSEWIC, 2008a)	• Ontario Reptile and Amphibian Atlas - square 18VR42
Western Chorus Frog (*Pseudacris triseriata*)	THR	NAR	• Terrestrial (humid prairie, moist woods, or meadows) and aquatic habitats (seasonally dry, temporary ponds, devoid of predators such as fish) in close proximity (COSEWIC, 2008b)	• Presence of habitat verified during 2017 field surveys
AVIFAUNA				
Bank Swallow (*Riparia riparia*)	THR	THR	• Breeds in a wide variety of natural and artificial sites with vertical banks • Sand-silt substrates are preferred for excavating nest burrows • Often situated near open terrestrial habitat used for aerial foraging	• Ontario Breeding Bird Atlas - square 18VR41, 18VR42, 18VR51

Species Name	SARA Status	ESA 2007 Status	Habitat Requirements	Background Source
			• Large wetlands used as communal nocturnal roost sites during post-breeding, migration, and wintering periods (COSEWIC 2013a)	
Barn Swallow (*Hirundo rustica*)	THR	THR	• In and on artificial structures, including barns and other outbuildings, bridges, and road culverts • Prefer various types of open habitats for foraging, including grassy fields, pastures, various agricultural crops, lake and river shorelines, cleared rights-of-way, farmyards and wetlands (COSEWIC, 2011a)	• Ontario Breeding Bird Atlas - square 18VR41, 18VR42, 18VR51
Bobolink (*Dolichonyx oryzivorus*)	THR	THR	• Nests in fields of forage crops (e.g., hayfields and pastures dominated by a variety of species such as Clover (*Melilotus* spp.), Timothy grass (*Phleum pratense*), Kentucky bluegrass (*Poa pratensis*), and broad-leaved plants • Also in various grassland habitats incl. wet prairie, graminoid peatlands, and abandoned fields dominated by tall grasses, remnants of uncultivated, no-till cropland, small-grain fields, restored surface mining sites, and irrigated fields in arid regions (COSEWIC, 2010b)	• Ontario Breeding Bird Atlas - square 18VR41, 18VR42, 18VR51
Canada Warbler (*Cardellina canadensis*)	THR	SC	• Deciduous, coniferous and mixed forests, with well-developed shrub layer and a structurally complex forest floor; most abundant in moist, mixed forests • Also occurs in riparian shrub forest on slopes and in ravines, regenerating forest and in old-growth forests with canopy openings	• Habitat verified during 2017 field surveys

Species Name	SARA Status	ESA 2007 Status	Habitat Requirements	Background Source
			and well-developed shrub layer (COSEWIC, 2008c)	
Eastern Meadowlark (*Sturnella magna*)	THR	THR	• Grassland habitats - native prairies and savannas, non-native pastures, hayfields, weedy meadows, herbaceous fencerows and airfields (COSEWIC, 2011b)	• Ontario Breeding Bird Atlas - square 18VR41, 18VR42, 18VR51
Eastern Whip-poor-will (*Antrostomus vociferus*)	THR	THR	• Nesting (summer) - semi-open forests or patchy forests with clearings, such as barrens; regenerating forests following major disturbances; areas with little ground cover; avoids wide-open spaces and closed canopy forests (COSEWIC, 2009)	• Ontario Breeding Bird Atlas - square 18VR51 • Habitat verified during 2017 field surveys
Eastern Wood-pewee (*Contopus virens*)	SC	SC	• Mid-canopy layer of forest clearings and edges of deciduous and mixed forests • Most abundant in intermediate-aged and mature forest stands with little understory vegetation (COSEWIC, 2012b)	• Ontario Breeding Bird Atlas - square 18VR41, 18VR42, 18VR51
Grasshopper Sparrow (*Ammodramus savannarum pratensis)*	SC	SC	• Open relatively short grassland habitat with relatively sparse cover in areas of poor soils, including alvars, moraines and sand plains; does not favour moist tall grass meadows • Also human-created hayfields and cereal fields (COSEWIC, 2013c)	• Presence of habitat verified during 2017 field surveys • Ontario Breeding Bird Atlas - square 18VR41, 18VR51
Short-eared Owl (*Asio flammeus)*	SC	SC	• Breeding – large number of open habitats including grasslands, arctic tundra, taiga, bogs, marshes, old pastures, and sand-sage with availability of preferred nesting sites • Preferred nesting sites – areas of dense grassland, as well as tundra	• eBird – 2013 observation in general area • Ontario Breeding Bird Atlas - square 18VR41

Species Name	SARA Status	ESA 2007 Status	Habitat Requirements	Background Source
			with areas of small willows; proximity to reliable source of small mammal prey (COSEWIC, 2008d)	
Wood Thrush (*Hylocichla mustelina*)	THR	SC	• Nesting - second-growth and mature deciduous and mixed forests, with saplings and well-developed understory layers; prefers large forest mosaics, but also uses small forest fragments (COSEWIC, 2012c)	• Ontario Breeding Bird Atlas - square 18VR41, 18VR42, 18VR51
MAMMALS				
Eastern Small-footed Bat (*Myotis leibii*)	**NS	END	• Spring and summer - roost in or under rocks, in rock outcrops, in buildings, under bridges, or in caves, mines, or hollow trees • Winter – hibernate in caves and abandoned mines; colder and drier sites than similar bats; high fidelity to hibernacula (Humphrey, 2017)	• Ontario Mammal Atlas, 1900-1993
Little Brown Myotis (*Myotis lucifugus*)	END	END	• Breeding - summer maternity colonies in buildings or large-diameter trees • Foraging - over water, along waterways, and forest edges; large open fields or clearcuts generally avoided • Overwintering - cold and humid hibernacula (caves/mines) (COSEWIC, 2013b)	• Ontario Mammal Atlas, 1900-1993
Northern Myotis (*Myotis septentrionalis*)	END	END	• Breeding - summer maternity colonies in large-diameter trees; sometimes buildings • Foraging - gaps in forest; along waterways, forest edges, over	• Ontario Mammal Atlas, 1900-1993

Species Name	SARA Status	ESA 2007 Status	Habitat Requirements	Background Source
			water; large open fields/clearcuts generally avoided • Overwintering - cold and humid hibernacula (caves/mines) (COSEWIC, 2013b)	
Tri-colored Bat (*Perimyotis subflavus*)	END	END	• Breeding - summer maternity colonies in large-diameter trees; sometimes buildings • Foraging - gaps in forest; along waterways, forest edges, over water; large open fields/clearcuts generally avoided • Overwintering - cold and humid hibernacula (caves/mines) (COSEWIC, 2013b)	• Ontario Mammal Atlas, 1900-1993

*NAR - Not at Risk: A species that has been evaluated and found to be not at risk of extinction given the current circumstances

It is likely that some species that are not currently listed as SAR may be added to federal and/or provincial SAR lists at/by the time of pre-construction considerations. These newly-added SAR will need to be considered for the determination of permitting requirements. As well, the status of some currently listed species may change, along with associated changes to their protection.

2.3 Field Investigations

MH conducted spring/summer field investigations in order to ground-truth the background information collected as well as to improve upon the knowledge of terrestrial SAR and SAR habitat existing conditions within and adjacent to the project area. The environmental study area was defined as lands within the project limits, and includes adjacent lands as noted below.

Field surveys of terrestrial communities and SAR habitat within the proposed Ellwood Diamond study area were completed on May 11th, June 7th, June 8th, October 23rd and November 8th 2017. Field surveys for Walkley Station were completed in 2016, on June 12th, 21st, 25th, and July 7th, 14th, 27th and 28th. Field surveys for the proposed Bowesville Station and Limebank Extension were carried out on August 11th, 21st, 24th, and October 11th, 2017. It should be noted that only habitat assessments were completed at the proposed Bowesville Station and Limebank Extension study areas due to the timing of the work approvals for the biophysical assessments and in order to provide SAR screening information to conduct geotechnical work. Wildlife observations for all study areas were based on visual confirmation, auditory confirmation, or by way of indicators (e.g. tracks, scat) during field investigations. The methodology employed for each SAR is described below, according to taxon.

PLANTS – One (1) provincially and federally END plant – Butternut had habitat availability within the project areas. Surveys consisted of a complete census of the all areas proposed for disturbance with a 50 m buffer applied based on the interim provincial permitting policy for Butternut (correspondence with MNRF- Kemptville District, 2016). Any Butternuts that were found were flagged with brightly-coloured flagging tape, and their global positioning system (GPS) locations recorded.

In order to assess the health characteristics of all Butternuts located on provincial lands within 50 m of the project areas (one tree near the proposed Ellwood Diamond project area), a Butternut health assessment (BHA) was completed on September 20, 2017. This process is pursuant to *O.Reg. 242/08*, s. 23.7, made under the ESA 2007. The BHA was carried out because the proposed activity is likely to result in the killing or harming of Butternut trees.

INVERTEBRATES – The only SAR invertebrate likely to occur within the project areas is Monarch (*Danaus plexippus*), which is listed both provincially and federally as SC. This species is critically dependent on its host plant – milkweed (*Asclepias* spp.) – for breeding. Therefore, any large patches of milkweed were noted during field investigations, along with incidental observations of Monarch adults and caterpillars.

HERPETOFAUNA – Based on information received from the MNRF following the completion of the approved EPR, Blanding's Turtle observations have been recorded within 2 km of the proposed Ellwood Diamond project area. Accordingly, two (2) daytime surveys were completed in May and June 2017, to confirm the potentialpresence of SAR turtles - Blanding's Turtle and/or Snapping Turtle (*Chelydra serpentina*) – or their habitat at Sawmill Creek within the proposed Ellwood Diamond project area. All potential basking surfaces were scanned using binoculars from various vantage points. Any observed basking turtles were counted and identified to species. Any incidental observations of Eastern Milksnakes were documented during the turtle basking surveys. Targeted surveys were not completed at Walkley Yard due to the lack of suitable habitat. Targeted surveys were not carried out at the proposed Bowesville Station or Limebank Extension, due to the timing of work approvals.

AVIFAUNA – Due to the impending listing of several bird species under SARA, two (2) surveys were conducted following the standard breeding bird survey protocol (OBBA, 2001) in May and June, in search of SAR birds that are known to be forest specialists at the proposed Ellwood Diamond project area and Walkley Yard project area; these included Canada Warbler, Eastern Wood-pewee, and Wood Thrush. Survey stations were located 250 m apart, within wooded areas adjacent to the Sawmill Creek crossing study area (Figure 2). At each survey station, the surveyor spent 10 minutes listening for the calls of each target species. Surveys were completed on fair weather days, ending no later than 11:00 am. Targeted surveys were not carried out at the proposed Bowesville Station or Limebank Extension, due to the timing of work approvals.

Another breeding bird survey was conducted on two (2) evenings of June 2016 and 2017, at the proposed Walkley Yard and Ellwood Diamond study areas, targeting Eastern Whip-poor-will, following the provincial protocol (MNRF, 2014a). The surveys were initiated at a half hour before moonrise, on a night when the moon was at a minimum of 50%. Survey stations were placed at 500-m intervals and consisted of 10 minutes of listening for the calls at each station. If the target species was heard, the location of the call was recorded in terms of compass direction and approximate distance (in metres) from the survey station. Targeted surveys were not carried out at the proposed Bowesville Station or Limebank Extension, due to the timing of work approvals.

Additionally, all structures located within the study areas with adequate nesting habitat within which Barn Swallow might nest were searched for the presence of nests. This species, along with Bank Swallow were also recorded incidentally if observed during the course of any other daytime survey.

Targeted surveys were not carried out for Bank Swallow as the design team identified the need for work on structures which might be used for nesting after the breeding bird window had passed.

Habitat assessments were carried out to identify suitable habitat for Grassland SAR birds, including Bobolink, Eastern Meadowlark, Grasshopper Sparrow, and Short-eared Owl, at the proposed Bowesville Station and Limebank Extension study areas.

MAMMALS – Four (4) species of bats – Eastern Small-footed Bat (*Myotis leibii*), Little Brown Myotis (*Myotis lucifugus*), Northern Myotis (*Myotis septentrionalis*), and Tri-colored Bat (*Perimyotis subflavus*) – comprise the suite of SAR mammals that are likely to occur within the project areas. As these species were recently listed as endangered under SARA and the ESA 2007, surveys were carried out. Surveys were common to all species, and consisted of (i) surveys for bat roost trees in order to ascertain availability of potential maternity roosting habitat and (ii) acoustic surveys to determine whether these SAR bats occur.

In order to identify potential maternity roosting habitat for SAR bats, thorough searches of all wooded areas proposed for disturbance (e.g., staging areas) with a 50 m buffer applied were undertaken during leaf-off within the proposed Ellwood Diamond and Walkley Yard project areas. Surveys to identify potential maternity roosting habitat for SAR bats within the proposed Bowesville Station and Limebank Extension were completed during leaf-on conditions, due to the timing of work approvals, and in order to provide SAR screening information to conduct geotechnical work. This 50-m search distance was selected because the limited literature on bat responses to noise/vibrations arising from linear transportation corridors (roads and trains) suggests that, although responses vary between species, as well as according to the volume and type of noise, in general, impacts begin to decline significantly at around 50-60 m from the source (e.g., Schaub et al. 2008, Siemers & Schaub 2011). According to MNRF (2011), any tree that is equal to or greater than 25 cm in Diameter at Breast Height (DBH), and has a cavity deep enough to accommodate a roosting bat could serve as a roost tree. All trees that met these basic criteria were recorded, and mapped using a GPS, as trees with the potential to provide roosting sites for bats (both maternity roosts as well as day roosts for male and non-breeding female bats).

In order to determine whether SAR bats occurred within the project area, surveyors walked the length of the Walkley Yard study area and near the proposed Ellwood Diamond study area, using a handheld device (Echo Meter Touch, ™ Wildlife Acoustics, Maynard, MA, U.S.A.), that auto-identifies species of echolocating bats using Kaleidoscope 3.1.5 software (™ Wildlife Acoustics Inc., Maynard, MA, U.S.A.). The surveys began after dusk on June 7th and 8th, 2017, and ended before midnight. The device recorded bat vocalizations while also providing a tentative identification of the species that were the most likely to have emitted the vocalization. No acoustic surveys to determine whether SAR bats occur within the proposed Bowesville Station and Limebank Extension project areas have been completed to date.

3. RESULTS OF SPECIES AT RISK SURVEYS

Below is an overview of the observations documented during the field investigations within each project area.

3.1 Ellwood Diamond

NATURAL HERITAGE SYSTEM - Identified by the City of Ottawa – Significant Valleylands and Significant Woodlands are present immediately west of the proposed Ellwood Diamond.

SIGNIFICANT WILDLIFE HABITAT - may be present within or immediately adjacent to boundaries of the proposed Ellwood Diamond.

- Reptile Hibernaculum – may be located in stone retaining walls along Sawmill Creek.
- Special Concern and Rare Wildlife Species – the forested area northeast of Ellwood Diamond may provide habitat for Eastern Wood-pewee or Wood Thrush. The stone retaining walls along Sawmill Creek may also provide habitat for Milksnake.

PLANTS – A total of ten (10) Butternuts were found within the project area (Figure 1) during the 2016 surveys. These Butternuts were not observed during the studies conducted for the approved EPR. One (1) Butternut was found within the project impact area. A BHA was conducted for this 3 cm DBH individual located on lands under provincial jurisdiction; it was classified as Category 1. The results were submitted to the MNRF for review on September 26th, 2017, and the BHA was accepted by the MNRF on November 16th, 2017. Due to this individual being assessed and approved as a Category 1, it may be removed without any further consultation or compensation requirements.

The remaining nine (9) Butternuts are located on federal lands and are located 7 to 81 m from the project footprint. Three (3) individuals are located > 50 m away, and are unlikely to be impacted by construction or operations. The other six (6) Butternuts are located <50 m from the project area and may experience minor and temporary indirect impacts during construction if protection measures are not in place. Therefore, the installation of protection fencing will be required around the Critical Root Zone[1] (CRZ) of these individuals prior to and during construction to avoid impacts. If the CRZ of these trees

[1] Critical Root Zone is the zone that needs to be protected during construction to avoid impacts to the tree. The International Society of Arboriculture defines the CRZ as an area equal to a 12 cm radius from the base of the tree's trunk for each 1 cm of the tree's diameter measured at 1.3 m above grade (referred to as diameter at breast height)

cannot be protected a permit may be required in order to harm and/or remove these individuals.

INVERTEBRATES – No Monarch caterpillars or adults were observed during 2017 field investigations. However, the host plant for Monarch caterpillars – Common Milkweed (*Asclepias syriaca*) – was observed within and adjacent to the proposed project areas. Best management practices should be implemented in order to protect the breeding habitat of this species. As well, ECCC may require further habitat studies should they be up-listed in the future.

HERPETOFAUNA – No herpetofauna were observed within the vicinity of project area during the 2017 field investigations. Although no suitable turtle overwintering, basking, or foraging habitat was found within the project area, marginal nesting habitat (in the form of loose substrate) is present adjacent to portions of Sawmill Creek. The creek may also be used as a migratory passage way.

There is a possibility of Blanding's, Musk, and Snapping Turtles entering the project area, therefore suitable mitigation and best management practices will be required to protect any individuals that could be impacted by construction.

AVIFAUNA – No SAR woodland birds were heard during targeted surveys within the vicinity of the project area. Habitat is present for woodland SAR birds within the treed areas east of the project area within federal lands.

A site near Ottawa (Oxford Mills, ON), with a known Eastern Whip-poor-will population, was used as a proxy site to identify suitable survey conditions. Eastern Whip-poor-will was heard calling at this proxy site on the evenings the crepuscular bird surveys were conducted within the project area. Therefore, it was concluded that although suitable habitat for this species is present, there are no breeding individuals within the vicinity of the project area.

Further, there was no evidence of Barn Swallow or Bank Swallow nesting within the project area. However, the Sawmill bridge does provide suitable habitat for Barn Swallow in the form of horizontal ledges or rough vertical surfaces with a sheltered overhang. Therefore, it is possible that this species might nest within the project area in coming years, and pre-construction surveys will be required to ensure that nesting habitat for this species is not compromised.

There was no habitat for grassland SAR birds, including Bobolink, Eastern Meadowlark, Grasshopper Sparrow, and Short-eared Owl within or adjacent to the project area.

MAMMALS – A total of 1 suitable bat roost tree (cavity tree) was found within 50 m of the project area (Figure 1). Analysis of acoustic recordings made on the hand-held recorder did not record SAR bats within the project area. However, due to the presence of SAR bats within a few kilometers of the study area (documented during the 2016 and 2017 field investigations), additional acoustic surveys using a stationary monitor are recommended, following the provincial protocol, prior to construction. If tree removal is expected within the area of impact, appropriate mitigation and compensation will be required to protect SAR bat habitat that may be impacted by construction.

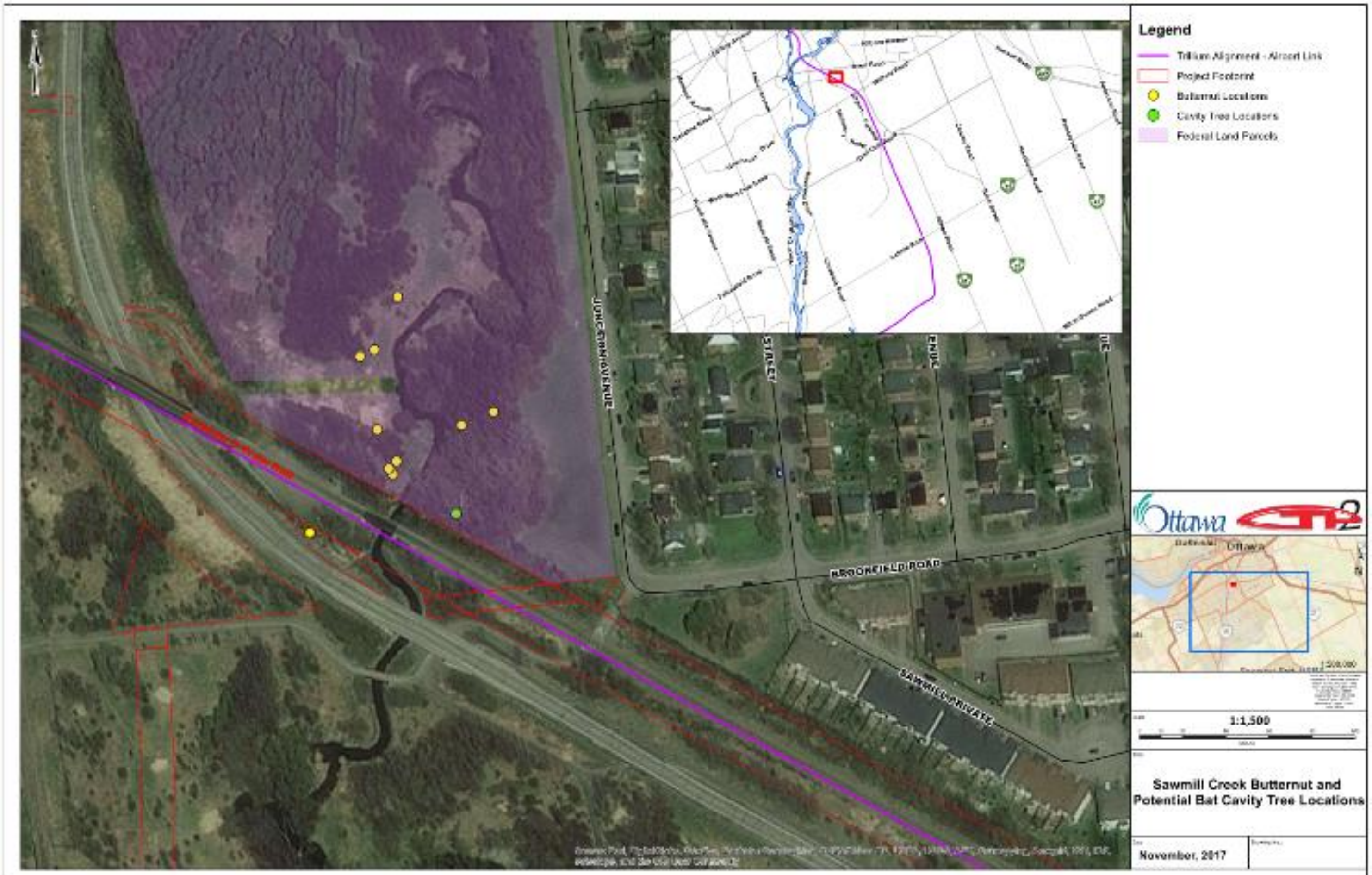

Figure 1: Butternuts and Potential Cavity Tree within the Ellwood Diamond Project Area

3.2 Walkley Yard

NATURAL HERITAGE SYSTEM - Identified by the City of Ottawa – An Urban Natural Feature (Figure 3 of City of Ottawa's Urban Natural Areas Report, 2005) is documented to be present immediately south of the proposed Walkley Yard, but it has since been disturbed and is no longer present. A floodplain is shown to be within the west side of project footprint according to Annex 14 of the City of Ottawa's Official Plan.

SIGNIFICANT WILDLIFE HABITAT – Significant Wildlife Habitat may be present within or immediately adjacent to boundaries of the proposed Walkley Yard.

- Bat Maternity Colonies – may be present within treed area north of the site.

- Shrub/Early Successional Bird Breeding Habitat – may be located immediately north of the proposed project footprint, and approximately 60 m south of the site.

PLANTS – No SAR plants have been reported by any previous studies from the vicinity of the Walkley Yard project area. As well, no SAR plants were observed within 50 m of the Walkley Yard project area.

INVERTEBRATES – No SAR invertebrates have been reported by any previous studies from the vicinity of the project area. No Monarch caterpillars or adults were observed during 2016 field investigations. However, the host plant for Monarch caterpillars – Common Milkweed – was observed within and adjacent to the proposed project area. Best management practices should be implemented in order to protect the breeding habitat of this species. As well, ECCC may require further habitat studies should they be up-listed in the future.

HERPETOFAUNA – No herpetofauna were observed within the vicinity of project area during the 2016 field investigations. No suitable turtle nesting, overwintering, basking, or foraging habitat was found within the project area. The creek on-site may be used as a migratory passage way as it is hydrologically connected to Sawmill Creek. There is a possibility of Blanding's, Musk, and Snapping Turtles entering the project area, therefore suitable mitigation and best management practices will be required to protect any individuals that could be impacted by construction.

Suitable habitat for Milksnake was identified within 50 m of the boundaries of the proposed Walkley Yard during the 2016 field investigations.

AVIFAUNA – No SAR woodland birds were heard during targeted surveys within the vicinity of the project area. Habitat is present for woodland SAR birds within the treed areas adjacent the project area.

A site near Ottawa (Oxford Mills, ON), with a known Eastern Whip-poor-will population, was used as a proxy site to identify suitable survey conditions. Eastern Whip-poor-will was heard calling at this proxy site on the evenings the crepuscular bird surveys were conducted within the project area. Therefore, it was concluded that although suitable habitat for this species is present, there are no breeding individuals within the vicinity of the project area.

There was evidence of previous Barn Swallow nesting within the project area. Two (2) inactive Barn Swallow nests were observed in a box culvert approximately 130 m west of Bank Street.

There was no habitat for grassland SAR birds, including Bobolink, Eastern Meadowlark, Grasshopper Sparrow, and Short-eared Owl.

MAMMALS – A total of 24 potential SAR bat roost trees were found within 50 m of the proposed Walkley Yard (Figure 2). Analysis of acoustic recordings made on the hand-held recorder did not record SAR bats within the project area. However, due to the presence of SAR bats within a few kilometers of the study area (documented during the 2016 and 2017 field investigations), additional acoustic surveys using a stationary monitor, are recommended, following the provincial protocol, prior to construction. If tree removal is expected within the area of impact, appropriate mitigation and compensation will be required to protect SAR bat habitat that may be impacted by construction.

Figure 2: Potential Cavity Trees within the Walkley Yard Project Area

3.3 Bowesville Station

Where the proposed alignment connects with the original Trillium alignment on the northernmost portion, the habitat adjacent the alignment contains mixed and deciduous forest as well as a corner of the Leitrim (also known as Albion) Provincially Significant Wetlands (PSW) which contains swamp near the alignment. The alignment does not directly impact the PSW, but is within 5 m. The area north of Earl Armstrong Road up to the forests is characterized by hedgerows adjacent the alignment, bordered by large meadows. South of Earl Armstrong Road, where the alignment curves west and meets with Bowesville Road, the habitat consists of hedgerows immediately south of Earl Armstrong Road, then primarily agricultural lands which are currently used for annual crops as the alignment curves to the west. A large 0.6 ha pond is located immediately west of where the alignment is recommended to curve to the west. The alignment crosses one (1) drainage ditch south of a 0.1 ha constructed pond, and north of swamp wetlands on the federal property bordering to the south.

NATURAL HERITAGE SYSTEM - IDENTIFIED BY THE CITY OF OTTAWA - The alignment passes immediately north of swamp wetlands adjacent to federal property. These wetlands are designated as Significant Woodlands on the City of Ottawa's Annex 14 mapping. They are also noted to contain organic soils as mapped on the Official Plan Schedule K. These swamp wetlands, as well as the regenerating woodlands partially encircling them to the east, south, and west, are mapped as 'Contributing' natural lands on the City of Ottawa's Greenspace Master Plan, Map 1.

SIGNIFICANT WILDLIFE HABITAT – Based on a review of background information, the following Significant Wildlife Habitats are potentially present:

- Waterfowl Stopover and Staging Areas (Terrestrial) – within agricultural fields south of Earl Armstrong Road and east of Bowesville, as well as within meadows to the east and west of the alignment north of Earl Armstrong Road.

- Waterfowl Stopover and Staging Areas (Aquatic) – within the constructed 0.1 ha pond north of the alignment and in the 0.6 ha pond 60 m the east of the proposed station.

- Raptor Wintering Areas – confirmed to be present in 2006 within areas overlapping of Earl Armstrong Road and mainly west of Bowesville Road, but partially within the alignment area.

- Bat Maternity Colonies – potentially within the wooded areas immediately north of this alignment, and within the swamp woodlands south of the alignment on federal lands.

- Turtle Wintering Areas - within the constructed 0.1 ha pond north of the alignment and in the 0.6 ha pond 60 m the east of the proposed station.

- Deer Yarding Areas – within swamp woodlands south of the alignment on federal lands.

- Deer Winter Congregation Area – within wooded areas immediately north of this alignment.
- Specialized Habitat for Wildlife:
  - Waterfowl Nesting Areas - within the constructed 0.1 ha pond north of the alignment and in the 0.6 ha pond 60 m the east of the proposed station.
  - Woodland Raptor Nesting Habitat - within wooded areas immediately north of this alignment.
  - Turtle Nesting Areas – adjacent the constructed 0.1 ha pond north of the alignment and in the 0.6 ha pond 60 m the east of the proposed station.
  - Seeps and Springs - within swamp woodlands south of the alignment on federal lands.
  - Amphibian Breeding Habitat (Woodland) - within swamp woodlands south of the alignment on federal lands.
  - Amphibian Breeding Habitat (Wetlands) - within the constructed 0.1 ha pond north of the alignment and in the 0.6 ha pond 60 m the east of the proposed station.
- Habitat for Species of Conservation Concern (not including Endangered and Threatened species):
  - Woodland Area-Sensitive Bird Breeding Habitat - within wooded areas immediately north of this alignment.
  - Open Country Bird Breeding Habitat – large meadows north of Earl Armstrong on both sides of the alignment.
  - Shrub/Early Successional Bird Breeding Habitat – on federal property south of the alignment, west of the swamp woodland, and east of Bowesville Road.
- Animal Movement Corridors:
  - Amphibian Movement Corridors – between the constructed 0.1 ha pond north of the alignment and the swamp wetland on the federal lands to the south, and between the 0.6 ha pond 35 m the east of the proposed alignment and the swamp wetland on the federal lands to the south.

Targeted surveys for these Significant Wildlife Habitats were not carried out due to the required project schedule. Further targeted surveys are required during a seasonally appropriate period using approved protocols to confirm the presence of these habitats.

PLANTS – No SAR plants were observed within 50 m of the proposed Bowesville Station or extension.

INVERTEBRATES – No Monarch caterpillars or adults were observed during 2017 field investigations. However, the host plant for Monarch caterpillars – Common Milkweed – was observed within and adjacent to the proposed project area. Best Management Practices should be implemented in order to protect the breeding habitat of this species. As well, ECCC may require further habitat studies should they be up-listed in the future.

HERPETOFAUNA – Suitable turtle nesting, overwintering, basking, and foraging habitat was found adjacent to the project area and south of Earl Armstrong Road, within the 0.1 ha constructed pond immediately north of the alignment within the farmland, and within the larger 0.6 ha pond located 35 m to the east. There is a possibility of Blanding's Turtles and Snapping Turtles entering the project area to seek out nesting sites and to migrate, therefore suitable mitigation and best management practices will be required to protect any individuals that could be impacted by construction.

Suitable habitat for Western Chorus Frog is present within the swamp south of the alignment on federal land, within the ditch that connects the swamp to the 0.1 ha constructed pond within the farmland, and within the 0.1 ha constructed pond, both of which are located on provincial lands.

Suitable habitat for Milksnake was identified within 50 m of the boundaries of the proposed Bowesville Station and alignment during the 2017 field investigations.

Targeted surveys are required during a seasonally appropriate period using approved protocols to confirm the presence of these habitats and SAR.

AVIFAUNA – Habitat is present for woodland SAR birds within the treed areas south of the project area and at the northern extent of the proposed Bowesville extension, where it connects to the Trillium alignment.

Multiple Barn Swallow were observed flying over the project area during the August 2017 surveys. Nesting evidence could not be verified on the adjacent farm buildings, however no nests were observed within the alignment.

Suitable nesting habitat for Bank Swallows was not present within the proposed work areas.

Suitable habitat was present for grassland SAR birds, including Bobolink, Eastern Meadowlark, Grasshopper Sparrow, and Short-eared Owl within the proposed park and ride and southern portion of the Bowesville extension, as well as adjacent to the Osgoode Pathway north of Earl Armstrong Road (Figure 3 and Figure 4).

Targeted surveys are required during a seasonally appropriate period using approved protocols to confirm the presence of these habitats and SAR.

MAMMALS – A total of 26 trees with a DBH of 25 cm or greater were observed within 50 m of the project area (Figure 3 and Figure 4). The presence of cavities could not be verified due to the timing of the surveys being conducted during the leaf-on period (conducted at this time to accommodate the project timelines). Due to the presence of SAR bats within a few kilometers of the study area (documented during the 2016 field investigations), additional acoustic surveys are recommended, following the provincial protocol, prior to construction. If tree removal is expected within the area of impact, appropriate mitigation and compensation will be required to protect SAR bat habitat that may be impacted by construction.

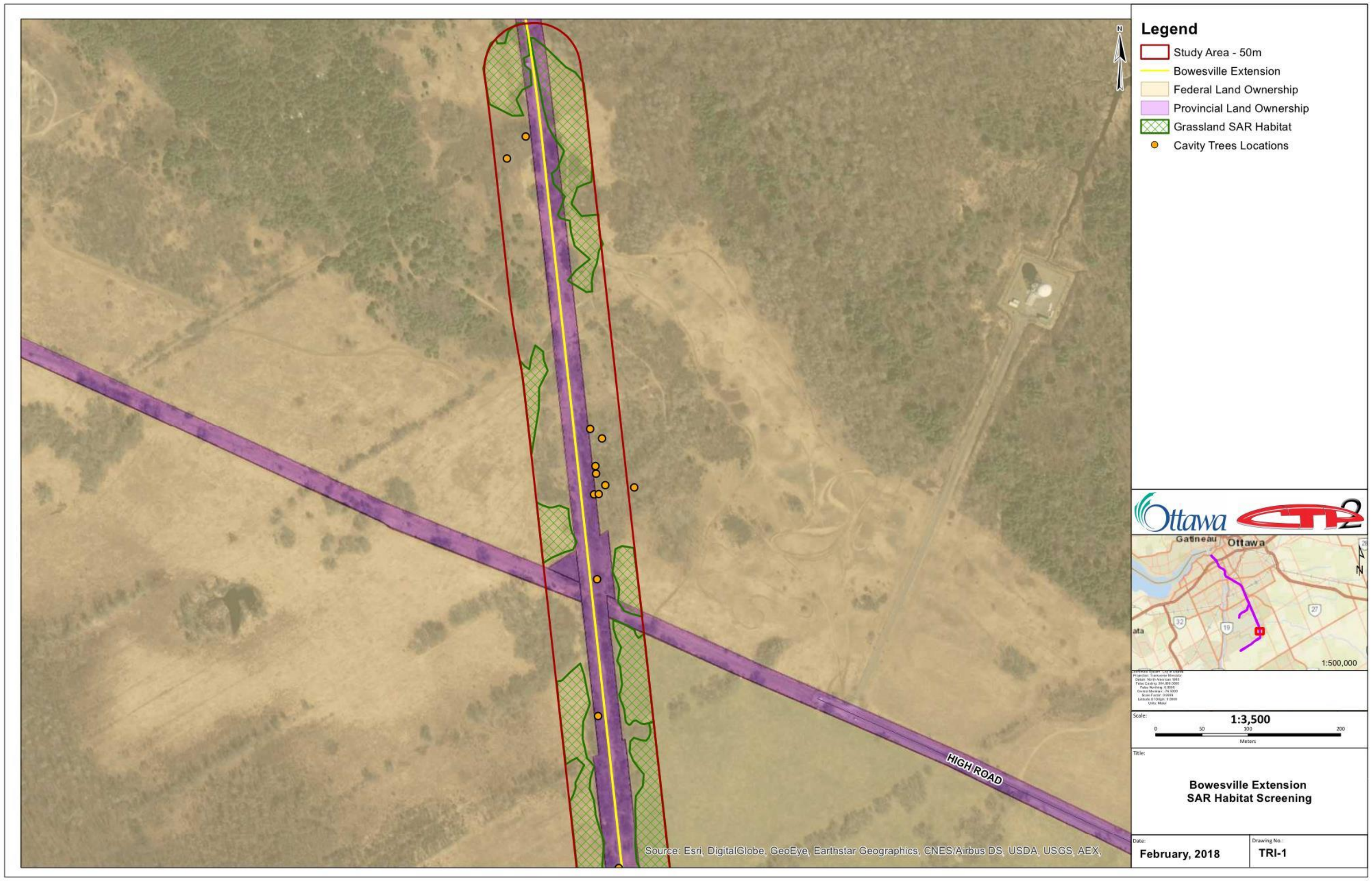

Figure 3: Potential Cavity Tree Locations and SAR Grassland Bird Habitat within the Bowesville Extension Project Area

Figure 4: Potential Cavity Tree Locations and SAR Grassland Bird Habitat within the Bowesville Extension Project Area

3.4 Limebank Extension

The proposed Limebank alignment passes through agricultural lands. During the 2017 field investigations, a majority of the fields were planted with annual row crops. Some fields, however, were fallow and contained short-lived annual weedy species, and some portions contained hayfields and meadows. The agricultural lands were interspersed with occasional hedgerows along fencelines, mainly consisting of buckthorn, and regenerating elm and ash, but also occasionally containing mature trees. Mosquito Creek passes through the proposed alignment within a well-defined lowland floodplain, which contains small groves of trees, willow thickets, and meadow marshes. At the westernmost extent, the proposed alignment is adjacent a large deciduous forest.

NATURAL HERITAGE SYSTEM - IDENTIFIED BY THE CITY OF OTTAWA - Mosquito Creek is designated as Significant Valleyland on the City of Ottawa's Annex 14 mapping and as Unstable Slopes on Schedule K. Woodlands to the west end of the alignment are designated as Significant Woodland. Mosquito Creek is also designated as City of Ottawa's Primary Natural Environment on Greenspace Mater Plan Map 1, and Natural Heritage System overlay on Schedule L3. Armstrong Road Woods are displayed on the mapping for Urban Natural Areas, and are noted to require ecological analysis to determine environmental rating.

SIGNIFICANT WILDLIFE HABITAT – Based on a review of background information, the following Significant Wildlife Habitats are potentially present:

- Waterfowl Stopover and Staging Areas (Terrestrial) – within agricultural fields west of Bowesville through which the proposed alignment passes.

- Raptor Wintering Areas – confirmed to be present in 2006 within areas overlapping of Earl Armstrong Road and mainly west of Bowesville Road; the LRT alignment is proposed for the southern boundary of the area (McCormick Rankin Corporation & Hatch Mott McDonald, 2006).

- Turtle Wintering Areas - within Mosquito Creek.

- Habitat for Species of Conservation Concern (not including END and THR species):

  - Open Country Bird Breeding Habitat – large meadows on both sides of the alignment (partially shown as Grassland SAR bird habitat on Figure 5).

  - Turtle habitat – within Mosquito Creek and along the banks and floodplain of this creek.

  - Snake habitat – within meadows and near potential hibernaculum created by old stone building foundation (Figure 5).

- Animal Movement Corridors:

- Amphibian Movement Corridors – along watercourses and between wetlands and ponds within the study area.

Although no deer wintering areas were noted to be present, there was evidence of use of the area by deer. It is expected that they move between habitats to the north and south across the proposed alignment.

Targeted surveys for these Significant Wildlife Habitats were not carried out due to the required project schedule. Further targeted surveys are required during a seasonally appropriate period using approved protocols to confirm the presence of these habitats.

PLANTS – No SAR plants were observed within 50 m of the proposed Limebank Extension.

INVERTEBRATES – One (1) adult Monarch was observed during 2017 field investigations. The host plant for Monarch caterpillars – Common Milkweed – was observed within and adjacent to the proposed project area. Best management practices should be implemented in order to protect the breeding habitat of this species. As well, ECCC may require further habitat studies should they be up-listed in the future.

HERPETOFAUNA – Suitable turtle nesting, overwintering, basking, and foraging habitat was found within Mosquito Creek (Figure 5). There is a possibility of Blanding's Turtle and Snapping Turtles entering the project area to seek out nesting sites and to migrate. Therefore suitable mitigation and best management practices will be required to protect any individuals that could be impacted by construction. If habitat within Mosquito Creek and its shorelines are impacted, further surveys should be carried out to determine the potential impacts, and consultation with the MNRF should be carried out.

Suitable habitat for Western Chorus Frog is present within the ditches and watercourses in the project area located on provincial lands (Figure 5).

Suitable foraging and overwintering habitat (an old stone foundation) for Milksnake was identified within 50 m of the boundaries of the proposed Limebank Extension during the 2017 field investigations (Figure 5).

Targeted surveys are required during a seasonally appropriate period using approved protocols to confirm the presence of these habitats and SAR.

AVIFAUNA – Habitat is present for woodland SAR birds within the woodlot east of Limebank Road at the end of the proposed Limebank Extension., No suitable Barn Swallow or Bank Swallow nesting habitat is present.

Suitable habitat was present for grassland SAR birds, including Bobolink, Eastern Meadowlark, Grasshopper Sparrow, and Short-eared Owl within and adjacent to the proposed project area. Targeted surveys are required during a seasonally appropriate period using approved protocols to confirm the presence of these habitats and SAR (Figure 5).

MAMMALS – No suitable maternity roosting habitat was observed during the surveys, however forgaing habitat is present within treed areas, open meadows, and near Mosquito Creek.

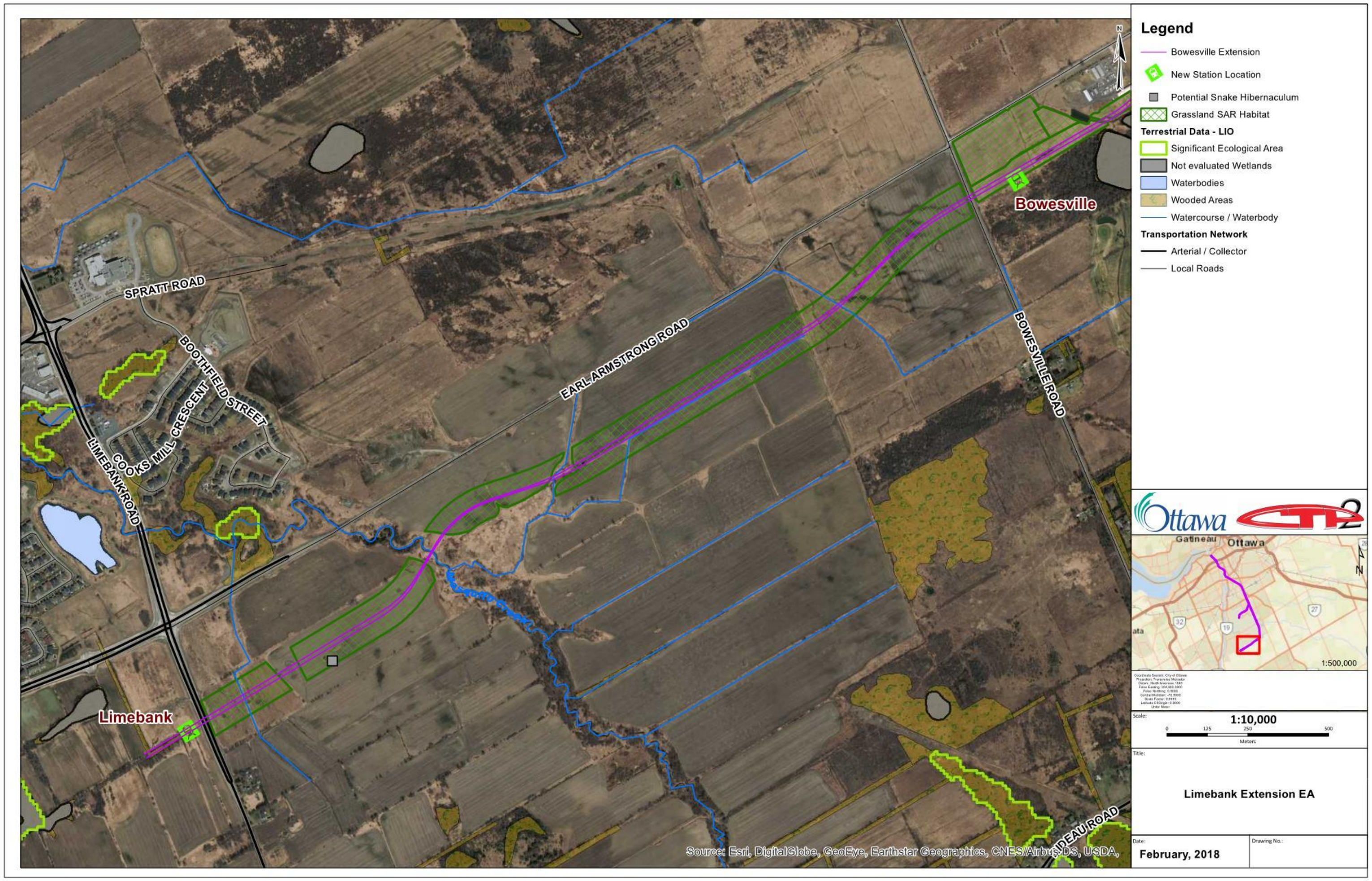

Figure 5: Terrestrial Features within the Limebank Extension Project Area

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Attachment A – Ministry of Natural Resources and Forestry Info Request Response

Ministry of Natural Resources and Forestry

Kemptville District

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Fax: 613 258-3920

Ministère des Richesses naturelles et des Forêts

District de Kemptville

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Ontario

Wed. Jan 31, 2018

Bettina Henkelman
Morrison Hershfield
2440 Don Reid Drive
Ottawa, Ontario
K1H 1E1
(613) 739-2910 ext 2470
bhenkelman@morrisonhershfield.com

Attention: Bettina Henkelman

Subject: Information Request - Developments
Project Name: OLRT Stage 2 - Limebank Extension
Site Address:
Our File No. 2018_GLO-4393

Natural Heritage Values

The Ministry of Natural Resources and Forestry (MNRF) Kemptville District has carried out a preliminary review of the above mentioned area in order to identify any potential natural resource and natural heritage values.

The following Natural Heritage values were identified for the general subject area:

- Candidate ANSI, Life Science, ALBION ROAD WETLAND (Provincial)
- Evaluated Wetland, Leitrim (Evaluated-Provincial)
- Municipal Drain, Findley Creek Municipal Drain
- Municipal Drain, Thomas Gamble Municipal Drain (Non-Sensitive)
- Pond (Non-Sensitive)
- Unevaluated Wetland (Not evaluated per OWES)

Municipal Official Plans contain information related to natural heritage features. Please see the local municipal Official Plan for more information, such as specific policies and direction pertaining to activities which may impact natural heritage features. For planning advice or Official Plan interpretation, please contact the local municipality. Many municipalities require environmental impact studies and other supporting studies be carried out as part of the development application process to allow the municipality to make planning decisions which are consistent with the Provincial Policy Statement (PPS, 2014).

The MNRF strongly encourages all proponents to contact partner agencies and appropriate municipalities early on in the planning process. This provides the proponent with early knowledge regarding agency requirements, authorizations and approval timelines; Ministry of the Environment and Climate Change (MOECC) and the local Conservation Authority may require approvals and permitting where natural values and natural hazards (e.g., floodplains) exist.

As per the Natural Heritage Reference Manual (NHRM, 2010) the MNRF strongly recommends that an ecological site assessment be carried out to determine the presence of natural heritage features and species at risk and their habitat on site. The MNRF can provide survey methodology for particular species at risk and their habitats.

The NHRM also recommends that cumulative effects of development projects on the integrity of natural heritage features and areas be given due consideration. This includes the evaluation of the past, present and possible future impacts of development in the surrounding area that may occur as a result of demand created by the presently proposed project.

In Addition, the following Fish species were identified: blacknose shiner, bluntnose minnow, brook stickleback, central mudminnow, creek chub, fathead minnow, logperch, longnose dace, northern redbelly dace, rock bass, spottail shiner, white sucker.

See table (2018_GLO-4393-LimebankExt-Fisheries_Site_Table) for specific information related to fisheries for provided UTM's.

Wildland Fire

MNRF woodland data shows that the site contains woodlands. The lands should be assessed for the risk of wildland fire as per PPS 2014, Section 3.1.8 "*Development shall generally be directed to areas outside of lands that are unsafe for development due to the presence of hazardous forest types for wildland fire. Development may however be permitted in lands with hazardous forest types for wildland fire where the risk is mitigated in accordance with wildland fire assessment and mitigation standards*". Further discussion with the local municipality should be carried out to address how the risks associated with wildland fire will be covered for such a development proposal. Please see the Wildland Fire Risk Assessment and Mitigation Guidebook (2016) for more information.

Significant Woodlands

Section 2.1.5 b) of the PPS states: *Development and site alteration shall not be permitted in significant woodlands unless it has been demonstrated that there will be no negative impacts on the natural features or their ecological functions.* The 2014 PPS directs that significant woodlands must be identified following criteria established by the Ontario Ministry of Natural Resources and Forestry, i.e. the Natural Heritage Reference Manual (NHRM), 2010. Where the local or County Official Plan has not yet updated significant woodland mapping to reflect the 2014 PPS, all wooded areas should be reviewed on a site specific basis for significance. The MNRF Kemptville District modelled locations of significant woodlands in 2011 based on NHRM criteria. The presence of significant woodland on site or within 120 metres should trigger an assessment of the impacts to the feature and its function from the proposed development.

Significant Wildlife Habitat

Section 2.1.5 d) of the PPS states: *Development and site alteration shall not be permitted in significant wildlife habitat unless it has been demonstrated that there will be no negative impacts on the natural features or their ecological functions.* It is the responsibility of the approval authority to identify significant wildlife habitat or require its identification. The MNRF has several guiding documents which may be useful in identification of significant wildlife habitat and characterization of impacts and mitigation options:

- Significant Wildlife Habitat Technical Guide, 2000
- The Natural Heritage Reference Manual, 2010
- Significant Wildlife Habitat Mitigation Support Tool, 2014
- Significant Wildlife Habitat Criteria Schedule for Ecoregion 5E and 6E, 2015

The habitat of special concern species (as identified by the Species at Risk in Ontario list) and Natural Heritage Information Centre tracked species with a conservation status rank of S1, S2 and S3 may be significant wildlife habitat and should be assessed accordingly.

Water

The Ministry of Natural Resources and Forestry (MNRF) has established timing window guidelines to restrict in-water work related to an activity during certain periods. These restricted periods are identified in order to protect fish from impacts of works or undertakings in and around water during spawning and other critical life stages. A suite of appropriate measures should be taken for projects involving in-water works to minimize and mitigate impacts to fish, water quality and fish habitat, and include:

- avoiding in-water works during the timing guidelines;
- installation of sediment/erosion control measures;
- avoiding the removal, alteration, or covering of substrates used for fish spawning, feeding, over-wintering or nursery areas; and
- debris control measures to manage falling debris (e.g. spalling).

Timing guidelines are based on species* presence and are therefore subject to change if new information becomes available. Timing guidelines in Kemptville District are:

Waterbody (and applicable geography or Fisheries Management Zone)	Timing Guidelines (no in-water works)
○ St. Lawrence River (FMZ 20)	March 15 – July 15 (Spring spawning species)
○ Ottawa River – Lac Des Chats (FMZ 12)	October 1 to July 15 (Spring and fall spawning species, including Lake Trout and Lake Whitefish)
○ Ottawa River – Lac Deschenes (FMZ 12)	October 15 to July 15 (Spring and fall spawning species, including Cisco)
○ Ottawa River – Lac Dollard des Ormeaux (FMZ 12)	January 1 to July 15 (Winter and spring spawning species, including Burbot)
○ Big Rideau Lake (South Burgess and South Elmsley Twps) ○ Charleston Lake (Lansdowne and Escott Twps)	October 1 to June 30 (Spring and fall spawning species, including Lake Trout)
○ Bass Lake (South Elmsley Twp) ○ Lower Rideau Lake (South Elmsley Twp) ○ Bob's Lake (South Sherbrooke Twp) ○ Christie Lake (South Sherbrooke Twp)	October 15 to June 30

○ Crow Lake (South Crosby Twp) ○ Dalhousie Lake (Dalhousie Twp) ○ Davern Lake (South Sherbrooke Twp) ○ Farren Lake (South Sherbrooke Twp) ○ Grippen Lake (Leeds Twp) ○ Indian Lake (South Crosby Twp) ○ Little Long Lake (Lansdowne Twp) ○ Millpond Lake (South Burgess) ○ Otter Lake (South Elmsley, South Burgess and Bastard Twps) ○ Otty Lake (North Burgess and North Elmsley Twps) ○ Pike Lake (North Burgess Twp) ○ Silver Lake (South Sherbrooke Twp) ○ Redhorse Lake (Lansdowne Twp) ○ Tay River (South Sherbrooke, Bathurst, Drummond and North Elmsley Twps) ○ Wolfe Lake (North Crosby Twp)	(Spring and Fall spawning species, including Lake Whitefish and Cisco)
○ Bennett Lake (Bathurst Twp) ○ Crosby Lake (North Crosby Twp) ○ Big Rideau Lake (South Burgess, Bastard and South Elmsley Twps) ○ Gananoque River (Leeds Twp) ○ Lac Georges (Plantagenet and Alfred Twps) ○ Gillies Lake (Lanark Twp) ○ Little Crosby Lake (North Crosby Twp) ○ McLaren Lake (North Burgess Twp) ○ Mississippi Lake (Drummond, Beckwith and Ramsay Twps) ○ Mississippi River (Beckwith, Ramsay, Pakenham and Fitzroy Twps) ○ Raisin River below Martintown dam (Charlottenburgh Twp) ○ Rideau River (Wolford, Oxford, Montague, Marlborough, South Gower, North Gower, Osgood, Nepean and Gloucester Twps) ○ South Lake (Leeds Twp) ○ South Nation River below Plantagenet weir (Plantagenet Twp) ○ Upper Rideau Lake (North Crosby Twp) ○ Westport Sand Lake (North Crosby Twp)	January 1 – June 30 (Winter and spring spawning species, including Burbot)
○ Small rivers and streams (denoted on 1:50,000 National Topographic System maps as being one lined) ○ All other waterbodies in FMZ 18	March 15 to June 30 (Spring spawning species)

**Please note: Additional timing restrictions may apply as they relate to endangered and threatened species for works in both water and wetland areas. Timing restrictions are subject to change, depending on species found in a given waterbody.*

In addition to adhering to the above timing guidelines, a work permit from the MNRF may be required depending on the nature and scope of work. No encroachment on the bed or banks of a waterbody/watercourse (e.g. abutments, embankments, etc.) is permitted without MNRF approval. Additional information regarding work permits may be found online at https://www.ontario.ca/page/crown-land-work-permits#section-2.

The MNRF does not have any water quality or quantity data available. We recommend that the Ministry of the Environment and Climate Change be contacted for such data along with the local Conservation Authority. For further information regarding fish habitat and protocols, please refer to the following interagency, document, *Fish Habitat Referral Protocol for* Ontario at: http://www.web2.mnr.gov.on.ca/mnr/ebr/fish_hab_referral/protocol_en.pdf.

Additional approvals and permits may be required under the Fisheries Act and the Species at Risk Act; please contact Fisheries and Oceans Canada to determine requirements and next steps. There may also be approvals required by the local Conservation Authority or Transport Canada, and these agencies should be contacted directly to determine requirements. As the MNRF is responsible for the management of provincial fish populations, we request ongoing involvement in such discussions in order to ensure population conservation.

Species at Risk

A review of the Natural Heritage Information Centre (NHIC) and internal records indicate that there is a potential for the following threatened (THR) and/or endangered (END) species on the site or in proximity to it:

- Bank Swallow (THR)
- Barn Swallow (THR)
- Blanding's Turtle (THR)
- Bobolink (THR)
- Butternut (END)
- Eastern Meadowlark (THR)
- Loggerhead Shrike (END)
- Whip poor will (THR)
- Chimney Swift (THR)
- Eastern Small-footed Myotis (END)
- Little Brown Bat (END)
- Northern Long-eared Bat (END)
- Tri-Colored Bat (END)

All endangered and threatened species receive individual protection under section 9 of the ESA and receive general habitat protection under Section 10 of the ESA, 2007. Thus any potential works should consider disturbance to the individuals as well as their habitat (e.g. nesting sites). General habitat protection applies to all threatened and endangered species. Note some species in Kemptville District receive regulated habitat protection. The habitat of these listed species is protected from damage and destruction and certain activities may require authorization(s) under the ESA. For more on how species at risk and their habitat is protected, please see: https://www.ontario.ca/page/how-species-risk-are-protected.

If the proposed activity is known to have an impact on any endangered or threatened species at risk (SAR), or their habitat, an authorization under the ESA may be required. It is recommended that MNRF Kemptville be contacted prior to any activities being carried out to discuss potential survey protocols to follow during the early planning stages of a project, as well as mitigation measures to avoid contravention of the ESA. Where there is potential for species at risk or their habitat on the property, an Information Gathering Form should be submitted to Kemptville MNRF at sar.kemptville@ontario.ca.

The Information Gathering Form may be found here:
http://www.forms.ssb.gov.on.ca/mbs/ssb/forms/ssbforms.nsf/FormDetail?OpenForm&ACT=RDR&TAB=PROFILE&ENV=WWE&NO=018-0180E

For more information on the ESA authorization process, please see:
https://www.ontario.ca/page/how-get-endangered-species-act-permit-or-authorization

One or more special concern species has been documented to occur either on the site or nearby. Species listed as special concern are not protected under the ESA, 2007. However, please note that some of these species may be protected under the Fish and Wildlife Conservation Act and/or Migratory Birds Convention Act. Again, the habitat of special concern species may be significant wildlife habitat and should be assessed accordingly. Species of special concern for consideration:

- Eastern Wood-Pewee (SC)
- Peregrine Falcon (SC)
- Red-headed Woodpecker (SC)
- Short-eared Owl (SC)
- Snapping Turtle (SC)
- Wood Thrush (SC)
- Monarch (SC)

If any of these or any other species at risk are discovered throughout the course of the work, and/or should any species at risk or their habitat be potentially impacted by on site activities, MNRF should be contacted and operations be modified to avoid any negative impacts to species at risk or their habitat until further direction is provided by MNRF.

Please note that information regarding species at risk is based largely on documented occurrences and does not necessarily include an interpretation of potential habitat within or in proximity to the site in question. Although this data represents the MNRF's best current available information, it is important to note that a lack of information for a site does not mean that additional features and values are not present. It is the responsibility of the proponent to ensure that species at risk are not killed, harmed, or harassed, and that their habitat is not damaged or destroyed through the activities carried out on the site.

The MNRF continues to strongly encourage ecological site assessments to determine the potential for SAR habitat and occurrences. When a SAR or potential habitat for a SAR does occur on a site, it is recommended that the proponent contact the MNRF for technical advice and to discuss what activities can occur without contravention of the Act. For specific questions regarding the Endangered Species Act (2007) or SAR, please contact MNRF Kemptville District at sar.kemptville@ontario.ca.

The approvals processes for a number of activities that have the potential to impact SAR or their habitat have recently changed. For information regarding regulatory exemptions and associated online registration of certain activities, please refer to the following website: https://www.ontario.ca/page/how-get-endangered-species-act-permit-or-authorization.

Please note: The advice in this letter may become invalid if:

- The Committee on the Status of Species at Risk in Ontario (COSSARO) re-assesses the status of the above-named species OR adds a species to the SARO List such that the section 9 and/or 10 protection provisions apply to those species; or
- Additional occurrences of species are discovered on or in proximity to the site.

This letter is valid until: Thu. Jan 31, 2019

The MNRF would like to request that we continue to be circulated on information with regards to this project. If you have any questions or require clarification please do not hesitate to contact me.

Sincerely,

Carolyn Hann
Management Biologist
carolyn.hann@ontario.ca

Encl.\
-ESA Infosheet
-NHIC/LIO Infosheet

Air Quality Assessment

Ottawa Light Rail Transit (Stage 2)

Ottawa, Ontario

Presented to:

City of Ottawa
180 Elgin Street
Ottawa, ON K2P 2K3

Work Package ID:

TRILLIUM_Limebank to Bowesville AQ Report_Rev1.docx

September 6, 2018

REVISION INDEX

Revision No.	Description	Issue Date
0	Draft for Review	August 24, 2018
1	Final Draft	September 6, 2018

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APPENDICES

1. INTRODUCTION

As part of the Ottawa LRT Stage 2 project, the Trillium Line South (TLS) Light Rail Transit (LRT) Extension will include a rail extension south past the Ottawa Macdonald-Cartier International Airport to Earl Armstrong Road at Bowesville Road and further along to Limebank Road. The rail line operates with diesel multiple unit (DMU) trains.

An Environmental Project Report (EPR) was submitted to the Ministry of the Environment, Conservation and Parks (MECP), formerly the Ministry of Environment and Climate Change (MOECC), on January 22, 2016 for the TLS LRT project in accordance with the Transit Project Assessment Process (TPAP) detailed in the *Environmental Assessment Act, Ontario Regulation (O.Reg.) 231/08*.

As outlined in the 2016 EPR, the TLS Extension will add 12 km of rail to the City's overall transit network and seven new LRT stations at Gladstone, Walkley, South Keys, Uplands, Airport, Leitrim and Bowesville. To provide the required capacity, the TLS LRT plan includes 77 m station platforms at all existing and new stations on all segments of the line. New passing tracks will provide 12-minute service along the main line and the Airport Rail Link.

Since the 2016 EPR submission, further discussion has resulted in changes to the preliminary design, including a change of location for the Bowesville transit station, the addition of a Park and Ride parking lot at the Bowesville transit station design, and the addition of a new terminal station at Limebank road with associated rail extension to this station.

An air quality impact assessment has been undertaken to determine the potential impact from construction and operation of the two new transit stations and the diesel rail line extension. The relevant assessment guidelines and methodologies are outlined in this report, along with the predicted air quality impacts and preliminary discussion on requirements for mitigation during construction of the new transit stations and the rail line extension.

1.1 Approach

The air quality study for the proposed extension involves the assessment of air emissions and impacts for one scenario:

- Future Build-Out conditions (2031), ten years after the estimated date of construction completion for the proposed extension.

The Future Build-Out conditions include the addition of approximately 4.6 kilometres of track for diesel powered light rail extending south from the previously approved location of Bowesville Station, south of the Ottawa Macdonald-Cartier International Airport, to Earl Armstrong Road, and west from Bowesville Road to Limebank Road. These conditions also include the addition of two new transit stations at Bowesville Road and Limebank Road. Emissions from diesel trains, transit buses, and passenger vehicles are anticipated at each of these stations. Figures of the proposed rail alignment, and transit station layouts are provided in Appendix A.

The air quality study for the proposed project was assessed in two stages:

- Assessment of mobile vehicular emissions using the U.S. EPA mobile emissions modelling software MOVES; and
- Assessment of local impacts from diesel train operation, OC Transit buses, and passenger vehicles using the U.S. EPA developed dispersion modelling software, AERMOD (software platform developed by Lakes Environmental).

Using the AERMOD model, hourly concentrations were predicted based on estimated worst-case hourly emission data and five years (1996–2000) of monitored hourly meteorological data, pre-processed for use in AERMOD by the MECP. The data set consists of surface data collected at the Ottawa airport, and the closest upper-air station, located in Maniwaki, Quebec.

Local air quality impacts were assessed at existing sensitive receptors and possible future representative sensitive receptors present within the Study Area. No critical receptors (i.e. hospitals, schools, extended care homes, etc.) were identified within the Study Area. In addition, a grid of receptors was placed throughout the Study Area at a resolution of 200 metres x 200 metres in order to determine the area most impacted by the modeled sources of emission. The modelled concentrations were combined with the measured ambient air concentrations of pollutants of interest. The total concentrations were then compared to the applicable Provincial and Federal air quality standards to determine if any impacts may be expected from the project.

1.2 Applicable Guidelines and Standards for Air Quality Assessment

The Ministry of Transportation (MTO) “Environmental Guide for Air Quality Impacts and Greenhouse Gas Emissions” (June 2012), Appendix 3: Assessment of Local Air Quality indicates the following pollutants as most relevant to traffic air quality assessments. The MECP indicates that certain polycyclic aromatic compounds (PAHs), specifically benzo(a)pyrene, are emitted in significant quantities from diesel train operations and should also be considered as a contaminant of interest in air quality studies.

1. carbon monoxide (CO);
2. nitrogen dioxide (NO_2);
3. particulate matter with diameter less than 10 micron (PM_{10});
4. particulate matter with diameter less than 2.5 micron ($PM_{2.5}$);
5. five (5) volatile air toxins (benzene, 1,3-butadiene, formaldehyde, acetaldehyde, and acrolein); and
6. benzo(a)pyrene (BaP).

Benzo(a)pyrene is also significantly present within the background air quality across Ontario, and was therefore estimated in the emissions of passenger vehicles, trucks and diesel train operations for this assessment.

The applicable standards for these pollutants are regulated by the following jurisdictions:

- MECP: Ambient Air Quality Criteria (AAQC); and
- Environment Canada and Climate Change (ECCC): Canadian Ambient Air Quality Standards (CAAQS).

A summary of the assessed pollutants and their applicable standards can be found in Table 1.1. The CAAQS denotes separate standards for 2015, 2020, and 2025, to encourage lower pollutant emissions in the future. The MECP interim 24-hour reference level for PM_{10} was included as a guide for decision making.

Table 1.1: Summary of Applicable Guidelines and Standards

Contaminant	Source of Standard	Averaging Period (hr)	Air Quality Threshold Value (µg/m^3)
CO	AAQC	1	36,200
	AAQC	8	15,700
NO2	AAQC	1	400
	AAQC	24	200
	CAAQS	1 (2020)	113
	CAAQS	1 (2025)	79
	CAAQS	Annual (2020)	32
	CAAQS	Annual (2025)	23
PM_{10}	AAQC	24	50
PM2.5	CAAQS	24 (2015)	28
	CAAQS	24 (2020)	27
	CAAQS	Annual (2015)	10
	CAAQS	Annual (2020)	8.8
Acetaldehyde	AAQC	24	500
Acrolein	AAQC	1	4.5
	AAQC	24	0.4
Benzene	AAQC	24	2.3
	AAQC	Annual	0.45
Benzo(a)pyrene	AAQC	24	0.00005
	AAQC	Annual	0.00001
1,3-Butadiene	AAQC	24	10
	AAQC	Annual	2
Formaldehyde	AAQC	24	65

Notes:
(1) µg/m^3 stands for "microgram per cubic metre"

(2) Grey standards indicate standards not used for comparison with this assessment due to the year of the future build-out scenario (2031)
(3) The CAAQS standards developed for NO_2 are published as parts per billion (ppb) and are shown here converted to µg/m^3 for consistency
(4) The PM_{10} 50 µg/m^3 24-hour standard represents an interim AAQC adopted in 1997
(5) The $PM_{2.5}$ µg/m^3 annual and 24-hr standards are reflective of current CAAQS, updated from the previous Canada-Wide Standards (CWS).

The AAQCs were developed by the MECP and are a list of desirable concentrations of a contaminant in air, based on protection against adverse effects on health or the environment. Limits are set based on “limiting effects” (i.e. adverse effects) which are provided alongside a contaminant’s AAQC value and averaging time, reflecting the lowest concentration at which an adverse effect may be expected to occur. Applicable limiting effects may include health, odour, vegetation, visibility, particulate, corrosion, or others. The concentrations noted in the AAQCs are based on averaging period, indicating various time periods at which adverse effects may be experienced. Ambient air quality studies, such as traffic studies, may use these AAQC limits to assess a project’s adverse effect on the local population and environment.

The CAAQS are health-based air quality objectives for pollutant concentrations in air. Under the Air Quality Management System, ECCC and Health Canada have established air quality standards for fine particulate matter and nitrous oxides. Ambient air quality studies, such as traffic studies, may use these CAAQS limits to assess a project’s health-based impact to the local population for fine particulates. More stringent limits are projected for future particulate levels (post-2020) and future NO_2 levels (post-2020 and -2025) to encourage reduction in emissions from all sectors (transportation, industrial, etc.).

1.3 Existing Ambient Air Quality

A study of existing ambient air quality for the pollutants of interest was completed using publically available air quality data from ambient air quality monitoring stations within Ontario and Quebec. The monitoring stations selected for this study are owned and operated by the MECP and ECCC under the National Air Pollution Surveillance (NAPS) program, and are listed below in Table 1.2 alongside their respective monitored contaminants.

Table 1.2: Summary of Monitoring Stations and Ambient Air Data

	NAPS Monitoring Stations				
Station Name	Ottawa Central	Ottawa Downtown	Gatineau-Hull	Saint Anciet, QC	Montréal Riviére des Pariries, QC
NAPS Number	60106	60104	50204	54401	50129
Address	960 Carling Ave.	Rideau St. & Wurtemburg St.	255 St-Redempteur, Hull	1128 de la Geurre	12400 Wilgrid-Ouellette
Latitude	45.382528	45.43433	45.435987	45.120627	45.651691
Longitude	-75.714194	-75.676	-75.723429	-74.288475	-73.573825
Station Type	Urban	Urban	Urban	Rural	Rural
Height of Air Intake	5 m	4 m	N/A	N/A	N/A
Elevation ASL	84 m	72 m	62 m	50 m	29 m
Pollutants Measured	O_3, NO_2, $PM_{2.5}$	O_3, CO, NO_2, $PM_{2.5}$, Benzene, 1,3-Butadiene	O_3, CO, NO_2, $PM_{2.5}$	CO, $PM_{2.5}$, Benzene, 1,3-Butadiene, Formaldehyde, Acetaldehyde, Acrolein	CO, $PM_{2.5}$, Benzene, 1,3-Butadiene, Formaldehyde, Acetaldehyde, Acrolein, Benzo(a)pyrene

Notes: ASL – Above Sea Level

For each contaminant, the highest of all applicable monitoring station's average 90th percentile values for the most recent three (3) years of complete data was taken as the representative background level. For most contaminants, the most recent and complete three-year data set was taken from the years 2014 to 2016. Table 1.3 below shows a summary of the maximum 90th percentile values for each contaminant for all respective averaging periods.

PM_{10} is not a monitored contaminant by either the MECP or ECCC, therefore ambient concentrations were estimated using the measured $PM_{2.5}$ ambient concentrations and a ratio of $PM_{2.5}$ / PM_{10} of 0.54, measured in an air quality study on ambient fine particulate concentrations published in the journal, *Atmospheric Environment,* issue 38 (2004), called "Estimation of historical annual $PM_{2.5}$ exposures for health effects assessment" (Lall et. al, 2004). This ratio is an MECP approved methodology for predicting PM_{10} background air quality levels.

Table 1.3: Background Ambient Air Quality Concentrations

Contaminant	Averaging Period (hr)	Station Name [1]	Station ID	2014	2015	2016	Maximum	Average
NO_2	1	Ottawa	060104	30.10	30.10	28.41	30.10	29.54
	24	Ottawa	060104	26.34	28.22	26.15	28.22	26.90
	Annual [2]	Ottawa	060104	13.17	13.17	12.98	13.17	13.11
CO	1	Ottawa	060104	343.68	343.68	343.68	343.68	343.68
	8	Ottawa	060104	343.68	343.68	343.68	343.68	343.68
PM_{10}[4]	24	Saint-Anicet	054401	24.07	24.07	20.37	24.07	22.84
$PM_{2.5}$	24	Saint-Anicet	054401	13.00	13.00	11.00	13.00	12.33
	Annual [2]	Ottawa	060104	9.00	7.00	7.00	9.00	7.67
Acetaldehyde	24	Saint-Anicet	054401	1.70	3.38	Incomplete[5]	3.38	2.54
Acrolein	1 [3]	Saint-Anicet	054401	0.02	2.73	Incomplete[5]	2.73	1.37
	24	Saint-Anicet	054401	0.02	0.04	Incomplete[5]	0.04	0.03
Benzene[6]	24	Ottawa	060104	0.75	0.80	0.59	0.80	0.71
	Annual [2]	St-Anciet	054401	0.43	0.46	0.42	0.46	0.44
Benzo(a)pyrene	24	Montreal	050129	2.27E-04	1.74E-04	5.73E-05	2.27E-04	1.53E-04
	Annual [2]	Montreal	050129	8.92E-05	1.05E-04	3.42E-05	1.05E-04	7.62E-05
1,3-Butadiene	24	Ottawa	060104	0.06	0.07	0.04	0.07	0.06
	Annual [2]	Ottawa	060104	0.03	0.03	0.03	0.03	0.03
Formaldehyde	24	Saint-Anicet	054401	2.40	0.04	Incomplete[5]	2.40	1.22

Notes:

(1) The station with the highest recorded value for each contaminant is shown from a selection of six separate stations in the Ottawa region.

(2) Annual averaging period shows the calculated Annual Average for each study year.

(3) VOC recorded data was provided as a daily average for the years 2014-2016, therefore hourly 90th percentile values were assumed to be equal to the daily 90th percentile measurements.

(4) $PM_{2.5}$ / PM_{10} = 0.54, as per Lall et. al, "Estimation of historical annual $PM_{2.5}$ exposures for health effects assessment", Atmospheric Environment 38 (2004)

(5) Only 9 months of measured data is available.

(6) 2016 annual maximum benzene level is recorded at Saint-Anicet Station.

The background concentrations for each contaminant were compared to the applicable Provincial and Federal concentration limits for all time averaging periods. All contaminants were found to be below the applicable limits, with the exception of benzo(a)pyrene which exceeded the 24-hr and Annual AAQC limit by 306% and 762%, respectively, as shown in Table 1.4.

Table 1.4: Comparison of Background Concentrations to Air Guidelines/Standards

Contaminant	Averaging Period (hr)	Background Concentration (µg/m^3)	AAQC Standard (µg/m^3)	% of AAQC/ CAAQS Standard
NO2	1 (2025)	30	79	37%
	24	27	200	13%
	Annual (2025)	13	23	58%
CO	1	344	36,200	1%
	8	344	15,700	2%
PM10	24	23	50	46%
PM2.5	24 (2023)	12	27	46%
	Annual (2023)	7.67	8.8	87%
Acetaldehyde	24	2.54	500	1%
Acrolein	1	1.37	4.5	31%
	24	0.031	0.4	8%
Benzene	24	0.71	2.3	31%
	Annual	0.437	0.45	97%
Benzo(a)pyrene	24	0.0002	**0.00005**	**306%**
	Annual	0.0001	**0.00001**	**762%**
1,3-Butadiene	24	0.057	10	1%
	Annual	0.031	2	2%
Formaldehyde	24	1.22	65	2%

Notes:
(1) Exceedances to air quality thresholds are shown in **red**

It was assumed that the historic ambient air quality background will be representative of Future Build-Out (2031) background air quality conditions. This is a conservative estimate as there are numerous Provincial and Federal initiatives in place to reduce levels of ambient air pollutants. It is also anticipated that increasingly stringent vehicle emission limits will lower on-road traffic emissions despite the anticipated rise in traffic volume.

2. METHODOLOGY

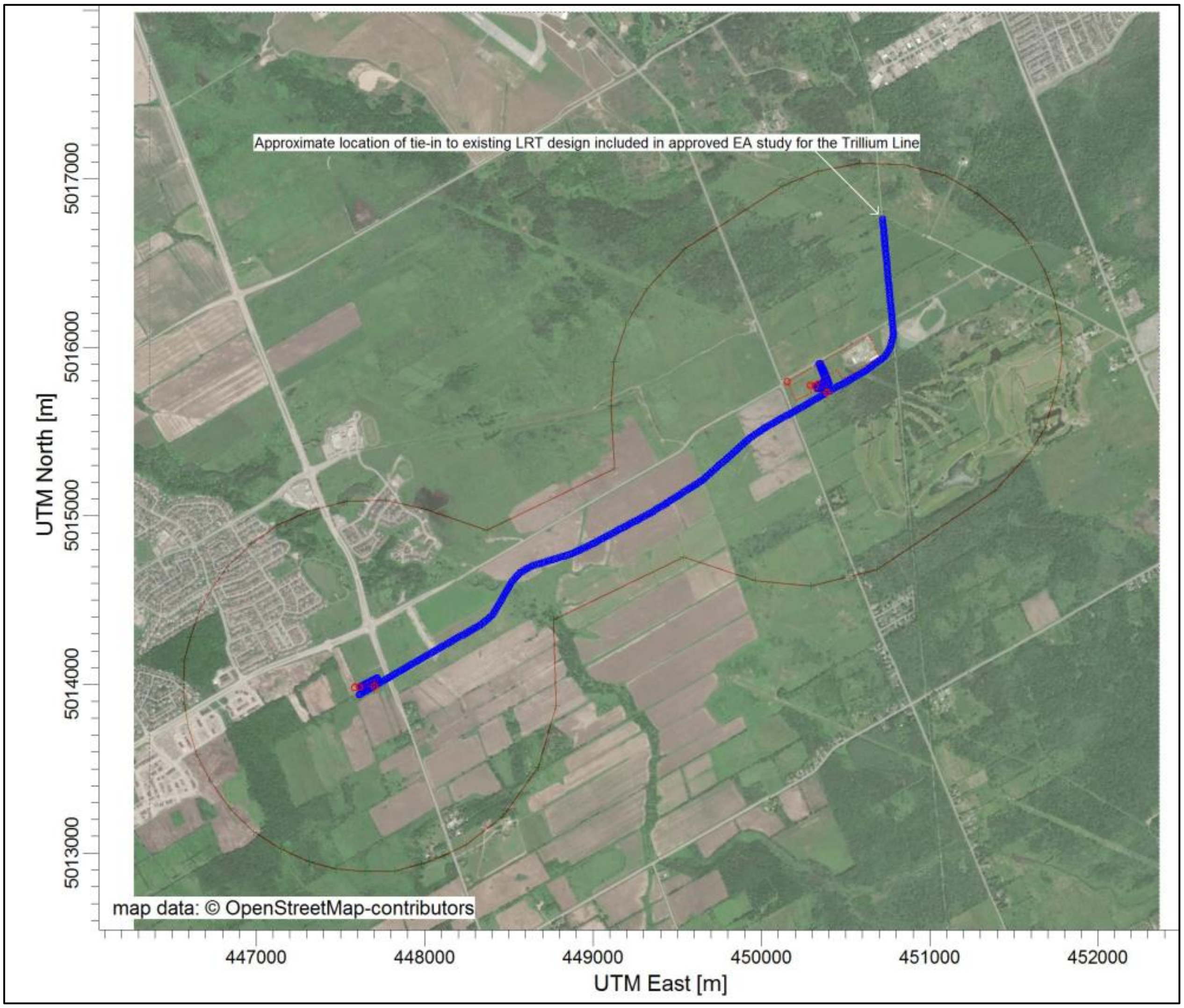
2.1 Study Area & Zoning

The study area includes the rail corridor extension from the previously proposed Bowesville transit station location (assessed in the existing EA submission for the Trillium Line) to the revised location of Bowesville transit station and further west to the new Limebank transit station. The study area includes all sources and receptors within a one (1) kilometre radius around each transit station, and within a 300 metre radius from the proposed rail extension.

There is an existing residential development to the north and north-west of the proposed Limebank transit station, and the remaining land uses are non-residential in nature with the exception of some houses on select plots of land zoned for agricultural use. The City of Ottawa has indicated that future residential development is anticipated in the future as better transit opportunities become available to the area. For conservative purposes, this assessment has assumed the entire study area will be treated as residentially zoned land use. A selection of 'possible future receptors' has been included in the model for assessment where no existing receptors currently exist.

The study area for this assessment is presented in Figure 2.1, showing the location of the rail corridor and transit stations included in the assessment.

Figure 2.1: Study Area



2.2 Receptor Selection

Within the study area, ninteen (19) sensitive receptor locations as listed in Table 2.1, were selected to determine the potential worst-case impact from the rail corridor extension. They were selected due to their proximity to the emission sources present within the study area.

In addition to these discrete receptors, a grid of 200 metre x 200 metre resolution was created within the study area, and along the study area boundary, to determine the predicted areas of highest impact.

Table 2.1: Representative Air Quality Sensitive Receptor Locations

Receptor ID [1]	UTM-X	UTM-Y	Receptor Type	Receptor Description
R1	447999.74	5014724.13	Residence	Existing house located at 948 Wildcarrot Crescent
R2	447636.40	5014718.92	Residence	Existing house located at 622 Whitecliffs Ave.
R3	447418.66	5014465.51	Residence	Existing house located at 554 Dusty Miller Crescent
R4	447328.69	5014246.79	Residence	Existing house located at 222 Eye Bright Crescent
R5	447903.51	5013835.51	Residence	Existing house located at 500 m south of Bowesville transit station on Bowesville Road
R6	450346.39	5015084.27	Residence	Existing house located at 230 m south of Limebank transit station on Limebank Road
R7	448249.99	5014851.44	Future Residence	Possible future house to the north-west of Limebank transit station
R8	447511.25	5013663.04	Future Residence	Possible future house to the south of Limebank transit station
R9	448317.14	5014071.83	Future Residence	Possible future house to the south-west of Limebank transit station
R10	449175.27	5014727.87	Future Residence	Possible future house to the south of Limebank extension
R11	448587.82	5014894.26	Future Residence	Possible future house to the north of Limebank extension
R12	449415.02	5015228.10	Future Residence	Possible future house to the north of Limebank extension
R13	449698.25	5014985.75	Future Residence	Possible future house to the south of Limebank extension
R14	450013.60	5015826.68	Future Residence	Possible future house to the north of Bowesville station
R15	450241.35	5015333.22	Future Residence	Possible future house to the south of Bowesville station
R16	450407.78	5016074.87	Future Residence	Possible future house to the north of Bowesville station
R17	450661.81	5015534.69	Future Residence	Possible future house to the south of Bowesville station
R19	450904.57	5016669.74	Future Residence	Possible future house east of Bowesville north extension
R20	450519.35	5016853.81	Future Residence	Possible future house west of Bowesville north extension

Notes:

(1) R18 was originally included in the modelling of the study area, however was removed due to the future expropriation of the lot. Figure A1 in Appendix A shows the location of this receptor, which was removed from the modelling results assessment.

Figure A1 in Appendix A shows the locations of the representative sensitive receptors in addition to the other modelled grid receptors within study area.

Zoning maps within the Study Area are included in Appendix B. Land use within the study area includes residentially zoned areas, agriculturally zoned areas, and parks or open space zones.

2.3 Emissions Sources

The following sources were assessed:

- Mobile Trillium Line diesel locomotives (Stadler FLIRT);
- Idling Trillium Line diesel locomotives (Stadler FLIRT) at the Bowesville and Limebank transit stations;
- OC Transpo diesel transit buses traveling within the Bowesville and Limebank transit stations;
- OC Transpo diesel transit buses idling within the Bowesville and Limebank transit stations;
- Passenger vehicles idling at the Passenger Pick-up and Drop-off (PPUDO) areas at Bowesville and Limebank transit stations; and
- Passenger vehicles moving, idling, and starting within the Park-n-Ride parking lot located at Bowesville transit station.

2.4 Emission Factors

2.4.1 OC Transpo Buses & Passenger Vehicles

The air quality assessment included emissions estimation using the U.S. EPA emissions modelling software MOVES2014a. This software provides emission rates for a wide variety of source types (i.e. passenger cars, motorcycles, long-haul trucks, etc.), speed bins, road types, and emission processes (i.e. running emissions, idling emissions, tire wear, brake wear, etc.).

The U.S. EPA emissions modelling software MOVES2014a calculates emissions from mobile sources using a variety of factors: time span, geographic bounds, vehicle type, road type, and emission or process type. The time span calculates emission using default fleet composition and fuel criteria specific to a pre-selected year, month, hour, and weekday/weekend profile. Fleet composition and fuel criteria are also specific to geographic location, with default database data provided for each county in the United States. For Canada, the closest US County to the project Study Area is selected to provide fleet and fuel characteristics as close of a match as possible. For this assessment, the, St. Lawrence County in New York State was selected to represent the Ottawa area.

There are thirteen vehicle types and five fuel types in MOVES2014a. For this assessment two combinations of source type and fuel type were assessed were passenger vehicles operating with gasoline fuel representing the vehicle fleet which will be using the Park-n-Ride parking lot at Bowesville transit station, and transit buses operating with diesel fuel to represent the OC Transpo bus fleet.

Emissions in MOVES2014a are divided into four major categories:

(1) Running emissions;
(2) Start emissions;
(3) Evaporative emissions; and
(4) Particulate emissions from brake wear and tire wear.

Evaporative emissions include the following the sub-categories: evaporative permeation, fuel vapour venting, fuel leaks, refueling displacement vapour loss, refueling spillage loss, vapour loss during running emissions, and vapour loss during idling. All types of evaporative emissions, except idling vapour emissions, are included within the calculated MOVES2014a running emission factor used in the air quality study.

The most recently released version of MOVES2014a (version 2014a) was used to estimate emissions from the study area. The model was used to generate running emission rates in a gram of pollutant per vehicle mile traveled (g/VMT) and idling emission rates in gram of pollutant per vehicle per hour for all pollutants of concern: CO, NO_X, PM_{10}, $PM_{2.5}$, benzo(a)pyrene, and each of the five volatile air toxics. Emission rates were generated for the months with the most extreme temperature conditions, namely January and July. The maximum emission rate of these two months was selected as the “worst-case” emission rate for dispersion modelling. Default MOVES values were used to estimate the average age distribution of the vehicle fleet for 2031.

Idling emission rates were estimated for passenger vehicles and transit buses using the applicable emission rate for the lowest speed bin in MOVES2014a. The product of this emission rate in grams per vehicle kilometer traveled (g/VKT) and the maximum vehicle speed rate of this speed bin (4.02 km/hr) was used for the estimation of vehicle fleet emissions for dispersion modelling. Start emission rates were conservatively assumed to be from a cold engine, namely after 6 to 12 hours of remaining parked.

Table 2.2 shows the applicable emission factors generated by MOVES2014a for the Future Build-Out scenario (2031) for use in the AQ study assessment.

Table 2.2: Summary of MOVES2014a Vehicle Emission Rates

Pollutant	Bus Emissions		Passenger Vehicle Emissions		
	Running (12-20 km/hr)	Idling	Running (12-20 km/hr)	Idling	Start (Soak 6-12 hr)
	(g/VKT)	(g/veh-hr)	(g/VKT)	(g/veh-hr)	(g/Start)
NO_X	2.1020	31.6601	0.0162	0.0644	0.6200
CO	0.6269	9.2550	1.2598	9.3469	21.8129
PM_{10}	0.5934	5.5180	0.1116	1.2953	0.0650
$PM_{2.5}$	0.1214	1.3577	0.0165	0.1874	0.0575
Acetaldehyde	0.0075	0.1183	0.0000	0.0002	0.0579
Acrolein	0.0012	0.0188	0.0000	0.0000	0.0036
Benzene	0.0015	0.0234	0.0003	0.0032	0.1129
Benzo(a)pyrene	0.0000	0.0001	0.0000	0.0000	0.0000
1,3-Butadiene	0.0003	0.0042	0.0000	0.0000	0.0256
Formaldehyde	0.0212	0.3334	0.0001	0.0005	0.0252

2.4.2 Locomotives

The U.S. EPA has established emission standards for oxides of nitrogen (NOx), hydrocarbons (HC), carbon monoxide (CO), and particulate matter (PM) for several different types of locomotives, divided by tiers of emission standard based on year of manufacture, as follows:

- Tier 0 standards apply to locomotive engines originally manufactured from 1973 to 1992;
- Tier 1 standards apply to locomotives and locomotive engines originally manufactured from 1993 to 2004;
- Tier 2 standards apply to locomotives and locomotive engines originally manufactured from 2005 to 2011;
- Tier 3 standards apply to locomotives and locomotive engines originally manufactured from 2012 to 2014; and
- Tier 4 standards apply to locomotives and locomotive engines originally manufactured after 2015.

Locomotive emissions were estimated using the U.S. EPA emission standards, assuming the most stringent Tier 4 of standards according to the engine emissions guarantee provided for the model of locomotive proposed for the rail corridor extension: the Stadler FLIRT four-car diesel multiple unit (DMU) train. The emission standards guaranteed by the manufacturer (Stadler) are provided in Appendix C.

This assessment includes emissions from the Stadler FLIRT trains, however elsewhere along the Trillium Line there will be another train model also in operation, the Alstom Coradia LINT train, which will provide service up to the Ottawa Macdonald-Cartier

International Airport, but no further south. For this reason, Alstom LINT train emissions were not included within the assessment.

Emissions of carbon monoxide (CO), nitrous oxides (NOx), and particulate matter (PM) were estimated directly from the provided U.S. EPA Tier 4 emission standards, however for other criteria air contaminants, a set of speciation factors were developed using heavy vehicle diesel combustion emissions (source ID 62: long-haul combination trucks) from MOVES2014a. These speciation factors are summarized below in Table 2.3.

Table 2.3: VOC and PM Speciation Factors for Locomotive Emissions

Pollutant	VOC Speciation Factor [1]	PM Speciation Factor [2]
NO_X	--	--
CO	--	--
PM_{10}	--	1
$PM_{2.5}$	--	0.92
Acetaldehyde	0.0384	--
Acrolein	0.0058	--
Benzene	0.0074	--
Benzo(a)pyrene	--	0.000059
1,3-Butadiene	0.0010	--
Formaldehyde	0.1136	--

Notes:
(1) VOC speciation factor is applied to the Stadler FLIRT HC emission rate.
(2) PM speciation factor is applied to the Stadler FLIRT PM emission rate

Volatile organic compound (VOC) speciation factors were determined by comparison to total gaseous hydrocarbons (HC) emissions. Fine particulate matter ($PM_{2.5}$) and benzo(a)pyrene (BaP) speciation factors were determined by comparison to total respirable particulate (PM_{10}) emission factors. Benzo(a)pyrene emissions are most often linked to respirable particulate from diesel engine emissions.

The emissions of criteria air contaminants (CACs) from the Stadler FLIRT trains were conservatively quantified by employing two settings of route-specific and engine-specific emission factors and exhaust parameters derived based on engine notch settings and power output, as provided by Stadler. Where information was not readily available from Stadler, published locomotive specific exhaust emission data was used to conservatively estimate missing data values for modelling.

To remain conservative in the assessment of locomotive emissions, it was assumed that trains traveling between stations would be operating at 100% power output and top speed. Trains were determined to have an approximate twelve (12) minute headway between arrival at each station, resulting in an assumed five (5) train per hour estimation. Trains at the Bowesville Station were determined to have an approximate two (2) minute idling period between arrival and departure, and trains at the Limebank Station were determined to have a worst-case twelve (12) minute idling period between arrival and departure to account for turn-around time at the terminal station of the Trillium Line. Real time estimates for terminal station idling would be lower in actual operation. These estimations were based on scheduling data provided by the City of Ottawa, as shown in Appendix C.

Table 2.4 presents the emission rates derived for the Stadler FLIRT trains from U.S. EPA Tier 4 emission standards and applicable VOC and PM speciation factors. These emission factors are provided for the two conditions assessed within the study area: idling at the transit stations and travel (at top notch) between stations.

Table 2.4: Stadler FLIRT DMU Locomotive Tier 4 Emission Factors

Pollutant	Train Emissions: Stadler	
	Running (g/veh-hr)	Idling (g/veh-hr)
NO_X	768	273
CO	6,720	2,385
PM_{10}	38.400	13.630
$PM_{2.5}$	35.328	12.540
Acetaldehyde	14.007	4.972
Acrolein	2.133	0.7571
Benzene	2.699	0.9579
Benzo(a)pyrene	0.0023	0.0008
1,3-Butadiene	0.3499	0.1242
Formaldehyde	41.439	14.709

2.4.3 AERMOD Emission Factors

Emission factors provided by MOVES2014a and U.S. EPA Tier 4 standards for vehicles and locomotives were used in conjunction with source-specific data to determine worst-case gram per second (g/s) emission rates to be applied to the dispersion modelling (AERMOD) source input. Table 2.5 shows the source specific data used to determine emission rates, with assumptions marked and explained within the notes below.

Table 2.5: Source Description & Parameters

Link Description	Link Dimensions	Vehicle / peak hour (vph)	Additional Source Parameters & Assumptions
Trains running between Bowesville and Limebank Stations: Line Volume Source	4.59 km	5	- 480 kW per engine (x4 per train) - 12 minute headway per station - 5 trains per hour
Trains idling at Bowesville Station: Point Source	--	5	- 170 kW per engine (x4 per train) - 12 minute headway - 1 minute of idling at platform
Trains Idling at Limebank Station: Point Source	--	5	- 170 kW per engine (x4 per train) - 12 minute headway - 12 minute of idling at platform (train turnover time at end of line)
OC Transpo buses idling at designated PPUDO area of Bowesville Station: Area Source	2,400 m^2	20	- 1 minute of idling per bus - 12 minutes headway - 4 bus platforms - 20 vehicles per hour
OC Transpo buses idling at designated PPUDO area of Limebank Station: Area Source	1,740 m^2	45	- 1 minute of idling per bus - 12 minutes headway - 9 bus platforms - 45 vehicles per hour
OC Transpo buses traveling through designated PPUDO area of Bowesville Station: Line Volume Source	0.4027 km	20	- Travel speed of 20 km/hr (0.4 km total) - 12 minutes headway - 4 bus platforms - 20 vehicles per hour
OC Transpo buses traveling through designated PPUDO area of Limebank Station: Line Volume Source	0.2474 km	45	- Travel speed of 20 km/hr (0.24 km total) - 12 minutes headway - 9 bus platforms - 45 vehicles per hour
Idling/Running/Starts emissions from passenger vehicles at the Bowesville Station Park-n-Go lot: Area Source	66,782 m^2	640.8	- Assumed cars idle 0.5 min before engine shut off and after engine start - Travel speed 15 km/hr (0.225 km total) - 1780 vehicle maximum capacity - AM Period 5 AM – 12 PM - PM Period 1 PM – 8 PM
Idling passenger vehicles at designated PPUDO area of Bowesville Station: Area Source	600 m^2	40	- 1 minute of idling per vehicle - 12 minutes headway (matching trains) - 8 PPUDO spots - 40 vehicles per hour
Idling passenger vehicles at designated PPUDO area of Limebank Station: Area Source	322 m^2	30	- 1 minute of idling per vehicle - 12 minutes headway (matching trains) - 6 PPUDO spots - 30 vehicles per hour

An example of the methodology used to convert the MOVES or U.S. EPA Tier 4 standard emission factors to a gram per second emission rate is shown in Appendix D, along with sample calculations for each source type. Table 2.6 shows the emission rates calculated for locomotives operating within the study area, while Table 2.7 shows the emission rates calculated for OC Transpo buses operating within the study area, and Table 2.8 shows the emission rates calculated for passenger vehicles operating within the study area.

Table 2.6: Stadler FLIRT Dispersion Model Emission Rates

Pollutant	Running Stadler FLIRT Trains (g/s)	Idling Stadler FLIRT Trains at Bowesville Station (g/s)	Idling Stadler FLIRT Trains at Limebank Station (g/s)
NO_X	1.067	0.0063	0.0757
CO	9.333	0.0552	0.6626
PM_{10}	0.0533	0.0003	0.0038
$PM_{2.5}$	0.0491	0.0003	0.0035
Acetaldehyde	1.95E-02	1.15E-04	1.38E-03
Acrolein	2.96E-03	1.75E-05	2.10E-04
Benzene	3.75E-03	2.22E-05	2.66E-04
Benzo(a)pyrene	3.14E-06	1.86E-08	2.23E-07
1,3-Butadiene	4.86E-04	2.87E-06	3.45E-05
Formaldehyde	5.76E-02	3.40E-04	4.09E-03

Table 2.7: OC Transpo Bus Dispersion Model Emission Rates

Pollutant	OC Transpo Bus Idling at Bowesville Station (g/s)	OC Transpo Bus Idling at Limebank Station (g/s)	OC Transpo Bus Traveling at Bowesville Station (g/s)	OC Transpo Bus Traveling at Limebank Station (g/s)
NO_X	0.0029	0.0066	0.0047	0.0065
CO	0.0009	0.0019	0.0014	0.0019
PM_{10}	0.0005	0.0011	0.0013	0.0018
$PM_{2.5}$	0.0001	0.0003	0.0003	0.0004
Acetaldehyde	1.095E-05	2.465E-05	1.681E-05	2.323E-05
Acrolein	1.737E-06	3.908E-06	2.666E-06	3.685E-06
Benzene	2.167E-06	4.875E-06	3.325E-06	4.596E-06
Benzo(a)pyrene	6.330E-09	1.424E-08	8.587E-09	1.187E-08
1,3-Butadiene	3.892E-07	8.757E-07	5.982E-07	8.269E-07
Formaldehyde	3.087E-05	6.946E-05	4.735E-05	6.546E-05

Table 2.8: Passenger Vehicle Dispersion Model Emission Rates

Pollutant	Passenger Vehicles at the Bowesville Station Park-n-Ride (PEAK AM) (g/s)	Passenger Vehicles at the Bowesville Station Park-n-Ride (PEAK PM) (g/s)	Passenger Vehicles Idling at the Bowesville Station PPUDO (g/s)	Passenger Vehicles Idling at the Limebank Station PPUDO (g/s)
NO_X	0.0007	0.1111	1.193E-05	8.949E-06
CO	0.0643	3.9470	1.731E-03	1.298E-03
PM_{10}	0.0064	0.0180	2.399E-04	1.799E-04
$PM_{2.5}$	9.400E-04	1.117E-02	3.470E-05	2.603E-05
Acetaldehyde	1.706E-06	1.031E-02	4.143E-08	3.107E-08
Acrolein	2.054E-07	6.392E-04	4.988E-09	3.741E-09
Benzene	1.841E-05	2.011E-02	5.834E-07	4.375E-07
Benzo(a)pyrene	7.733E-08	5.442E-06	2.749E-09	2.061E-09
1,3-Butadiene	0.000E+00	4.552E-03	0.000E+00	0.000E+00
Formaldehyde	3.803E-06	4.492E-03	9.237E-08	6.928E-08

The Park-n-Ride parking lot passenger vehicle emissions at Bowesville station were estimated assuming a different type of operation during AM peak hour and PM peak hour. It was assumed in the morning that the only type of emission occurring would be vehicles entering the parking lot, traveling an average distance to find a parking spot, and idling for 30 seconds prior to shutting off their engines. In the PM peak hour, it was assumed that those same operations would occur, with the addition of emissions from a cold-engine start. To remain realistically conservative, a generic vehicle distribution was applied to each of the AM and PM assumed periods of operation (5 AM – 12 PM, and 1 PM – 8 PM; with a peak AM hour occurring between 7 AM – 8 AM and a peak PM hour occurring between 5 PM – 6 PM). The assumed peak hour vehicle volume was then applied to each hour of the AM and PM periods, respectively. This method is explained in detail within Appendix D.

2.5 Dispersion Modelling

The calculated emissions and road traffic for each pollutant per study area link were modelled using AERMOD, an emission dispersion model developed by the U.S. EPA. The model is capable of predicting impacts from a variety of source types, including stationary sources (e.g. stacks), line-volume sources (e.g. roads), stationary volume sources (e.g. pile unloading), and area sources (e.g. waste water lagoons). This model was used instead of the U.S. EPA mobile source emission model, CAL3HQCR, due to the presence of idling and parking lot emissions from buses and passenger vehicles at both the Bowesville transit station and Limebank transit station. AERMOD predicts contaminant impacts using high level calculations based on the Gaussian dispersion model in conjunction with hourly meteorological data. A five-year meteorological data set of the Ottawa region was pre-processed by the MECP for direct use in AERMOD for the years 1996-2000 using raw meteorological data from surface and upper air meteorological stations close to the study area. For each link and area source, a worst-case hourly profile of emissions and source data was input into the model. AERMOD source, meteorological, and terrain input data is described in the following sections.

2.5.1 Source Parameters

Three types of sources were used to estimate emissions from the Bowesville and Limebank transit stations and Trillium Line rail extension: point sources (idling Stadler FLIRT trains), Line-Volume sources (vehicle travel within transit stations and Trillium Line moving locomotives), and area sources (vehicle idling and parking lots). The source-specific input data for point sources, line-volume sources, and area sources are presented in Table 2.9, Table 2.10, and Table 2.11, respectively.

Table 2.9: Point Source Input Parameters

Link ID	Release Height (m)	Exit Temp. (°C)	Stack Inside Diameter (m)	Exit Flow Rate (m^3/s)	Exit Velocity (m/s)
Idling Trains at Bowesville	4.2	139	0.150	0.1699	9.61
Idling Trains at Limebank	4.2	139	0.150	0.1699	9.61

Table 2.10: Line-Volume Source Input Parameters

Link ID	Release Height [1] (m)	Plume Height [2] (m)	Plume Width (m)	Initial Sigma Z (m)	Initial Sigma Y (m)
Running Trains	4.2	4.37	19	2.03	8.84
Running Buses at Bowesville	2.975	5.95	8.59	2.77	4.00
Running Buses at Limebank	2.975	5.95	8.59	2.77	4.00

Notes:
(1) Train release height was set to the height of the train cars, as provided by Stadler for the FLIRT Ottawa Trillium Line trains.
(2) Train plume height was calculated using SCREEN3 with accurate exhaust parameters provided by Stadler for the FLIRT Ottawa Trillium Line trains.

Table 2.11: Area Source Input Parameters

Link ID	Release Height [1,2] (m)	Length of X Side (m)	Length of Y Side (m)	Orientation Angle from North (m)	Initial Vertical Dimension [3] (m)
Buses Idling at Bowesville	3.5	30	80	63	1.628
Buses Idling at Limebank	3.5	15	116	62.84	1.628
Park-n-Ride Lot	0.5	~155	~138	~62	0.698
PPUDO at Bowesville	0.5	10	60	62	0.698
PPUDO at Limebank	0.5	14.12	22.80	-24.31	0.698

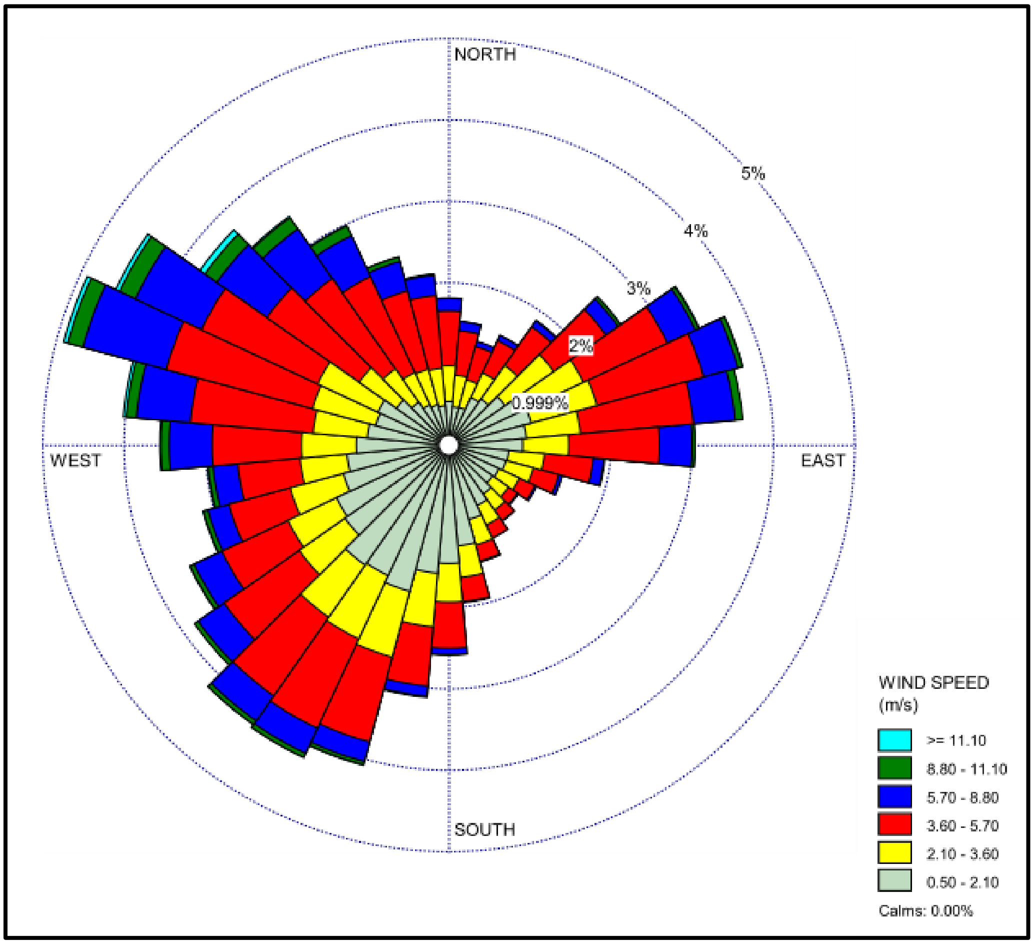
Notes:
(1) Assumed average height of a passenger vehicle is 1.5 m with an exhaust release height of 0.5 m
(2) Assumed average height of an OC Transpo bus is 3.5 m, with an exhaust release at the same height
(3) Initial vertical dimension was calculated using the assumed vehicle height divided by 2.15

2.5.2 Meteorology

Five years of pre-processed regional meteorological data from 1996-2000 for the Ontario Eastern region (Ottawa, Peterborough, Belleville) was obtained from the MECP. This dataset uses raw meteorological data collected from the Ottawa airport surface station (station ID 6101000), and the corresponding upper-air station located in Maniwaki (station ID 7034480).

The data is generally accepted by the MECP for Environmental Assessment and Air Quality Assessment purposes. The wind rose for the five (5) year period showing wind direction (blowing from) and wind speed is presented in Figure 2.2. The prevalent wind direction is blowing from the southwest and northwest.

Figure 2.2: Wind Rose for Eastern Region, Ontario



2.5.3 Terrain

Digital elevation model (DEM) data were obtained from the MECP. The DEM data were used to include effects of terrain in the dispersion modelling source and receptor impacts. The terrain used is from the Ottawa region DEM data set: tiles 1353_4 and 1354_4.

3. ASSESSMENT OF CUMULATIVE IMPACTS

A local air quality impact assessment was conducted to determine maximum cumulative contaminant concentrations. The modelled worst-case hourly concentrations due to combined emissions from trains, OC Transpo buses, and passenger vehicles were combined with background concentrations for each contaminant to determine cumulative maximum concentration at sensitive and critical receptors. For any contaminants showing an exceedance of one or more standards, a frequency analysis was conducted to estimate the potential period of exposure.

3.1 NO_2 Assessment using Ozone Limiting Method (OLM)

The concentration of nitrogen dioxide (NO_2) in the atmosphere is affected by the reaction of nitrous oxide (NO) with ozone (O_3), which is a by-product of mobile vehicle fuel combustion. The atmospheric reaction of NO with ozone is demonstrated as follows:

$$\mathbf{NO + O_3 \rightarrow NO_2 + O_2}$$

It is assumed that the rate of conversion of NO to NO_2 is controlled by the availability of ozone in the ambient atmosphere. This principle is called the “ozone limiting method” (OLM). Using the same principles, given a high enough concentration of ozone in the ambient atmosphere, all of the emitted NO emissions will convert to NO_2 and disperse in the same way as other intert combustion products from mobile vehicles.

According to NO_X studies done by the U.S. EPA, emissions of NO_X from combustion are primarily in the form of NO (U.S. EPA, 1999). Modelled concentrations of NO_X were therefore used along with ambient measured concentrations of background ozone levels from nearby MECP and Environment Canada monitoring stations to calculate the concentrations of NO_2 at a given sensitive receptor. The Québec Ministry of the Environment published a technical guide for calculating atmospheric concentration of NO_2 using the OLM method (Couture, 2008), described as follows:

- If the concentration (part per million, ppm) of NO is lower than that of ozone ($[NO] < [O_3]$ or, more precisely, $[O_3 > 0.9\ [NO_X]$), then we assume that all of NO was converted to NO_2 : $[NO_2] = [NO_X]$

- If the concentration (ppm) of NO is greater than that of ozone ($[NO] > [O_3]$), then the concentration of NO equal to the concentration (ppm) of ozone is converted to NO_2 : $[NO_2] = [O_3] + 0.1*[NO_X]$

The concentration of ambient ozone was taken as the overall average of the maximum 90^{th} percentile value of measured ozone concentrations at the NAPS Ottawa Downtown (NAPS ID 060104), Ottawa Central (NAPS ID 060106), and Gatineau-Hull (NAPS ID 050204) for a three-year period from 2013 to 2015
(Table 3.1).

Table 3.1: Local Ambient Ozone Levels

			90^{th} Percentile Concentrations (ppb)				
Contaminant	Averaging Period (hour)	Data Source	2014	2015	2016	Maximum	Average
O_3	1	NAPS	41	42	41	42	41
	24	NAPS	38	39	37	39	38
	Annual	NAPS	27	24	23	27	25

The modelled concentration of NO_X for the Future Build-Out conditions (2031) and the resulting calculated NO_2 concentration using the OLM method are shown in Table 3.2.

Table 3.2: NO_2 Calculation Using OLM Method

Scenario	Averaging Period (hour)	Modelled NOx Concentration (ppb)	Background O_3 Concentration (ppb)	OLM NO_2 Concentration (ppb)	OLM NO_2 Concentration ($\mu g/m^3$)
2031 Build-Out	1	48	41	46	86.1
	24	14	38	14	25.4
	Annual	3	25	3	4.73

3.2 Cumulative Maximum Receptor Impacts

Table 3.3 shows the predicted pollutant concentrations through modelling, including background air quality levels, evaluated at all selected sensitive receptors within the study area. The maximum receptor concentrations are compared to the respective time averaging period air quality threshold from either AAQC or CAAQS standards. The maximum impacts for each receptor are shown in Appendix F for all pollutants.

Table 3.3: Cumulative Concentrations – Future Build-Out Conditions (2031)

Averaging Period	Pollutant	Background Level ($\mu g/m^3$) (3)	Modelled Concentration (Maximum) ($\mu g/m^3$)	Cumulative Concentration (Maximum) ($\mu g/m^3$)	Air Quality Threshold ($\mu g/m^3$)	Maximum Impacted Receptor
1-hour	**NO_2**	**29.54**	**71.64**	**101.18**	**79**	**R14**
	CO	344	1864	2208	36,200	R14
	Acrolein	1.374	0.3332	1.707	4.5	R14
8-hour	CO	344	687	1031	15,700	R16
24-hour	NO_2	26.90	25.41	52.31	200	R12
	PM_{10}	22.84	2.115	24.95	50	R16
	$PM_{2.5}$	12.33	1.409	13.74	27	R16
	Benzo(a)pyrene	**0.00015**	**0.00038**	**0.00053**	**0.00005**	**R16**
	Acetaldehyde	2.539	0.8779	3.417	500	R16
	Acrolein	0.0311	0.0817	0.1128	0.4	R16
	Benzene	0.7127	1.310	2.023	2.3	R16
	Formaldehyde	1.225	1.357	2.582	65	R12
	1,3-Butadiene	0.0571	0.2922	0.3493	10	R16
Annual	NO_2	13.11	4.728	17.84	23	R12
	$PM_{2.5}$	7.667	0.2193	7.886	8.8	R12
	Benzo(a)pyrene	**0.00008**	**0.00004**	**0.0001**	**0.00001**	**R16**
	Benzene	**0.4372**	**0.1316**	**0.5688**	**0.45**	**R16**
	1,3-Butadiene	0.0306	0.0288	0.0594	2	R16

Notes:

(1) NO_2 is represented using the MOVES emission rate for NO_X; it is converted to NO_2 concentration using the ozone limiting method (OLM).

(2) Air Quality Threshold for fine particulate ($PM_{2.5}$) is based on the 98^{th} percentile ambient measurement (24-hour), annually averaged over three years. This standard is referenced from the appropriate year of

the Canadian Ambient Air Quality Standards (CAAQs): 2020 CAAQs for the 2031 Future No-Build and Build-out year. The CAAQs are voluntary objectives.

(3) 1 hour, 8 hour, and 24 hour ambient concentrations for the contaminants were obtained from the 90th percentile of hourly measurements from representative air quality monitoring stations. Annual ambient concentrations for the contaminants were obtained from the mean measurements at the representative air quality monitoring stations.

(4) Exceedances to air quality thresholds are shown in **red**.

From the results shown in Table 3.3, it is clear that benzene and benzo(a)pyrene both exceed their respective air quality limits. This is due in part to the existing presence of high level background concentrations in the area, and in part to the modelled contributions from the project. For example, though the background levels of benzo(a) pyrene already exceed the applicable air quality thresholds, the modelled concentrations are also significant exceeding contributors. Nitrogen oxide also exceeds the stringent 2025 air quality limit, which was introduced this year by the CQAAS. The frequency of exceedance for the 24 hour and 1 hour averaging periods is provided in further detail in Section 3.3. Isopleths showing the areas of highest impact for all averaging periods exceeded are provided in Appendix A.

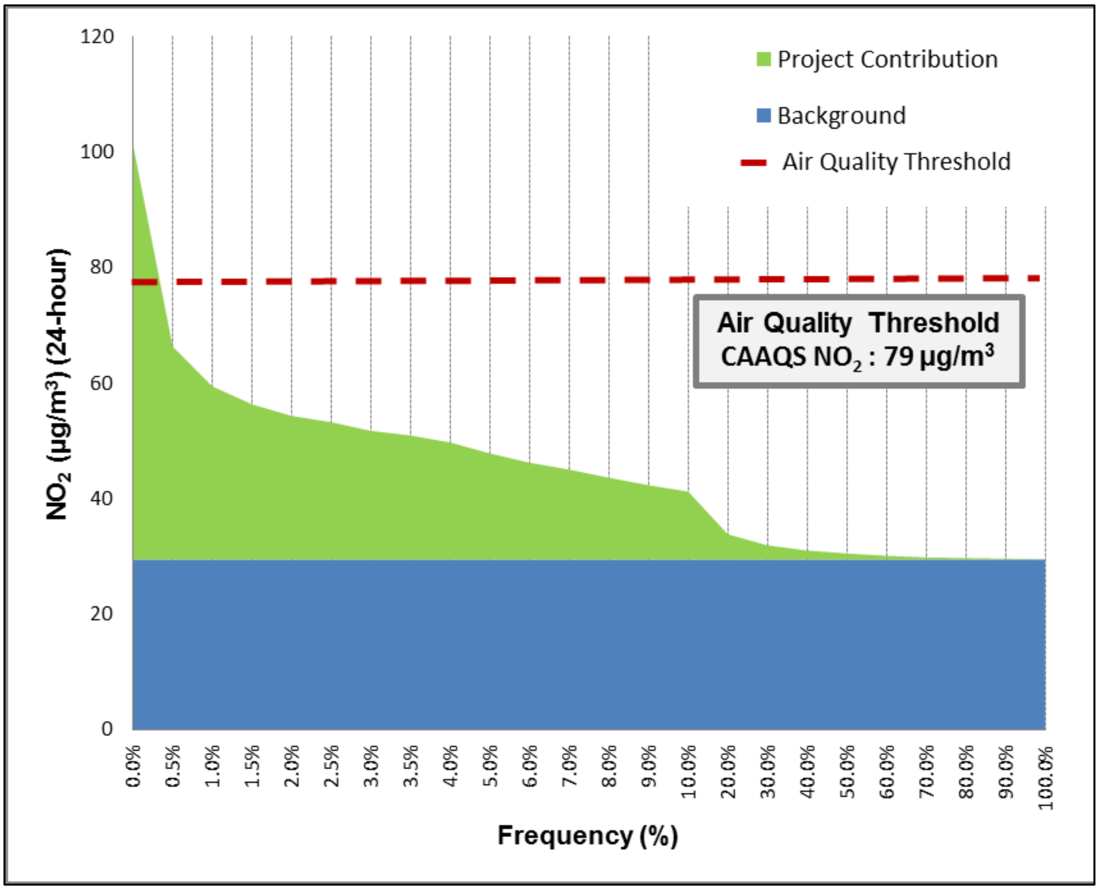
3.3 Frequency Analysis

For the Future Build Scenario (2031) a series of frequency analysis were conducted to estimate the potential period of exposure for contaminants which exceeded their respective time averaging period air quality standards at the most impacted receptor. The impacts from both modelled and background air quality were included in this assessment to show the relative contribution from the project emissions. Each of the following figures shows the percentage of time at which the most impacted receptor is experiencing any given concentration, with the respective air quality standard limits noted for reference.

3.3.1 1-Hour Average NO_2

Figure 3.1 shows the frequency analysis curve that represents the percentage of time at which the most impacted receptor is experiencing a given concentration of NO_2 averaged over a 1-hour period, in relation to the relevant air quality standard. The contribution from background air quality is shown in blue, while the contribution of the project is shown in green. The figure shows that project emissions are contributing more than 40% of the cumulative concentration only 4% of the time. It also shows that project emissions are contributing less than 10% of the cumulative concentration for 80% of the time.

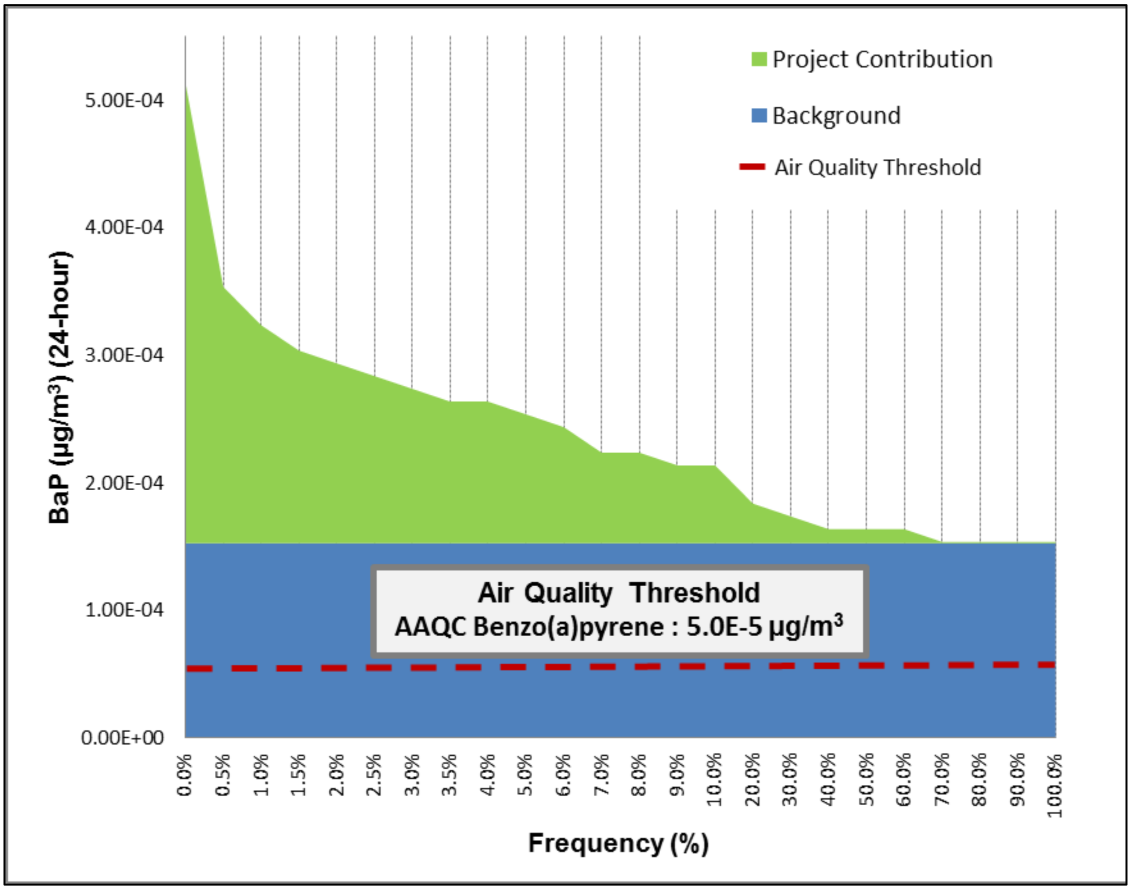
Figure 3.1: Frequency Analysis at the Most Impacted Receptor: 1-hr NO_2



3.3.2 24-Hour Average Benzo(a)pyrene

Figure 3.2 shows the frequency analysis curve that represents the percentage of time at which the most impacted receptor is experiencing a given concentration of benzo(a)pyrene averaged over a 24-hour period, in relation to the relevant air quality standard. The contribution from background air quality is shown in blue, while the contribution of the project is shown in green. The figure shows that project emissions are contributing more than 40% of the cumulative concentration only 5% of the time. It also shows that project emissions are contributing less than 12% of the cumulative concentration for 70% of the time.

Figure 3.2: Frequency Analysis at the Most Impacted Receptor: 24-hr BaP



3.4 Regional Air Quality and Greenhouse Gas Impacts

The annual emissions from the project were estimated for key air quality impact pollutants and greenhouse gases (GHG) in order to determine regional impact. The analysis was conducted by comparing the net emissions from the Bowesville transit station, Limebank transit station, and interconnecting rail line to the transportation (rail) sector annual emissions in both Ontario and Canada. The analysis focused on criteria air contaminants (CAC) NO_2, CO, and $PM_{2.5}$, which are contributors to smog, as well as GHGs. Table 3.4 shows the relative CAC contributions of the project compared to the Ontario and Canada rail transportation sector CAC contributions.

Table 3.4: Regional Emissions Compared to Project Emissions (2031)

Contaminant	Future Build-Out (2031) Scenario (tonnes)	Rail Transportation Emissions (Ontario: 2031) (tonnes)	% Project Contribution	Rail Transportation Emissions (Canada: 2031) (tonnes)	% Project Contribution
NO_X	31.25	24,138	0.13%	110,000	0.03%
CO	325.0	3,508	9.26%	16,000	2.03%
$PM_{2.5}$	1.570	564	0.28%	2,500	0.06%

Notes:
(1) Source: Environment Canada, 2018 Air Pollutant Emission Inventory (APEI) for the rail transportation sector, showing results for the most recent complete year of data (2016).
(2) NO_2 is expressed as NOx in the APEI.

Mobile vehicles emit the following GHGs in significant amounts:

- Carbon dioxide (CO_2);
- Methane (CH_4); and
- Nitrous oxide (N_2O).

Total GHG emissions were calculated using a combination of MOVES emission rates and total annual traffic projections. MOVES is capable of calculating atmospheric carbon dioxide (CO_2), Methane (CH_4), and Nitrous oxide (N_2O) emissions varying with vehicle class, speed, and emission process type (i.e. running emissions, starting emissions, etc.). Annual total GHG emissions were calculated by combining the grams per second (g/s) emission rates derived from MOVES County Scale and Project Scale output for each of the GHG pollutants with the projected annual source usage to extrapolate an annual emission.

Individual greenhouse gases have differing abilities to absorb heat in the atmosphere. These varying heat absorption properties are quantified by an individual global warming potential (GWP) factor for each contaminant which converts the mass of a GHG to the representative equivalent mass of CO_2 ($CO_{2\ eq}$). The GWPs are calculated based on the amount of heat trapping potential that would result from the emission of 1 kg of a given GHG to the emission of 1 kg of CO_2. GWPs for various GHG compounds are defined by Environment Canada in their *Technical Guidance on Reporting Greenhouse Gas Emissions* (2016) document, summarized for compounds of interest below in Table 3.5.

Table 3.5: Greenhouse Gas 100-year GWP

Greenhouse Gas	100-year GWP
Carbon dioxide (CO_2)	1
Methane (CH_4)	25
Nitrous oxide (N_2O)	298

Currently there are no GHG emission standards in Canada or the United States on a per-source basis. However, Ontario's Climate Change Update, published in 2014[1], outlines GHG targets for various industrial sectors, including the Transportation sector. Figure 11 of the 2014 Climate Change Update report shows historical and projected megatons (Mt) of $CO_{2\ eq}$ produced by the transportation sector. The Project contributions of GHG in the Air Quality Assessment year (2021) were compared to the projected $CO_{2\ eq}$ contributions from the Ontario Transportation sector, shown below in Table 3.6.

Table 3.6: Greenhouse Gas (GHG) Emissions Compared to Project GHG Emissions (2031)

Contaminants	Future Build-Out (2031) Scenario (tonnes)	Projected Rail Transportation Emissions (Ontario: 2031) (Mt)	% Project Contribution	Rail Transportation Emissions (Canada: 2016) (Mt)	% Project Contribution
CO_2	2348	--	--	--	--
N_2O	0.081	--	--	--	--
CH_4	0.491	--	--	--	--
$CO_{2,}eq$	2384	56	0.004%	173	0.001%

Notes:

1. (1) Mt = Megatons
2. (2) $CO_{2,}eq$ was calculated using GWP conversion for N_2O and CH_4
3. (3) Ontario GHG projected emissions for 2031 sourced from the MECP's "Ontario's Climate Change Update, 2014" Figure 11, Page 23.
4. (4) Canada GHG emissions for 2016 were sourced from the "National Inventory Report 1990-2016 GHG Sources and Sinks in Canada, Part 3"

[1] MECP's "Ontario's Climate Change Update 2014" accessed March 24, 2017
https://dr6j45jk9xcmk.cloudfront.net/documents/3618/climate-change-report-2014.pdf

4. MITIGATION MEASURES

4.1 During Operation

The implementation of this Trillium Line rail extension is anticipated to provide an overall net benefit to the Air Quality of the City of Ottawa. Increased accessible public transit options reduce the number of individual passenger vehicles travelling through arterial roads within outlying communities and traveling within the city core. This reduces overall traffic and congestion, especially during high volume periods of travel during the morning and afternoon.

The modelled cumulative results presented in Table 3.3 show an air quality threshold limit exceedance of nitrogen oxide, benzene, and benzo(a)pyrene. The exceedances of benzo(a)pyrene, benzene, and nitrogen oxides are attributed to both of their respective existing background concentrations, and also to the emissions from the project. The frequency of exceedance presented in Figure 3.1 for nitrogen oxides at the most impacted receptor shows that cumulative impacts from both the project contributions and background air quality exceeds the applicable air quality threshold less than 1% of the time.

Reductions in project contribution may be achieved by implementing a “no idling” policy at each station for passenger vehicles, and reducing the idling time of both trains and buses as much as possible. The City of Ottawa already has policies of this nature in place, as described within their Idling Control By-law (No. 2007-266).

4.2 During Construction Activity

Construction activity creates and releases fine particulates and traces of other vapours into the surrounding community. Both construction workers and members of the general public residing near any construction site may be affected by the release of these contaminants. It is therefore recommended to control the creation and release of particulates, especially during hot and dry weather, as typically occurs during the summer months. Construction activities which potentially prove most impactful to the local air quality include, but are not limited to:

- Clearing and grubbing;
- Grading and rock blasting;
- Road and surface paving;
- Storage of granular material;
- Structure construction/deconstruction; and
- Mobile on-site equipment.

As shown in Figure 2.2 Section 2.5.2, the prevailing winds blow from the southwestern direction and northwest direction. The worst-case impact to the local community and on-site workers during construction activity would occur during periods of low-velocity surface wind characteristics and stable atmospheric conditions, which would promote minimal local dispersion for particulates and other contaminants at ground level. Therefore, the most impacted area by any construction activity would be expected to be located northeast and southeast of the construction site.

Factors that affect the local impacts of construction activity include the proximity of a receptor to the construction site, the hours of operation of the construction site, the number of machines running or activities occurring on a construction site at any given time, and the meteorological conditions at which those activities or operations occur. When considering mitigation strategies and practices, special consideration should be given to predominant wind directions, and operation during early morning and evening hours which typically have lower dispersion and wind activity. Special care should also be taken near areas zoned as Open Space, Conservation.

Exposure to construction related emissions can be mitigated by the following:

- Ensuring all mobile equipment is in good condition, properly and regularly maintained, and compliant with applicable federal and provincial regulations for off-road diesel engines;
- Ensuring all machinery is maintained and operated in accordance to manufacturer's specification;
- Locating stationary equipment (i.e. generators, compressors, etc.) as far away from sensitive receptors as practical;
- Ensuring stationary and mobile equipment are not operated during early morning (before 6 AM, or sunrise) or evening periods (after 8 PM, or sunset) as often as practical;
- Implementing a Dust Management Plan for the duration of the construction phase, which includes practices to minimize fine particulate release from mobile equipment, materials handling, and wind erosion; and
- Ensuring that the areas most impacted by particulate levels are vegetated to reduce the cumulative particulate impacts.

In addition, the MECP recommends the *Cheminfo Services Inc. Best Practices for the Reduction of Air Emissions from Construction and Demolition Activities* Report prepared for Environment Canada (March 2005) for a comprehensive list of fugitive dust prevention and air emission control measures.

5. REFERENCES

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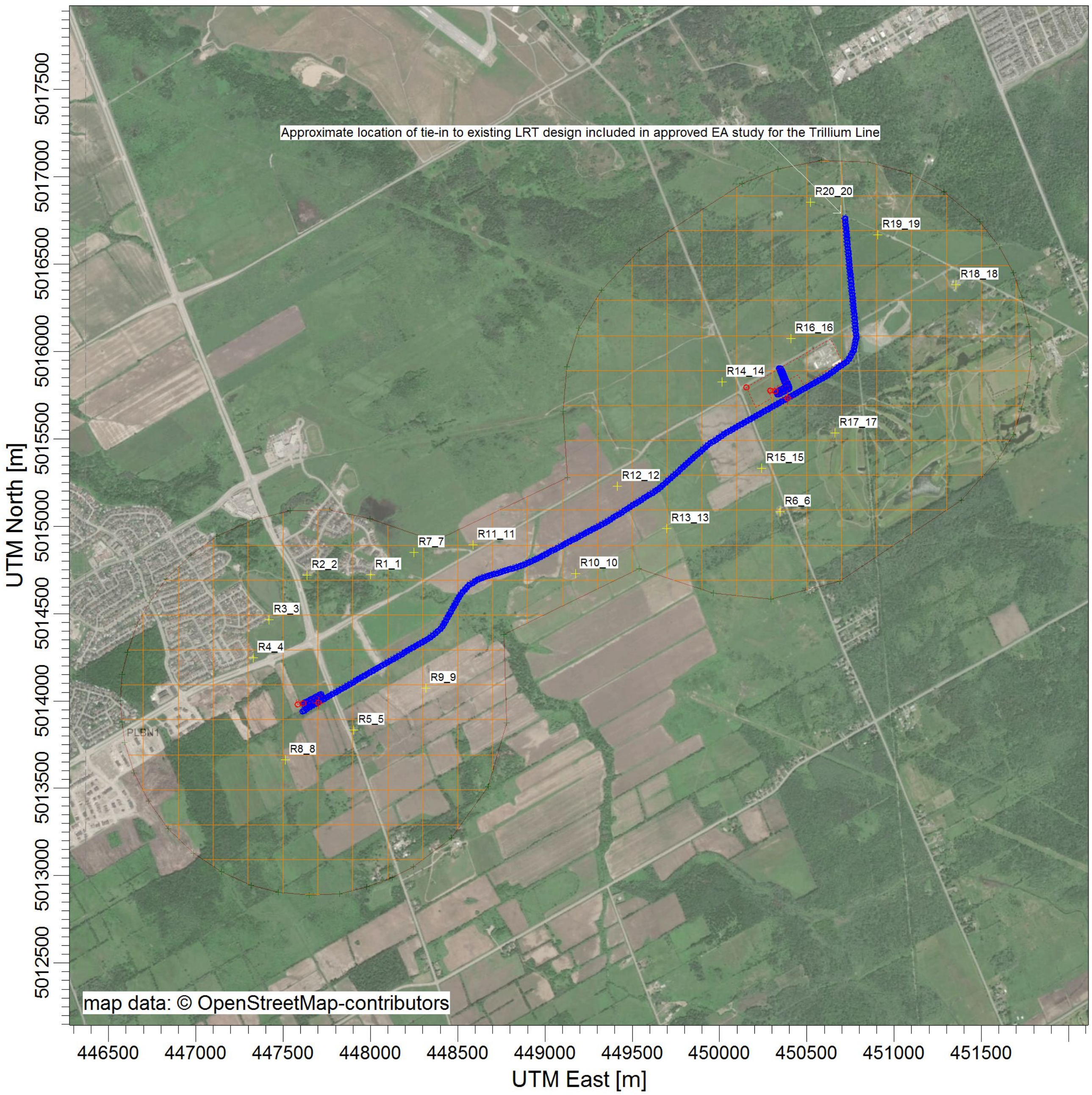
APPENDIX A
FIGURES

PROJECT TITLE:

Figure A1: OLRT Trillium Limebank Extension Receptors



COMMENTS:

Orange grid represents 200 m x 200 m uniform cartesian receptors.

Yellow labeled indicators represent discrete cartesian receptors for both existing residences and potential future developments.

SOURCES:

10

RECEPTORS:

793

COMPANY NAME:

AECOM Canada Ltd.

SCALE: 1:36,705

0 — 1 km

DATE:

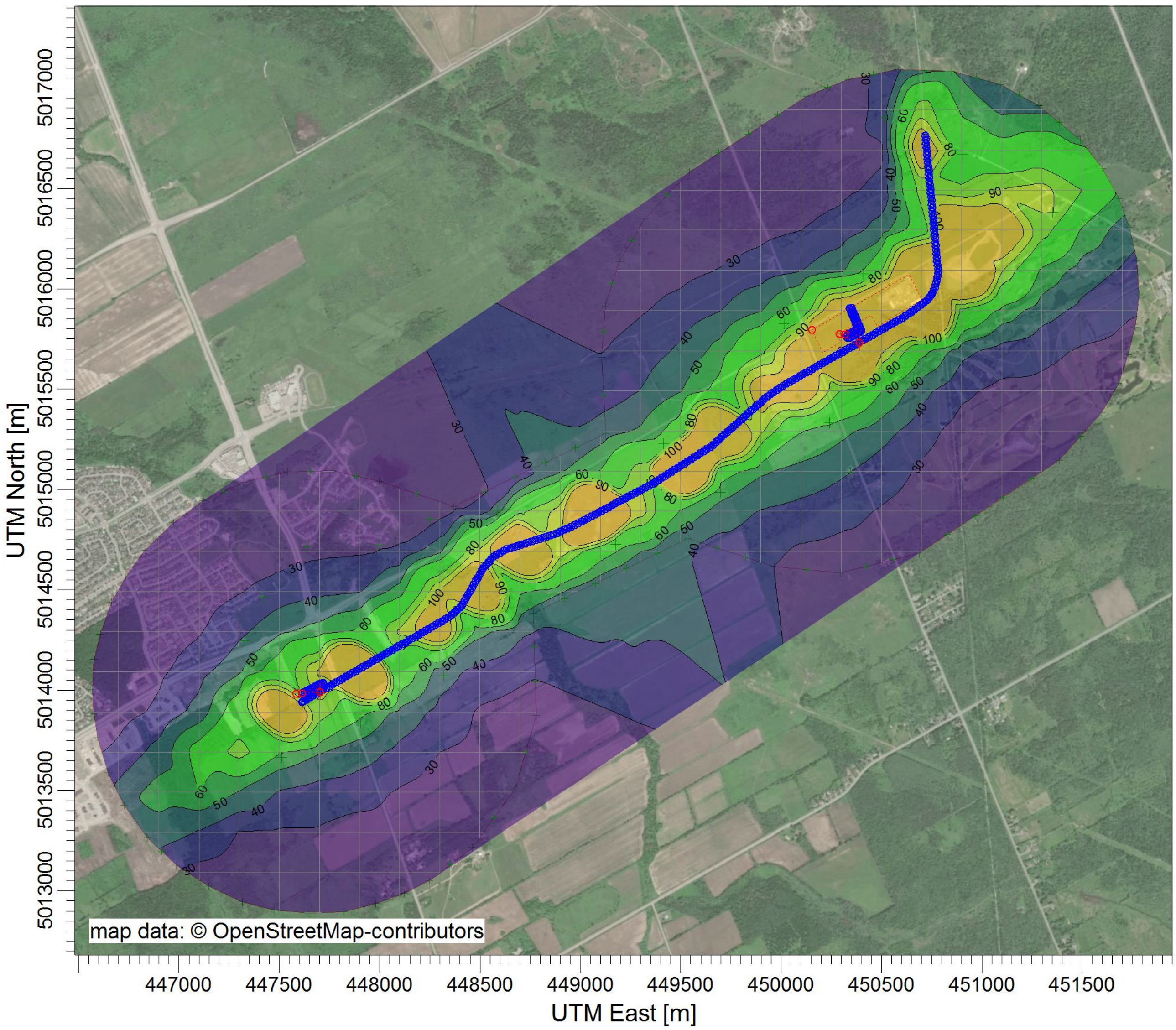
8/24/2018

PROJECT NO.:

60444198

PROJECT TITLE:

Figure A2: OLRT Trillium Limebank Extension NOx 1-hr Isopleth



PLOT FILE OF HIGH 1ST HIGH 1-HR VALUES FOR SOURCE GROUP: ALL

ug/m^3

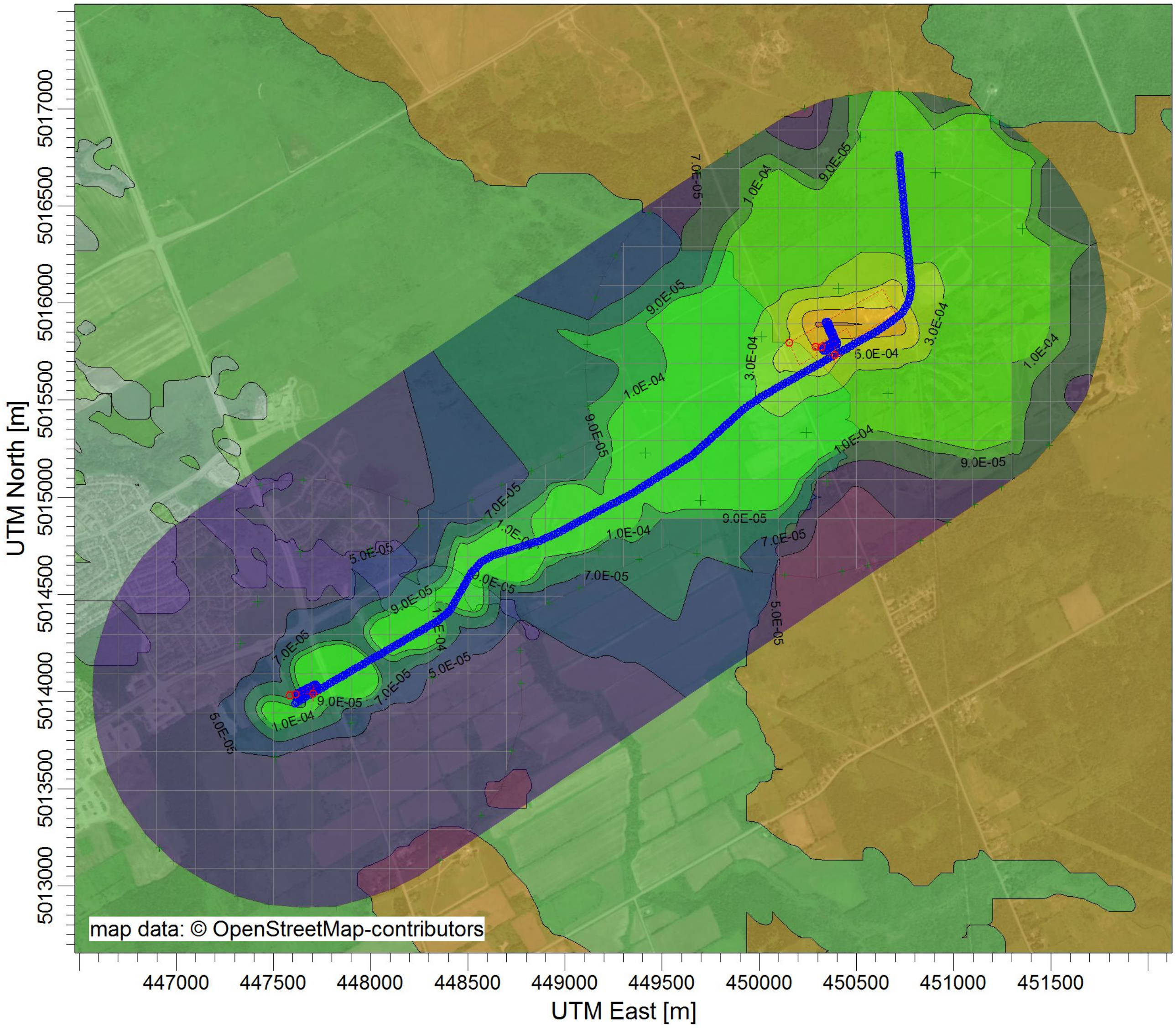
Max: 209 [ug/m^3] at (450299.15, 5015691.63)

16 | 30 | 40 | 50 | 60 | 80 | 90 | 100 | 200 | 209

COMMENTS:	SOURCES:	COMPANY NAME:	
CAAQS Compliance in conjuction with existing background air quality levels for NO2 are approximately shown at the 50 ug/m3 isopleth mark	**10**	**AECOM Canada Ltd.**	
	RECEPTORS: **793**		AECOM
	OUTPUT TYPE: **Concentration**	SCALE: 1:34,381 (0 — 1 km)	
	MAX: **209 ug/m^3**	DATE: **8/23/2018**	PROJECT NO.: **60444198**

PROJECT TITLE:

Figure A3: OLRT Trillium Limebank Extension Benzo(a)pyrene 24-hr isopleth



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: ALL

ug/m^3

Max: 9.3E-04 [ug/m^3] at (450299.15, 5015891.63)

2.0E-05 5.0E-05 7.0E-05 9.0E-05 1.0E-04 3.0E-04 5.0E-04 7.0E-04 9.0E-04 9.3E-04

COMMENTS:

SOURCES:

10

COMPANY NAME:

AECOM Canada Ltd.

RECEPTORS:

793

AECOM

OUTPUT TYPE:

Concentration

SCALE:

1:35,507

0 1 km

MAX:

9.3E-04 ug/m^3

DATE:

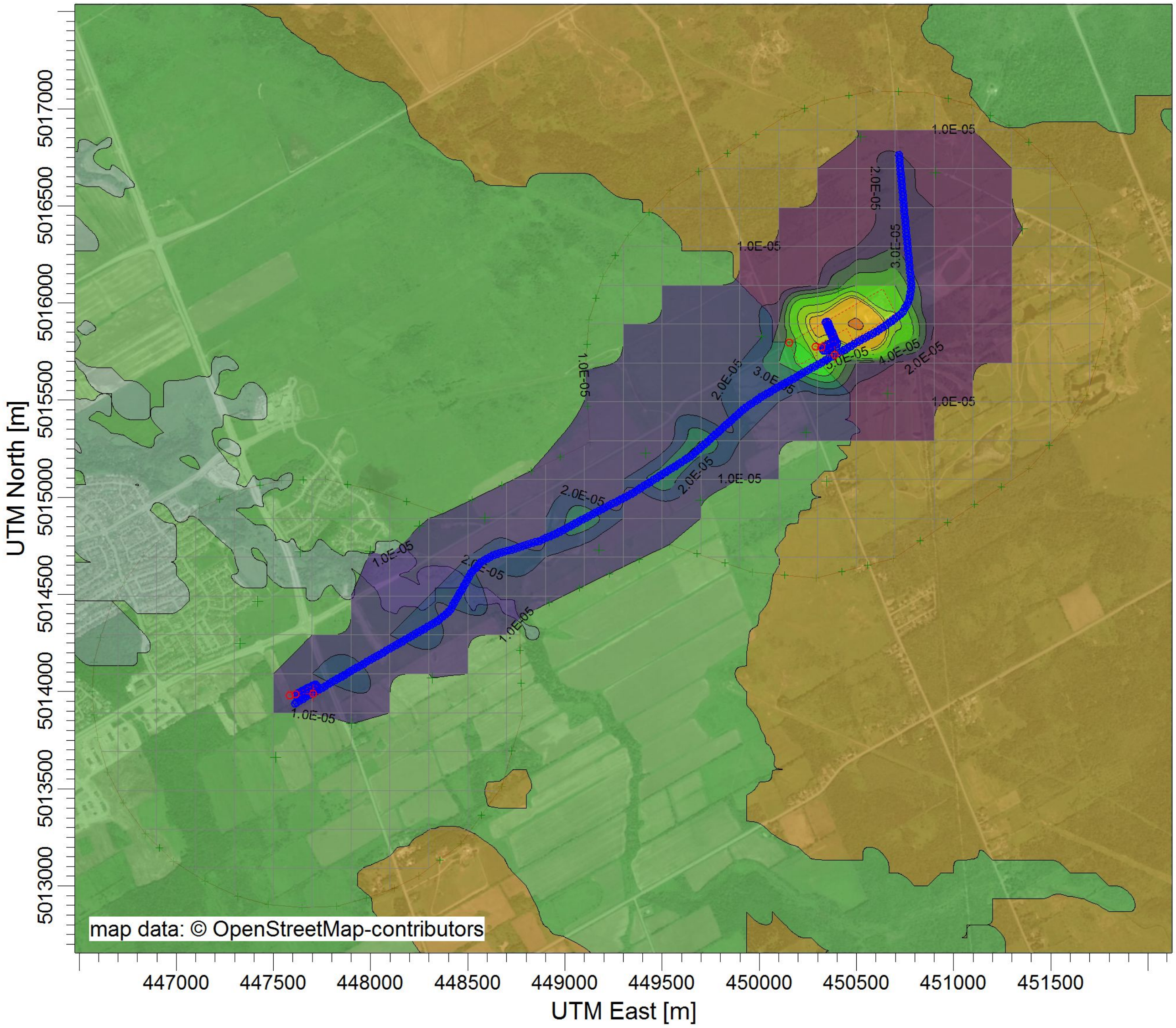
8/23/2018

PROJECT NO.:

60444198

PROJECT TITLE:

Figure A4: OLRT Trillium Limebank Extension Benzo(a)pyrene annual isopleth



PLOT FILE OF ANNUAL VALUES AVERAGED ACROSS 5 YEARS FOR SOURCE GROUP: ALL   ug/m^3

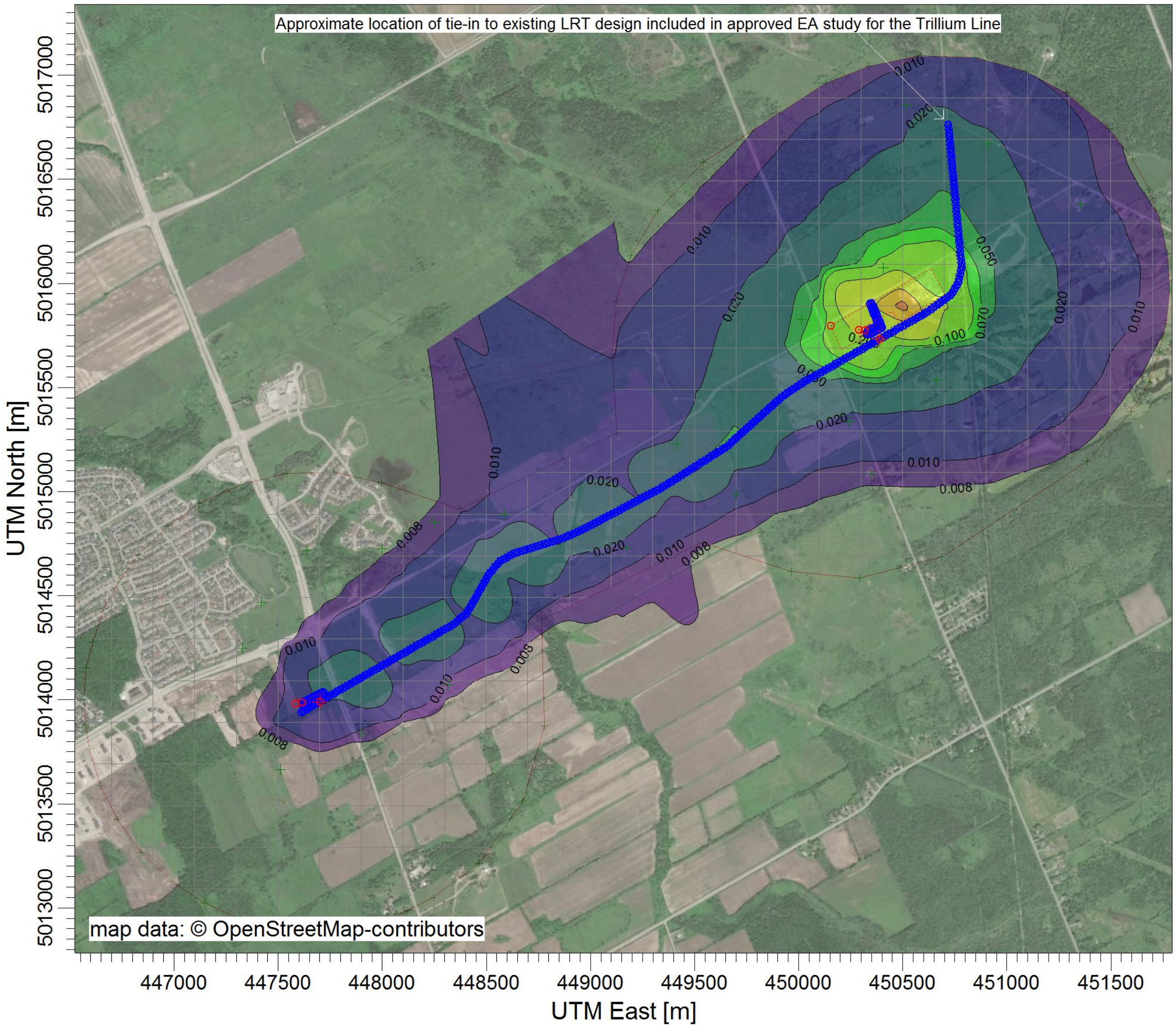
Max: 2.3E-04 [ug/m^3] at (450499.15, 5015891.63)

1.0E-05 2.0E-05 3.0E-05 4.0E-05 5.0E-05 7.0E-05 9.0E-05 1.0E-04 2.0E-04 2.3E-04

COMMENTS:	SOURCES: **10**	COMPANY NAME: **AECOM Canada Ltd.**	
	RECEPTORS: **793**		AECOM
	OUTPUT TYPE: **Concentration**	SCALE: 1:35,507 0 — 1 km	
	MAX: **2.3E-04 ug/m^3**	DATE: **8/23/2018**	PROJECT NO.: **60444198**

PROJECT TITLE:

Figure A5: OLRT Trillium Limebank Extension Benzene Annual Isopleth



PLOT FILE OF ANNUAL VALUES AVERAGED ACROSS 5 YEARS FOR SOURCE GROUP: ALL ug/m^3

Max: 0.776 [ug/m^3] at (450499.15, 5015891.63)

0.008 0.010 0.020 0.050 0.070 0.100 0.200 0.500 0.700 0.776

COMMENTS:

SOURCES:

10

COMPANY NAME:

AECOM Canada Ltd.

RECEPTORS:

793

OUTPUT TYPE:

Concentration

SCALE: 1:33,143

0 1 km

MAX:

0.776 ug/m^3

DATE:

8/23/2018

PROJECT NO.:

60444198

APPENDIX B
ZONING MAPS

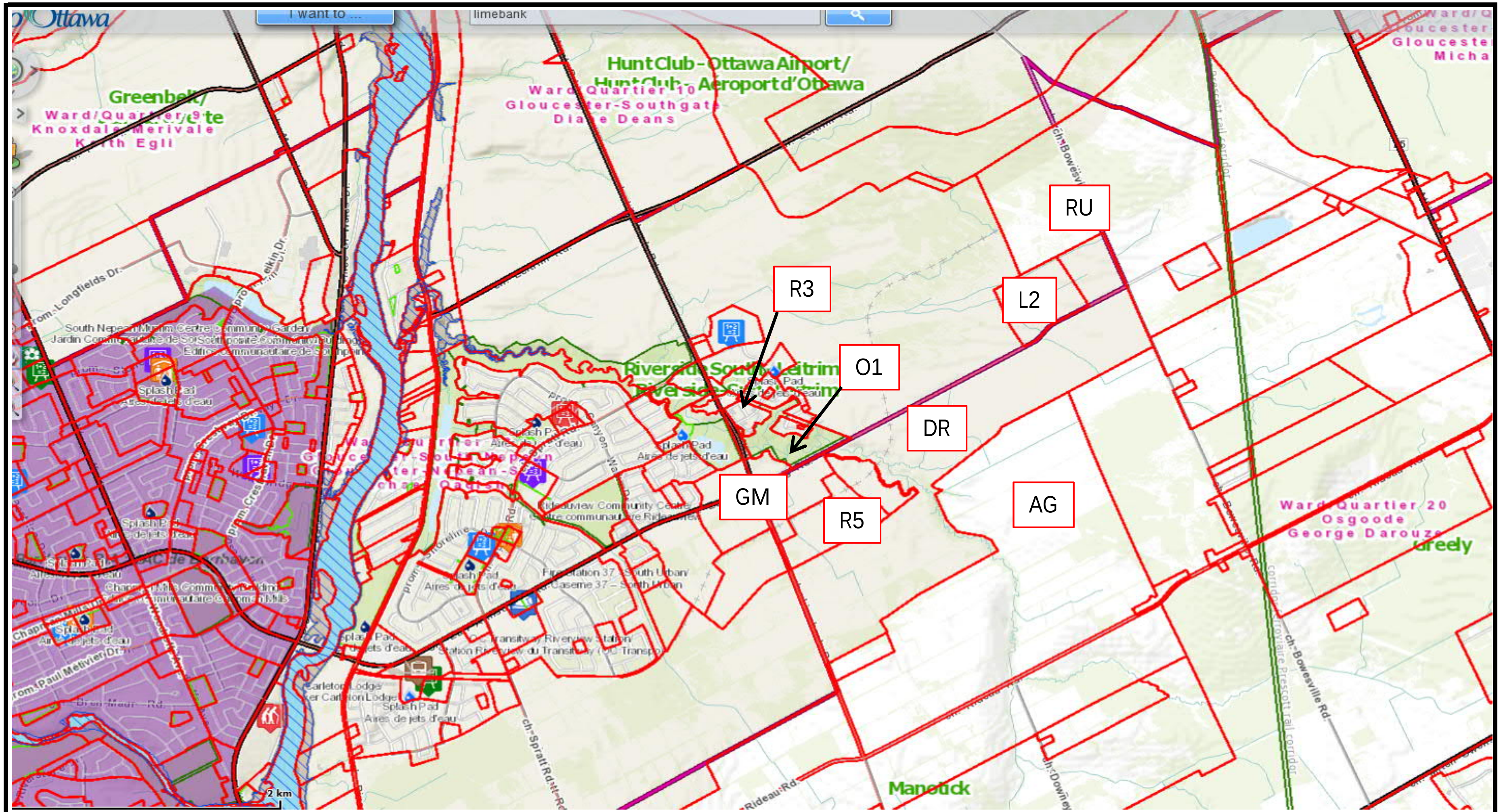


Figure B1 : Ottawa Zoning Map, OLRT Trillium Line

Notes:

[1] Zoning Map from City of Ottawa (http://maps.ottawa.ca/geoOttawa/?layer=Zoning)

[2] Zoning Codes as indicated on this map may be found in the following written sections, provided by the City of Ottawa online zoning map

AECOM

AG - Agricultural Zone (Sec. 211-212)

Purpose of the Zone

The purpose of the AG - Agricultural Zone is to:

*(1) recognize and permit agricultural uses in areas designated **Agricultural Resource Area** in the Official Plan;*

(2) *restrict the range of permitted uses to agricultural, forestry and related accessory uses in order to preserve these prime agricultural lands from loss to other uses;*

(3) regulate uses in a manner that respects the character of the area and minimizes land use conflicts; and,

(4) identify, through the use of subzones, those existing farm lots having lot area and lot width minimums that are less than the minimums required in the principal Agricultural zone.

211. In the AG Zone:

Permitted Uses

(1) The following uses are permitted subject to the following:

(a) the provisions of subsections 211(3) to (5);

(b) a maximum of 3 guest bedrooms is permitted in a **bed and breakfast**; (By-law 2008-326)

(c) a maximum of 10 persons are permitted in a **group home**; (By-law 2008-326)

agricultural use, *see Part 2, Section 62*
bed and breakfast*, see Part 5, Section 121*
one **detached dwelling**
environmental preserve and educational area
equestrian establishment
forestry operation
group home, *see Part 5, Section 125*
home-based business, *see Part 5, Sections 127 and 128*
home-based daycare, *see Part 5, Section 129*
kennel, see *Part 3, Section 84*
secondary **dwelling** unit**,** *see Part 5, Section 133*

Conditional Permitted Uses

(2) The following conditional uses are permitted subject to the following:

(a) the provisions of subsection 211(3) to (5);

(b) provided that they are located on the same lot and are accessory or ancillary to an **agricultural use** and the main detached **dwelling**;

(c) provided that they serve as housing for farm help and the minimum lot size must be 10 hectares;

(d) provided that in addition to the main detached **dwelling** there is a maximum of either: i) one additional detached **dwelling** and two **mobile homes** or **bunk house dwelling**, or, ii) three **mobile homes** or **bunk house dwelling**;

bunk house dwelling

DR - Development Reserve Zone (Sec. 237-238)

Purpose of the Zone

The purpose of the DR - Development Reserve Zone is to:

(1) *recognize lands intended for future urban development in areas designated as* ***General Urban Area*** *and* ***Developing Communities*** *in the Official Plan, and future village development in areas designated as* ***Village*** *in the Official Plan;*

(2) *limit the range of permitted uses to those which will not preclude future development options; and*

(3) *impose regulations which ensure a low scale and intensity of development to reflect the characteristics of existing land uses.*

(4) *permit limited lot creation on existing public streets in villages that will not preclude future development options in the DR3 – Development Reserve Subzone 3.* (By-law 2013-58)

237. In the DR Zone,

Permitted Uses

(1) The following uses are permitted subject to:

(a) the provisions of subsection 237(2);

agricultural use
emergency service
environmental preserve and education area
forestry operation
group home, *see Part 5, Section 125*
home-based business, *see Part 5, Section 127*
marine facility
one detached **dwelling** accessory to a permitted use
park
secondary dwelling unit,*see Part 5, Section 133*
urban agriculture (By-law 2017-148)

Zone Provisions

(2) The zone provisions are set out in Table 237 below.

TABLE 237– DR ZONE REGULATIONS

I Zoning Mechanisms	II Zone Provisions
(a) Minimum Lot Width (m) (b) Minimum Lot Area (m^2)	No minimum

GM - General Mixed Use Zone (Sec. 187-188)

Purpose of the Zone

The purpose of the GM – General Mixed-Use Zone is to:

*(1) allow residential, commercial and institutional uses, or mixed use development in the **General Urban Area** and in the **Upper Town, Lowertown and Sandy Hill West Character Areas** of the **Central Area** designations of the Official Plan;*

(2) limit commercial uses to individual occupancies or in groupings in well defined areas such that they do not affect the development of the designated Traditional and Arterial Mainstreets as viable mixed-use areas;

(3) permit uses that are often large and serve or draw from broader areas than the surrounding community and which may generate traffic, noise or other impacts provided the anticipated impacts are adequately mitigated or otherwise addressed; and

(4) impose development standards that will ensure that the uses are compatible and complement surrounding land uses.

187. In the GM Zone,

Permitted Non-Residential Uses

(1) The following non-residential uses are permitted subject to:

(a) the provisions of subsections 187(3), (4) and (5).

animal care establishment
animal hospital
artist studio
bank
bank machine
catering establishment}
click and collect facility (By-law 2016-289)
community centre
community health and resource centre
convenience store
day care
diplomatic mission, *see Part 3, Section 88*
drive-through facility
emergency service
funeral home
home-based busines, *see Part 5, Section 127*
home-based day care**,** *see Part 5, Section 129*
instructional facility
library
medical facility
municipal service centre
office
payday loan establishment (By-law 2017-302)
personal service business

L2 - Major Leisure Facility Zone (Sec. 175-176)

Purpose of the Zone

The purpose of the L2-Major Leisure Facility Zone is to:

(1) *accommodate major, urban City-wide sports, recreational and cultural facilities addressed under the Major Urban Facilities policies of the Official Plan;*

(2) *permit a broad range and intensity of leisure, recreational, cultural and related uses; and*

(3) *allow a moderate density and scale of development.*

175. In the L2 Zone:

Permitted Uses

(1) The following uses are permitted subject to:

(a) the provisions of subsection 175(2).

amusement park
community centre
community health and resource centre
day care
fairground
golf course
library
museum
park
place of assembly
recreational and athletic facility
retail food store, limited to a farmers' market (By-law 2016-134)
school
sports arena
theatre
urban agriculture, *see Part 3, Section 82* (By-law 2017-148)

(b) the following use is permitted only in association with amusement park, library, sports arena and theatre:

drive-through facility (OMB Order #PL080959 issued March 18, 2010)

(c) Where an outdoor farmers' market is located on a lot with another use, the primary or subzone provisions do not apply and the farmers' market may only by located in a:

(i) parking lot;

(ii) yard abutting a parking lot; and,

(iii) front or corner side yard;

associated with the other use. (By-law 2016-134)

Zone Provisions

(2) The zone provisions are set out in Table 175 below.

TABLE 175 - L2 ZONE REGULATIONS

I Zoning Mechanisms	II Zone Provisions
(a) Minimum Lot Width (m)	No minimum
(b) Minimum Lot Area (m^2)	No minimum
(c) Minimum Front Yard Setback (m)	7.5
(d) Minimum Rear Yard Setback (m)	
(e) Minimum Interior Side Yard Setback (m)	
(f) Minimum Corner Side Yard Setback (m)	
(g) Maximum Height (m)	11
(h) Maximum Lot Coverage (%)	75

(3) For other applicable provisions, see Part 2- General Provisions, Part 3- Specific Use Provisions and Part 4-Parking, Queuing and Loading Provisions.

L2 SUBZONES

176. In the L2 Zone, the following subzones apply:

L2A SUBZONE - NEPEAN SPORTSPLEX

(1) In the L2A Subzone, the provisions set out in Table 176 below apply.

TABLE 176 - L2A SUBZONE REGULATIONS

I Zoning Mechanism	II Regulation
(a) Minimum Yard Setbacks (m)	10
(b) Maximum Lot Coverage (%)	35

L2B SUBZONE - CENTRAL AREA FACILITIES

(2) In the L2B Subzone,

(a) the following additional uses are permitted:

restaurant
retail store

(b) Table 175 does not apply.

L2C SUBZONE - LANSDOWNE

(3) In the L2C Subzone,

(a) The following uses are permitted provided they are located on the

O1 - Parks and Open Space Zone (Sec. 179-180)

Purpose of the Zone

The purpose of the O1-Parks and Open Space Zone is to:

*(1) permit parks, open space and related and compatible uses to locate in areas designated as **General Urban Area**, **General Rural Area**, **Major Open Space**, **Mixed Use Centre**, **Village, Greenbelt Rural** and **Central Area** as well as in **Major Recreational Pathway areas** and along **River Corridors** as identified in the Official Plan, and*

(2) ensure that the range of permitted uses and applicable regulations is in keeping with the low scale, low intensity open space nature of these lands.

179. In the O1 Zone:
Permitted Uses

(1) The following uses are permitted subject to:

(a) the provisions of subsection 179(2).

environmental preserve and education area
park
urban agriculture, *see Part 3, Section 82* (By-law 2017-148)

(b) a **retail food store, limited to a farmer's market** is a permitted use in the O1A, O1B, O1D, O1E, O1F, O1G, O1H subzones, subject to:

(i) no building or structure other than one farmer's market stand is permitted;

(ii) the farmer's market stand is not subject to the primary or subzone provisions, however the maximum height is 3.5 metres and the maximum size of the farmer's market stand is 28 square metres, and;

(iii) a farmer's market stand may only be located in a parking lot or in a front or corner side yard. (By-law 2016-135)

Zone Provisions

(2) The zone provisions are set out in Table 179 below.

TABLE 179 - O1 ZONE REGULATIONS

I Zoning Mechanisms	II Zone Provisions
(a) Minimum Lot Width (m)	No minimum
(b) Minimum Lot Area (m^2)	No minimum
(c) Minimum Front Yard Setback (m)	

R5 - Residential Fifth Density Zone (Sec. 163-164)

Purpose of the Zone

The purpose of the R5 - Residential Fifth Density Zone is to:

(1) allow a wide mix of residential building forms ranging from detached to mid-high rise apartment dwellings in areas designated as ***General Urban Area****,* ***Mixed Use Centre*** *or* ***Central Area*** *in the Official Plan;*

(2) allow a number of other residential uses to provide additional housing choices within the fifth density residential areas;

(3) permit ancillary uses to the principal residential use to allow residents to work at home and to accommodate convenience retail and service uses of limited size ;

(4) ensure that residential uses predominate in selected areas of the ***Central Area****, while allowing limited commercial uses;*

(5) regulate development in a manner that is compatible with existing land use patterns so that the mixed building form, residential character of a neighbourhood is maintained or enhanced; and (By-law 2009-392*)*

(6) permit different development standards identified in the Z subzone, primarily for areas designated as ***Developing Communities****, which promote efficient land use and compact form while showcasing newer design approaches.*

163. In the R5 Zone:

Permitted Uses

(1) The following uses are permitted uses subject to:

(a) the provisions of subsection 163 (3) to (18);

(b) a maximum of ten guest bedrooms in a bed and breakfast ;

(c) a maximum of ten residents are permitted in a group home. (By-law 2008-341)

(d) (By-law 2008-341)

apartment **dwelling**, low rise

apartment dwelling, mid-high rise (Subject to By-law 2014-292)
bed and breakfast, *see Part 5, Section 121*
detached **dwelling**
diplomatic mission, *see Part 3, Section 88*
duplex dwelling, *see Part 5, Section 138* (By-law 2010-307)
dwelling unit
group home, *see Part 5, Section 125*
home-based business, *see Part 5, Section 127*
home-based daycare, *see Part 5, Section 129*
linked-detached dwelling, *see Part 5, Section 138*(By-law 2010-307)
park
planned unit development, *see Part 5, Section 131*
residential care facility
retirement home, converted, *see Part 5, Section 122*
retirement home
rooming house
secondary dwelling unit, *see Part 5, Section 133*
semi-detached dwelling, *see Part 5, Section 138*(By-law 2010-307)
shelter, *see Part 5, Section 134*
stacked dwelling, *see Part 5, Section 138* (By-law 2010-307)
three-unit **dwelling**
townhouse dwelling, *see Part 5, Section 138* (By-law 2012-334) (By-law 2010-307) (By-law 2014-189)
urban agriculture, *see Part 3, Section 82* (By-law 2017-148) (By-law 2018-206)

Conditional Permitted Uses

(2) Conditional uses are also permitted in the R5 zone, subject to the following:

(a) they are listed in Column III of Table 164A; and

(b) they are subject to additional provisions as identified by the subscript in Column III of Table 164A, which refers to a number in Column I of Table 164B which sets out the additional provision.

Zone Provisions

(3) The zone provisions are set out in Table 164A and 164B. (By-law 2009-18)

(4) Where a planned unit development is permitted on a lot in the subzone, the provisions of Section 131 apply, and the associated subzone provisions identified in Table 164 A affecting permission of uses, minimum lot widths and lot areas, as well as minimum required setbacks apply to the whole of the lot, while the maximum height applies to each permitted dwelling type within the planned unit development.

(5) A diplomatic mission and group home that is not a prohibited use listed in Column II of Table 164A, is subject to the subzone provisions for a detached dwelling if included in Column IV, otherwise it will be subject to the subzone provisions for an apartment dwelling, low rise.

(6) A retirement home, rooming house, mixed use building and any other permitted non-residential use that is not a prohibited use listed in Column II of Table 164A, and that is four storeys or less in height, is subject to the subzone provisions for an apartment dwelling, low rise. A retirement home, rooming house, mixed use building and any other permitted non-residential use that is not a prohibited use listed in Column II of Table 164A and that is more than four storeys in height, is subject to the subzone provisions for

RU - Rural Countryside Zone (Sec. 227-228)

Purpose of the Zone

The purpose of the RU – Rural Countryside Zone is to:

*(1) accommodate agricultural, forestry, country residential lots created by severance and other land uses characteristic of Ottawa's countryside, in areas designated as **General Rural Area, Rural Natural Features** and **Greenbelt Rural** in the Official Plan;*

(2) recognize and permit this range of rural-based land uses which often have large lot or distance separation requirements; and

(3) regulate various types of development in manners that ensure compatibility with adjacent land uses and respect the rural context.

227. In the RU Zone:

Permitted Uses

(1) The following uses are permitted subject to the following:

(a) the provisions of subsection 227(2) to (5);

(b) a maximum of 10 guest bedrooms is permitted in a bed and breakfast

(c) a maximum of 10 persons are permitted in a group home,

(d) a maximum of 10 persons are permitted in a retirement home, converted

agricultural use, *see Part 2, Section 62*
animal care establishment
animal hospital
artist studio
bed and breakfast, *see Part 5, Section 121*
cemetery
detached **dwelling**
equestrian establishment
environmental preserve and educational area
forestry operation
group home, *see Part 5, Section 125*
home-based business, *see Part 5, Sections 127 and 128*
home-based day care, *see Part 5, Section 129*
kennel, *see Part 3, Section 84*
retirement home, converted, *see Part 5, Section 122*
secondary **dwelling** unit, *see Part 5, Section 133*

Zone Provisions

(2) In the RU Zone, development must comply with the provisions of Table 227:

TABLE 227 - RU ZONE PROVISIONS

	PROVISIONS		
I ZONING MECHANISMS	II AGRICULTURAL USE, EQUESTRIAN	III KENNEL	IV OTHER

APPENDIX C
STADLER TRAIN SPECIFICATIONS

RFVSO Reference: Part 2.2 a (i)

Proposal Document No.: 100.145a

Customer:	City of Ottawa
Tender Name:	Ottawa Stage 2 LRT Trillium Line Extension
Solicitation Number:	09717-55800-P01
Stadler-Document-No.:	522’617

Fuel Efficiency

Dynamic performance and Fuel consumption

Table of Contents

1 Introduction

Considering the Trillium Service Plan included at Annex I, we are obliged to provide the estimated annual fuel consumption assuming a continuous passenger load of AW1.

Requirements

Considering the Trillium Service Plan included at Annex I, and the alignment data, provide the estimated annual fuel consumption assuming a continuous passenger load of AW1. Provide substantiation of your analysis.

1.1 Abbreviations

AUX	Auxiliary operation systems
DMU	Diesel Multiple Unit
ED	Electro-Dynamic brake (motor brake)
FLIRT	Stadler Vehicle Family: Fast Light Innovative Regional Train
HVAC	Air condition unit

2 Fuel consumption simulation

2.1 Vehicle Performance

See document 100.150 showing accelerating, braking and driving diagrams as well as driving times in different load configurations.

2.2 Computer Simulation

Stadler performed a computer simulation assuming the following conditions:

- Limebank - Bayview – Limebank in neutral (low energy-consumption for HVAC) and winter (high energy-consumption for HVAC) conditions
- Dwell times as requested by the City of Ottawa are used for the calculations. Dwell times are stated in document 100.150.
- Maximal speed according to the sample line data

Simulation was done in this example for an AW1 load case. The assumptions for the vehicle are as per the data noted in the document 100.150. The real diesel consumption values might decrease, depending on weather and passenger load conditions.

Note: In the simulation, all acceleration and braking events are performed with maximum traction capability (highest rate of acceleration and deceleration) in order to attain the shortest travel time. This provides the operator with options of decreasing the rate of acceleration to reduce the fuel consumption. The fuel consumption can be further drastically reduced when the vehicle is operated with smooth acceleration and braking and reduced maximum speed but still maintaining the operation schedule.

3 Fuel Consumption

As per the above calculation the maximum fuel consumption in AW1 load condition will be around 4.3 liter/km while the average value will be approximately 3.4 liter/km (including long turn-around-times at Bayview and Limebank and with maximum acceleration/braking).

	Expected average Consumption	Maximum Consumption
Liter per km	3.4	4.3
Liter per roundtrip	130	164
Liter per day	1’950	2’460
Liter per year	712’000	897’000
Liter per year (whole fleet)	4’271’000	5’382’000

4 Revision History

Rev.	Change	Date	Created	Checked	Released
_	First Edition	30th. Aug. 2017	J. Rauprich	B. Schmid	K. Roth
a	Update 4 Diesel and new Service Plan	14th Jun. 2018	J. Rauprich	T. Pfeifer	K. Roth
b					
c					
d					

RFVSO Reference: Part 2.2 a (i)

Proposal Document No.: 100.150b

Customer:	City of Ottawa
Tender name:	Ottawa Stage 2 LRT Trillium Line Extension
Solicitation number:	09717-55800-P01
Stadler document number:	522,618

Propulsion and Braking System

Table of contents

1 Introduction

This document provides a description of the propulsion and braking system for the Stadler FLIRT³ DMU proposal for the Trillium Line Extension.

1.1 Requirement

Describe the proposed propulsion and braking systems. Describe the advantages in maintenance costs, annual fuel consumption and historical reliability offered by the systems proposed, considering the characteristics of the Trillium alignment.

1.2 Abbreviations

CAC	Charge air cooling
CAN	Controller Area Network
DC	Direct current
DMU	Diesel multiple unit
EMU	Electric multiple unit
ED brake	Electro-dynamic brake
EP brake	Electro-pneumatically controlled friction brake
EPA	Environmental Protection Act
ETV	Emergency transfer valve
FLIRT	Stadler vehicle family: Fast Light Intercity and Regional Train
GTW	Stadler vehicle family: Gelenktriebwagen (German for: articulated multiple unit train)
LPLV	Load-pressure-limiting valve
PEBB	Power Electronic Building Blocks
VCU	Vehicle Control Unit

1.1 Legal regulations, standards and guidelines

All standards, unless otherwise specified, have been applied in the versions current on the date of Stadler's offer.

IEC 60349-2:2008	Electric traction – Rotating electrical machines for rail and road vehicles – Part 2: Electronic converter-fed alternating current motors

1.2 References

No references.

1.3 Annexes

No annexes.

2 Description of the propulsion system

Stadler has a strong history having produced over 1,500 GTW and FLIRT trainsets in both EMU and DMU propulsion configuration. Our proposal to the City of Ottawa is based on our FLIRT DMU propulsion configuration. Originally built as an electrically powered vehicle, the FLIRT was re-designed to incorporate a diesel power plant in a separate car to become a DMU. The diesel-electric traction system enables the engines to always run at the optimal working point, reducing fuel consumption and simplifying control of the traction system. Furthermore, it enables recuperating part of the braking energy, resulting in a transportation system with minimized environmental impact.

2.1 General data

The Stadler DMU 4-car vehicle for the Trillium Line Extension consists of proven components and features the following properties:

Vehicle mass at AW1	178 t	
Vehicle mass at AW1 plus 3.3 Passengers per square meter		
	196 t	
Maximum speed	130 km/h	
Maximum diesel engine power	1920 kW	4 × 480 kW
Maximum power (at wheels) – traction *	1440 kW	4 × 360 kW
Continuous power (at wheels) **	1180 kW	4 × 295 kW
Gear ratio	1 : 5.347	
Wheel diameter (new/worn)	920/850 mm	
Starting tractive effort ***	172 kN	4 × 43 kN
Maximum power (at wheels) – braking	1800 kW	4 × 450 kW
Maximum electrical braking force***	–180 kN	4 × -45 kN
Max acceleration (0 to 13 km/h)***	0.75 m/s^2	
Mean acceleration 0 to 50 km/h***	0.65 m/s^2	
Mean acceleration 50 to 80 km/h***	0.30 m/s^2	

* = Power on wheel depends on auxiliary load; maximum power at wheel with no comfort auxiliary load.
** = Typical power at wheel; auxiliary load of 172 kVA/146 kW assumed.
*** = Adhesion factor of 0.25 and 1440 kW at wheel assumed

2.2 Power generation: engine generator set

The electrical energy for the offered vehicle is produced by burning fuel in diesel engines and converting the movement into electricity using generators. The engine generator sets are mounted in a separate Power Pack car. A separate car for the power generation keeps noise and vibrations away from the passenger compartments and allows for better accessibility to facilitate maintenance. Large doors in the outer shell and at the aisle allow access to the engines and generators from both sides. For an overview of the diesel engine compartment see Figure 1.

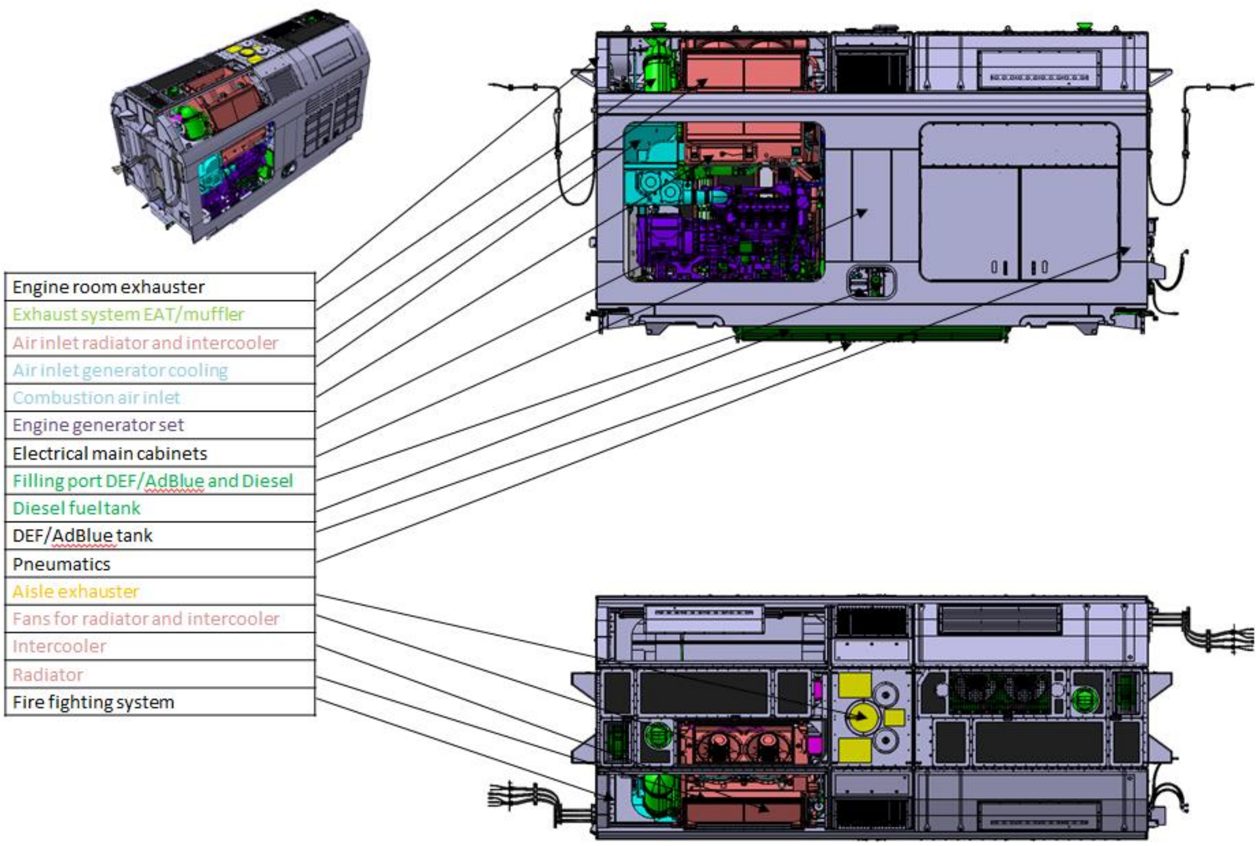


Figure 1: Overview of the Power Pack car

The diesel engines are chosen to minimize the impact on the environment. They are built to achieve high fuel efficiency and are certified to EPA Tier 4f emission standards. This requires exhaust emission after-treatment, which is monitored by sensors during operation. The motors are water-cooled, high-speed engines. They are equipped with a high-pressure injection system (Common Rail System), turbocharging and charge air cooling (CAC). Cold starting is possible down to a temperature of –40 degrees Celsius using cooling water and flame preheating. Without preheating, starting is possible down to –32 degrees Celsius. The engine compartment is protected by a fire suppression system.

Each diesel engine is connected to a standard design three-phase asynchronous generator. The diesel engine is either cranked via the generator or by means of a battery-powered starter motor. The generator is self-ventilated by an integrated fan rotating with the same speed as the shaft at all times. The generator temperature is measured by two Pt100 sensors. The generator is designed according to the IEC 60349-2 standard, and its isolation class is 220 (R).

2.3 Power converter

The electrical energy provided by the engine generator sets is processed in the power converter to be usable for propulsion and auxiliary equipment. There is one power converter in each end car of the vehicle. They are independent and of identical design, each of them powering one of the motor bogies (motor converter). Furthermore, they are equipped with auxiliary converters to power the common auxiliary network. An overview of the propulsion system is shown in Figure 2. Each propulsion system consists of:

- 2 × three-phase motor converters
- 1 × voltage limiter/brake chopper unit
- 1 × sine-filtered 3 × 480 V/60 Hz/220 kVA auxiliary converter
- 1 × controller unit
- 1 × pre-charge unit
- 2 × three-phase generator converters
- 1 × DC voltage link

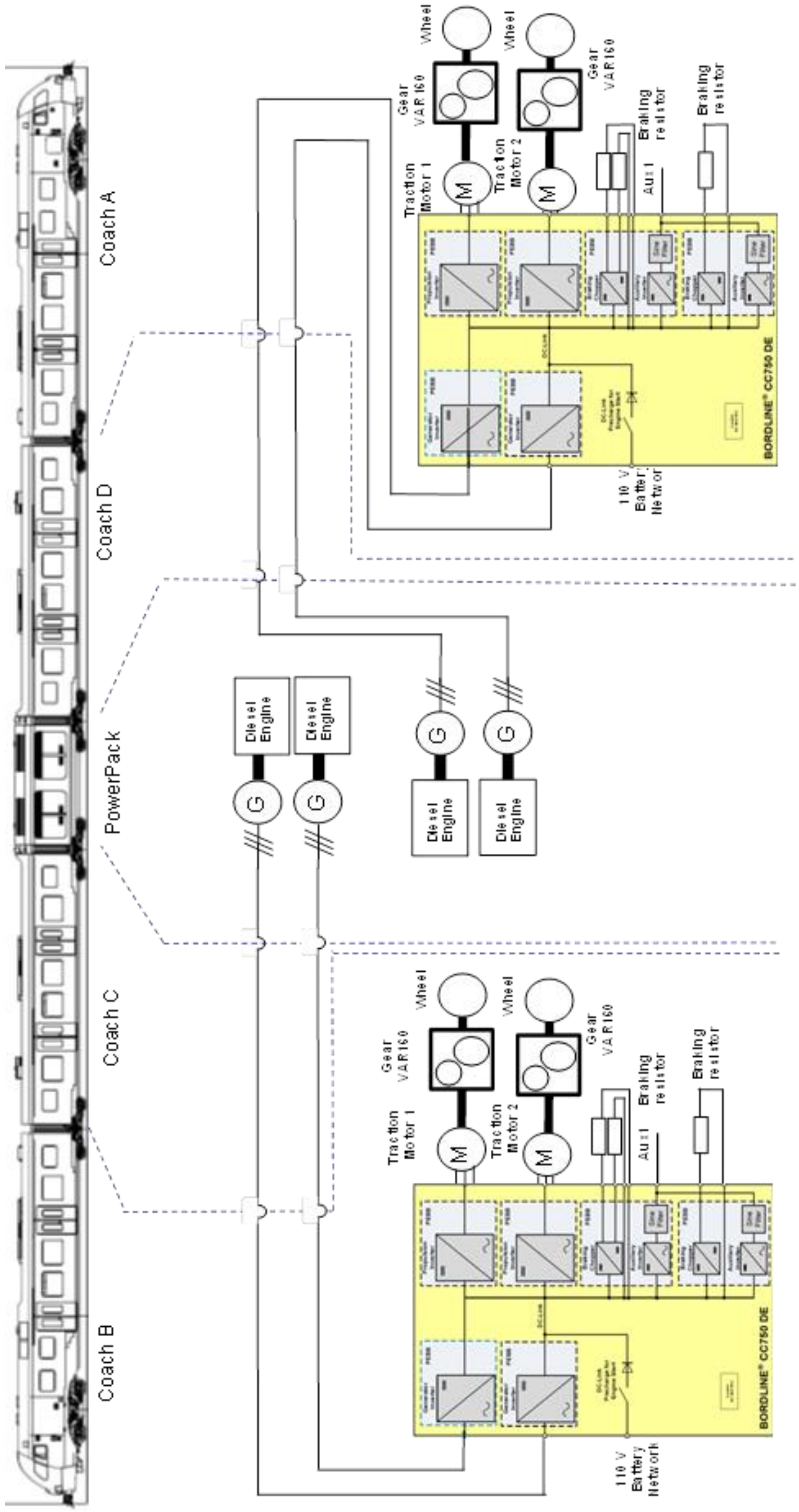


Figure 2: Block schematic of the propulsion system

2.4 Traction motor and gear

Four well-proven and highly efficient asynchronous traction motors are used (each motor generates a maximum power of 450 kW and continuous power of 300 kW). They are installed in the motor bogies positioned at the ends of the vehicle. Every traction motor is fed by its own motor converter. The motor temperature is measured by two Pt100 sensors. The motor is designed according to the IEC 60349 standard, and its isolation class is 220 (R).

During braking, the traction motors are used as generators to provide dynamic brake force. The energy gained is fed to the auxiliary systems (on-board network) to reduce total energy consumption. Surplus energy is directed to the brake resistor.

Identical traction motors are installed on other FLIRT DMU vehicles as, for example, on trains in Estonia, which have been in daily operation since the beginning of 2013 (> 1 million kilometres of service across the entire fleet); there, they have proven their reliability and robust design during harsh winter and hot summer conditions.

For power transfer between traction motors and wheels, two-stage spur gear VAR 160 transmissions are used. They are designed as fully suspended drive units and have a constant ratio of 1: 5.347 and no switching elements. The efficiency of the transmissions achieves up to 98%.

2.5 Brake resistor

To handle surplus energy, each power converter is joined to an external, roof-mounted brake resistor. The brake resistor is has natural-air-cooling. It is connected to the braking chopper of the power converter and is used to limit overvoltage on the converter DC link, to discharge the DC link capacitors and to dissipate excess energy that is generated during electro-dynamic braking.

A brake resistor with a high power rating is chosen to allow generous use of the ED brake in order to reduce wear of the EP brake.

2.6 Propulsion control

The control of the propulsion system is designed with the Vehicle Control Unit (VCU) at the highest level of the control hierarchy. The VCU detects the ground speed of the vehicle, controls the friction (EP) brake, observes the overall machine state and monitors energy consumption.

At a lower level of hierarchy, the diesel engine controller monitors the combustion process and the power generation of the engine.

The controller of the power converter regulates the motor and generator torque/flux, controls slip/slide of the powered wheels, steers the brake chopper and executes energy monitoring and protection functions.

For the communication between the different controllers, a vehicle bus (CAN) is used. It transduces in both directions and transmits different signals:

- Reference and actual values
- Torque
- Converter status
- Acceleration limits
- Vehicle ground and axle speed

2.7 Reliability of the propulsion system

Railway passengers expect a safe, reliable and comfortable ride. To conform to these wishes the proposed railway vehicle is designed in a way that even failures of mayor parts do not lead to a total standstill of the vehicle. This chapter describes the influence of failing of mayor traction components to the vehicles performance.

Redundancy refers to the duplication of critical components with the intention of increasing the reliability of the railway vehicle. On the other hand the duplication of all critical traction components would lead to an excessively heavy and expensive train. To combine redundancy with only modest increase of cost and weight STADLER follows the approach to use duplicate systems with less power. In normal operation all systems are working. If a critical component breaks a part of the traction system is switched off, all other parts are still working. Even though a critical component fails the vehicle will still be able to move under its own power, only the performance is limited.

In case of a failure, there is minimal impact on vehicle functionality. Different failure scenarios are shown in Table 1.

Failure scenario	Impact on traction chain	Impact on auxiliary supply
1 Diesel engine fails	Power reduction can occur Traction/ED brake effort still fully available	A minor reduction in power can occur
1 Generator fails	Power reduction can occur Traction/ED brake effort still fully available	A minor reduction in power can occur
1 DC link/converter control fails	50 % Traction effort available, ED brake compensated by EP brake	50% installed auxiliary supply available (total load: 180 kVA)
1 Traction motor fails	75% traction and ED brake effort available	No impact
1 Auxiliary supply block fails	No impact	75% installed auxiliary supply available (total load: 270 kVA)
1 Braking resistor fails	ED brake compensated by EP brake	No impact

Table 1: Failure scenarios of the propulsion system

Due to the redundancy of the System a single failure does not prevent the vehicle from moving under own power. None of those failures would cause a rescue operation. The worst case scenario is a failed DC link or converter control. In this case the available electrical power is reduced by 50% (for the propulsion as well as for the auxiliary supply). Dynamic performance would be reduced as well as the power for the HVAC. The vehicle would most likely not be able to meet the service plan and passenger comfort would be decreased. It would be reasonable to remove the train from service.

The other failures do not have such a drastic impact. The consequences would be dependent on different factors. A failure of an Auxiliary supply block for example would propably not cause any problem on a cold day, on a hot day however the performance of the HVAC-System would be downgraded. The reason is that the auxiliary system has to provide energy for the cooling system of the propulsion-system as well as for the HVAC-system.

2.8 Dynamic performance

2.8.1 Tractive effort versus speed chart

The power at wheel depends on the load on the auxiliary system. The charts assume a “typical” power of 1180 kW at wheel.

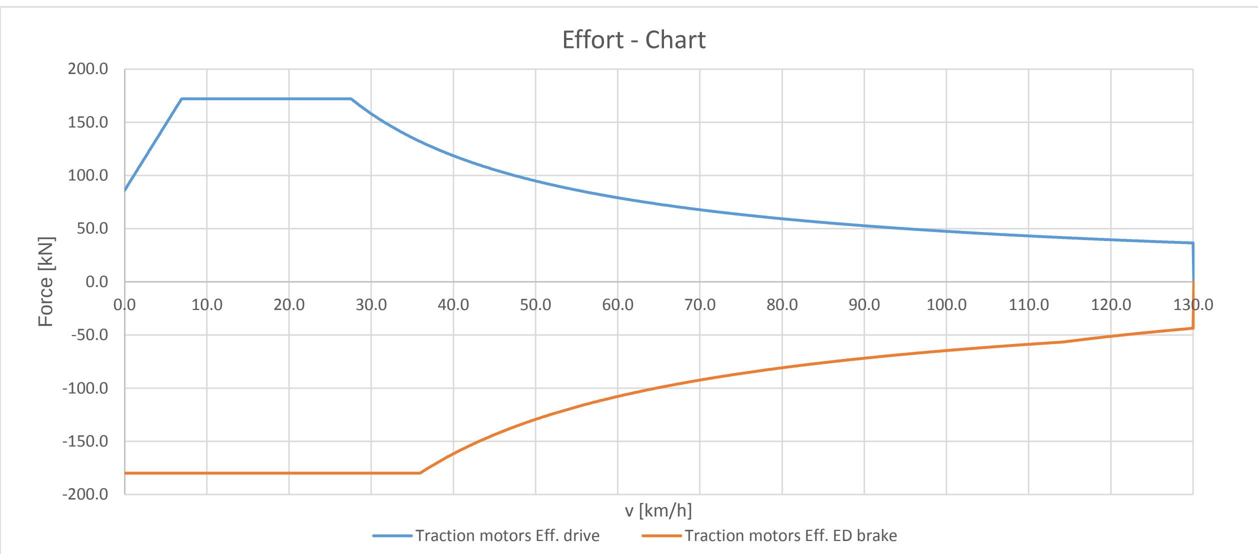


Figure 3: Tractive effort versus speed diagram[1]

On an inverter-controlled vehicle, the tractive effort is independent of wheel diameter.

[1] Assumptions: four-car DMU with semi-worn wheels (diameter: 885 mm).

2.8.2 Acceleration versus speed chart

The chart below shows the possible but uncompensated acceleration for the load cases AW0–AW3. Compensation would have to fix the maximum allowed acceleration to the curve of the AW3 case.

The mean acceleration from 0 to 50 km/h is approximately 0.65 m/s^2, while the mean acceleration from 50 to 80 km/h is approximately 0.30 m/s^2.

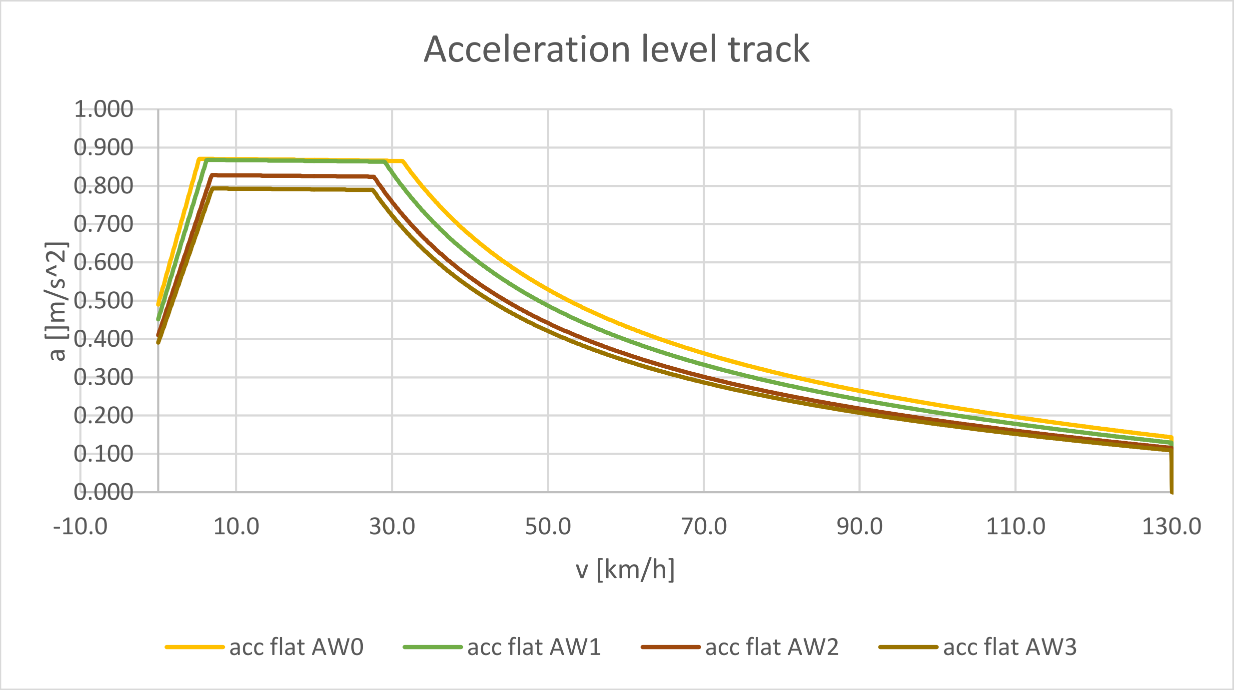


Figure 4: Acceleration versus speed diagram (level tangent track) at AW0 – AW3

3 Friction brake system

The brake system consists of proven components and includes three different braking methods: an electro-dynamic brake (ED), a pneumatic friction disc brake (EP) and a spring-applied/air release parking brake. Braking commands are initiated from the driver’s desk, utilizing the master controller or the emergency stop buttons, or remotely from the train control system, the Vehicle Control Unit (VCU) or with a train line command.

3.1 General

Each bogie has a local EP control system (see **Fehler! Verweisquelle konnte nicht gefunden werden.** and **Fehler! Verweisquelle konnte nicht gefunden werden.**). Air for the brake system is supplied by the brake pipe and the main reservoir pipe. Depending on the position of the emergency transfer valve (ETV), the electro-pneumatic (EP) or the automatic braking system is activated.

The ETV is controlled by the brake pipe pressure. When the brake pipe pressure is high, the ETV switches over and activates the EP braking system. When the brake pipe pressure is low or completely vented (in case of emergency braking), the ETV switches back to basic position and activates the automatic braking system. The direct EP brake is controlled electrically by the VCU with solenoid valves. The EP brake valves are also used for blended braking together with the ED brake. The load-pressure-limiting valve (LPLV) corrects the brake cylinder pressure according to the load of the vehicle in order to achieve a uniform deceleration rate, independent of whether the vehicle is loaded or empty. The load weight correction utilizes a pneumatic signal from the air suspension system. Each axle on the vehicle is protected with a wheel slide protection system consisting of electric protection valves. The vehicle can be towed with the braking system in the de-energized state.

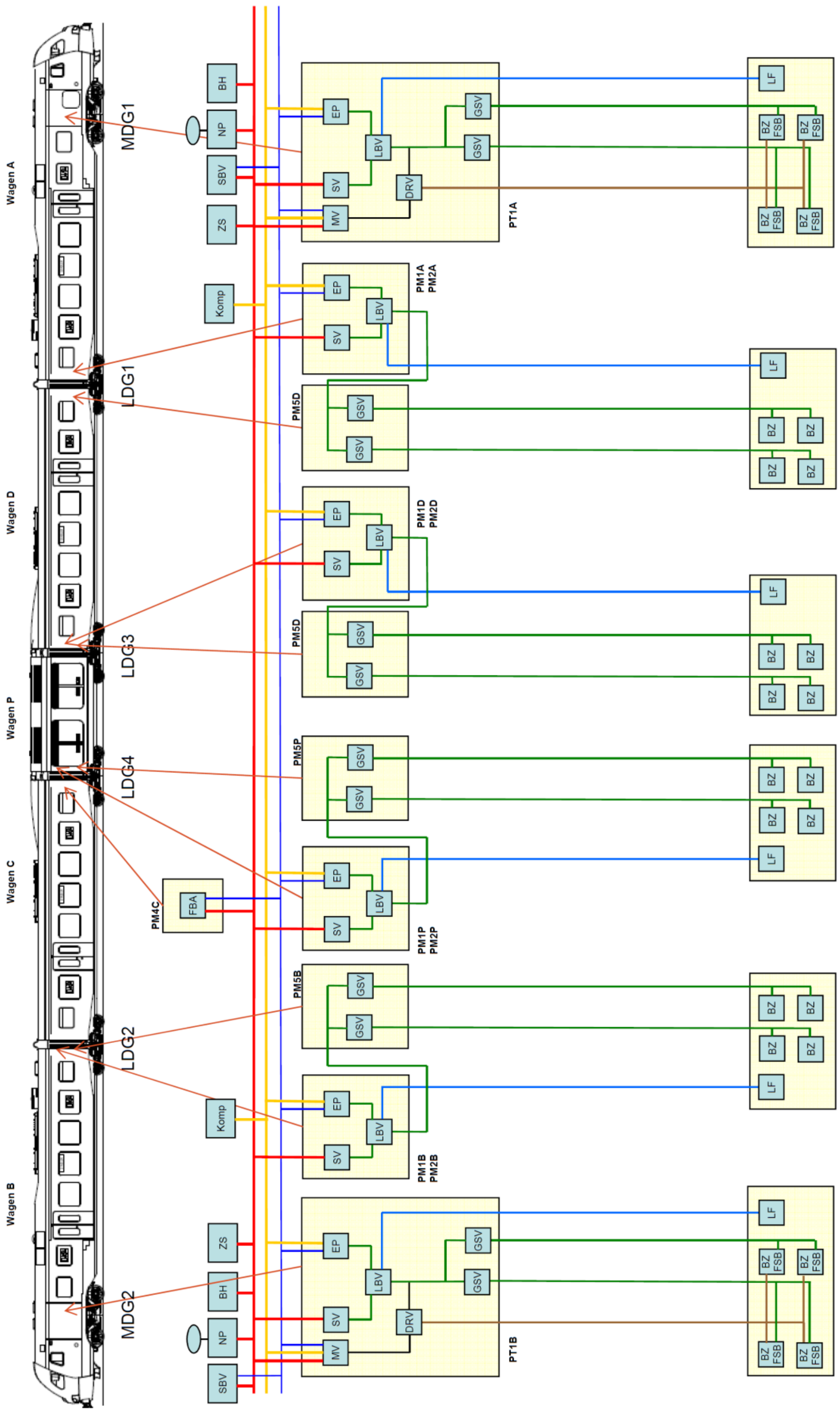


Figure 5: Concept diagram of the pneumatic equipment

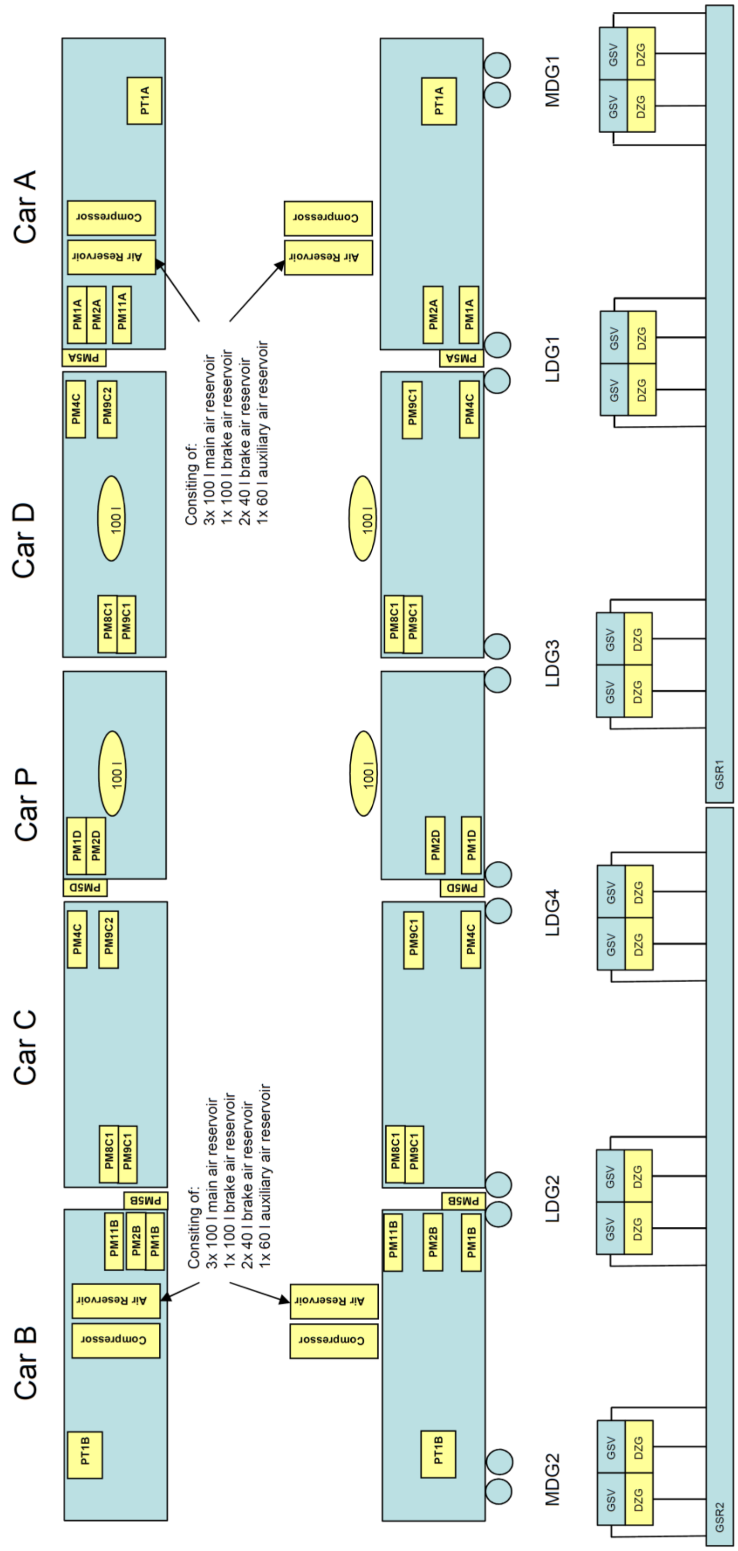


Figure 6: Layout of the pneumatic equipment and wheel slide protection

3.2 Operation and indication

The driver engages the brake with the master controller or the emergency stop. The pressure in the brake pipe, air reservoir pipe and brake cylinder is indicated on gauges located on the driver's desk and, in addition, logged on the diagnostics display. The status of the brake can also be read off the visual pressure indicators on the outside of each bogie.

The emergency brake position of the master controller opens the electrical emergency brake loop. The electrical emergency brake loop triggers all the emergency brake valves on the train, emptying the brake pipe from various locations simultaneously. The emergency stop also opens the emergency brake loop and empties the brake pipe directly with a large cross-section valve.

The brake check procedure is performed with the master controller. The brake check procedure has to be completed at least once after initiation of the cab. The driver checks the state of all brakes in the train with indicators on the driver's desk. The airtight integrity check of the brake pipe is initiated by a button on the diagnostics display and verified with the pressure gauges on the desk.

3.3 Service brake application

The service brake application is initiated with the master controller. The full service brake application is reached when the master controller is placed in the full service brake position. The master controller generates EP brake force on the motor axles and complements the brake force on the trailing axles to achieve the required brake force (blending). The VCU distributes the brake force to all axles in order to achieve a balanced thermal load across all brake discs. If the brake on one bogie is isolated, the braking force is redistributed to the other bogies by thermally balancing the load. Both the ED and EP brakes are capable of delivering sufficient braking force for normal operation of the vehicle independently. Braking with the master controller is the preferred method of braking as it is virtually wear-free. The recuperated braking energy is fed into the DC link of the traction converters and can be used to supply the vehicle's auxiliary power network; excessive energy is passed to the brake resistors. The motor brake force is reciprocal to the speed.

3.4 Mechanical function

The friction brake equipment of the vehicle uses two brake discs, which are located close to each wheel.

All trailer bogies have normal, self-adjusting callipers and all motor bogies have callipers, including the spring-loaded accumulators for the parking brake. Without air pressure, the spring applies a constant force, keeping the vehicle stationary. With air pressure applied, the parking brake is released. For maintenance or towing purposes, the parking brakes can be bypassed by pulling a release handle.

3.5 Brake Rates

Even though the brake systems capabilities are not used in everyday use (since the braking is mainly electro-dynamic) it is designed for good performance. With a brake caliper at every wheel the brake systems main limitation is the maximum force that can be transmitted from the wheel to the track.

Under an emergency brake application, the brake system has a nominal net braking rate of approximately 1.1 m/s^2. This rate is achieved throughout the speed range from 100 km/h down to zero, at a loading of up to AW3, but a minimum adhesion of 0.15 is required.

The maximum brake rate with bad adhesion is approximately 0.8 to 0.9 m/s^2 (depending on the actual condition of the track).

All run time simulations are calculated with a maximum brake rade of 0.8 m/s^2

The brake system is adjustet to a maximum service brake rate of 0.9 to 1.0 m/s^2, for comfort reasons the jerk rate is limited to 0.5 to 0.6 m/s^3.

4 Service Plan

This chapter provides the travel time of the proposed STADLER FLIRT³ DMU vehicles on the railway line between Bayview and Limebank. The data is the result of a computer simulation modeling the dynamic performance of the vehicle.

The intended service of the vehicle is determined to be performed with 7 vehicles and headway of 12 minutes, leading to a desired round trip time of 84 minutes.

The service plan intends the following dwell times:

Northbound travel	AM Peak	Midday	PM Peak	Evening
Limebank	**-**	-	-	-
Collector Road 'D'	**25**	25	25	25
Armstrong	**25**	25	25	25
Bowesville	**25**	25	25	25
Leitrim	**45**	36	44	30
South Keys	**30**	26	29	23
Greenboro	**44**	35	42	29
Walkley	**20**	20	20	20
Confederation	**23**	21	23	20
Carleton	**115**	85	110	65
Carling	**34**	28	33	24
Gladstone	**21**	20	21	20
Bayview (turn around)	**720**	720	720	720

Table 2: Northbound travel dwell times

Southbound travel	AM Peak	Midday	PM Peak	Evening
Bayview	**-**	-	-	-
Gladstone	**22**	20	22	20
Carling	**25**	22	25	20
Carleton	**90**	67	86	52
Confederation	**22**	20	21	20
Walkley	**20**	20	20	20
Greenboro	**20**	20	20	20
South Keys	**20**	20	20	20
Leitrim	**20**	20	20	20
Bowesville	**20**	20	20	20
Armstrong	**20**	20	20	20
Collector Road 'D'	**20**	20	20	20
Limebank (turn around)	**750**	750	750	750

Table 3: Southbound travel dwell times

4.1 Computer simulation

The computer simulation was performed assuming the following conditions:

- Round trip Limebank – Bayview – Limebank
- Dwell times at stations according to service plan, only AM Peak times are used for simulation (worst case).
- Fast driving style, remaining time can be used for a more energy efficient driving style.
- Two cases with different vehicle load, climatic conditions and adhesion factors are calculated.
- Track Data was provided by the City of Ottawa as a Excel-file (Trillium Line Track Data w Xovers.xlsx).

4.2 Results:

4.2.1 Case 1:

Case 1 is calculated with AW1 passenger load (all seats occupied, no standees) on a day with neutral weather (heating and air-conditioning consumes on a low level) and good adhesion (μ=0.25):

Station	At m	Arrive	Departure
Limebank	**17030**		**00:00:00**
Collector Road D	17470	00:00:48	00:01:14
Armstrong W	18730	00:02:48	00:03:14
Bowesville	20200	00:04:49	00:05:14
Leitrim	22810	00:08:00	00:08:46
South Keys	27645	00:12:51	00:13:22
Greenboro	28340	00:14:23	00:15:07
Walkley	29490	00:16:44	00:17:05
Confederation	31240	00:19:01	00:19:25
Carleton	32690	00:21:22	00:23:17
Carling	34485	00:25:28	00:26:03
Gladstone	35360	00:27:47	00:28:09
Bayview	**36119**	**00:29:18**	**00:41:18**
Gladstone	35360	00:42:28	00:42:50
Carling	34485	00:44:33	00:44:59
Carleton	32690	00:47:11	00:48:42
Confederation	31240	00:50:45	00:51:07
Walkley	29490	00:53:07	00:53:27
Greenboro	28340	00:55:05	00:55:26
South Keys	27645	00:56:29	00:56:50
Leitrim	22810	01:00:57	01:01:18
Bowesville	20200	01:03:59	01:04:20
Armstrong E	19290	01:05:31	01:05:51
Collector Road D	17470	01:07:52	01:08:13
Limebank	**17030**	**01:09:01**	**01:21:31**

Table 4: Computer simulation round trip time case 1

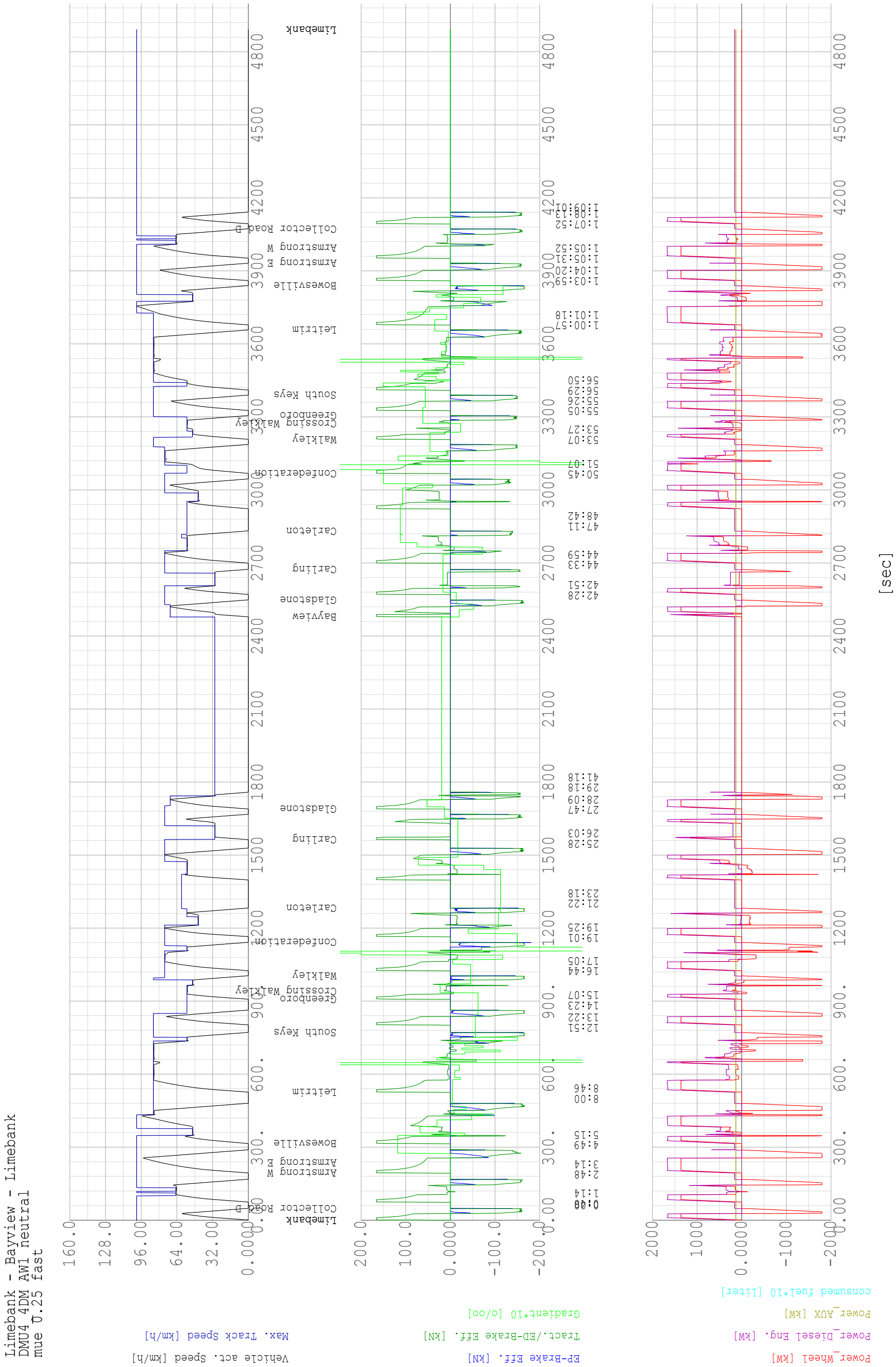


Figure 7: Time-based Diagrams of round trip case 1

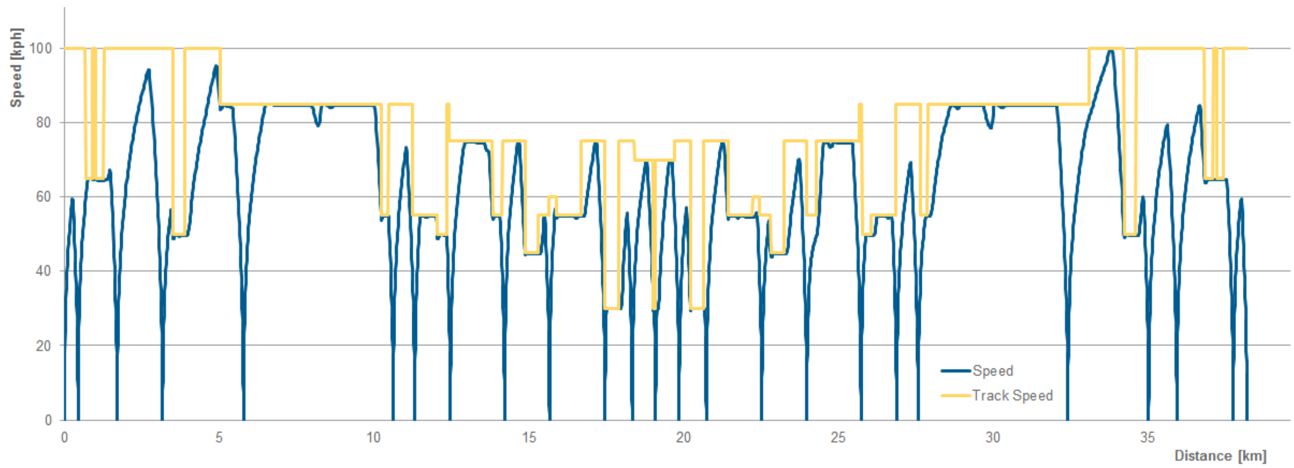


Figure 8: Speed-Distance Diagram Case 1

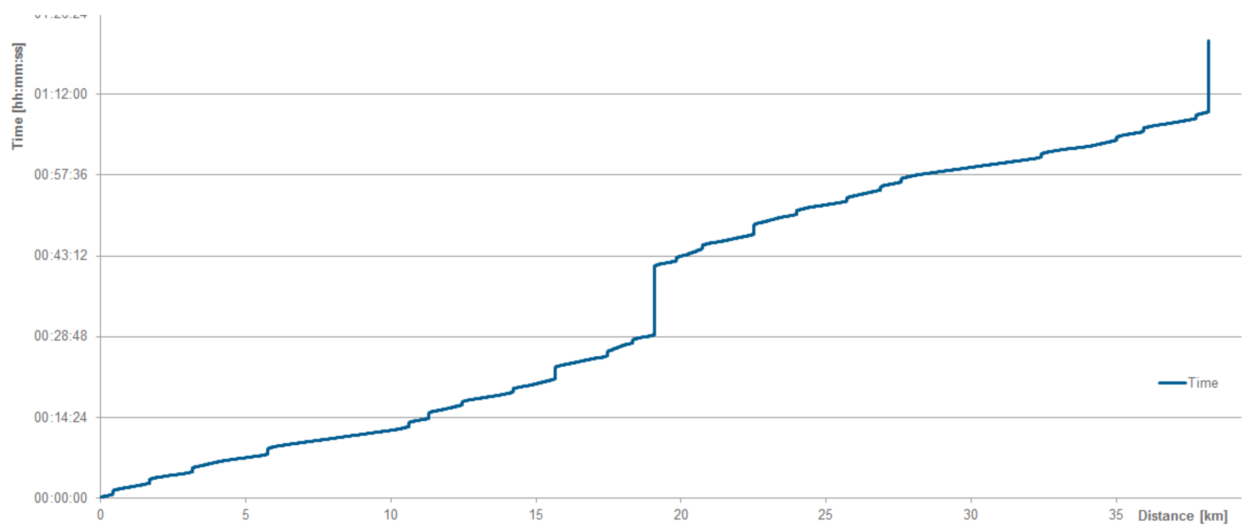


Figure 9: Time-Distance Diagram Case 1

4.2.2 Case 2:

Case 2 is calculated with AW1 passenger load plus standees (3.3 P/m²) on a cold day (heating consumes much energy) and bad adhesion (μ=0.16):

Station	At m	Arrive	Departure
Limebank	**17030**		**00:00:00**
Collector Road D	17470	00:00:49	00:01:15
Armstrong W	18730	00:02:50	00:03:15
Bowesville	20200	00:04:53	00:05:19
Leitrim	22810	00:08:06	00:08:52
South Keys	27645	00:12:59	00:13:30
Greenboro	28340	00:14:32	00:15:16
Walkley	29490	00:16:54	00:17:14
Confederation	31240	00:19:12	00:19:35
Carleton	32690	00:21:34	00:23:29
Carling	34485	00:25:41	00:26:16
Gladstone	35360	00:28:01	00:28:22
Bayview	**36119**	**00:29:32**	**00:41:33**
Gladstone	35360	00:42:43	00:43:06
Carling	34485	00:44:50	00:45:15
Carleton	32690	00:47:29	00:49:00
Confederation	31240	00:51:04	00:51:27
Walkley	29490	00:53:28	00:53:49
Greenboro	28340	00:55:27	00:55:48
South Keys	27645	00:56:53	00:57:13
Leitrim	22810	01:01:22	01:01:43
Bowesville	20200	01:04:27	01:04:48
Armstrong E	19290	01:06:00	01:06:21
Collector Road D	17470	01:08:24	01:08:44
Limebank	**17030**	**01:09:33**	**01:22:03**

Table 5: Computer simulation round trip time case 2

STADLER

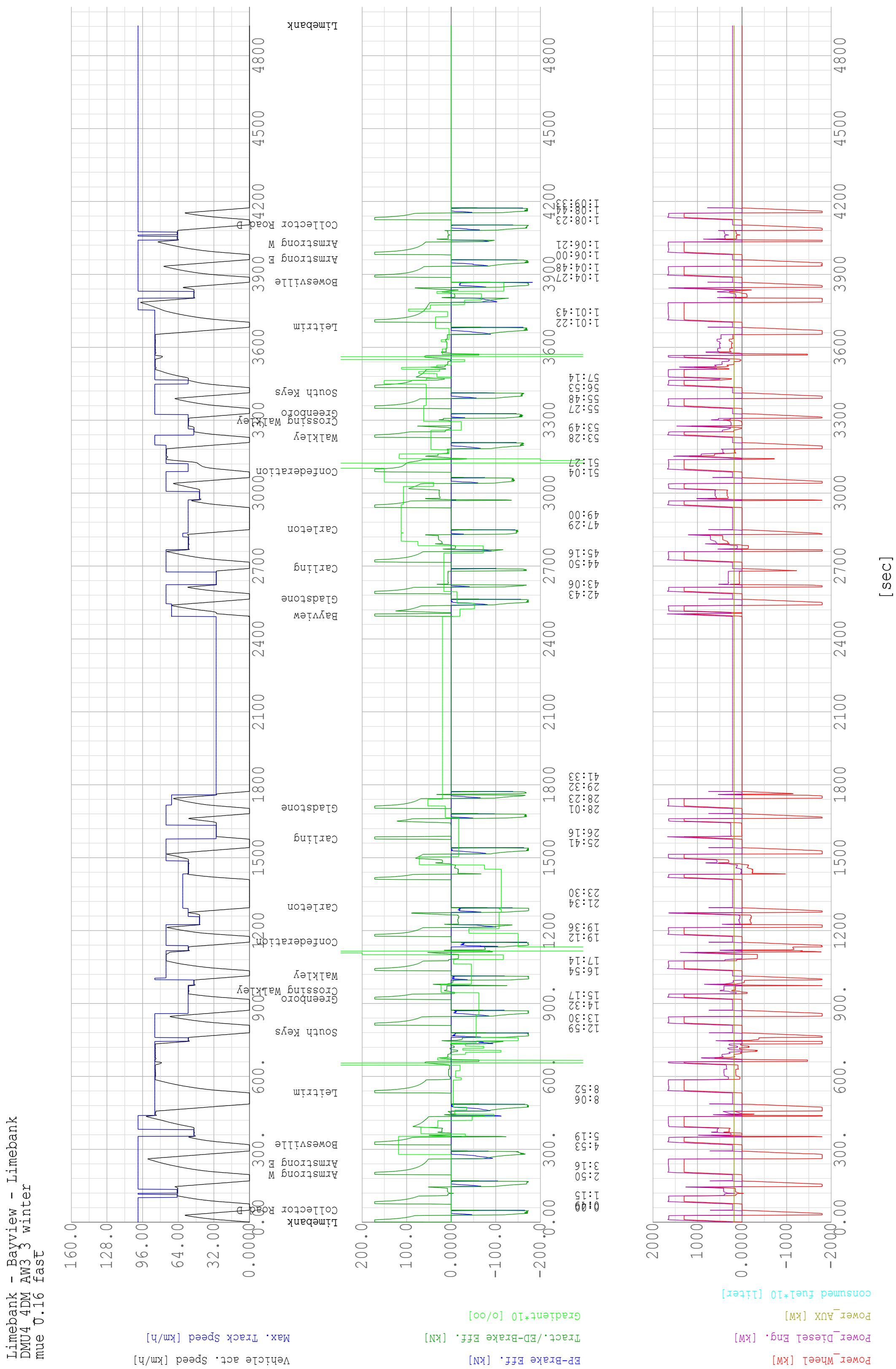


Figure 10: Time-based Diagrams of round trip case 2

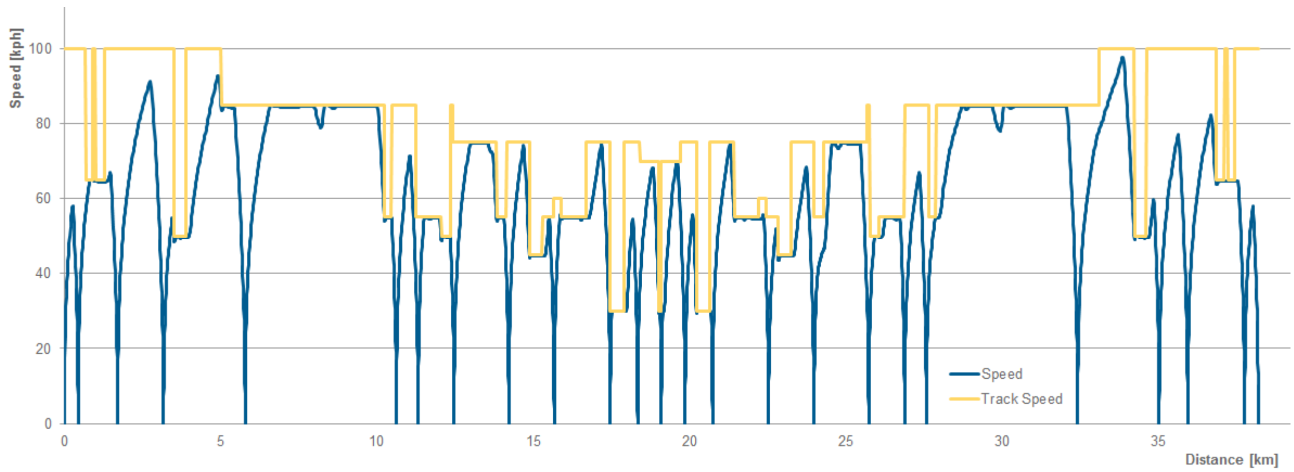


Figure 11: Speed-Distance Diagram Case 2

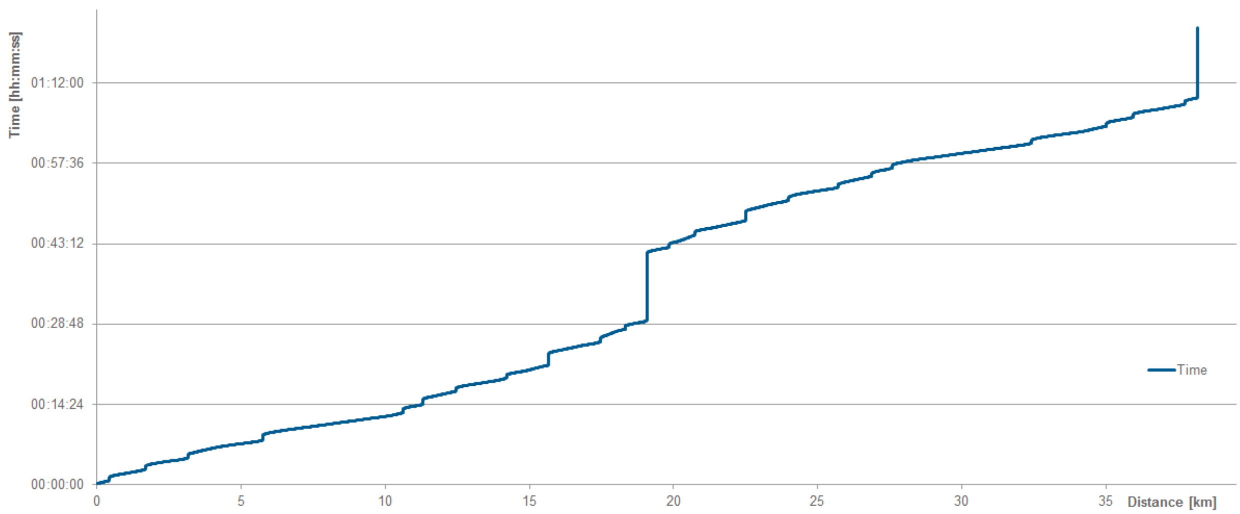


Figure 12: Time-Distance Diagram Case 2

4.3 Conclusion

The proposed STADLER FLIRT³ DMU vehicle is able to achieve the required round trip travel time of 84 min.

5 Revision history

Rev.	Change	Date	Created by	Checked by	Released by
_	First edition	04.07.2017	A. Solowiewski	B. Schmid	K. Roth
a	Update BAFO	07.06.2018	A. Solowiewski	J. Rauprich	K. Roth
b	Revision Acceleration	20.07.2018	J. Rauprich	K. Roth	J. Rauprich
c					
d					

RFVSO Reference: Part 2.2 a (i)
Proposal Document No.: 100.165_

Customer:	City of Ottawa
Tender Name:	Ottawa Stage 2 LRT Trillium Line Extension
Solicitation Number:	09717-55800-P01
Stadler-Document-No.:	522’628

Vehicle Emissions

Table of Contents

1 Introduction

This document describes the vehicle technical specifications.

Requirements

State the vehicle emission standard with which the proposed Vehicle will be compliant. Detail the *emissions* of particulate matter, oxides of nitrogen, non-methane hydrocarbon (either combined or separate) and carbon monoxide for the annual operation of the Trillium Service

1.1 Abbreviations

FLIRT	Stadler Vehicle Family: Fast Light Innovative Regional Train
GTW	Stadler Vehicle Family: Gelenktriebwagen (German for: articulated rail car)
EPA	United States Environmental Protection Agency
SCR	Selective Catalytic Reduction

1.2 Legal Regulations, Standards and Guidelines

All standards, if not otherwise specified, have been applied in the versions current on the date of Stadler's offer.

2012/46/EU	Measures against the emission of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery
SOR/2005-32	Canada Off-Road Compression-Ignition Engine Emission Regulations
CFR 1039	Control of Emissions from new and in-use no road Compression-Ignition Engines

1.3 References

No references.

1.4 Annexes

No annexes.

2 Vehicle Emissions Tier 4f (final)

As per the emission standards Canada SOR/2005-32 section 10 (1) (c) respectively the herein mentioned standard CFR 1039 section 101 Table 1 in subpart B, the Stadler FLIRT3 vehicle is fully compliant with the latest and required emission stage Tier 4f (final).

2.1 Emission comparison

The old emission standard Stage IIIb which is equivalent to EPA Tier 4 interim was introduced in 2011. Nitrous oxides irritate and damage the respiratory system and have a negative effect on the pulmonary function of children and adults. They are also responsible for the ozone formation during smog in larger agglomerations as well as global warming.
In 2014 EPA Tier 4f (final) has been introduced compulsory in North America for all off-road applications including rail car applications. The nitrous oxide emission limit has been reduced with this new emission stage by factor 5 (see Table 1).

	Stage IIIb (RC B) 130 < kW < 560	Tier 4 interim 130 < kW <560	Tier 4 final 130 < kW < 560	Stage V 130 < kW < 560
Year of introduction	2011	2011 till 2013	2014	2019
NOx [g/kWh]	2.0	4.0	0.4	0.4
HC [g/kWh]	0.19		0.19	0.19
CO [g/kWh]	3.5	3.5	3.5	3.5
PM [g/kWh]	0.025	0.02	0.02	0.015
PN [#/kWh]	-	-	-	1×10^{12}

Emission of the STADLER FLIRT3 as per Canada SOR/2005-32 and CFR 1039

Table 1: comparison of the Stage IIIb/Tier 4 interim values to the Stage Tier 4f (final)

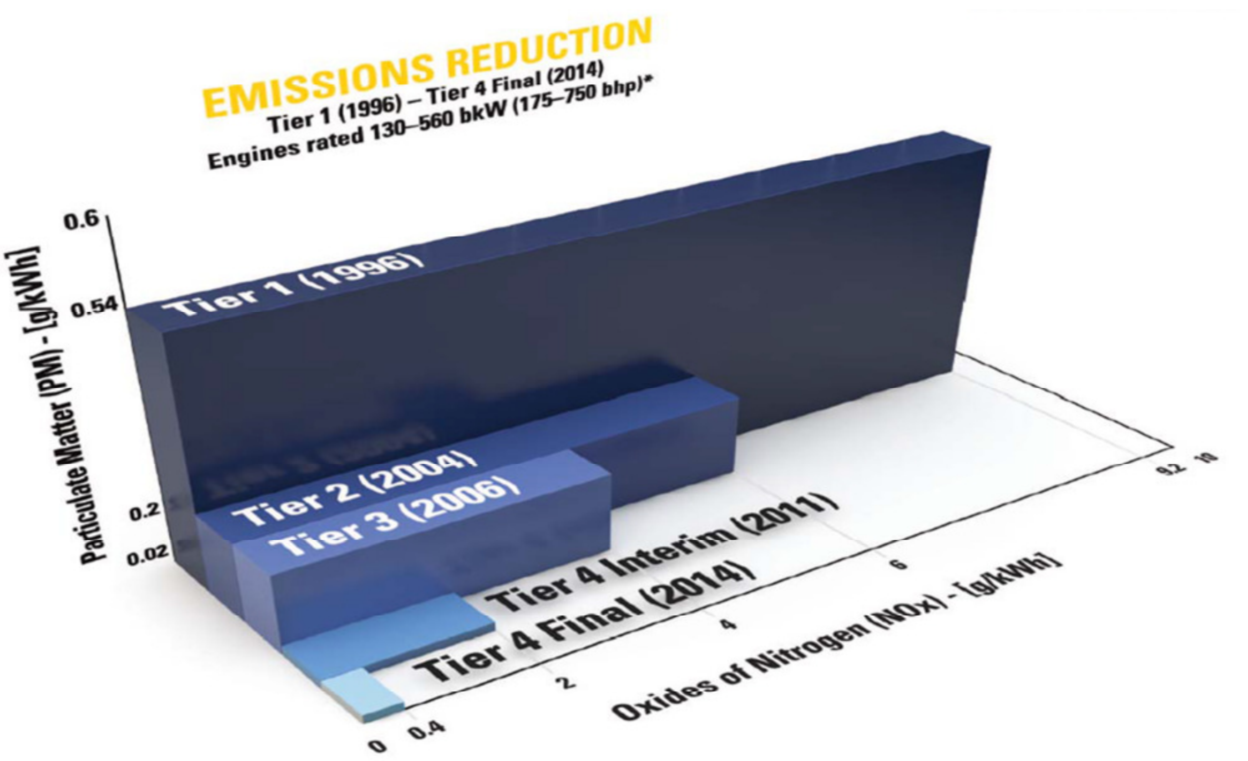


Figure 1: comparison of the different Tier stages

2.2 System description Tier 4f (final)

The Deutz system consists of two SCR systems in row with two completely independent AdBlue dosing systems which are controlled altogether by three NOx-Sensors, two exhaust gas temperature sensors and two exhaust gas backpressure sensors. Therefore NOx reduction can be performed very dependable and can react quicker on engine load changes than a single SCR system. A clean-up catalyst at the very end prevents the output of N2O, which has a 300 times higher global warming potential than CO2.

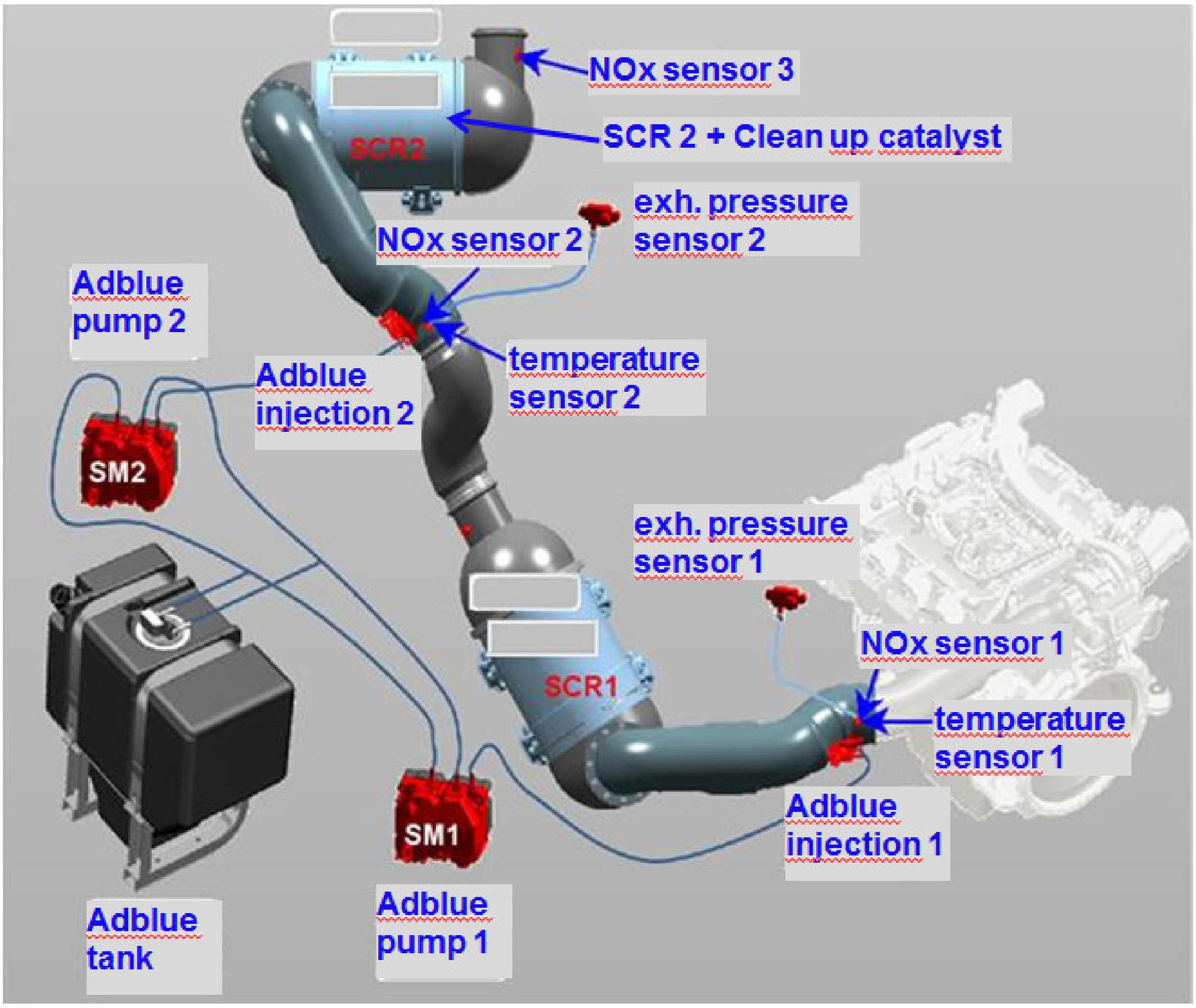


Figure 2: Overview of the Tier 4f (final) SCR system

3 Revision History

Rev.	Change	Date	Created	Checked	Released
_	First Edition	13. 09. 2017	M. Jauch	K. Roth	B. Schmid
a					
b					
c					
d					

APPENDIX D
CALCULATIONS

OLRT Trillium Line Limebank Extension Air Quality Assessment
Sample Emission Rate Calculations

Example No. 1: Running Busses at Bowesville Station (CO Emissions)

CO Emission Rate developed by MOVES2014a:	0.6269 g/VKT
Bus headway at Bowesville Station:	12 minutes
Bus platforms available at Bowesville Station:	4
Busses per hour arriving at Bowesville Station:	20 bus/hr *
Distance traveled by busses within Bowesville Station:	0.403 km

* *Busses per hour derived as follows: 60 mins / 12 mins = 5 busses per hour x 4 bus platforms*

Sample Calculation for AERMOD Emission Rate:

MOVES2014a emission rate [g/VKT] x Busses per hour arriving at Bowesville Station [veh/hr] x Distance traveled [km]
= 0.6269 g/VKT x 20 veh/hr x 0.403 km x 1 hr/3600 s
= 0.0047 g/s

Example No. 2: Trains Idling at Limebank Station (CO Emissions)

CO Emission Rate from U.S. EPA Tier 4 Standards:	2385 g/veh-hr
Train headway at Limebank Station:	12 minutes
Train idling time at Limebank Station:	12 minutes
Trains per hour arriving at Limebank Station:	5 trains/hr

Sample Calculation for AERMOD Emission Rate

Tier 4 Emission Rate [g/veh-hr] x No. of trains per hour x Idling time per hour
= 2385 g/veh-hr x 5 veh x 12 mins/60 mins x 1 hr/3600 s
= 0.6626 g/s

Example No. 3: Cars leaving the Park-n-Ride Parking Lot: PM Peak hour (CO Emissions)

CO Emission Rate (MOVES) for Running Cars:	1.2598 g/VKT
CO Emission Rate (MOVES) for Idling Cars:	9.3469 g/veh-hr
CO Emission Rate (MOVES) for Starting Cars:	21.8129 g/start
Amount of time idling per vehicle following start:	0.5 minutes
Number of vehicles leaving during peak PM hour:	641 vehicles *
Average distance traveled by a car within the lot:	225 m

* *See hourly fraction for determining peak hour lot usage for AM and PM volumes.*
Note: peak hour emission rates were applied to all AM or PM operational hours to remain conservative

Sample Calculation for AERMOD Emission Rate

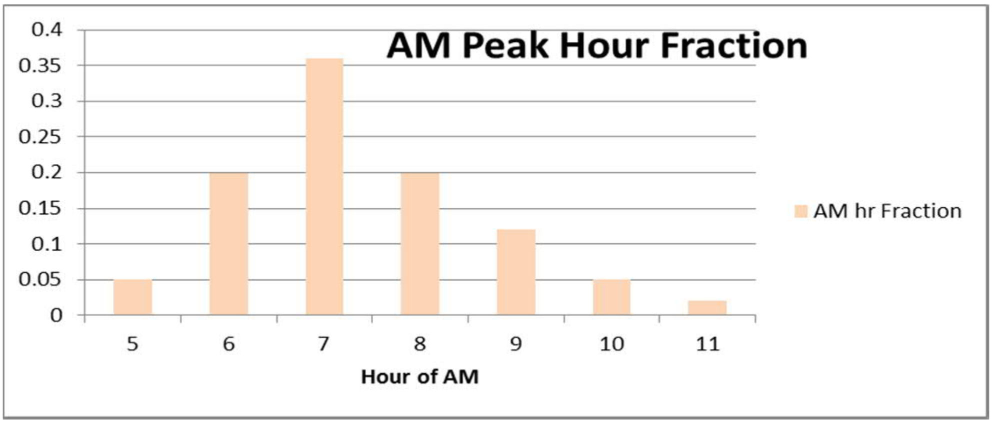
Idling emission rate [g/veh-hr] x no. of vehicles x idling time per hour
= 9.3469 g/veh-hr x 641 veh x 0.5 min/ 60 min x 1 hr / 3600 s
= 0.0139 g/s

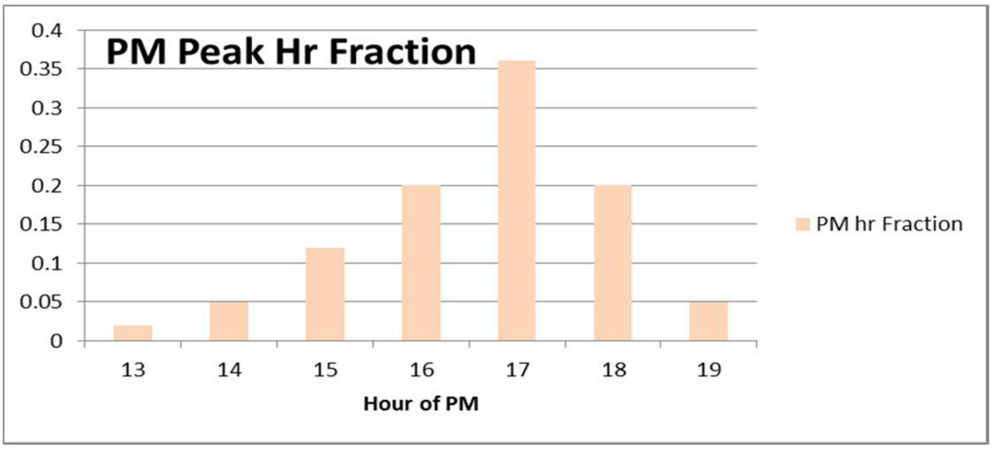
Running emission rate [g/VKT] x no. of vehicles x distance traveled [km]
= 1.2598 g/VKT x 641 veh x 0.225 km x 1 hr / 3600 s
= 0.0505 g/s

Starting emisison rate [g/start] x no. of vehicles starting in an hour
= 21.8129 g/start x 641 vehicles/hr x 1 hr / 3600 s
= 3.8839 g/s

Total emission rate = 0.0139 g/s + 0.0505 g/s + 3.8839 g/s
= 3.947 g/s

Peak AM and PM hour fraction for the Park-n-Ride Lot (assumed)





Notes:
[1] Peak AM hour is assumed to be from 7 AM to 8 AM
[2] Peak PM hour is assumed to be from 5 PM to 6 PM
[3] Total number of available parking spots is 1780
[4] Peak hour fraction of 0.36 is applied to total parking lot capacity to determine peak hour volume
0.36 x 1780 vehicles = 641 vehicles

APPENDIX E
BACKGROUND DATA

2016

	NAPS ID	City	P/T	Location	Latitude	Longitude	Elevation	Type	ID	Minimum	10th Percentile	30th Percentile	50th Percentile	70th Percentile	80th Percentile	90th Percentile	95th Percentile	98th Percentile	99th Percentile	99.9th Percentile	Maximum	Percent Completeness	Mean	Standard Deviation
CO (ppm)	050204	Gatineau	QC	255 St-Redempteur, Hull	45.4360	-75.7234	62	PE,LU,P5,R	1HR	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.4	0.5	0.6	0.9	1.1	95	0.2	0.1
	054401	Saint-Anicet	QC	1128 De La Guerre	45.1206	-74.2896	50	RB,NU,P2,A	1HR	0.0	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.8	96	0.2	0.1
	060104	Ottawa	ON	Rideau And Wurtenberg	45.4343	-75.6760	72	PE,LU,P6,R	1HR	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.4	0.5	0.5	0.7	0.9	98	0.2	0.1
NO2 (ppb)	050204	Gatineau	QC	255 St-Redempteur, Hull	45.4360	-75.7234	62	PE,LU,P5,R	1HR	0	1	2	3	6	9	14	21	28	33	45	50	89	6	7
	054401	Saint-Anicet	QC	1128 De La Guerre	45.1206	-74.2896	50	RB,NU,P2,A	1HR	0	1	1	2	3	3	5	8	12	15	26	37	96	3	3
	060104	Ottawa	ON	Rideau And Wurtenberg	45.4343	-75.6760	72	PE,LU,P6,R	1HR	0	2	3	5	8	10	15	21	28	32	43	48	99	7	7
CO (ppm)	050204	Gatineau	QC	255 St-Redempteur, Hull	45.4360	-75.7234	62	PE,LU,P5,R	8HR	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.4	0.4	0.5	0.7	0.8	99	0.2	0.1
	054401	Saint-Anicet	QC	1128 De La Guerre	45.1206	-74.2896	50	RB,NU,P2,A	8HR	0.0	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	100	0.2	0.1
	060104	Ottawa	ON	Rideau And Wurtenberg	45.4343	-75.6760	72	PE,LU,P6,R	8HR	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.4	0.5	0.5	0.6	0.7	98	0.2	0.1
NO2 (ppb)	050204	Gatineau	QC	255 St-Redempteur, Hull	45.4360	-75.7234	62	PE,LU,P5,R	8HR	0	1	2	4	7	9	14	18	24	29	37	42	89	6	6
	054401	Saint-Anicet	QC	1128 De La Guerre	45.1206	-74.2896	50	RB,NU,P2,A	8HR	0	1	1	2	3	4	5	7	11	14	27	30	100	3	3
	060104	Ottawa	ON	Rideau And Wurtenberg	45.4343	-75.6760	72	PE,LU,P6,R	8HR	1	2	3	5	8	10	15	19	24	29	37	40	100	7	6
CO (ppm)	050204	Gatineau	QC	255 St-Redempteur, Hull	45.4360	-75.7234	62	PE,LU,P5,R	24HR	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.6	0.7	98	0.2	0.1
	054401	Saint-Anicet	QC	1128 De La Guerre	45.1206	-74.2896	50	RB,NU,P2,A	24HR	0.0	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	100	0.2	0.1
	060104	Ottawa	ON	Rideau And Wurtenberg	45.4343	-75.6760	72	PE,LU,P6,R	24HR	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.6	98	0.2	0.1
NO2 (ppb)	050204	Gatineau	QC	255 St-Redempteur, Hull	45.4360	-75.7234	62	PE,LU,P5,R	24HR	0	2	3	4	7	9	12	15	21	24	29	30	88	6	5
	054401	Saint-Anicet	QC	1128 De La Guerre	45.1206	-74.2896	50	RB,NU,P2,A	24HR	0	1	1	2	3	3	4	6	9	12	21	23	100	3	2
	060104	Ottawa	ON	Rideau And Wurtenberg	45.4343	-75.6760	72	PE,LU,P6,R	24HR	1	2	4	5	8	10	14	17	21	25	30	31	100	7	5
PM2.5 (µg/m3)	050204	Gatineau	QC	255 St-Redempteur, Hull	45.4360	-75.7234	62	PE,LU,P5,R	24HR	1	3	4	6	8	9	11	14	18	22	31	31	91	7	4
	054401	Saint-Anicet	QC	1128 De La Guerre	45.1206	-74.2896	50	RB,NU,P2,A	24HR	1	2	4	6	8	10	11	13	16	19	26	27	100	6	4
	060104	Ottawa	ON	Rideau And Wurtenberg	45.4343	-75.6760	72	PE,LU,P6,R	24HR	0	2	4	5	7	8	11	13	16	18	29	29	98	6	4

2015

	NAPS ID	City	P/T	Location	Latitude	Longitude	Elevation	Type	ID	Minimum	10th Percentile	30th Percentile	50th Percentile	70th Percentile	80th Percentile	90th Percentile	95th Percentile	98th Percentile	99th Percentile	99.9th Percentile	Maximum	Percent Completeness	Mean	Standard Deviation
CO (ppm)	050204	Gatineau	QC	255 St-Redempteur, Hull	45.436	-75.7234	62	Residential	1HR	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.4	0.5	0.6	0.7	0.9	94	0.2	0.1
	054401	Saint-Anice	QC	1128 De La Guerre	45.1206	-74.2885	50	Agricultura	1HR	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.6	82		
	060104	Ottawa	ON	Rideau And Wurtenberg	45.4343	-75.676	72	Commercia	1HR	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.5	0.7	0.8	99	0.2	0.1
NO2 (ppb)	050204	Gatineau	QC	255 St-Redempteur, Hull	45.436	-75.7234	62	Residential	1HR	0	1	2	3	6	8	14	20	27	30	40	43	98	6	6
	054401	Saint-Anice	QC	1128 De La Guerre	45.1206	-74.2885	50	Agricultura	1HR	0	1	1	2	3	4	6	9	12	15	38	45	94	3	3
	060104	Ottawa	ON	Rideau And Wurtenberg	45.4343	-75.676	72	Commercia	1HR	0	2	3	5	8	11	16	22	30	37	45	51	99	7	7
CO (ppm)	050204	Gatineau	QC	255 St-Redempteur, Hull	45.436	-75.7234	62	Residential	8HR	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.4	0.4	0.5	0.6	0.7	98	0.2	0.1
	054401	Saint-Anice	QC	1128 De La Guerre	45.1206	-74.2885	50	Agricultura	8HR	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.6	85		
	060104	Ottawa	ON	Rideau And Wurtenberg	45.4343	-75.676	72	Commercia	8HR	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.6	0.6	100	0.2	0.1
NO2 (ppb)	050204	Gatineau	QC	255 St-Redempteur, Hull	45.436	-75.7234	62	Residential	8HR	0	1	2	4	6	9	13	18	23	27	33	36	98	6	5
	054401	Saint-Anice	QC	1128 De La Guerre	45.1206	-74.2885	50	Agricultura	8HR	0	1	1	2	3	4	6	8	11	13	35	40	98	3	3
	060104	Ottawa	ON	Rideau And Wurtenberg	45.4343	-75.676	72	Commercia	8HR	1	2	4	5	8	11	16	21	28	31	39	43	100	7	6
CO (ppm)	050204	Gatineau	QC	255 St-Redempteur, Hull	45.436	-75.7234	62	Residential	24HR	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.6	0.6	97	0.2	0.1
	054401	Saint-Anice	QC	1128 De La Guerre	45.1206	-74.2885	50	Agricultura	24HR	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.5	84		
	060104	Ottawa	ON	Rideau And Wurtenberg	45.4343	-75.676	72	Commercia	24HR	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.6	100	0.2	0.1
NO2 (ppb)	050204	Gatineau	QC	255 St-Redempteur, Hull	45.436	-75.7234	62	Residential	24HR	0	2	3	4	6	9	12	15	19	22	29	32	98	6	5
	054401	Saint-Anice	QC	1128 De La Guerre	45.1206	-74.2885	50	Agricultura	24HR	1	1	2	2	3	4	5	7	10	12	28	30	98	3	2
	060104	Ottawa	ON	Rideau And Wurtenberg	45.4343	-75.676	72	Commercia	24HR	1	3	4	6	8	11	15	19	24	27	32	35	100	7	5
PM2.5 (µg/m3)	050204	Gatineau	QC	255 St-Redempteur, Hull	45.436	-75.7234	62	Residential	24HR	0	2	4	5	7	9	12	14	18	21	32	36	96	6	4
	054401	Saint-Anice	QC	1128 De La Guerre	45.1206	-74.2885	50	Agricultura	24HR	0	2	4	6	8	10	13	16	19	22	37	38	85		
	060104	Ottawa	ON	Rideau And Wurtenberg	45.4343	-75.676	72	Commercia	24HR	0	3	4	6	8	10	13	15	19	23	33	36	99	7	4

2014

	NAPS ID	City	P/T	Location	Latitude	Longitude	Elevation	Type	ID	Minimum	10th Percentile	30th Percentile	50th Percentile	70th Percentile	80th Percentile	90th Percentile	95th Percentile	98th Percentile	99th Percentile	99.9th Percentile	Maximum	Percent Completeness	Mean	Standard Deviation
CO (ppm)	050204	Gatineau	QC	255 St-Redempteur, Hull	45.436	-75.7234	62	Residential	1HR	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.5	0.7	0.9	90	0.2	0.1
	054401	Saint-Anice	QC	1128 De La Guerre	45.1206	-74.2885	50	Agricultura	1HR	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.5	95	0.2	0.1
	060104	Ottawa	ON	Rideau And Wurtenberg	45.4343	-75.676	72	Commercia	1HR	0	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.6	0.8	98	0.2	0.1
NO2 (ppb)	050204	Gatineau	QC	255 St-Redempteur, Hull	45.436	-75.7234	62	Residential	1HR	0	1	2	4	6	9	13	17	24	28	39	46	97	6	6
	054401	Saint-Anice	QC	1128 De La Guerre	45.1206	-74.2885	50	Agricultura	1HR	0	1	1	2	3	4	5	7	12	18	31	39	95	3	3
	060104	Ottawa	ON	Rideau And Wurtenberg	45.4343	-75.676	72	Commercia	1HR	0	2	3	5	8	11	16	20	28	32	43	47	99	7	6
CO (ppm)	050204	Gatineau	QC	255 St-Redempteur, Hull	45.436	-75.7234	62	Residential	8HR	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.7	94	0.2	0.1
	054401	Saint-Anice	QC	1128 De La Guerre	45.1206	-74.2885	50	Agricultura	8HR	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.4	98	0.2	0.1
	060104	Ottawa	ON	Rideau And Wurtenberg	45.4343	-75.676	72	Commercia	8HR	0	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.6	98	0.2	0.1
NO2 (ppb)	050204	Gatineau	QC	255 St-Redempteur, Hull	45.436	-75.7234	62	Residential	8HR	0	2	3	4	6	8	12	15	20	23	29	37	97	6	5
	054401	Saint-Anice	QC	1128 De La Guerre	45.1206	-74.2885	50	Agricultura	8HR	0	1	1	2	3	4	5	7	12	17	28	31	99	3	3
	060104	Ottawa	ON	Rideau And Wurtenberg	45.4343	-75.676	72	Commercia	8HR	1	2	4	6	8	11	15	19	24	28	33	41	100	7	6
CO (ppm)	050204	Gatineau	QC	255 St-Redempteur, Hull	45.436	-75.7234	62	Residential	24HR	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	93	0.2	0.1
	054401	Saint-Anice	QC	1128 De La Guerre	45.1206	-74.2885	50	Agricultura	24HR	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.4	98	0.2	0.1
	060104	Ottawa	ON	Rideau And Wurtenberg	45.4343	-75.676	72	Commercia	24HR	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	98	0.2	0
NO2 (ppb)	050204	Gatineau	QC	255 St-Redempteur, Hull	45.436	-75.7234	62	Residential	24HR	1	2	3	5	7	8	11	13	16	19	22	23	96	6	4
	054401	Saint-Anice	QC	1128 De La Guerre	45.1206	-74.2885	50	Agricultura	24HR	1	1	2	2	3	4	5	7	11	14	18	19	99	3	2
	060104	Ottawa	ON	Rideau And Wurtenberg	45.4343	-75.676	72	Commercia	24HR	1	3	4	6	9	11	14	17	21	24	27	28	100	7	5
PM2.5 (µg/m3)	050204	Gatineau	QC	255 St-Redempteur, Hull	45.436	-75.7234	62	Residential	24HR	1	3	5	7	9	10	13	15	19	20	23	23	94	7	4
	054401	Saint-Anice	QC	1128 De La Guerre	45.1206	-74.2885	50	Agricultura	24HR	1	3	5	6	9	10	13	15	19	21	29	31	98	7	4
	060104	Ottawa	ON	Rideau And Wurtenberg	45.4343	-75.676	72	Commercia	24HR	0	3	5	6	8	10	12	15	20	22	27	28	98	7	4

Concentrations (ug/m3) at St. Anicet NAPS 54401 - Raw Data				
	Day of the Year	Formaldehyde ug/m3	Acetaldehyde ug/m3	Acrolein ug/m3
1/6/2015	6	0.4247	0.0000	0.0448
1/12/2015	12	1.0395	0.0000	0.0404
1/18/2015	18	0.5631	0.7527	0.0570
1/24/2015	24	0.9996	0.8608	0.0447
1/30/2015	30	0.4757	0.0000	0.0406
2/5/2015	36	0.3505	0.0016	0.0000
2/11/2015	42	0.9653	1.1456	0.0000
2/17/2015	48	0.7263	0.7403	0.0000
2/23/2015	54	0.3609	0.8025	0.0000
3/1/2015	60	1.0002	0.6007	0.0000
3/7/2015	66	1.0002	0.1059	0.0000
3/13/2015	72	0.6238	0.0000	0.0000
3/19/2015	78	1.0038	1.3285	0.0000
3/25/2015	84	1.1224	0.4139	0.0000
3/31/2015	90	0.5926	0.1783	0.0000
4/6/2015	96	0.8866	0.7617	0.0000
4/12/2015	102	0.9791	0.6006	0.0507
4/18/2015	108	1.1236	0.5648	0.0000
4/24/2015	114	0.4609	0.5924	0.0000
4/30/2015	120	0.8063	0.4213	0.0084
5/6/2015	126	1.2777	1.2492	0.0000
5/18/2015	138	4.4334	4.1820	0.0210
5/30/2015	150	3.5200	2.1683	0.0118
6/5/2015	156	2.5018	1.2651	0.0165
6/17/2015	168	1.8815	1.1970	0.0000
6/23/2015	174	2.3256	2.7171	0.0000
7/11/2015	192	-999.0000	-999.0000	-999.0000
7/17/2015	198	-999.0000	-999.0000	-999.0000
7/23/2015	204	-999.0000	-999.0000	-999.0000
7/29/2015	210	4.8108	3.2829	0.0315
8/4/2015	216	1.4545	1.7279	0.0000
8/10/2015	222	3.3404	2.9772	0.0000
8/16/2015	228	2.4809	1.4686	0.0000
8/22/2015	234	1.3479	0.9203	0.0000
8/28/2015	240	1.7795	0.0000	0.0000
10/3/2015	276	18.4097	2.7861	0.1066
10/9/2015	282	1.8450	1.4084	0.0271
10/15/2015	288	-999.0000	-999.0000	-999.0000
10/21/2015	294	-999.0000	-999.0000	-999.0000
10/27/2015	300	-999.0000	-999.0000	-999.0000
11/2/2015	306	-999.0000	-999.0000	-999.0000
11/8/2015	312	-999.0000	-999.0000	-999.0000
11/14/2015	318	-999.0000	-999.0000	-999.0000
11/20/2015	324	-999.0000	-999.0000	-999.0000
11/26/2015	330	-999.0000	-999.0000	-999.0000
12/2/2015	336	-999.0000	-999.0000	-999.0000
12/8/2015	342	0.3832	1.1135	0.0236
12/14/2015	348	0.2615	0.4834	0.0129
12/20/2015	354	0.0000	0.1573	0.0000
12/26/2015	360	0.0592	0.3275	0.0216

2015 VOC Concentrations (ug/m3) **NAPS Station: 60104 (Ottawa)**

Sampling Date	**Day of the Year**	**1,3-Butadiene (ug/m3)**	**Benzene (ug/m3)**
2015/01/06	6	0.099	1.051
2015/01/12	12	0.045	0.734
2015/01/18	18	0.094	1.290
2015/01/24	24	0.027	0.574
2015/01/30	30	0.023	0.500
2015/02/05	36	0.039	0.641
2015/02/11	42	0.033	0.693
2015/02/17	48	0.106	1.378
2015/02/23	54	0.028	0.702
2015/03/01	60	0.040	0.911
2015/03/07	66	0.023	0.634
2015/03/13	72	0.054	0.780
2015/03/19	78	0.032	0.534
2015/03/25	84	0.035	0.680
2015/03/31	90	0.011	0.355
2015/04/06	96	0.021	0.457
2015/04/12	102	0.013	0.322
2015/04/18	108	0.009	0.308
2015/04/24	114	0.016	0.331
2015/04/30	120	0.014	0.229
2015/05/06	126	0.026	0.352
2015/05/12	132	0.022	0.338
2015/05/18	138	0.032	0.384
2015/05/24	144	0.018	0.274
2015/05/30	150	0.018	0.304
2015/06/05	156	0.017	0.233
2015/06/11	162	0.019	0.449
2015/06/17	168	0.017	0.163
2015/06/23	174	0.012	0.146
2015/06/29	180	0.014	0.145
2015/07/05	186	0.020	0.350
2015/07/11	192	0.021	0.287
2015/07/17	198	0.033	0.325
2015/07/23	204	0.019	0.199
2015/07/29	210	0.023	0.315
2015/08/04	216	0.020	0.188
2015/08/10	222	0.021	0.279
2015/08/16	228	0.045	0.409
2015/08/22	234	0.042	0.291
2015/08/28	240	0.027	0.279
2015/09/03	246	0.018	0.411
2015/09/09	252	0.023	0.323
2015/09/15	258	0.017	0.252
2015/09/21	264	0.042	0.366
2015/09/27	270	0.048	0.490
2015/10/03	276	0.011	0.143
2015/10/09	282	0.024	0.235
2015/10/15	288	0.025	0.279
2015/10/21	294	0.020	0.262
2015/10/27	300	0.119	0.795
2015/11/02	306	0.043	0.388
2015/11/08	312	0.000	0.000
2015/11/14	318	0.016	0.279
2015/11/20	324	0.017	0.305
2015/11/26	330	0.038	0.578
2015/12/02	336	0.077	0.812
2015/12/08	342	0.069	0.692
2015/12/14	348	0.036	0.474
2015/12/20	354	0.023	0.359
2015/12/26	360	0.039	0.476

APPENDIX F
INDIVIDUAL RECEPTOR IMPACTS

Table F1: Predicted Maximum Concentration at Discrete Receptors - Carbon Monoixde (CO)

Receptors	1-hr Background Level (µg/m^3)	Modelled 1-Hr Concentration (Maximum) (µg/m^3)	1-Hr Cumulative Concentration (Maximum) (µg/m^3)	8-hr Background Level (µg/m^3)	Modelled 8_Hr Concentration (Maximum) (µg/m^3)	8-Hr Cumulative Concentration (Maximum) (µg/m^3)	Air Quality Threshold (µg/m^3) (1-Hr/8-Hr)
R1	376	404	779	376	198	574	36,200/15,700
R2	376	343	719	376	137	513	36,200/15,700
R3	376	317	693	376	149	525	36,200/15,700
R4	376	350	726	376	175	551	36,200/15,700
R5	376	473	848	376	289	664	36,200/15,700
R6	376	711	1086	376	203	579	36,200/15,700
R7	376	450	826	376	204	580	36,200/15,700
R8	376	551	927	376	303	678	36,200/15,700
R9	376	540	916	376	208	584	36,200/15,700
R10	376	922	1298	376	306	682	36,200/15,700
R11	376	604	980	376	288	664	36,200/15,700
R12	376	1135	1511	376	412	787	36,200/15,700
R13	376	908	1284	376	312	688	36,200/15,700
R14	376	1864	2240	376	656	1031	36,200/15,700
R15	376	1101	1476	376	360	736	36,200/15,700
R16	376	1428	1804	376	687	1063	36,200/15,700
R17	376	919	1295	376	355	731	36,200/15,700
R19	376	1058	1434	376	461	836	36,200/15,700
R20	376	530	905	376	215	591	36,200/15,700

Table F2: Predicted Maximum Concentration at Discrete Receptors - NOx

Receptors	1-hr Background Level (µg/m³)	Modelled 1-Hr Concentration (Maximum) (µg/m³)	1-Hr Cumulative Concentration (Maximum) (µg/m³)	24-hr Background Level (µg/m³)	Modelled 24-Hr Concentration (Maximum) (µg/m³)	24-Hr Cumulative Concentration (Maximum) (µg/m³)	Annual Background Level (µg/m³)	Modelled Annual Concentration (Maximum) (µg/m³)	Annual Cumulative Concentration (Maximum)	Air Quality Threshold (µg/m³) (1-Hr/24-Hr)	Air Quality Threshold CAAQS (2025) 1-hr/Annual (µg/m³)
R1	32.3	28.1	60.4	29.4	10.3	39.7	7.0	1.6	8.5	400/200	79/23
R2	32.3	26.5	58.8	29.4	8.9	38.3	7.0	1.0	7.9	400/200	79/23
R3	32.3	33.3	65.6	29.4	8.8	38.2	7.0	0.9	7.9	400/200	79/23
R4	32.3	41.4	73.7	29.4	10.7	40.1	7.0	1.0	8.0	400/200	79/23
R5	32.3	56.6	88.9	29.4	20.9	50.3	7.0	2.4	9.3	400/200	79/23
R6	32.3	39.9	72.2	29.4	8.1	37.5	7.0	1.2	8.1	400/200	79/23
R7	32.3	26.2	58.5	29.4	12.3	41.8	7.0	1.8	8.7	400/200	79/23
R8	32.3	55.3	87.6	29.4	17.0	46.4	7.0	1.0	8.0	400/200	79/23
R9	32.3	44.0	76.3	29.4	13.6	43.0	7.0	2.3	9.2	400/200	79/23
R10	32.3	65.1	97.4	29.4	17.8	47.2	7.0	3.0	10.0	400/200	79/23
R11	32.3	44.6	76.9	29.4	18.8	48.3	7.0	3.1	10.0	400/200	79/23
R12	32.3	65.0	97.3	29.4	25.4	54.8	7.0	4.4	11.4	400/200	79/23
R13	32.3	53.5	85.7	29.4	14.5	43.9	7.0	2.5	9.5	400/200	79/23
R14	32.3	71.6	103.9	29.4	18.4	47.8	7.0	2.9	9.8	400/200	79/23
R15	32.3	61.5	93.8	29.4	14.2	43.6	7.0	2.9	9.8	400/200	79/23
R16	32.3	62.2	94.5	29.4	23.5	52.9	7.0	3.4	10.3	400/200	79/23
R17	32.3	50.2	82.5	29.4	14.5	43.9	7.0	2.0	8.9	400/200	79/23
R19	32.3	68.5	100.8	29.4	18.4	47.8	7.0	3.0	10.0	400/200	79/23
R20	32.3	36.2	68.5	29.4	11.6	41.0	7.0	1.3	8.2	400/200	79/23

Table F3: Predicted Maximum Concentration at Discrete Receptors -PM10

Receptors	24-hr Background Level ($\mu g/m^3$)	Modelled 24-Hr Concentration (Maximum) ($\mu g/m^3$)	24-Hr Cumulative Concentration (Maximum) ($\mu g/m^3$)	Air Quality Threshold ($\mu g/m^3$)
R1	22.8	0.599	23.4	50.0
R2	22.8	0.515	23.4	50.0
R3	22.8	0.581	23.4	50.0
R4	22.8	0.667	23.5	50.0
R5	22.8	1.46	24.3	50.0
R6	22.8	0.598	23.4	50.0
R7	22.8	0.672	23.5	50.0
R8	22.8	1.07	23.9	50.0
R9	22.8	0.692	23.5	50.0
R10	22.8	0.975	23.8	50.0
R11	22.8	0.982	23.8	50.0
R12	22.8	1.37	24.2	50.0
R13	22.8	1.01	23.9	50.0
R14	22.8	1.80	24.6	50.0
R15	22.8	1.09	23.9	50.0
R16	22.8	2.12	25.0	50.0
R17	22.8	1.34	24.2	50.0
R19	22.8	1.18	24.0	50.0
R20	22.8	0.664	23.5	50.0

Table F4: Predicted Maximum Concentration at Discrete Receptors - PM2.5

Receptors	24-hr Background Level (µg/m^3)	Modelled 24-Hr Concentration (Maximum) (µg/m^3)	24-Hr Cumulative Concentration (Maximum) (µg/m^3)	Annual Background Level (µg/m^3)	Modelled Annual Concentration (Maximum) (µg/m^3)	Annual Cumulative Concentration (Maximum) (µg/m^3)	Air Quality Threshold (µg/m^3) (24-Hr/Annual)
R1	12.3	0.498	12.8	7.67	0.073	7.74	27/8.8
R2	12.3	0.410	12.7	7.67	0.046	7.71	27/8.8
R3	12.3	0.409	12.7	7.67	0.044	7.71	27/8.8
R4	12.3	0.509	12.8	7.67	0.047	7.71	27/8.8
R5	12.3	0.972	13.3	7.67	0.110	7.78	27/8.8
R6	12.3	0.427	12.8	7.67	0.056	7.72	27/8.8
R7	12.3	0.569	12.9	7.67	0.082	7.75	27/8.8
R8	12.3	0.788	13.1	7.67	0.048	7.71	27/8.8
R9	12.3	0.627	13.0	7.67	0.104	7.77	27/8.8
R10	12.3	0.823	13.2	7.67	0.140	7.81	27/8.8
R11	12.3	0.870	13.2	7.67	0.141	7.81	27/8.8
R12	12.3	1.205	13.5	7.67	0.205	7.87	27/8.8
R13	12.3	0.756	13.1	7.67	0.117	7.78	27/8.8
R14	12.3	1.212	13.5	7.67	0.149	7.82	27/8.8
R15	12.3	0.809	13.1	7.67	0.103	7.77	27/8.8
R16	12.3	1.409	13.7	7.67	0.192	7.86	27/8.8
R17	12.3	0.880	13.2	7.67	0.098	7.76	27/8.8
R19	12.3	0.937	13.3	7.67	0.144	7.81	27/8.8
R20	12.3	0.544	12.9	7.67	0.061	7.73	27/8.8

Table F5: Predicted Maximum Concentration at Discrete Receptors - Benenze

Receptors	24-hr Background Level (µg/m^3)	Modelled 24-Hr Concentration (Maximum) (µg/m^3)	24-Hr Cumulative Concentration (Maximum) (µg/m^3)	Annual Background Level (µg/m^3)	Modelled Annual Concentration (Maximum) (µg/m^3)	Annual Cumulative Concentration (Maximum) (µg/m^3)	Air Quality Threshold (µg/m^3) (24-Hr/Annual)
R1	0.713	0.129	0.842	0.437	0.007	0.445	2.3/0.45
R2	0.713	0.081	0.793	0.437	0.005	0.442	2.3/0.45
R3	0.713	0.093	0.806	0.437	0.005	0.442	2.3/0.45
R4	0.713	0.097	0.810	0.437	0.005	0.442	2.3/0.45
R5	0.713	0.081	0.794	0.437	0.009	0.446	2.3/0.45
R6	0.713	0.188	0.901	0.437	0.008	0.446	2.3/0.45
R7	0.713	0.146	0.859	0.437	0.008	0.446	2.3/0.45
R8	0.713	0.088	0.800	0.437	0.004	0.441	2.3/0.45
R9	0.713	0.095	0.808	0.437	0.009	0.446	2.3/0.45
R10	0.713	0.180	0.893	0.437	0.013	0.450	2.3/0.45
R11	0.713	0.187	0.900	0.437	0.013	0.451	2.3/0.45
R12	0.713	0.322	1.04	0.437	0.021	0.458	2.3/0.45
R13	0.713	0.296	1.01	0.437	0.012	0.449	2.3/0.45
R14	0.713	1.240	1.95	0.437	0.060	0.498	2.3/0.45
R15	0.713	0.543	1.26	0.437	0.016	0.453	2.3/0.45
R16	0.713	1.310	2.02	0.437	0.118	0.555	2.3/0.45
R17	0.713	0.689	1.40	0.437	0.029	0.466	2.3/0.45
R19	0.713	0.419	1.13	0.437	0.023	0.460	2.3/0.45
R20	0.713	0.337	1.05	0.437	0.014	0.451	2.3/0.45

Table F6: Predicted Maximum Concentration at Discrete Receptors -1,3-Butadiene

Receptors	24-hr Background Level ($\mu g/m^3$)	Modelled 24-Hr Concentration (Maximum) ($\mu g/m^3$)	24-Hr Cumulative Concentration (Maximum) ($\mu g/m^3$)	Annual Background Level ($\mu g/m^3$)	Modelled Annual Concentration (Maximum) ($\mu g/m^3$)	Annualr Cumulative Concentration (Maximum) ($\mu g/m^3$)	Air Quality Threshold ($\mu g/m^3$) (24-Hr/Annual)
R1	0.057	0.028	0.085	0.031	0.001	0.032	10.0/2.0
R2	0.057	0.017	0.074	0.031	0.001	0.031	10.0/2.0
R3	0.057	0.020	0.077	0.031	0.001	0.031	10.0/2.0
R4	0.057	0.021	0.078	0.031	0.001	0.031	10.0/2.0
R5	0.057	0.015	0.072	0.031	0.001	0.032	10.0/2.0
R6	0.057	0.041	0.098	0.031	0.002	0.032	10.0/2.0
R7	0.057	0.031	0.088	0.031	0.001	0.032	10.0/2.0
R8	0.057	0.016	0.073	0.031	0.001	0.031	10.0/2.0
R9	0.057	0.019	0.076	0.031	0.001	0.032	10.0/2.0
R10	0.057	0.036	0.093	0.031	0.002	0.032	10.0/2.0
R11	0.057	0.040	0.097	0.031	0.002	0.033	10.0/2.0
R12	0.057	0.069	0.126	0.031	0.003	0.034	10.0/2.0
R13	0.057	0.062	0.120	0.031	0.002	0.032	10.0/2.0
R14	0.057	0.277	0.334	0.031	0.013	0.043	10.0/2.0
R15	0.057	0.119	0.176	0.031	0.003	0.033	10.0/2.0

Table F7: Predicted Maximum Concentration at Discrete Receptors - Formaldehyde

Receptors	24-hr Background Level ($\mu g/m^3$)	Modelled 24-Hr Concentration (Maximum) ($\mu g/m^3$)	24-Hr Cumulative Concentration (Maximum) ($\mu g/m^3$)	Air Quality Threshold ($\mu g/m^3$)
R1	1.22	0.542	1.77	65.0
R2	1.22	0.461	1.69	65.0
R3	1.22	0.441	1.67	65.0
R4	1.22	0.551	1.78	65.0
R5	1.22	1.03	2.25	65.0
R6	1.22	0.417	1.64	65.0
R7	1.22	0.654	1.88	65.0
R8	1.22	0.865	2.09	65.0
R9	1.22	0.730	1.95	65.0
R10	1.22	0.958	2.18	65.0
R11	1.22	1.01	2.24	65.0
R12	1.22	1.36	2.58	65.0
R13	1.22	0.761	1.99	65.0
R14	1.22	0.948	2.17	65.0
R15	1.22	0.717	1.94	65.0
R16	1.22	1.17	2.40	65.0
R17	1.22	0.705	1.93	65.0
R19	1.22	0.964	2.19	65.0
R20	1.22	0.624	1.85	65.0

Table F8: Predicted Maximum Concentration at Discrete Receptors - Acetaldehyde

Receptors	24-hr Background Level ($\mu g/m^3$)	Modelled 24-Hr Concentration (Maximum) ($\mu g/m^3$)	24-Hr Cumulative Concentration (Maximum) ($\mu g/m^3$)	Air Quality Threshold ($\mu g/m^3$)
R1	2.54	0.217	2.76	500.0
R2	2.54	0.156	2.69	500.0
R3	2.54	0.155	2.69	500.0
R4	2.54	0.205	2.74	500.0
R5	2.54	0.347	2.89	500.0
R6	2.54	0.205	2.74	500.0
R7	2.54	0.231	2.77	500.0
R8	2.54	0.293	2.83	500.0
R9	2.54	0.250	2.79	500.0
R10	2.54	0.345	2.88	500.0
R11	2.54	0.351	2.89	500.0
R12	2.54	0.509	3.05	500.0
R13	2.54	0.364	2.90	500.0
R14	2.54	0.820	3.36	500.0
R15	2.54	0.462	3.00	500.0
R16	2.54	0.878	3.42	500.0
R17	2.54	0.524	3.06	500.0
R19	2.54	0.452	2.99	500.0
R20	2.54	0.262	2.80	500.0

Table F9: Predicted Maximum Concentration at Discrete Receptors - Acrolein

Receptors	24-hr Background Level ($\mu g/m^3$)	Modelled 24-Hr Concentration (Maximum) ($\mu g/m^3$)	24-Hr Cumulative Concentration (Maximum) ($\mu g/m^3$)	Annual Background Level ($\mu g/m^3$)	Modelled Annual Concentration (Maximum) ($\mu g/m^3$)	Annual Cumulative Concentration (Maximum) ($\mu g/m^3$)	Air Quality Threshold ($\mu g/m^3$) (24-Hr/Annual)
R1	1.37	0.085	1.46	0.031	0.029	0.061	4.5/0.4
R2	1.37	0.071	1.45	0.031	0.024	0.055	4.5/0.4
R3	1.37	0.084	1.46	0.031	0.023	0.054	4.5/0.4
R4	1.37	0.103	1.48	0.031	0.029	0.060	4.5/0.4
R5	1.37	0.141	1.52	0.031	0.053	0.084	4.5/0.4
R6	1.37	0.151	1.53	0.031	0.024	0.056	4.5/0.4
R7	1.37	0.095	1.47	0.031	0.034	0.065	4.5/0.4
R8	1.37	0.145	1.52	0.031	0.045	0.076	4.5/0.4
R9	1.37	0.130	1.50	0.031	0.038	0.069	4.5/0.4
R10	1.37	0.219	1.59	0.031	0.049	0.081	4.5/0.4
R11	1.37	0.127	1.50	0.031	0.052	0.083	4.5/0.4
R12	1.37	0.238	1.61	0.031	0.072	0.103	4.5/0.4
R13	1.37	0.196	1.57	0.031	0.044	0.075	4.5/0.4
R14	1.37	0.333	1.71	0.031	0.069	0.100	4.5/0.4
R15	1.37	0.232	1.61	0.031	0.047	0.078	4.5/0.4
R16	1.37	0.264	1.64	0.031	0.082	0.113	4.5/0.4
R17	1.37	0.183	1.56	0.031	0.050	0.081	4.5/0.4
R19	1.37	0.240	1.61	0.031	0.055	0.086	4.5/0.4
R20	1.37	0.102	1.48	0.031	0.032	0.063	4.5/0.4

Table F10: Predicted Maximum Concentration at Discrete Receptors - Benzo(a)pyrene

Receptors	24-hr Background Level (µg/m³)	Modelled 24-Hr Concentration (Maximum) (µg/m³)	24-Hr Cumulative Concentration (Maximum) (µg/m³)	Annual Background Level (µg/m³)	Modelled Annual Concentration (Maximum) (µg/m³)	Annual Cumulative Concentration (Maximum) (µg/m³)	Air Quality Threshold (µg/m³) (24-Hr/Annual)
R1	1.53E-04	5.00E-05	2.03E-04	7.62E-05	1.00E-05	8.62E-05	0.00005/0.00001
R2	1.53E-04	3.00E-05	1.83E-04	7.62E-05	0.00E+00	7.62E-05	0.00005/0.00001
R3	1.53E-04	4.00E-05	1.93E-04	7.62E-05	0.00E+00	7.62E-05	0.00005/0.00001
R4	1.53E-04	4.00E-05	1.93E-04	7.62E-05	0.00E+00	7.62E-05	0.00005/0.00001
R5	1.53E-04	6.00E-05	2.13E-04	7.62E-05	1.00E-05	8.62E-05	0.00005/0.00001
R6	1.53E-04	6.00E-05	2.13E-04	7.62E-05	0.00E+00	7.62E-05	0.00005/0.00001
R7	1.53E-04	5.00E-05	2.03E-04	7.62E-05	1.00E-05	8.62E-05	0.00005/0.00001
R8	1.53E-04	5.00E-05	2.03E-04	7.62E-05	0.00E+00	7.62E-05	0.00005/0.00001
R9	1.53E-04	4.00E-05	1.93E-04	7.62E-05	1.00E-05	8.62E-05	0.00005/0.00001
R10	1.53E-04	8.00E-05	2.33E-04	7.62E-05	1.00E-05	8.62E-05	0.00005/0.00001
R11	1.53E-04	7.00E-05	2.23E-04	7.62E-05	1.00E-05	8.62E-05	0.00005/0.00001
R12	1.53E-04	1.10E-04	2.63E-04	7.62E-05	1.00E-05	8.62E-05	0.00005/0.00001
R13	1.53E-04	1.10E-04	2.63E-04	7.62E-05	1.00E-05	8.62E-05	0.00005/0.00001
R14	1.53E-04	3.60E-04	5.13E-04	7.62E-05	2.00E-05	9.62E-05	0.00005/0.00001
R15	1.53E-04	1.70E-04	3.23E-04	7.62E-05	1.00E-05	8.62E-05	0.00005/0.00001
R16	1.53E-04	3.80E-04	5.33E-04	7.62E-05	4.00E-05	1.16E-04	0.00005/0.00001
R17	1.53E-04	2.10E-04	3.63E-04	7.62E-05	1.00E-05	8.62E-05	0.00005/0.00001
R19	1.53E-04	1.40E-04	2.93E-04	7.62E-05	1.00E-05	8.62E-05	0.00005/0.00001
R20	1.53E-04	1.00E-04	2.53E-04	7.62E-05	1.00E-05	8.62E-05	0.00005/0.00001

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